CAMELOT LANDFILL
CITY OF LEWISVILLE, DENTON COUNTY
TCEQ PERMIT NO. MSW-1312B

MAJOR PERMIT AMENDMENT APPLICATION

VOLUME 2 OF 6

Prepared for

City of Farmers Branch

March 2012

JEFFREY P. YOUNG
79809

3-21-12

Prepared by

Weaver Boos Consultants, LLC–Southwest
TBPE Registration No. F-3727
6420 Southwest Boulevard, Suite 206
Fort Worth, Texas 76109
817-735-9770

WBC Project No. 1339-351-11-02-6B

This document is intended for permitting purposes only.

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VOLUME 2 OF 6

CONTENTS

PART III – SITE DEVELOPMENT PLAN

STATE OF TEXAS
JEFFREY P. YOUNG
79809
LICENSED
PROFESSIONAL ENGINEER

3-21-12

CAMELOT LANDFILL
CITY OF LEWISVILLE, DENTON COUNTY
TCEQ PERMIT NO. MSW-1312B

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIB
WASTE CONTAINMENT SYSTEM DESIGN
POINT OF COMPLIANCE DEMONSTRATION

Prepared for

City of Farmers Branch

March 2012

NEVZAT TURAN
84059

3-21-12

Prepared by

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STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

3-21-12

TABLES AND FIGURES

1 INTRODUCTION

1.1 Purpose

The proposed continued development of the Camelot Landfill includes a vertical expansion over the pre-Subtitle D portion of the landfill. The purpose of this appendix is to demonstrate that the proposed containment system design for the pre-Subtitle D area meets the point of compliance (POC) requirements set forth in Title 30 TAC §330.331(a). This is achieved by demonstrating that the predicted concentrations of selected leachate chemical constituents do not exceed maximum contaminant levels listed in Table 1 in §330.331(a)(1) in the uppermost aquifer at the POC.

Section 1.2 provides a description of the containment system design and Section 1.3 presents an overview of the POC demonstration.

1.2 Containment System Design

The locations of the pre-Subtitle D area, the overliner area, and the point of compliance are shown on Figure 1.1. The overliner area will consist of Cells O1 through O6, which comprises approximately 61.7 acres of the total 236.8-acre solid waste disposal area footprint. The waste containment system design is shown on Figure 1.2. Each component of the design is described below.

- I – In-situ Bottom Liner. This relatively thick geologic layer prevents the downward migration of leachate. The thickness of the unweathered Shale Strata below the pre-Subtitle D area has an average thickness of over 90 feet (refer to Figure IIIG-C-4 in Appendix IIIG-C).
- II and III – 3-foot-thick Compacted Clay Sidewall Liner and Slurry Wall. These two components of the containment system form a dual barrier to prevent the lateral migration of leachate from the landfill. The extent of the slurry wall, or soil bentonite cutoff wall, is shown on Figure 1.1. As shown, the slurry wall surrounds the southern and eastern perimeter of the pre-Subtitle D area. The slurry wall will be keyed into the unweathered Shale Strata and will provide an additional hydraulic barrier between the pre-Subtitle D area and groundwater. The slurry wall backfill will have a permeability of no more than 1x10^{-7} cm/s.
- IV – Overliner System. The overliner consists of a composite liner system that is designed to prevent the percolation of leachate from the vertical expansion area to the existing waste in the pre-Subtitle D area. The overliner system will convey

leachate generated from the vertical expansion area over the existing pre-Subtitle D area to leachate collection sumps located along the perimeter of the overliner area, as well as to sumps located in the Subtitle D area.

- V and VI – Final Cover System. The purpose of the final cover system is to prevent the infiltration of stormwater into the disposal area.

1.3 POC Demonstration Overview

The purpose of the POC demonstration is to show that the proposed containment system design for the pre-Subtitle D area will meet the POC requirements set forth in §330.331 (a)(1). This is achieved by demonstrating that the predicted concentration of a wide range of leachate chemical constituents do not exceed allowable values. As shown on Figure 1.2, the concentration of various constituents at the POC is determined by calculating a dilution attenuation factor (DAF), which is calculated by the following equation.

$$\text{DAF} = \frac{C_O\text{, Initial Constituent Concentration of Leachate Within the Landfill}}{C_P\text{, Constituent Concentration at the POC}}$$

As noted in the above equation, the DAF represents the factor by which the constituent concentration is expected to decrease between the landfill and the POC. When the constituent's concentration in leachate is divided by the model predicted DAF, the resulting concentration must be less than the allowable maximum contaminant levels (MCLs) in groundwater for the chemical parameters listed in Table 1 included in Title 30 TAC §330.331(a)(1).

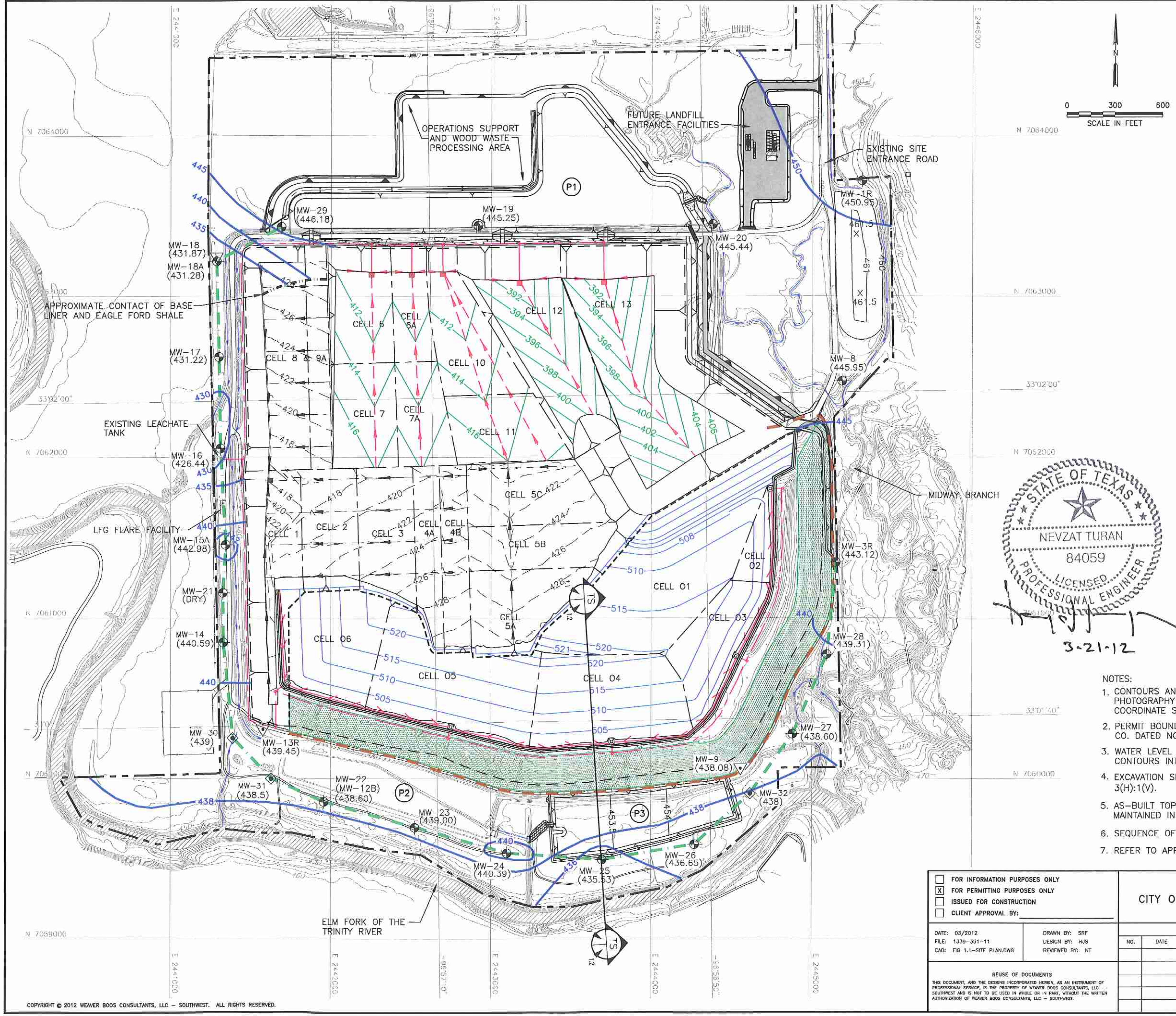
Section 2 discusses the models used to calculate the DAF for the POC demonstration. Sections 3 and 4 discuss the various demonstration input parameters, as well as how the input parameters vary as the site develops. The results of the POC demonstration for the waste containment design are summarized in Section 5.0.

1.4 Additional Demonstrations

This appendix also includes the following demonstrations that are related to the POC demonstration.

- Section 6 includes a demonstration that shows that the proposed alternative composite liner (geosynthetic clay liner (GCL)/geomembrane/leachate collection layer) is equivalent to the composite liner specified in Title 30 TAC §330.331(a)(2) (compacted clay liner (CCL)/geomembrane/leachate collection layer).

- Section 7 provides additional POC demonstrations to show the effectiveness of the waste containment design. Various input parameters are modified to show their effect on the estimated DAFs.
- Section 8 demonstrates the effectiveness of the Shale Strata as a lower confining unit. As noted in Appendix IIIG, the uppermost aquifer at the site and the Woodbine Aquifer Strata are hydraulically separated by the unweathered Shale Strata; therefore, the groundwater monitoring system is designed to monitor the uppermost aquifer located in the Alluvial Strata located above the Shale Strata. This section summarizes an assessment that was completed to verify that the Shale Strata effectively restricts the potential downward flow from the site.



LEGEND

▬ ▬ · ▬	PERMIT BOUNDARY
— — — —	LIMITS OF WASTE
- - - - -	LIMITS OF PRE-SUBTITLE D WASTE
N 7064000	STATE PLANE COORDINATE SYSTEM
33°02'00"	GEODETIC COORDINATE SYSTEM
500	EXISTING CONTOUR
——	CELL BOUNDARY
398	EXCAVATION CONTOUR
461	REGRADED BUFFER ZONE AREA
430	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (SEE NOTE 3)
— ◄ —	LEACHATE LINE
🟥	LEACHATE COLLECTION SUMP
→	LEACHATE RISER
422	AS-BUILT TOP OF SUBTITLE D GEOMEMBRANE LINER (SEE NOTE 5)
— ◄ —	EXISTING LEACHATE LINE
■	EXISTING LEACHATE COLLECTION SUMP
→	EXISTING LEACHATE RISER
Y Y Y	3H:1V SLOPE (TYPICAL)
515	TOP OF OVERLINER CONTOUR
→ →	OVERLINER LEACHATE LINE
⊡	OVERLINER LEACHATE COLLECTION SUMP
— · —	LEACHATE FORCEMAIN
— · —	POINT OF COMPLIANCE
— · —	APPROXIMATE LOCATION OF SLURRY WALL (SEE NOTE 7)
MW-3R (443.12)	EXISTING MONITORING WELL WITH GROUNDWATER ELEVATION POSTED IN FT-MSL
MW-30 (439)	PROPOSED MONITORING WELL WITH GROUNDWATER ELEVATION POSTED IN FT-MSL
MW-9 (438.08)	EXISTING MONITORING WELL PROPOSED FOR REMOVAL AFTER REPLACEMENT WELL BACKGROUND CONCENTRATIONS ESTABLISHED (WITH GROUNDWATER ELEVATION POSTED IN FT-MSL)
▨	CONSTRUCTED FINAL COVER

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED PROFESSIONAL ENGINEER

3-21-12

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.
3. WATER LEVEL MEASUREMENTS COLLECTED BY WBC ON DECEMBER 5, 2010. POTENTIOMETRIC CONTOURS INTERPOLATED BY WBC.
4. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (E.G. CHANNELS) ARE TYPICALLY 3(H):1(V).
5. AS-BUILT TOP OF GEOMEMBRANE LINER CONTOURS WERE DEVELOPED FROM HISTORICAL SLERS MAINTAINED IN THE SITE OPERATING RECORD.
6. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA.
7. REFER TO APPENDIX IIIA-A FOR OVERLINER SYSTEM, LINER SYSTEM AND SLURRY WALL DETAILS.

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DATE: 03/2012
FILE: 1339-351-11
CAD: FIG 1.1-SITE PLAN.DWG

DRAWN BY: SRF
DESIGN BY: RJS
REVIEWED BY: NT

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PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT SITE PLAN

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727
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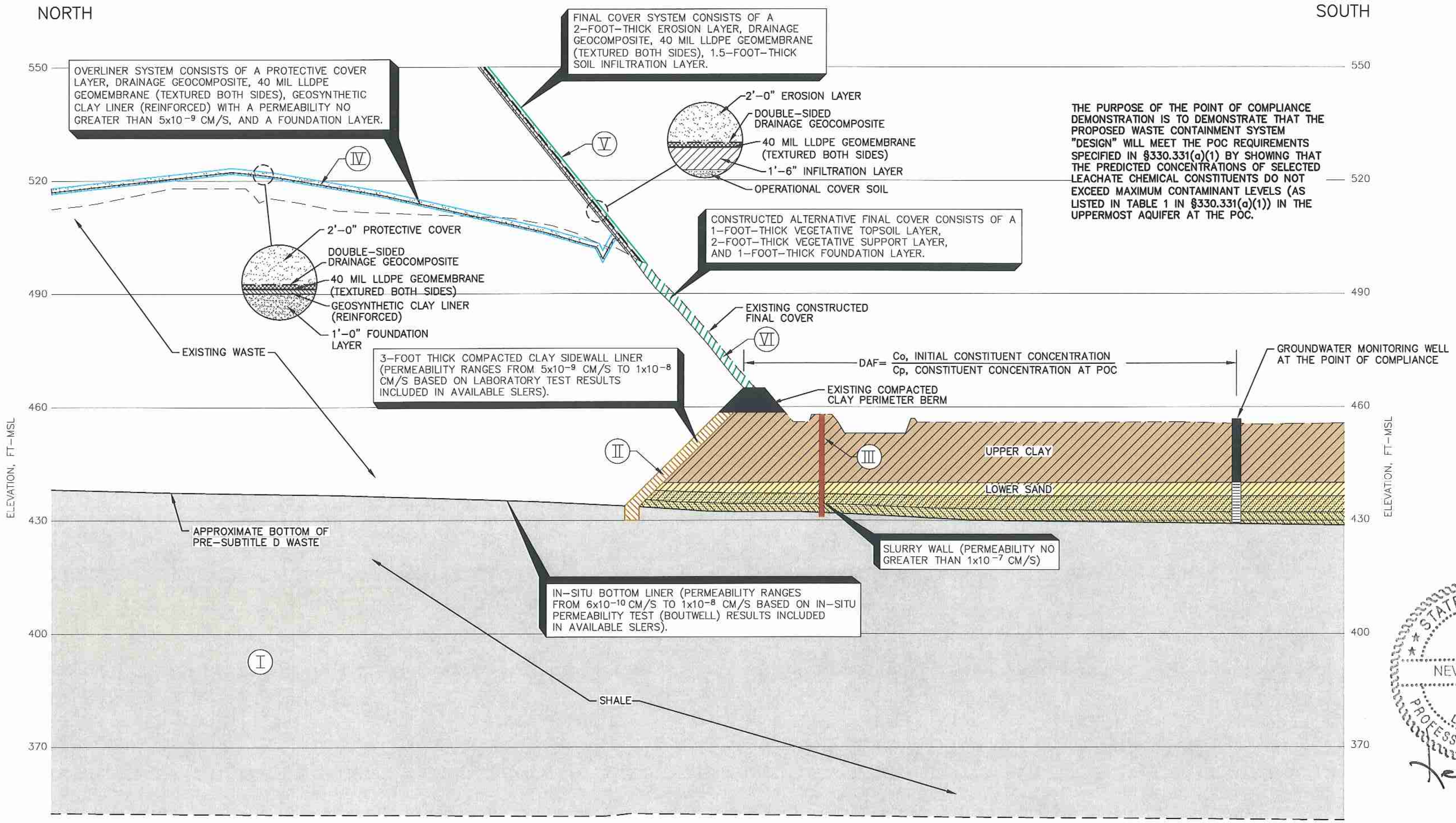
COLUMBUS, OH
DENVER, CO
FORT WORTH, TX
(817) 735-9770
GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE 1.1

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIG 1.1-SITE PLAN.dwg, 3/20/2012 4:39:31 PM, rsellers

WASTE CONTAINMENT SYSTEM DESIGN



THE PURPOSE OF THE POINT OF COMPLIANCE DEMONSTRATION IS TO DEMONSTRATE THAT THE PROPOSED WASTE CONTAINMENT SYSTEM "DESIGN" WILL MEET THE POC REQUIREMENTS SPECIFIED IN §330.331(a)(1) BY SHOWING THAT THE PREDICTED CONCENTRATIONS OF SELECTED LEACHATE CHEMICAL CONSTITUENTS DO NOT EXCEED MAXIMUM CONTAMINANT LEVELS (AS LISTED IN TABLE 1 IN §330.331(a)(1)) IN THE UPPERMOST AQUIFER AT THE POC.

I	IN-SITU BOTTOM LINER
II	3-FOOT-THICK COMPACTED CLAY SIDEWALL LINER
III	SLURRY WALL
IV	OVERLINER SYSTEM
V	FINAL COVER SYSTEM
VI	CONSTRUCTED ALTERNATIVE FINAL COVER

SECTION
(NTS)
TS
1.1 | 1.2

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED PROFESSIONAL ENGINEER

Nevzat Turan
3-21-12

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIG 1.2-TYPICAL EXIST SECTION.dwg, jwilson, 1:2

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☐ CLIENT APPROVAL BY: ____________

DATE: 03/2012
FILE: 1339-351-11
CAD: 1.2-SECTION.DWG

DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

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REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
TYPICAL EXISTING
LANDFILL SECTION
CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

FORT WORTH, TX
(817) 735-9770

GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE 1.2

2 POINT OF COMPLIANCE DEMONSTRATION METHODS

This point of compliance (POC) demonstration has been developed using (1) the HELP model to estimate leachate generation at the landfill and (2) the MODFLOW model to perform pollutant fate and transport simulations between the landfill and the point of compliance. A description of the HELP and MODFLOW models is presented in the following subsections.

2.1 HELP Model

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 was used to estimate the rate of percolation through the proposed overliner and final cover as well as groundwater recharge between the limits of waste and the POC. The percolation rate was determined for various landfill configurations as discussed in Section 3.

The HELP Model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of the landfill. The model uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects on run-off, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage. A detailed discussion of the HELP model is included in Appendix IIIC – Leachate and Contaminated Water Management Plan.

2.2 MODFLOW Model

2.2.1 Introduction

MODFLOW is a USGS modular finite-difference flow model, which is a computer code that solves the groundwater flow equation. The program is used to simulate the flow of groundwater through aquifers. Since its original development in the early 1980s, the USGS has had four major releases, and is now considered to be the standard code for aquifer simulation. Visual MODFLOW (Version 2009.1 Pro®), developed by Schlumberger Water Services, has been used for the simulations included in the application. A two-dimensional model simulation has been developed using various stages of landfill development and geology/hydrogeology data obtained from the Geology Report (Appendix IIIG) and the Groundwater Monitoring, Sampling and Analysis Plan (Appendix IIIH). Capabilities of MODFLOW utilized include a representation of subsurface soil lithology and hydrogeology as well as the waste containment system design components.

2.2.2 Groundwater Flow Analysis

The Preconditioned Conjugate-Gradient 2 (PCG2) solver, which is a module in MODFLOW, was selected for the POC demonstration to solve transient (i.e., non-steady state) flow produced with varying recharge and percolation values with respect to time. The PCG2 solver works on a two-tier approach to a solution at one time step, inner and outer iterations. Outer iterations are used to vary the preconditioned parameter matrix in an approach toward the solution. An outer iteration is where the hydrogeological parameters of the flow system are updated (i.e., transmissivity, saturated thickness, storativity) in the preconditioned set of matrices. The inner iterations continue until the final convergence criteria are met. The PCG2 solver is described in the USGS Water-Resources Investigations Report 90-4048 (Hill, 1990).

2.2.3 Fate and Transport Model Analysis

The fate and transport modeling has the capability to track the concentration of contaminants in groundwater with respect to time. The fate and transport model is also capable of modeling sources (e.g., defined boundaries of contaminated groundwater and percolation) and sinks (e.g., dilution). Developed by Zheng in 1990 for the United States Environmental Protection Agency (EPA), MT3D code, which is a module in MODFLOW, is the primary model for fate and transport.

MT3D Code

MT3D (Modular 3-Dimensional Transport Model) is a transport model for simulating advection, dispersion, and chemical reactions of contaminants in groundwater flow systems. MT3D code solves the transport equation after the flow solution has been obtained from the groundwater flow model (i.e., PCG2). Various versions of MT3D code have been commonly used in contaminant transport modeling and remediation assessment studies (e.g., MT3Dv1.1, MT3Dv1.5, MT3Dv1.86, MT3D96, MT3D99, and MT3DMS).

The partial differential equation describing the fate and transport of contaminants of species k in three-dimensional, transient (i.e., non-steady state) groundwater flow systems can be written as follows:

$$\frac{\partial(\theta C^k)}{\partial t}=\frac{\partial}{\partial x_i}\left(\theta D_{ij}\frac{\partial C^k}{\partial x_j}\right)-\frac{\partial}{\partial x_i}\left(\theta v_i C^k\right)+q_s C_s^k+\sum R_n$$

where

C^k is the dissolved concentration of species k, ML^{-3};

θ is the porosity of the subsurface medium, dimensionless;

t is time, T;

x_i is the distance along the respective Cartesian coordinate axis, L;

D_{ij} is the hydrodynamic dispersion coefficient tensor, L^2T^{-1};

v_i is the seepage or linear pore water velocity; LT^{-1}; it is related to the specific discharge or Darcy flux through the relationship, $v_i = q_i / \theta$

q_s is the volumetric flow rate per unit volume of aquifer representing fluid sources (positive) and sinks negative, T^{-1};

C_s^k is the concentration of the source or sink flux for species k, ML^{-3};

$\sum R_n$ is the chemical reaction term, $ML^{-3}T^{-1}$.

MT3DMS Solver Selection

MT3DMS (Modular 3-Dimensional Multispecies Transport Model) was selected for the POC demonstration to simulate changes in concentrations of miscible contaminants in groundwater considering advection and dispersion with various types of boundary conditions and external sources or sinks. Zheng and Wang developed this multi-species transport model in June 1998 for the US Army Corps of Engineers (USACE). MT3DMS can accommodate very general spatial discretization schemes and boundary conditions, including: 1) confined, unconfined or variably confined/unconfined aquifer layers; 2) inclined model layers and variable cell thickness within same layer; 3) specified concentration or mass flux boundaries; and 4) the solute fate and transport effects of external hydraulic sources (i.e., recharge and percolation). Note no chemical reactions were simulated in this demonstration.

MT3DMS Solution Method

The Method of Characteristics (MOC) module is available in all versions of MT3D. MOC uses a conventional particle tracking technique based on a mixed Eulerian-Lagrangian method for solving the advection term. The dispersion, sink/source mixing and chemical reaction terms are solved with the finite difference method, which tracks a large number of moving particles forward in time and keeps track of the concentration and position of each particle.

Fate and Transport Output

The MT3DMS fate and transport model was run from existing site condition (i.e., beginning of 2011) through the end of postclosure (i.e., end of 2069) to represent the entire life of the site. The resulting DAF contours were developed using the model output.

3 LANDFILL CONFIGURATIONS ANALYZED AND PERCOLATION ESTIMATES

3.1 Section Locations and Model Development

The locations of the three typical sections developed to represent the area between the waste disposal area and the POC are shown on Figure 3.1. Each section is located on the downgradient portion of the landfill and the distance between the limits of waste disposal area and the POC varies between 180 feet and 420 feet.

Figure 3.2 is presented to show how each section is developed. In the waste disposal area, Figure 3.2 shows each element of the containment system (e.g., pre-Subtitle D liner, overliner, final cover system, and slurry wall). In addition, the site specific subsurface soils and hydrogeologic information is also shown in the waste disposal area and in the area between the landfill and the POC. All of the information shown is input into the MODFLOW model to estimate the fate and transport of constituents in the unlikely event that there is a release from the landfill.

As shown on Figure 3.2, the model is divided into five zones to estimate percolation and groundwater recharge throughout the life of the site and the postclosure period. Zones I, II, and III are located within the landfill. The estimated percolation rate during the life of the site is discussed in detail in Section 3.2. However, one conservative assumption that was similar in each case is that the percolation through the overliner or the final cover system placed over the pre-Subtitle D area sideslope was assumed to flow directly to the bottom of the landfill. This assumption ignores the travel time, absorption, and consumption of water that occurs within the solid waste fill area.

As also shown on Figure 3.2, groundwater recharge is modeled between the landfill perimeter berm and the POC. An estimate of recharge was developed using the HELP model. It is assumed that no percolation occurs in Zone IV, located between the groundwater recharge zone and Zone III. For this area, any percolation that occurs through the final cover system will be diverted down the 3(H):1(V) sideslope of the pre-Subtitle D sidewall liner to the bottom of the landfill and any stormwater runoff will be diverted down the landfill perimeter berm.

3.2 Sequence of Site Development and Percolation Estimates

Figure 3.3 provides a summary of how the site development will occur. The various stages of development were reproduced from the sector development drawings provided in Parts I/II, Appendix I/IIA. As discussed in Appendix IIIM – Site Life, the site is projected to close in 2039. Therefore, the 30-year postclosure period will be between 2039 and 2069.

As shown on Figure 3.3, the slurry wall will be constructed within three years after this permit amendment application is approved. In addition, the site will develop the overliner area toward the end of the active site life. The majority of the Subtitle D area (northern portion of the site) will be developed as much as possible prior to the initial construction event for the overliner system, which is projected to occur in 2028. Construction of overliner cells O1 through O6 should be complete by 2034.

Figure 3.4 shows how the percolation rate in each zone varies over the life of the site and the postclosure period. As shown, the percolation rate into the existing waste disposal area below the overliner decreases significantly after the overliner is constructed. As discussed in Appendix IIIA, the overliner system includes a leachate collection system that will remove leachate that is generated from the waste placed in the vertical expansion area, virtually eliminating percolation into the existing waste fill area.

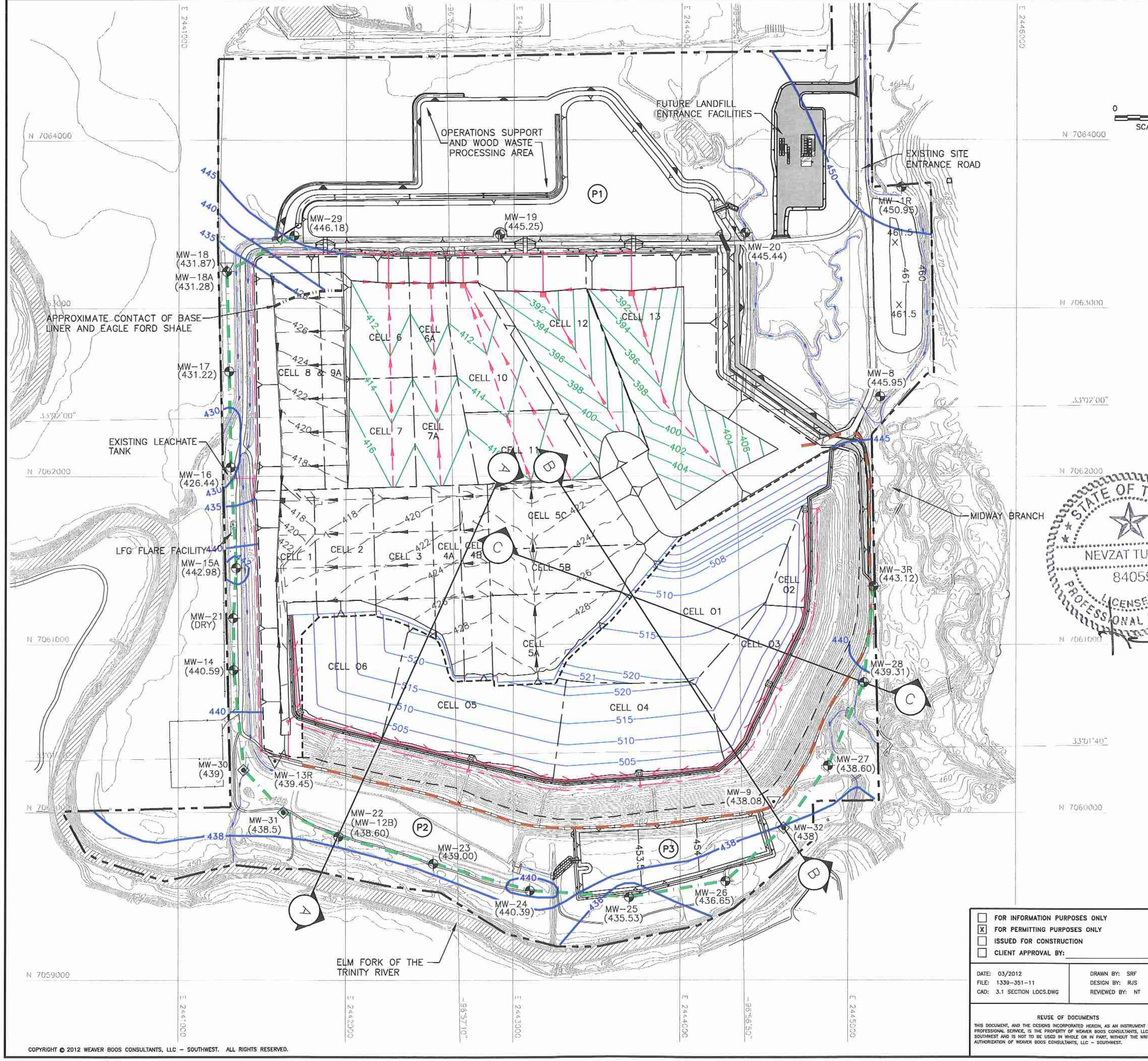
The HELP model was used to estimate each of the percolation rates shown on Figure 3.4, except for the existing alternative soil final cover areas. The percolation rate for this area was assumed to be 4 mm/year. As noted in the permit modification titled, "Alternative Soil Final Cover System Design and Certification Report," the average percolation rate for this area is actually less than 1 mm/year.

The HELP model results are included in Appendix IIIB-A. A detailed discussion of the HELP model and some of the key parameters are provided in Appendix IIIC – Leachate and Contaminated Water Management Plan. A summary of the key assumptions used to develop the percolation rates specific to the POC demonstration in this appendix are listed below.

- As noted in Section 3.1, the percolation through the intermediate cover, overliner, and final cover was assumed to flow directly to the bottom of the landfill. This is a conservative assumption because the travel time, absorption, and consumption of water that enters the landfill is not accounted for with this assumption. There has been a substantial amount of research completed over the last two decades that shows that municipal solid waste (MSW) landfills have the capacity to absorb and consume a tremendous quantity of water in the waste decomposition process. The decomposition process proceeds relatively slowly until the moisture content of the waste material within the landfill reaches 35 percent or more. Typically, the moisture content of waste when it is first disposed of in the landfill is approximately 25 percent. The water loss is due to (1) the waste biodegradation process, which involves microorganisms breaking down the organic portion of the waste material into carbon dioxide and methane, and (2) the removal of landfill gas (LFG) from the landfill.

- The analysis assumes that in 2011, the bottom 4 feet of the waste disposal area contains saturated waste. Between 2005 and 2011, 71 LFG extraction wells were installed at the site. A review of the construction reports for each event show that the existing waste fill area is relatively dry. By starting the model in 2011, the saturated zone expands to about 10 feet by the time the overliner construction starts due to the conservative assumption noted in the above bullet.

- To conservatively estimate the percolation through the overliner system, it was assumed that during the filling of overliner cells O1 through O6, this area only contained 10 feet of solid waste on the overliner system. This condition overestimates the amount of leachate that will be produced from this area between 2028 and 2039.



NEVZAT TURAN
84059
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LEGEND

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6. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.

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☐ CLIENT APPROVAL BY: ____________

DATE: 03/2012
FILE: 1339-351-11
CAD: 3.1 SECTION LOCS.DWG

DRAWN BY: SRF
DESIGN BY: RJS
REVIEWED BY: NT

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PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT SECTION LOCATIONS

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

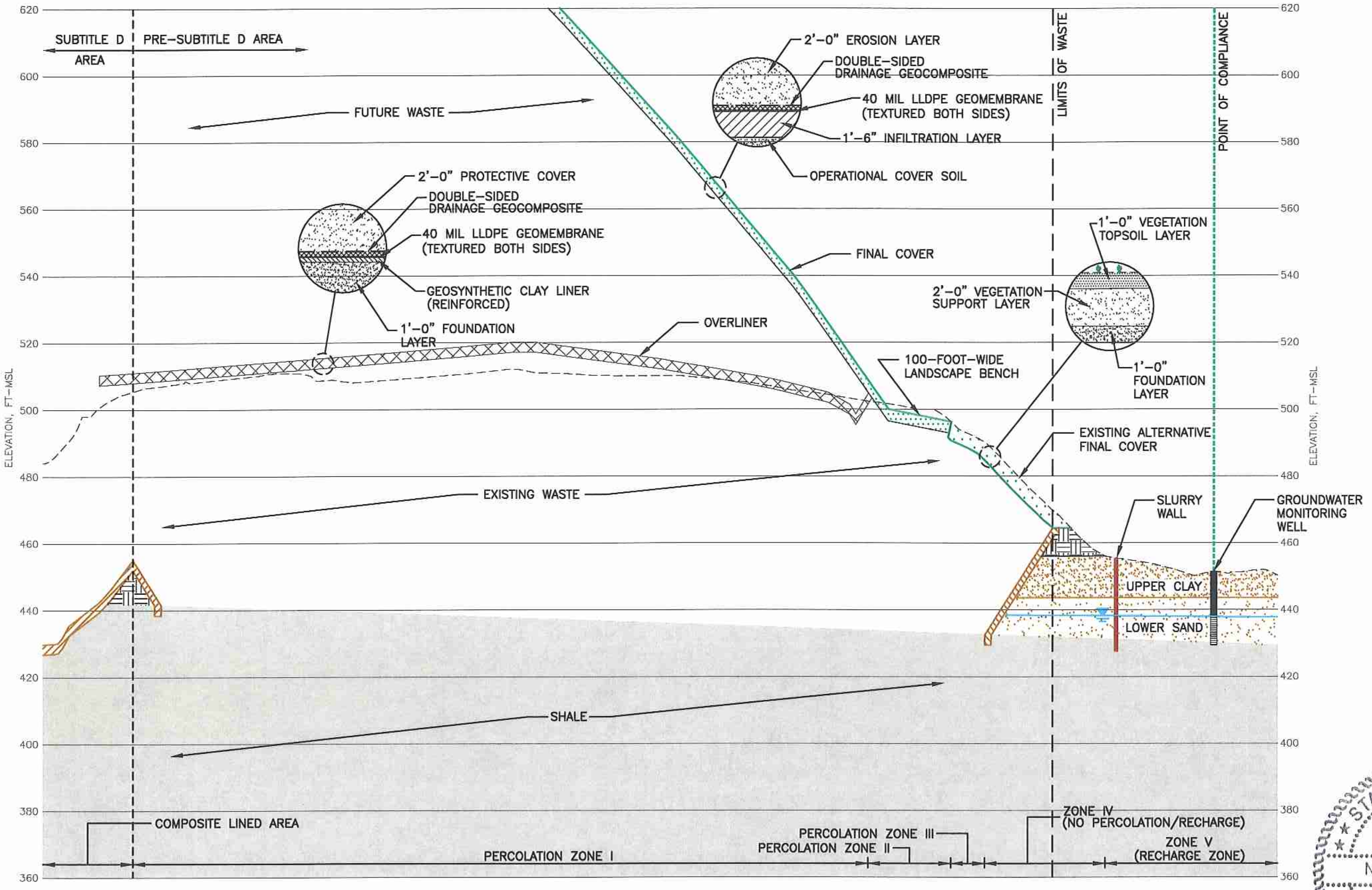
CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

FORT WORTH, TX
(817) 735-9770

GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE 3.1

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIG 3.1 SEC LOCS.dwg, 3/20/2012 4:37:15 PM, rsellers



TYPICAL SECTION B

0 100 200
HORIZONTAL SCALE IN FEET

0 20 40
VERTICAL SCALE IN FEET

LEGEND

- — — — — — LIMITS OF WASTE
- - - - - - - - - LIMITS OF PRE-SUBTITLE D WASTE
- GROUNDWATER TABLE
- - - - - - - - - EXISTING GRADE
- ··········· POINT OF COMPLIANCE
- APPROXIMATE LOCATION OF SLURRY WALL

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3-21-12

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DATE: 03/2012
FILE: 1339-351-11
CAD: 3.2 TYP. SECTION.DWG

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DESIGN BY: RJS
REVIEWED BY: NT

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PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
TYPICAL SECTION

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

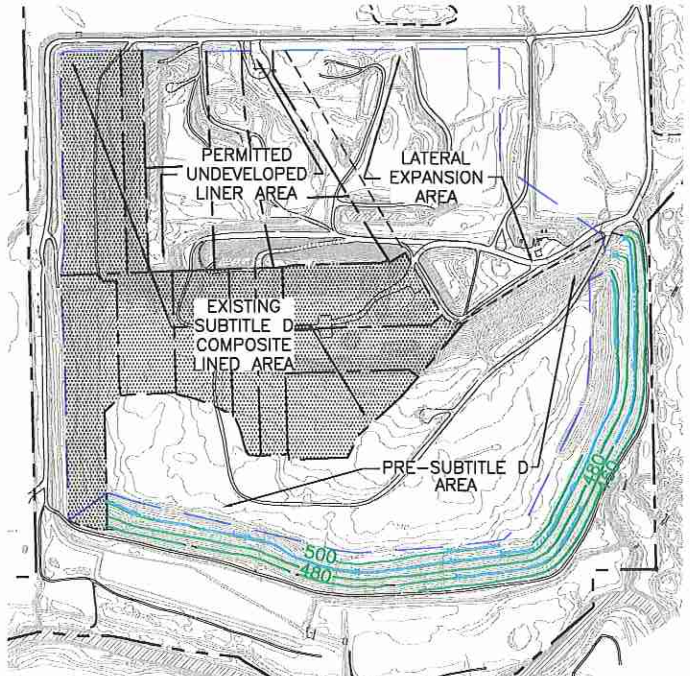
FORT WORTH, TX
(817) 735-9770

GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE 3.2

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIG 3.2 TYP SECTION.dwg, sford, 1:2

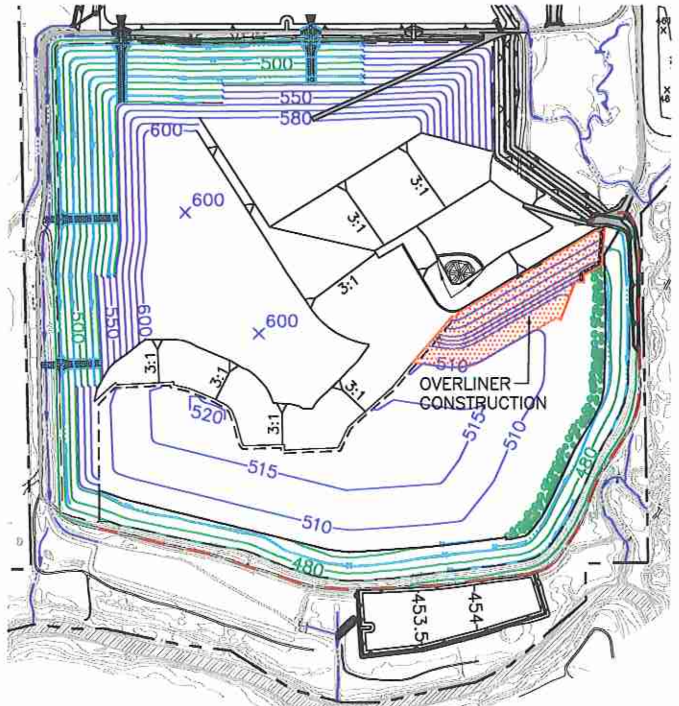
`O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIG 3.3 SEQUENCE OF DEVELOPMENT.dwg, sford, 1:2`



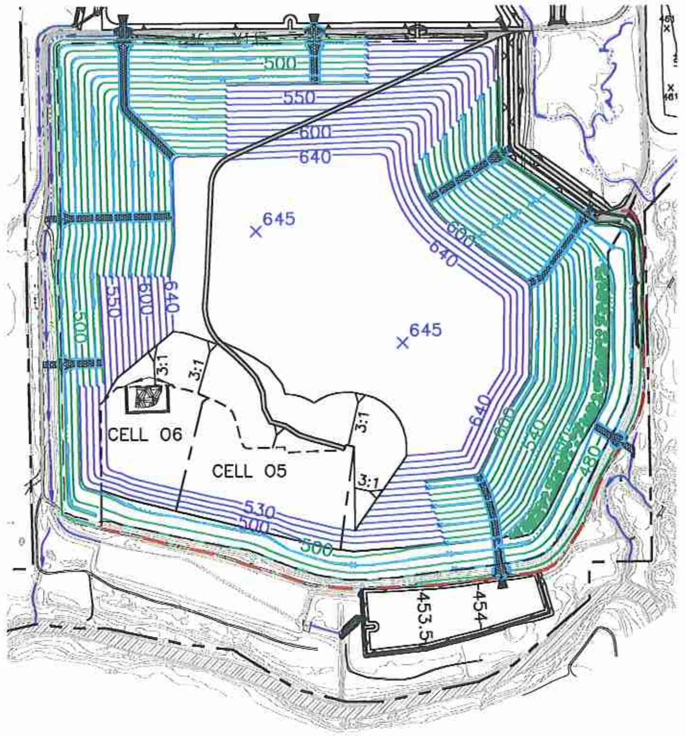
Ⅰ EXISTING CONDITION 2011

SLURRY WALL WILL BE CONSTRUCTED WITHIN 3 YEARS AFTER THE ISSUE OF TCEQ PERMIT NO. 1312B.

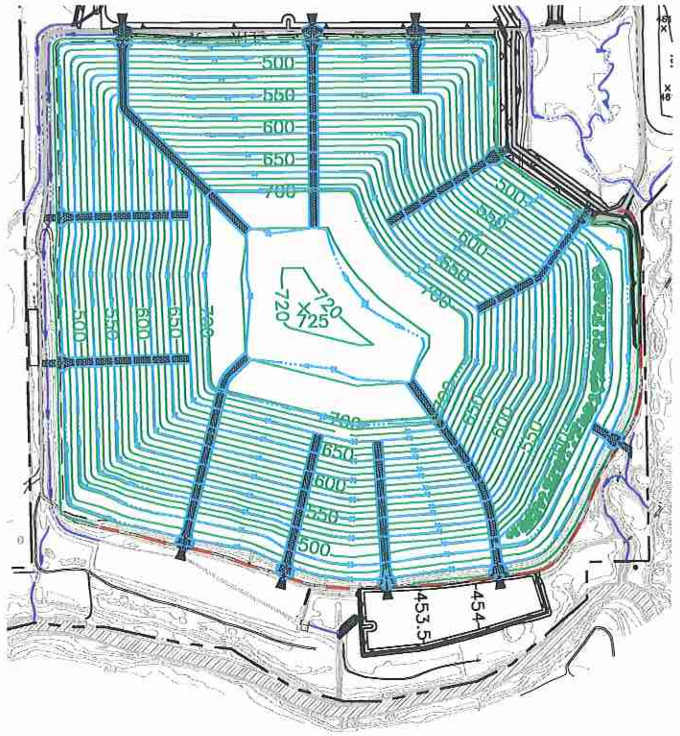
Ⅱ BETWEEN 2011 AND 2028 THE SITE WILL CONTINUE TO DEVELOP NON-OVERLINER AREAS



Ⅲ FIRST OVERLINER AREA IS PROJECTED TO BE CONSTRUCTED IN 2028



Ⅳ BETWEEN 2028 AND 2039 THE SITE WILL CONTINUE TO DEVELOP CELLS 01 THROUGH 06 AND FILL IN ALL DEVELOPED AREAS



Ⅴ BETWEEN 2039 AND 2069 THE SITE WILL BE CLOSED FOR A 30-YEAR POST CLOSURE PERIOD

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84059

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DESIGN BY: JAE
REVIEWED BY: JPY

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SEQUENCE OF DEVELOPMENT

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Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

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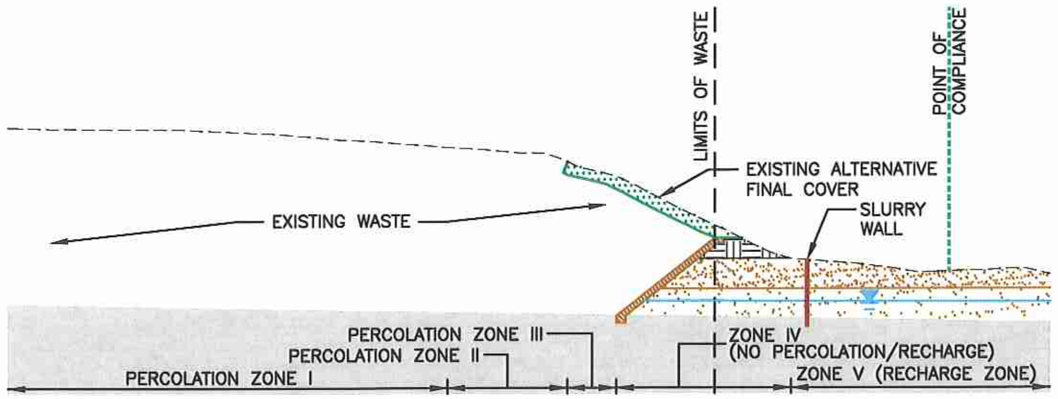
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

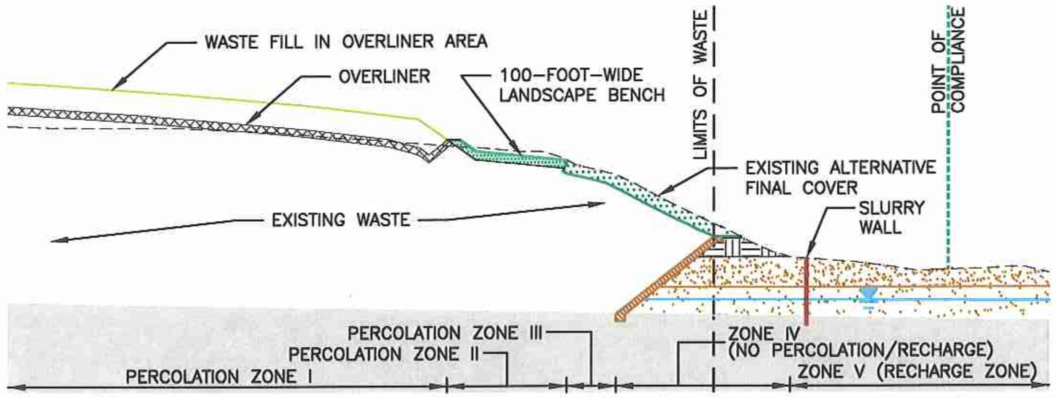
FORT WORTH, TX
(817) 735-9770

GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

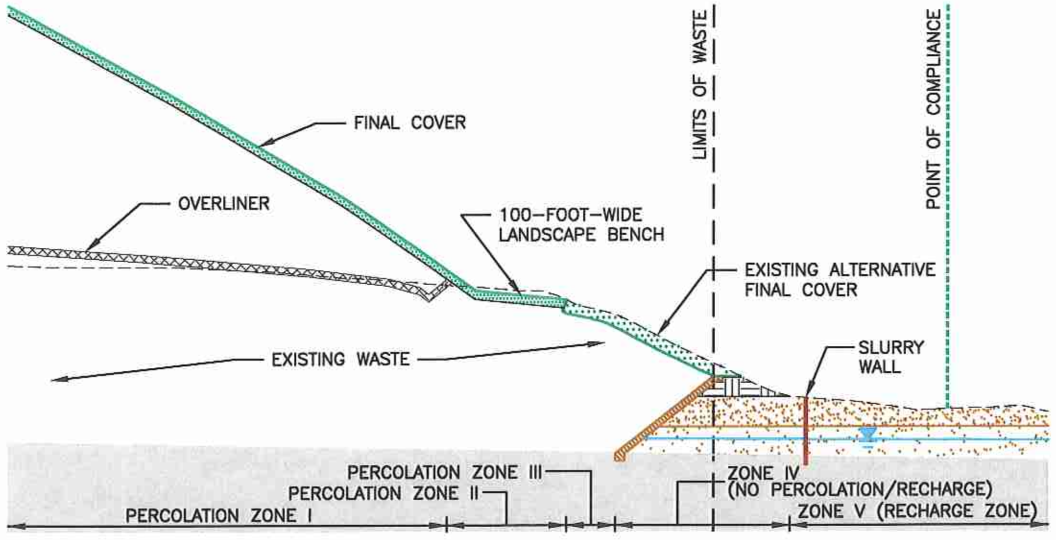
FIGURE 3.3



BETWEEN 2011 AND 2028 THE SITE WILL CONTINUE TO DEVELOP IN NON-OVERLINER AREAS



BETWEEN 2028 AND 2039 THE SITE WILL DEVELOP CELLS 01 THROUGH 06 AND FILL IN OVERLINER AREAS



BETWEEN 2039 AND 2069 THE SITE WILL BE CLOSED FOR A 30-YEAR POSTCLOSURE PERIOD

YEAR 2011–2028
(EXISTING SITE CONDITIONS TO OVERLINER CONSTRUCTION)

ZONE #	DESCRIPTION	PERCOLATION
PERCOLATION ZONE I	INTERMEDIATE COVER	130 MM/YR
PERCOLATION ZONE II	INTERMEDIATE COVER	130 MM/YR
PERCOLATION ZONE III	ALTERNATIVE FINAL COVER	4 MM/YR
ZONE IV (NO RECHARGE/ PERCOLATION)	LINER SIDESLOPE/ PERIMETER BERM	0 MM/YR
ZONE V (RECHARGE ZONE)	OUTSIDE LANDFILL	7.4 MM/YR

YEAR 2028–2039
(OVERLINER CONSTRUCTION TO CLOSURE)

ZONE #	DESCRIPTION	PERCOLATION
PERCOLATION ZONE I	OVERLINER	$2.5x10^{-4}$MM/YR
PERCOLATION ZONE II	FINAL COVER	6.5 MM/YR
PERCOLATION ZONE III	ALTERNATIVE FINAL COVER	4 MM/YR
ZONE IV (NO RECHARGE/ PERCOLATION)	LINER SIDESLOPE/ PERIMETER BERM	0 MM/YR
ZONE V (RECHARGE ZONE)	OUTSIDE LANDFILL	7.4 MM/YR

YEAR 2039–2069
(CLOSURE TO END OF POSTCLOSURE)

ZONE #	DESCRIPTION	PERCOLATION
PERCOLATION ZONE I	OVERLINER/ FINAL COVER	$5.1x10^{-4}$MM/YR
PERCOLATION ZONE II	FINAL COVER	6.5 MM/YR
PERCOLATION ZONE III	ALTERNATIVE FINAL COVER	4 MM/YR
ZONE IV (NO RECHARGE/ PERCOLATION)	LINER SIDESLOPE/ PERIMETER BERM	0 MM/YR
ZONE V (RECHARGE ZONE)	OUTSIDE LANDFILL	7.4 MM/YR

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED PROFESSIONAL ENGINEER

3-21-12

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FILE: 1339-351-11
CAD: 3.4 TYP. SEC. SEQUENCE.DWG

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DESIGN BY: RJS
REVIEWED BY: NT

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NO.	DATE	DESCRIPTION

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TYPICAL SECTION SEQUENCE

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DENTON COUNTY, TEXAS

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TBPE REGISTRATION NO. F-3727

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NAPERVILLE, IL
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GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE 3.4

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIG 3.4 TYP SEC. SEQUENCE.dwg, sford, 1:2

4 MODFLOW INPUT PARAMETERS

4.1 Subsurface Information

The input parameters for the subsurface soils between the landfill and the POC are summarized on Figure 4.1 and Table 4-1. This information is based on site specific geology and hydrogeologic information included in Appendices IIIG and IIIH. In general, the facility is located upon a mapped outcrop of Quaternary-age alluvium (Barnes et al, 1997). The alluvium consists of coarsening downward mixtures of clay, silt, sand, and gravel. The facility's uppermost aquifer occurs in the basal portion of the alluvium sediments. The alluvium was deposited unconformably on top of the low permeability Shale Strata. This Shale Strata is an aquiclude and lower confining unit for the uppermost aquifer in the Alluvial Strata. Beneath the Shale Strata is the confined Cretaceous-age Woodbine Aquifer Strata. The uppermost aquifer and Woodbine aquifer are not hydraulically connected due to the presence of the thick sequence of low permeability Shale Strata.

Although not classified by the Texas Water Development Board as a regional aquifer, groundwater that occurs in the Alluvial Strata comprises the uppermost aquifer for groundwater monitoring purposes. The facility's uppermost aquifer groundwater flows from northeast to west or south around the landfill's waste footprint to the Elm Fork Trinity River. The uppermost aquifer is recharged by precipitation infiltration on the areas around the landfill's limits of waste. The uppermost aquifer generally discharges to the Elm Fork Trinity River. The site has collected a substantial amount of groundwater level information since 1996. As noted in Appendix IIIG, the facility's groundwater elevations are typically higher than the adjacent river base flow elevations.

The information listed on Figure 4.1 and Table 4-1 was used as input into MODFLOW to develop the three representative sections shown on Figure 3.1 (note that each of the three sections is also shown on Figures 5.1 through 5.4 in Section 5).

4.2 Leachate Quality Information

As discussed in Section 1.3, the DAF is calculated by the following equation.

$$\text{DAF} = \frac{C_O\text{, Initial Constituent Concentration of Leachate Within the Landfill}}{C_P\text{, Constituent Concentration at the POC}}$$

As noted in the above equation, the DAF represents the factor by which the constituent concentration is expected to decrease between the landfill and the POC. When the constituent's concentration in leachate is divided by the model predicted DAF, the resulting concentration must be less than the allowable maximum contaminant levels (MCLs) in groundwater for the chemical parameters listed in Table 1 included in Title 30 TAC §330.331(a)(1).

Table 4-2 presents a summary of the MCLs listed in Table 1 of §330.331(a)(1), in addition to (1) leachate quality information obtained from analytical results performed on leachate samples obtained from the Camelot Landfill, (2) the leachate quality input data historically used for POC demonstrations in Texas. As noted in Table 4-2, the DAFs range from less than 1 to 260. A DAF of 1 or less indicates that no dilution or attenuation is needed for that specific constituent (i.e., the leachate within the landfill is already below the requirement for that specific parameter). The highest listed DAF is 260, which indicates that if a trichloroethylene concentration of 1.3 mg/l exists within the landfill, then the concentration would have to be reduced by a factor of 260 prior to the constituent reaching the POC to meet the 0.005 mg/l MCL for this constituent $(DAF = \frac{1.3mg/l}{0.005mg/l} = 260)$. A DAF of 260 has been the historical standard used in POC demonstrations approved by the TCEQ and is the standard discussed in the original TCEQ guidance document for POC demonstrations (*Texas Water Commission Alternate Liner Design Handbook*, August 1993).

A single simulation can account for all 24 constituents by assuming the constituents act as particles that do not experience carbon absorption, or chemical or biological decay. This very conservative assumption discounts natural attenuation processes that normally act to reduce chemical concentrations. If the input leachate concentration is assumed to be 1, then the DAF at the POC becomes the reciprocal of the output concentration calculated by MODFLOW. The reciprocal of the MODFLOW result must then equal or exceed the most critical DAF to meet TCEQ requirements.

For this demonstration, a DAF of 260 will be used as this has been the historical practice of TCEQ for POC demonstrations. However, this does represent a conservative assumption given that the site specific leachate testing information shows that leachate samples have always been below the detection limit for trichloroethylene (the detection limit for trichloroethylene is 0.005 mg/l). Additionally, as presented in Table 4-2, site specific leachate quality (maximum recorded concentrations from leachate samples collected from 2002 to 2011) has historically been much less than the MCLs listed in Table 1 of §330.331(a)(1). As noted above, the input leachate concentration is assumed to be 1 mg/l; however, if site specific leachate quality were considered for this demonstration, the representative value would be calculated by the following equation.

$$Site\ Specific\ Leachate\ Quality\ Input = 1.0\left(\frac{Site\ Specific\ Leachate\ Quality}{Historically\ Used\ Leachate\ Quality}\right)$$

As shown on Table 4-2, leachate quality samples from a 9-year period indicate that only two constituents (arsenic and barium) have been detected above the MCL. Although selenium has never been detected, the detection limit is set at 0.05 mg/l, which is higher than the MCL. Therefore, if it is assumed that selenium was present in leachate at a concentration of 0.05 mg/l, then selenium would be the most critical constituent that exceeded the MCL listed in §330.331(a)(1). Therefore, applying the equation above for selenium, the MODFLOW input for site specific leachate quality was calculated to be 0.05 mg/l, as shown below.

$$\textit{Site Specific Leachate Quality Input} = 1.0\left(\frac{0.05}{1.0}\right) = 0.05 \text{ mg/l}$$

As noted above, for each POC demonstration the input leachate concentration is assumed to be 1 mg/l. However, this represents a very conservative assumption given that the leachate concentration using site specific data is much less – 0.05 mg/l.

Table 4-1
Hydraulic Properties of Subsurface Soils and Landfill Components

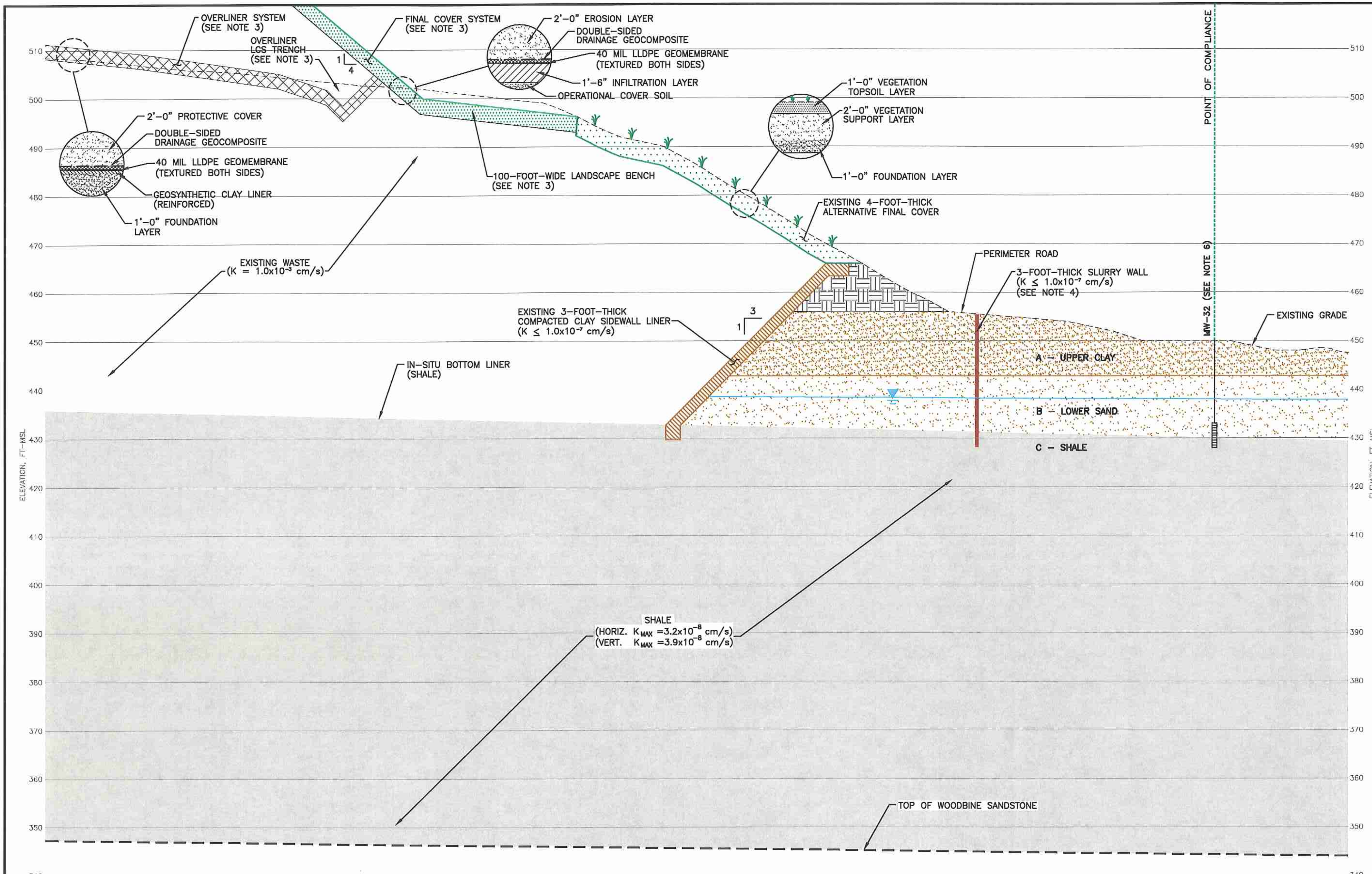
Strata/Landfill Component	Maximum		Average		Specific Storage $(S_S)^{3,4,5}$	Specific Yield $(S_y)^{6,7}$	Effective Porosity $(n_e)^{8,9}$	Total Porosity $(n_T)^{8,9}$
	Horizontal Hydraulic Conductivity $(cm/s)^{1,2}$	Vertical Hydraulic Conductivity $(cm/s)^{1,2}$	Horizontal Hydraulic Conductivity $(cm/s)^{1,2}$	Vertical Hydraulic Conductivity $(cm/s)^{1,2}$				
A - Upper Clay Zone	8.5E-07	5.4E-08	2.7E-07	1.8E-08	2.1E-04	0.02	0.06	0.42
B - Lower Sand Zone	3.0E-03	3.0E-03	7.8E-04	7.8E-04	2.1E-04	0.26	0.30	0.39
C - Shale Strata	3.2E-08	3.9E-08	1.6E-08	2.5E-08	1.0E-06	0.01	0.03	0.05
Municipal Solid Waste	1.0E-03	1.0E-03	-	-	1.0E-01	0.10	0.20	0.67
Pre-Subtitle D Compacted Clay Sidewall Liner	1.0E-07	1.0E-07	-	-	3.1E-04	0.02	0.06	0.43
Slurry Wall(10)	1.0E-07	1.0E-07	-	-	N/A	N/A	N/A	N/A

[1] Maximum and average hydraulic conductivity values for subsurface soils and shale obtained from laboratory test data and slug test data. Refer to Table 3-4 and Table 3-5 of Appendix IIIG.
[2] Hydraulic conductivity values for landfill components obtained from HELP Engineering Documentation, Version 3.
[3] Specific storage values for subsurface soils and shale obtained from Domenico (1972).
[4] Specific storage value for pre-Subtitle D compacted clay sidewall liner obtained from Grisak and Cherry (1975).
[5] Specific storage values for municipal solid waste obtained from Kavazanjian, et al. (1999).
[6] Specific yield values for subsurface soils and shale obtained from Johnson, A.I. (1967).
[7] Specific yield value of pre-Subtitle D compacted clay sidewall liner was assumed to be consistent with clay soil defined by Johnson, A.I. (1967).
[8] Effective porosity and total porosity values for subsurface soils and shale obtained from McWorter and Sunada (1977).
[9] Effective porosity and total porosity values for landfill components obtained from HELP Engineering Documentation, Version 3.
[10] Hydraulic conductivity for the slurry wall represents the highest allowable value. Other hydraulic properties are not assigned to the slurry wall in MODFLOW simulations.

Table 4-2
Chemical Constituent Concentrations in Leachate

Constituent	MCL (mg/l) Listed in §330.331(a)(1)	Site Specific Leachate Quality[1] (mg/l)	Leachate Quality Information Historically Used for POC Demonstrations in Texas (mg/l)	Required DAF Range
Arsenic	0.05	0.064	5.0	1.28 to 100
Barium	1.0	1.8	100.0	1.8 to 100
Benzene	0.005	0.00277	0.814	1 to 163
Cadmium	0.01	<0.025	1.0	2.5 to 100
Carbon tetrachloride	0.005	<0.005	0.5	1 to 100
Chromium (hexavalent)	0.05	<0.035	5.0	1 to 100
2,4-Dichlorophenoxy acetic acid	0.1	<0.1	10.0	1 to 100
1,4-Dichlorobenzene	0.075	<0.011	7.5	1 to 100
1,2-Dichloroethane	0.005	<0.005	0.5	1 to 100
1-1-Dichloroethylene	0.007	<0.007	0.7	1 to 100
Endrin	0.0002	<0.0001	0.05	1 to 250
Fluoride	4			
Lindane	0.004	<0.004	0.4	1 to 100
Lead	0.05	<0.05	5.0	1 to 100
Mercury	0.002	<0.002	0.2	1 to 100
Methoxychlor	0.1	<0.0001		
Nitrate	10	<10		
Selenium	0.01	<0.050	1.0	5 to 100
Silver	0.05	<0.05	5.0	1 to 100
Toxaphene	0.005	<0.0025	0.5	1 to 100
1,1,1-Trichloroethane	0.2	<0.005		
Trichloroethylene	0.005	<0.005	1.3	1 to 260
2,4,5-Trichlorophenoxy acetic acid	0.01		1.0	100
Vinyl Chloride	0.002	<0.002	0.2	1 to 100

[1] Leachate concentrations represent maximum concentration obtained from leachate samples analyzed from 2002 through 2011. Non-detects for the site specific data indicated as "<MCL."



TYPICAL SECTION B

0 30 60
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

SUBSURFACE SOILS INFORMATION

A = UPPER CLAY
(HORIZ. $K_{MAX}=8.5 \times 10^{-7}$ cm/s)
(VERT. $K_{MAX}=5.4 \times 10^{-8}$ cm/s)

B = LOWER SAND
(HORIZ. $K_{MAX}=3.0 \times 10^{-3}$ cm/s)
(VERT. $K_{MAX}=3.0 \times 10^{-3}$ cm/s)

C = SHALE
(HORIZ. $K_{MAX}=3.2 \times 10^{-8}$ cm/s)
(VERT. $K_{MAX}=3.9 \times 10^{-8}$ cm/s)

NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8–28–2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. WATER LEVEL MEASUREMENTS COLLECTED BY WBC ON DECEMBER 5, 2010. GROUNDWATER TABLE WITHIN THE PRE–SUBTITLE D AREA IS APPROXIMATE.
3. OVERLINER SYSTEM COMPONENTS, FINAL COVER SYSTEM COMPONENTS, AND SLURRY WALL DESIGN SPECIFICATIONS ARE PROVIDED IN APPENDIX IIIA.
4. POINT OF COMPLIANCE AND MONITORING WELL LOCATIONS ARE PROVIDED IN APPENDIX IIIH. REFER TO APPENDIX IIIH FOR GROUNDWATER MONITORING, SAMPLING, AND ANALYSIS PLAN.
5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 32 IS SCREENED BETWEEN THE DEPTHS OF 433.0 FT–MSL AND 428.0 FT–MSL.

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84059

3-21-12

LEGEND

▽	GROUNDWATER TABLE (SEE NOTE 3)
- - -	EXISTING GRADE (SEE NOTE 1)
······	POINT OF COMPLIANCE
▬	APPROXIMATE LOCATION OF SLURRY WALL
▯	MONITOR WELL WITH RISER (TOP) AND SCREEN (BOTTOM)

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DATE: 03/2012
FILE: 1339–351–11
CAD: FIG B.2–SECTION B.DWG

DRAWN BY: SRF
DESIGN BY: RJS
REVIEWED BY: NT

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CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

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TYPICAL SECTION

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F–3727

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GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE 4.1

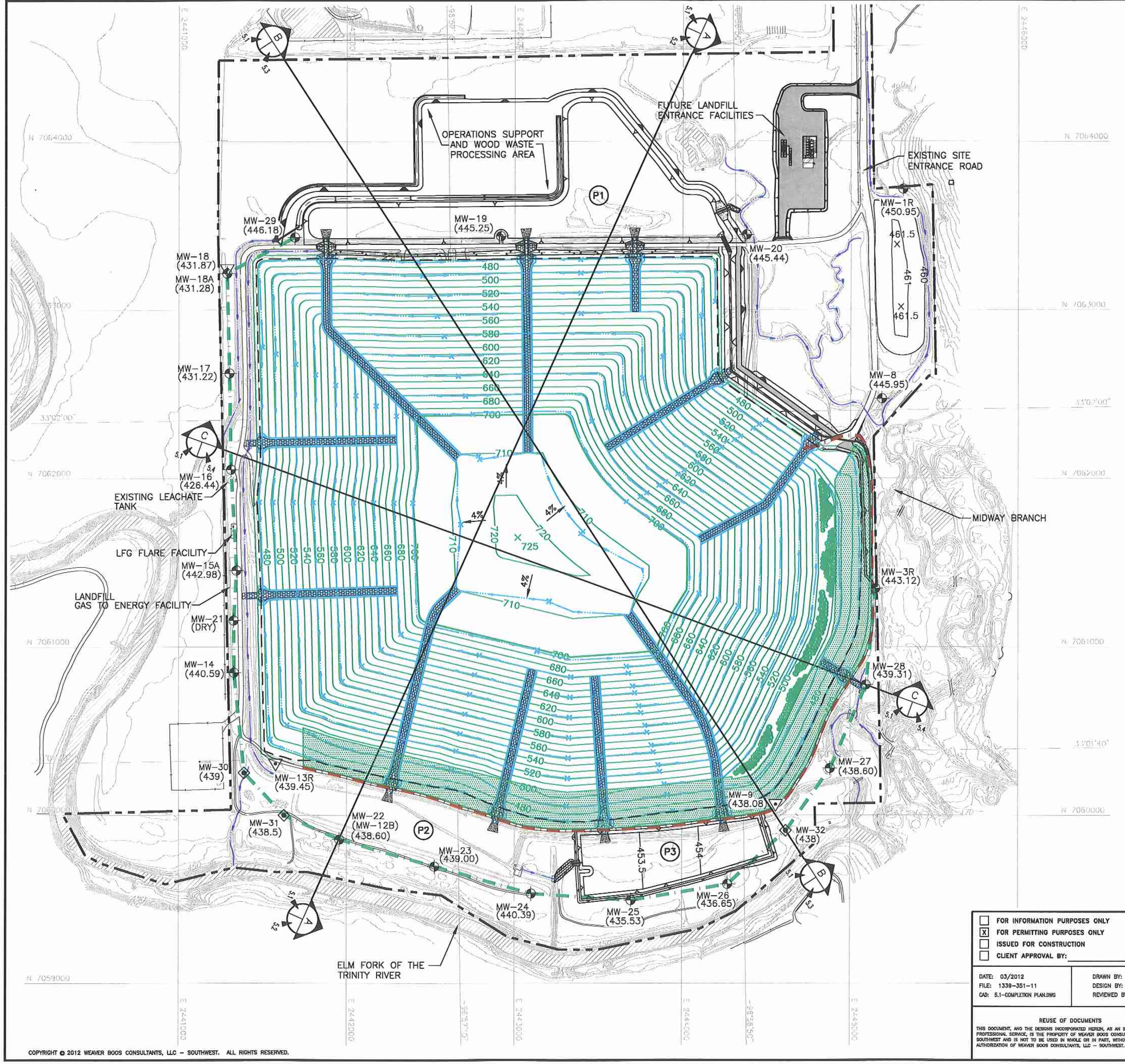
O:\1339\351\EXPANSION 2009\PART III–SDP\IIIB\FIG 4.1 TYP SECTION.dwg, sford, 1:2

5 POINT OF COMPLIANCE DEMONSTRATION RESULTS

The results of the POC demonstration are summarized in Table 5-1 and graphically illustrated on Figures 5.2 through 5.4. The results demonstrate that the proposed waste containment system design, including the pre-Subtitle D liner, overliner system, slurry wall, and final cover system result in a DAF that is well in excess of the minimum required value of 260. Based on the model simulation results, it is concluded that the "waste containment system design" included in this permit amendment application meets or exceeds the requirements of Title 30 TAC §330.331(a)(1).

Table 5-1
Summary of MODFLOW Design Simulation Results

Model Section	Design Case Calculated DAF	Minimum Required DAF	Design Compliant with §330.331(a)(1)
Section A	1.01×10^{33}	260	Yes
Section B	1.66×10^{22}	260	Yes
Section C	2.80×10^{20}	260	Yes



LEGEND

▬ ▬ ▬	PERMIT BOUNDARY
— — —	LIMITS OF WASTE
N 7064000	STATE PLANE COORDINATE SYSTEM
33°02'00"	GEODETIC COORDINATE SYSTEM
500	EXISTING CONTOUR
398	FINAL COVER CONTOUR
460	REGRADED BUFFER ZONE AREA
▨	DRAINAGE LETDOWN
✕	DRAINAGE SWALE
🟩	POINT OF COMPLIANCE
🟥	APPROXIMATE LOCATION OF SLURRY WALL
⊕ MW-3R (443.12)	EXISTING MONITORING WELL WITH GROUNDWATER ELEVATION POSTED IN FT-MSL
◈ MW-30 (439)	PROPOSED MONITORING WELL WITH GROUNDWATER ELEVATION POSTED IN FT-MSL
▽ MW-9 (438.08)	EXISTING MONITORING WELL PROPOSED FOR REMOVAL AFTER REPLACEMENT WELL BACKGROUND CONCENTRATIONS ESTABLISHED (WITH GROUNDWATER ELEVATION POSTED IN FT-MSL)
▨	CONSTRUCTED FINAL COVER
🟩	LANDSCAPE BENCH

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.

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MAJOR PERMIT AMENDMENT LANDFILL COMPLETION PLAN

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

DATE: 03/2012
FILE: 1339-351-11
CAD: 5.1-COMPLETION PLAN.DWG

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DESIGN BY: RJS
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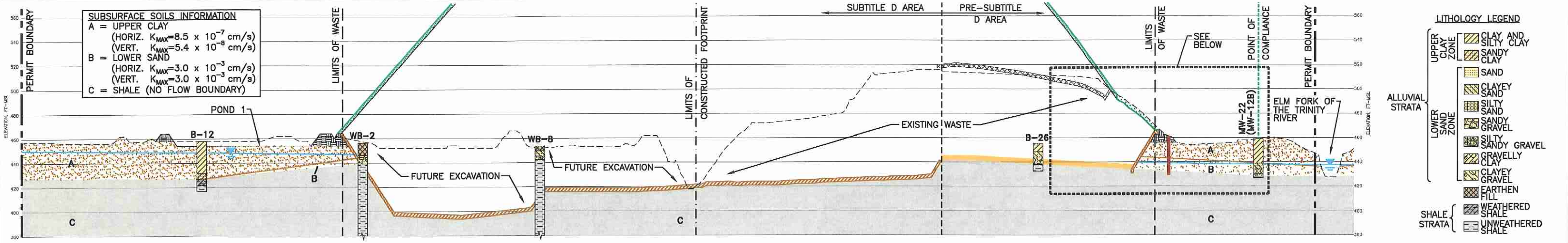
FIGURE 5.1

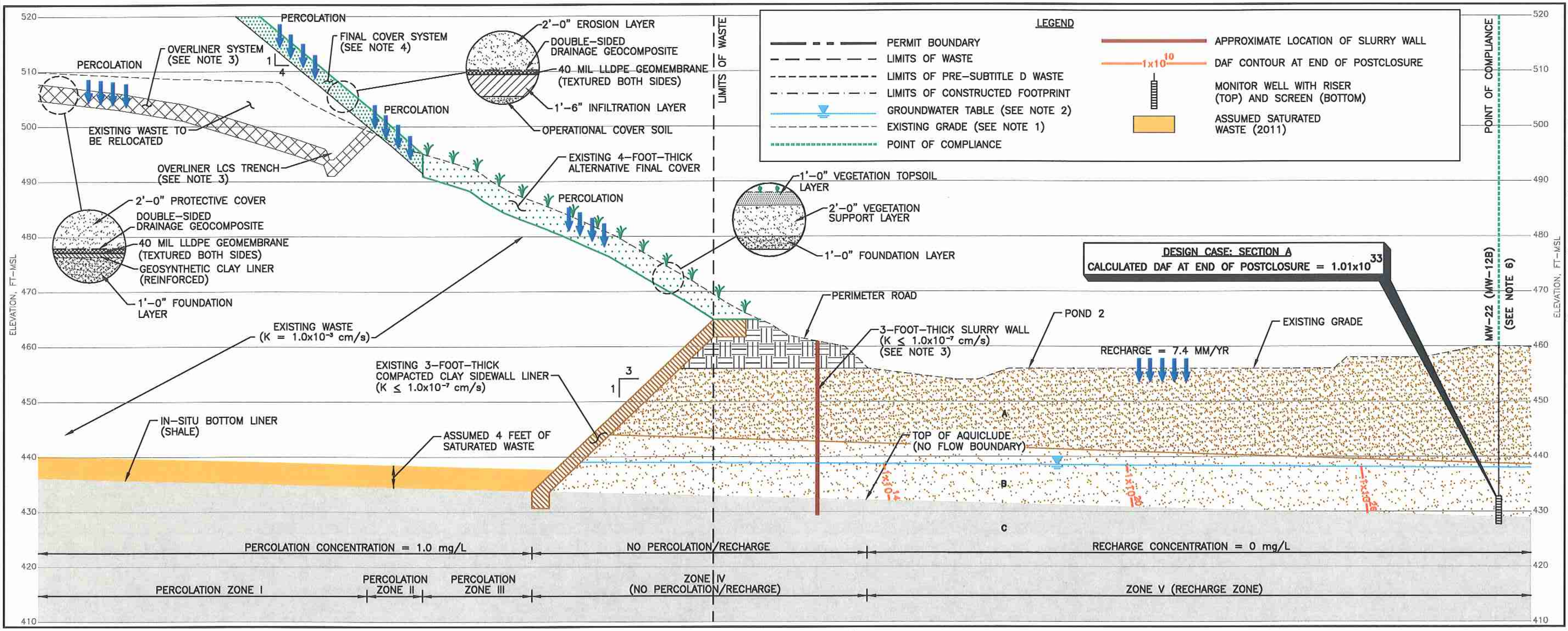
O:\1339\351\EXPANSION 2009\PART III-SDP\IIIE\FIG 5.1-COMPLETION PLAN.dwg, sford, 1:2



SECTION A (A / 5.1 5.2)

0 200 400 HORIZONTAL SCALE IN FEET

0 40 80 VERTICAL SCALE IN FEET



YEAR 2011–2069
(EXISTING SITE CONDITION TO END OF POSTCLOSURE)

0 30 60 HORIZONTAL SCALE IN FEET

0 10 20 VERTICAL SCALE IN FEET

NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8–28–2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. WATER LEVEL MEASUREMENTS COLLECTED BY WBC ON DECEMBER 5, 2010.
3. OVERLINER SYSTEM COMPONENTS, FINAL COVER SYSTEM COMPONENTS, AND SLURRY WALL DESIGN SPECIFICATIONS ARE PROVIDED IN APPENDIX IIIA.
4. POINT OF COMPLIANCE AND MONITORING WELL LOCATIONS ARE PROVIDED IN APPENDIX IIIH. REFER TO APPENDIX IIIH FOR GROUNDWATER MONITORING, SAMPLING, AND ANALYSIS PLAN.
5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 22 IS SCREENED BETWEEN THE DEPTHS OF 432.7 FT–MSL AND 427.7 FT–MSL.

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LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2039	OVERLINER CONSTRUCTION	CLOSURE	OVERLINER	2.5x10^{-4}MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2039	12/31/2069	CLOSURE	END OF POSTCLOSURE	OVERLINER/FINAL COVER	5.1x10^{-4}MM/YR				

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REVIEWED BY: NT

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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
OVERLINER POC DEMONSTRATION
DESIGN CASE–SECTION A
CAMELOT LANDFILL
DENTON COUNTY, TEXAS

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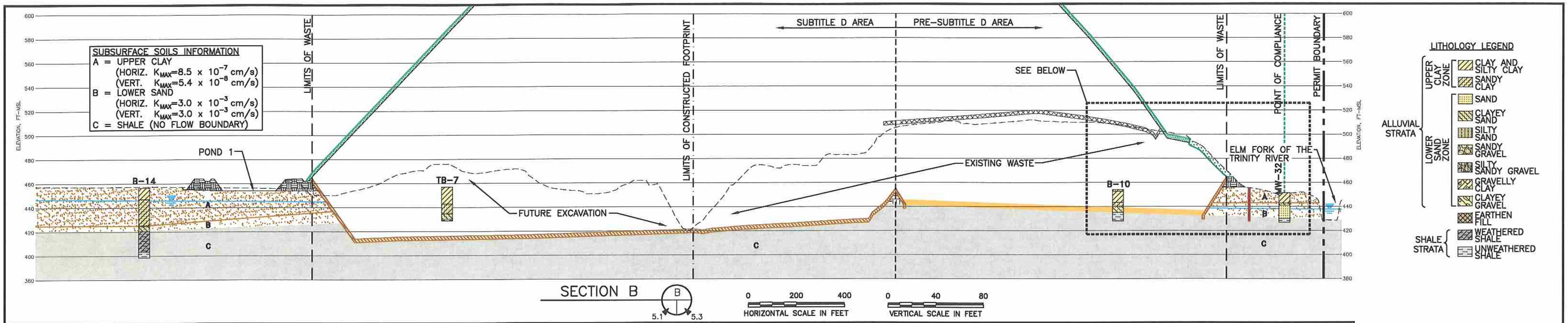
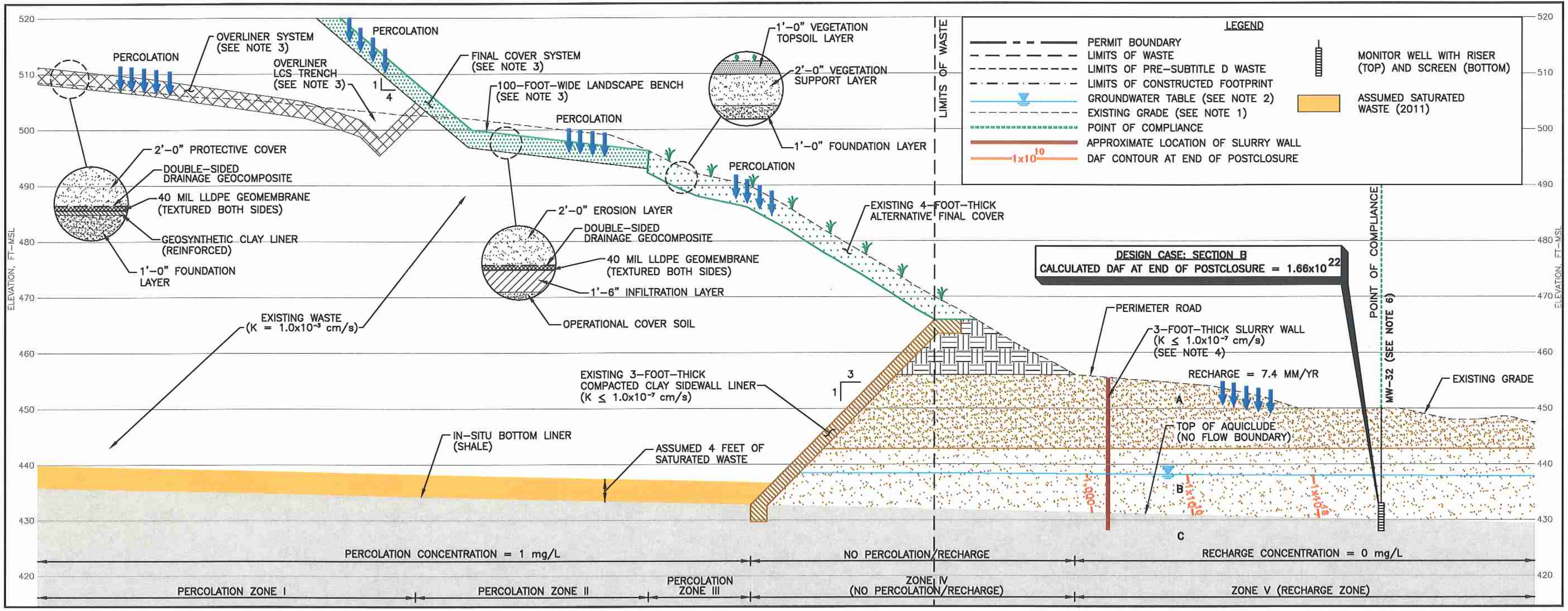
FIGURE 5.2

O:\1339\351\EXPANSION 2009\PART III–SDP\IIIB\FIGURE 5.2 – SECTION A – DESIGN CASE.dwg, sford, 1:2





YEAR 2011–2069
(EXISTING SITE CONDITION TO END OF POSTCLOSURE)

NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8–28–2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
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4. POINT OF COMPLIANCE AND MONITORING WELL LOCATIONS ARE PROVIDED IN APPENDIX IIIH. REFER TO APPENDIX IIIH FOR GROUNDWATER MONITORING, SAMPLING, AND ANALYSIS PLAN.
5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 32 IS SCREENED BETWEEN THE DEPTHS OF 433.0 FT–MSL AND 428.0 FT–MSL.

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3-21-12

LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2039	OVERLINER CONSTRUCTION	CLOSURE	OVERLINER	$2.5x10^{-4}$ MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2039	12/31/2069	CLOSURE	END OF POSTCLOSURE	OVERLINER/FINAL COVER	$5.1x10^{-4}$ MM/YR				

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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
OVERLINER POC DEMONSTRATION
DESIGN CASE–SECTION B

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
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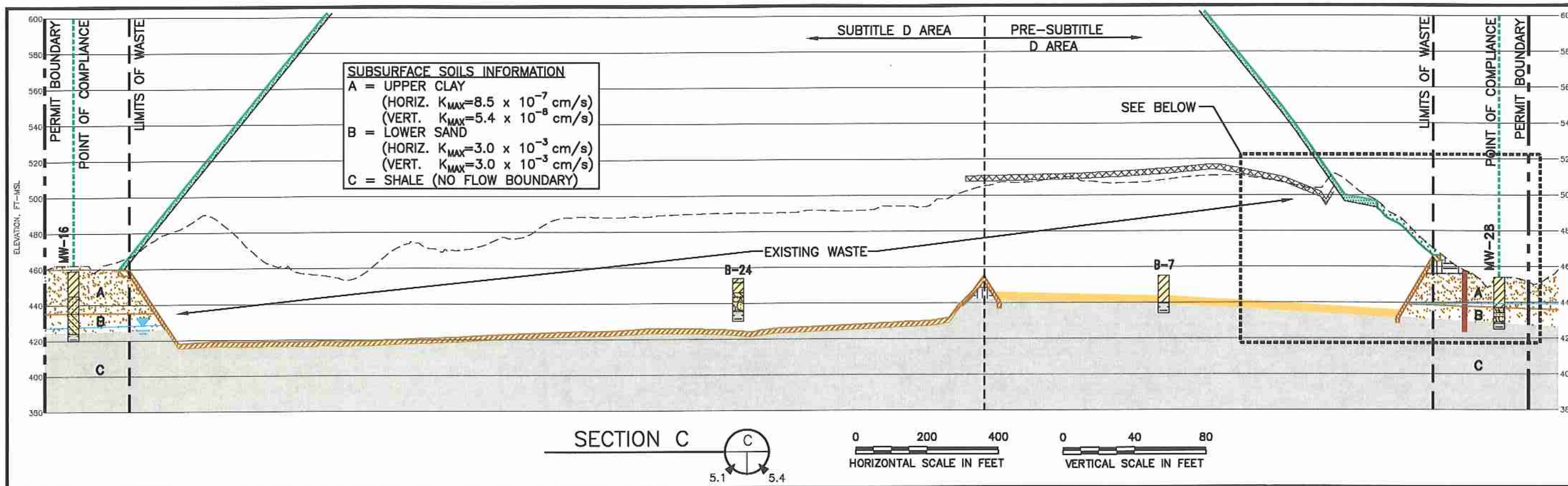
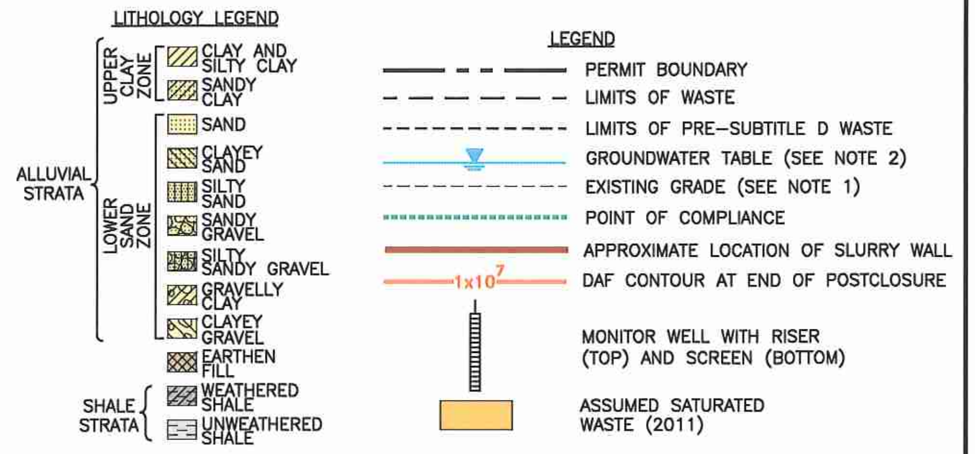
FIGURE 5.3

O:\1339\351\EXPANSION 2009\PART III–SDP\IIIH\FIGURE 5.3 – SECTION B – DESIGN CASE.dwg, sford, 1:2



SECTION C



NOTES:

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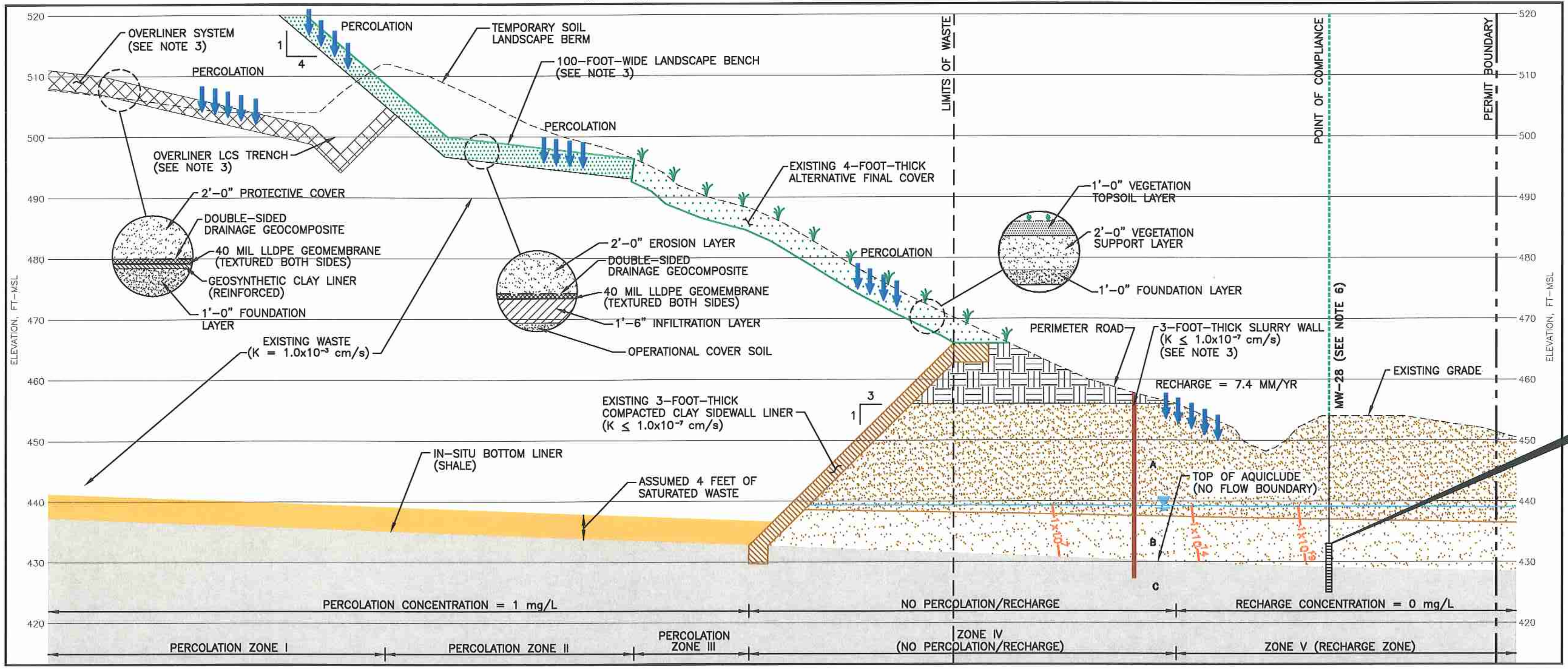
6. MONITORING WELL 28 IS SCREENED BETWEEN THE DEPTHS OF 433.3 FT–MSL AND 425.8 FT–MSL.



DESIGN CASE: SECTION C

CALCULATED DAF AT END OF POSTCLOSURE = 2.80×10^{20}

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3-21-12

YEAR 2011–2069
(EXISTING SITE CONDITION TO END OF POSTCLOSURE)

0 30 60 HORIZONTAL SCALE IN FEET
0 10 20 VERTICAL SCALE IN FEET

LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT									
TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2039	OVERLINER CONSTRUCTION	CLOSURE	OVERLINER	2.5×10^{-4} MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2039	12/31/2069	CLOSURE	END OF POSTCLOSURE	OVERLINER/FINAL COVER	5.1×10^{-4} MM/YR				

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MAJOR PERMIT AMENDMENT
OVERLINER POC DEMONSTRATION
DESIGN CASE–SECTION C

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FIGURE 5.4

O:\1339\351\EXPANSION 2009\PART III–SDP\IIIB\FIGURE 5.4 – SECTION C – DESIGN CASE.dwg, sford, 1:2

6 ADDITIONAL LINER EQUIVALENCY DEMONSTRATION

The POC demonstration discussed in Sections 2 through 5 is required because a composite liner that meets the requirements of Title 30 TAC §330.331(a)(2) is not included in the proposed waste containment system design.

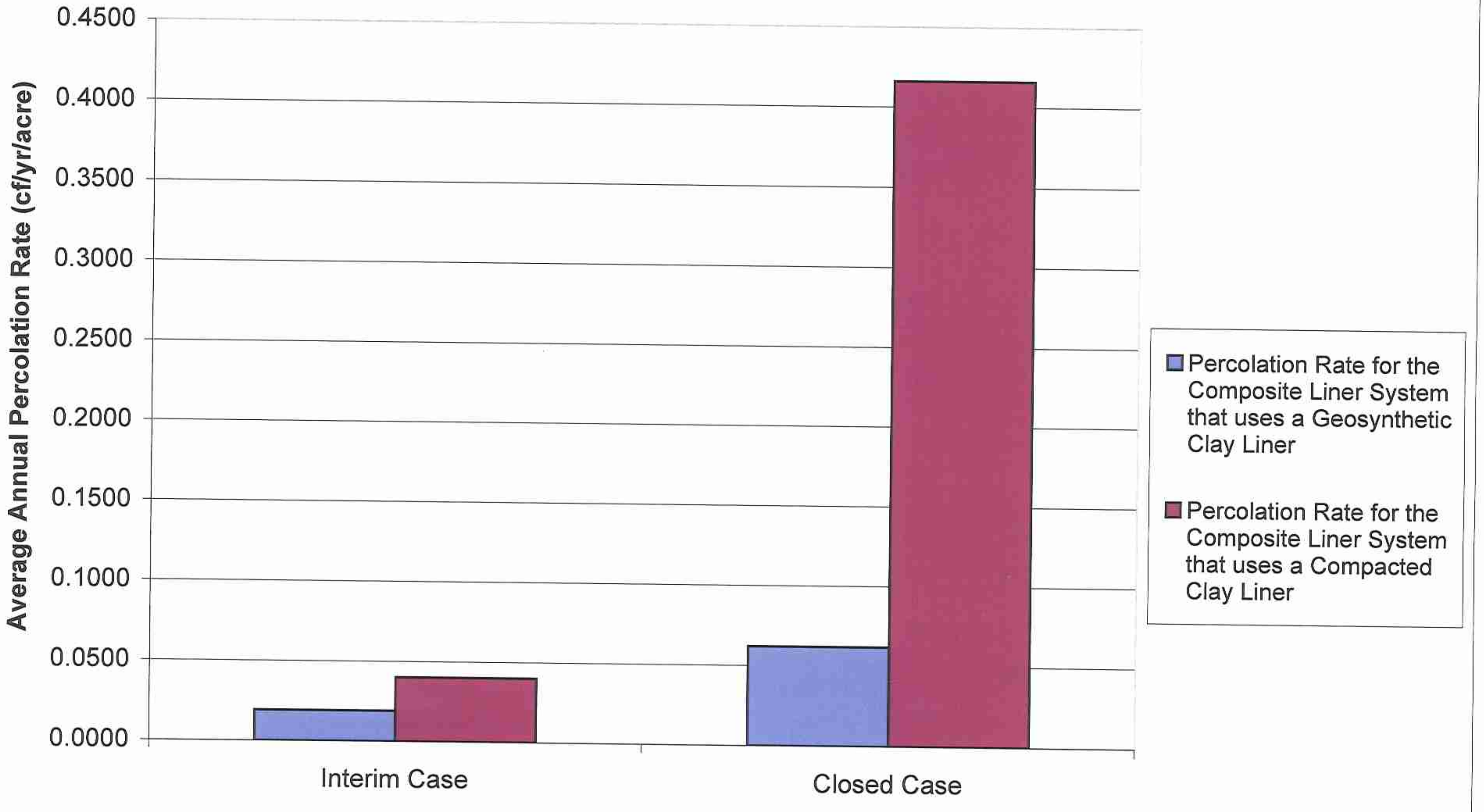
The purpose of this section is to demonstrate that the proposed alternative composite liner (GCL/geomembrane/leachate collection layer) is equivalent to the composite liner specified in Title 30 TAC §330.331(a)(2) (CCL/geomembrane/leachate collection layer). Figure 6.1 shows the estimated percolation rates calculated using HELP for the following cases:

- Overliner with GCL – Interim Case. This percolation rate is for the 10-foot-thick waste column configuration obtained from the HELP model analysis included in Appendix IIIB-A.
- Overliner with CCL – Interim Case. This percolation rate was obtained from the above HELP model analysis with the substitution of a CCL for the GCL layer and is included in Appendix IIIB-B.
- Overliner with GCL – Closed Case. This percolation rate was obtained from the closed condition HELP model analysis included in Appendix IIIB-A.
- Overliner with CCL – Closed Case. This percolation rate was obtained from the above closed condition HELP model analysis with the substitution of a CCL for the GCL layer and is included in Appendix IIIB-B.

The results are presented graphically on Figure 6.1. As shown, the percolation rates for the composite liner system that includes a CCL is higher than for the composite liner system that includes a GCL. Therefore, the alternative composite liner is more protective than the composite liner specified in Title 30 TAC §330.331(a)(2).

It should be noted that a POC demonstration would not be required if a CCL was used in lieu of a GCL for the proposed design. However, a GCL was selected based on the GCL's ability to perform better than a CCL for an overliner application (e.g., a GCL withstands settlement better than a CCL and a GCL also provides a more protective infiltration layer, as demonstrated above).

Figure 6.1
Comparison of Percolation Rates for Two Liner Systems



7 ADDITIONAL POC DEMONSTRATIONS

7.1 Purpose

The POC demonstration described in Sections 2 through 5 is based on the waste containment system design that includes several barrier layers that work together to (1) minimize the percolation of leachate into the existing waste fill area and (2) to prevent migration of leachate constituents to the POC, in the unlikely event there is a release from the landfill.

The waste containment system design does not rely on just one containment system component, rather the various containment system components (e.g., overliner, slurry wall, final cover system) work together to provide for a redundant system that provides a high degree of environmental protection that exceeds the design criteria listed in Title 30 TAC §330.331(a)(1) for the waste containment system design.

The following lists two scenarios that modify the "design case" demonstration to show the waste containment system's ability to meet the design criteria listed in §330.331(a)(1).

- Case 1 (Section 7.2). In this case, the only change to the model involves the removal of the overliner system from the design. This will increase the percolation rate through the existing waste to test the ability of the slurry wall to prevent the migration of contaminants.
- Case 2 (Section 7.3). This case involves modeling an initial 10 feet of saturated waste on the in-situ liner and tripling the overliner active life. This case will also test the ability of the slurry wall to continue to prevent leachate migration.

7.2 Case I – Overliner System is Removed from the Design

For this case, the model assumptions are the same as the information presented in Section 2 through 5. The only change to the model involves the removal of the overliner system from the design. The results of this analysis are shown on Figure 7.1 through 7.3 and summarized in the following table.

Table 7-1
Design Case and Case I Comparison

Model Section	Design Case Calculated DAF	Case I – Same as Design Case With No Overliner
Section A	1.01×10^{33}	1.35×10^{29}
Section B	1.66×10^{22}	2.42×10^{20}
Section C	2.80×10^{20}	2.91×10^{11}

7.3 Case II – Artificially Increased Percolation Rate Assumptions

The purpose of this demonstration is to vary several key model parameters that relate to leachate generation to gauge how they affect the calculated DAF for the proposed waste containment system design. The changes to the model are summarized below.

- The percolation rate through the overliner system (Zone I) was increased to 6.5 mm/yr. As noted in Section 3, the percolation rates for the "design case" are based on a detailed modeling effort. The 6.5 mm/yr estimate for this case represents a substantial increase of the modeled percolation estimate used for the "design case" (e.g., 0.00025 mm/year for the overliner).
- The duration of waste disposal activities that will occur in the overliner area was extended. As noted in Section 3, the "design case" conservatively established a percolation rate through the overliner by assuming 10-foot of solid waste on the liner system between 2028 and 2039. For this case, this time frame was tripled for the overliner active life to estimate the impact of this parameter. This assumption significantly increased the volume of leachate that will percolate to the existing pre-Subtitle D area.
- The saturated limit of waste at the bottom of the landfill was changed to 10 feet. This change affects the model starting condition in 2011. This depth matches the approximate depth of the GCCS. According to the site operator, none of the GCCS extraction wells contain water or leachate. Therefore, this is a very conservative assumption.

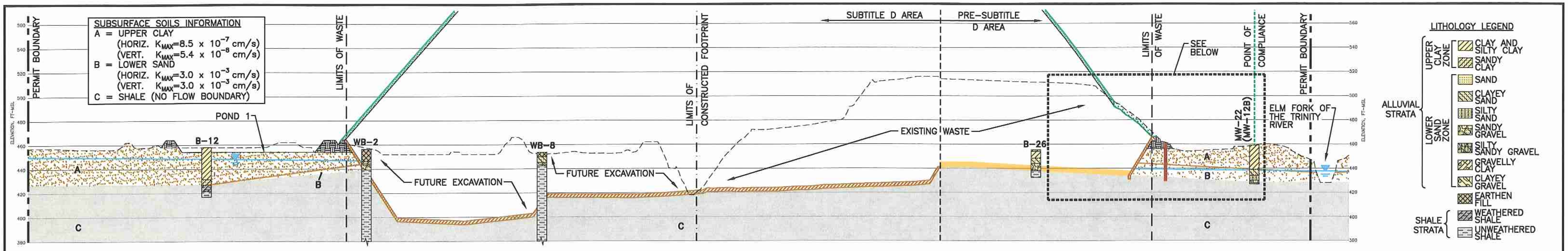
The results of this analysis are summarized on Figures 7.4 through 7.6 and listed in the following table.

Table 7-2
Design Case and Case II Comparison

Model Section	Design Case Calculated DAF	Case II – Artificially Increased Percolation Rate Assumptions
Section A	$1.01\text{x}10^{33}$	$3.24\text{x}10^{18}$
Section B	$1.66\text{x}10^{22}$	$2.25\text{x}10^{10}$
Section C	$2.80\text{x}10^{20}$	$4.21\text{x}10^{7}$

7.4 Summary

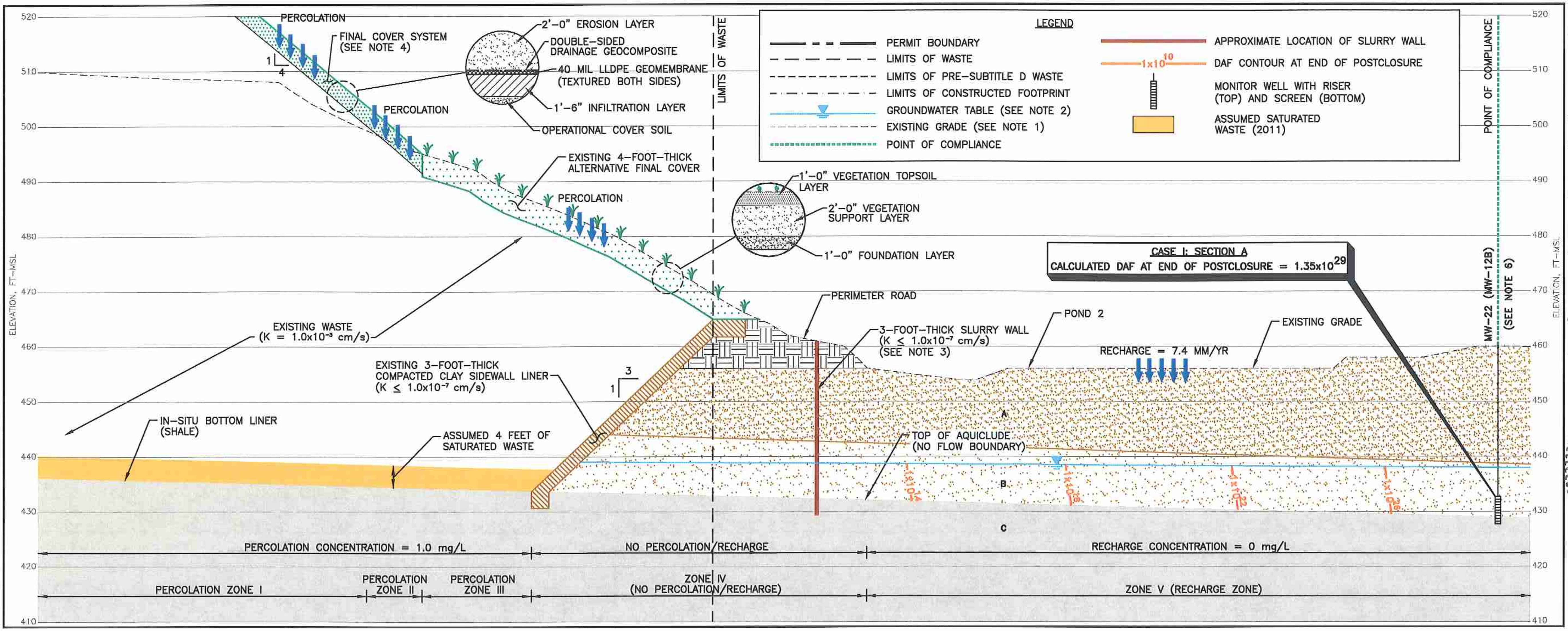
The additional POC demonstrations discussed in Sections 7.2 and 7.3 result in DAF values well above the minimum required DAF of 260.



SECTION A (SEE NOTE 7) Ⓐ

0 200 400 HORIZONTAL SCALE IN FEET

0 40 80 VERTICAL SCALE IN FEET



YEAR 2011–2069
(EXISTING SITE CONDITION TO END OF POSTCLOSURE)

0 30 60 HORIZONTAL SCALE IN FEET

0 10 20 VERTICAL SCALE IN FEET

NOTES:

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5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 22 IS SCREENED BETWEEN THE DEPTHS OF 432.7 FT–MSL AND 427.7 FT–MSL.
7. REFER TO FIGURE 5.1 FOR SECTION LOCATION.

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LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2039	OVERLINER CONSTRUCTION	CLOSURE	INTERMEDIATE COVER	130 MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2039	12/31/2069	CLOSURE	END OF POSTCLOSURE	FINAL COVER	6.5 MM/YR				

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DESIGN BY: RJS
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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT OVERLINER POC DEMONSTRATION CASE I–SECTION A

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DENTON COUNTY, TEXAS

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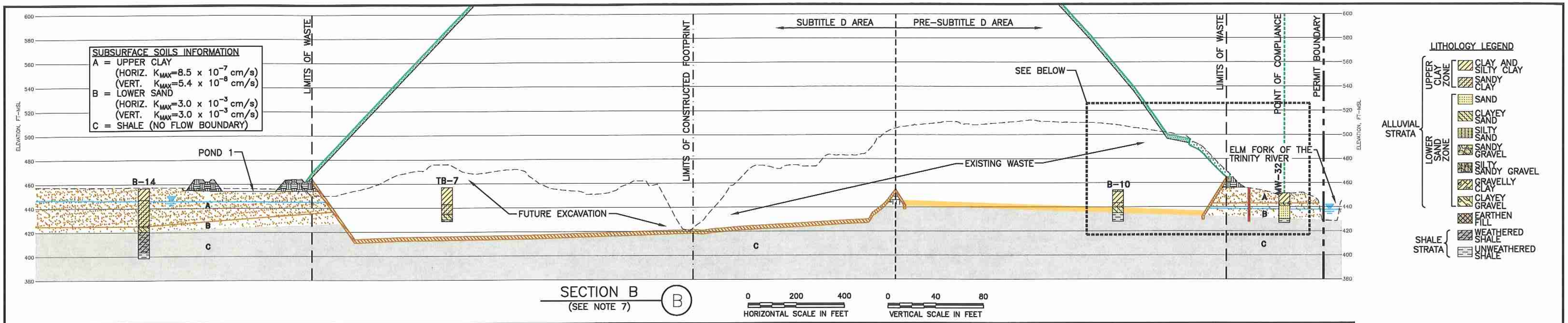
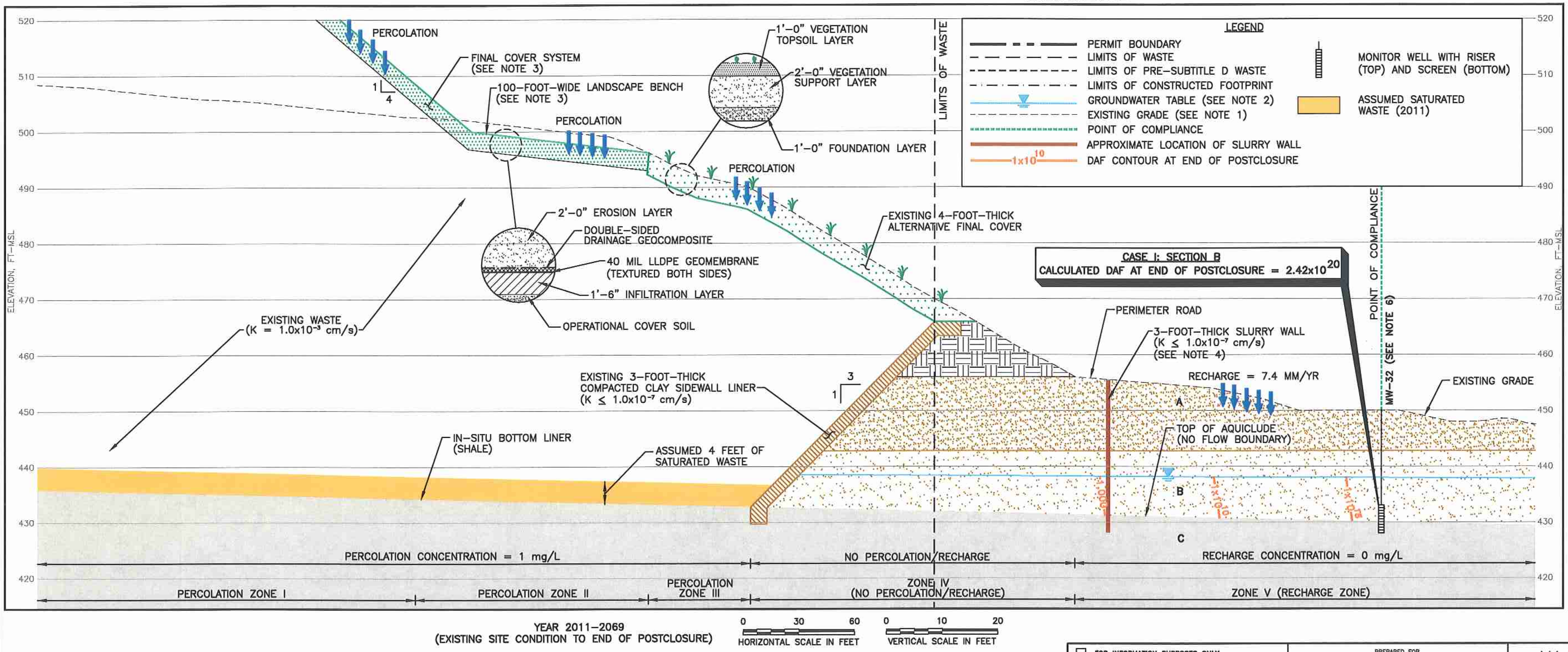
FIGURE 7.1

O:\1339\351\EXPANSION 2009\PART III–SDP\IIIH\FIGURE 7.1 – SECTION A – Case 1.dwg, sford, 1:2



SECTION B (B)
(SEE NOTE 7)



YEAR 2011-2069
(EXISTING SITE CONDITION TO END OF POSTCLOSURE)

NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
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6. MONITORING WELL 32 IS SCREENED BETWEEN THE DEPTHS OF 433.0 FT-MSL AND 428.0 FT-MSL.
7. REFER TO FIGURE 5.1 FOR SECTION LOCATION.

NEVZAT TURAN
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3-21-12

LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2039	OVERLINER CONSTRUCTION	CLOSURE	INTERMEDIATE COVER	130 MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2039	12/31/2069	CLOSURE	END OF POSTCLOSURE	FINAL COVER	6.5 MM/YR				

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DATE: 03/2012
FILE: 1339-351-11
CAD: FIGURE 7.2.DWG

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DESIGN BY: RJS
REVIEWED BY: NT

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REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT OVERLINER POC DEMONSTRATION CASE I-SECTION B

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DENTON COUNTY, TEXAS

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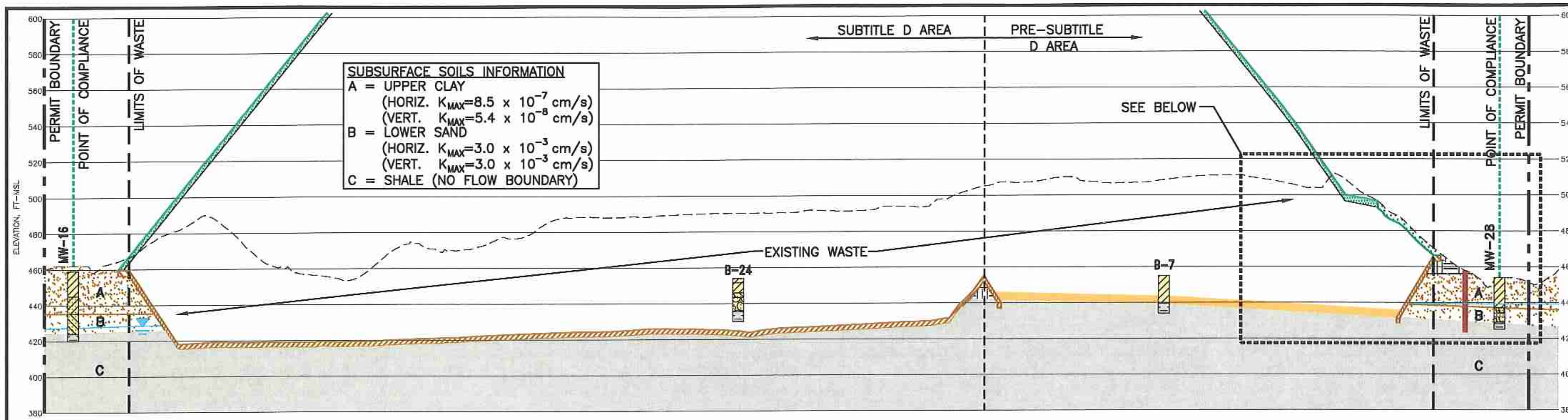
FIGURE 7.2

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIGURE 7.2 - SECTION B - CASE 1.dwg, sford, 1:2



SECTION C
(SEE NOTE 7)

0 200 400
HORIZONTAL SCALE IN FEET

0 40 80
VERTICAL SCALE IN FEET

LITHOLOGY LEGEND

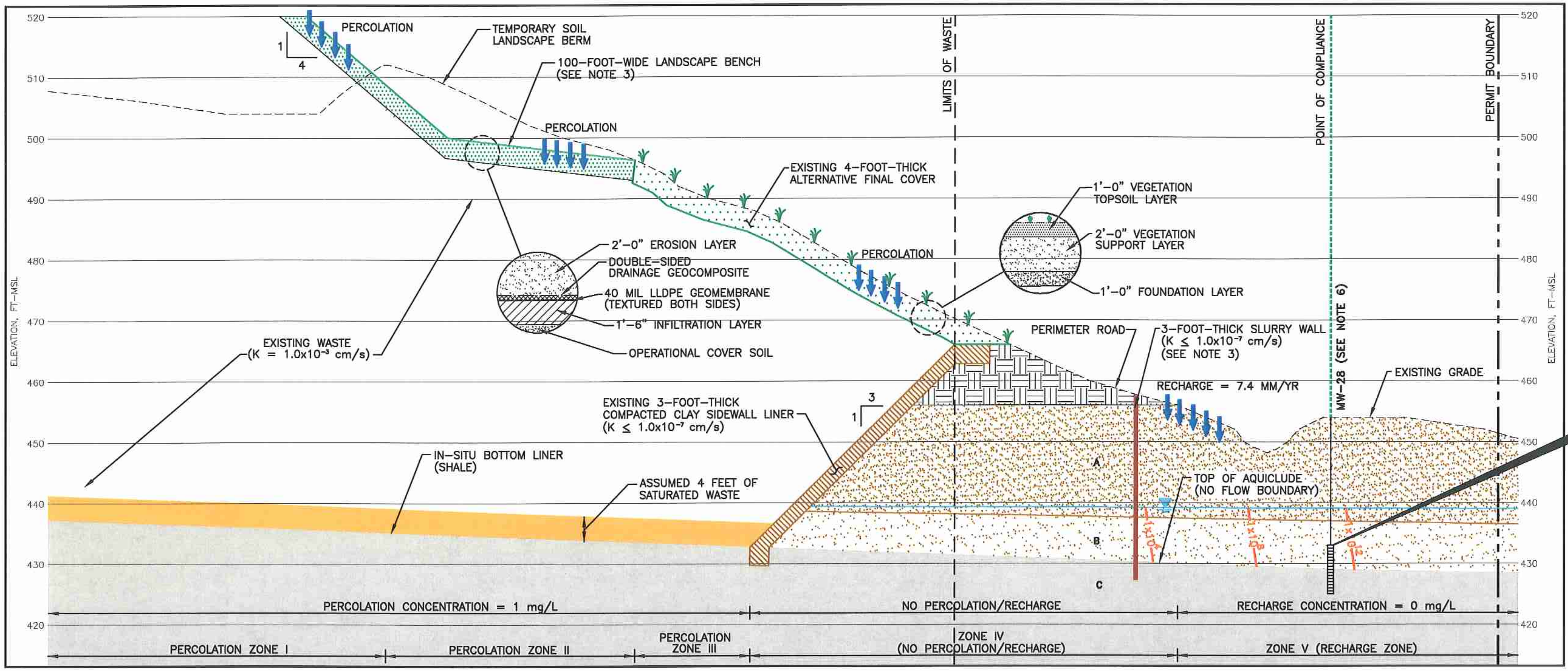
ALLUVIAL STRATA
- UPPER CLAY ZONE
  - ▨ CLAY AND SILTY CLAY
  - ▨ SANDY CLAY
- LOWER SAND ZONE
  - ▨ SAND
  - ▨ CLAYEY SAND
  - ▨ SILTY SAND
  - ▨ SANDY GRAVEL
  - ▨ SILTY SANDY GRAVEL
  - ▨ GRAVELLY CLAY
  - ▨ CLAYEY GRAVEL

▨ EARTHEN FILL

SHALE STRATA
- ▨ WEATHERED SHALE
- ▨ UNWEATHERED SHALE

LEGEND

— - - — PERMIT BOUNDARY
— — — LIMITS OF WASTE
- - - - - LIMITS OF PRE-SUBTITLE D WASTE
▽ GROUNDWATER TABLE (SEE NOTE 2)
- - - - - EXISTING GRADE (SEE NOTE 1)
▪▪▪▪ POINT OF COMPLIANCE
▬ APPROXIMATE LOCATION OF SLURRY WALL
—1x10^10— DAF CONTOUR AT END OF POSTCLOSURE
MONITOR WELL WITH RISER (TOP) AND SCREEN (BOTTOM)
🟧 ASSUMED SATURATED WASTE (2011)



CASE I: SECTION C
CALCULATED DAF AT END OF POSTCLOSURE = 2.91×10^{11}

NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. WATER LEVEL MEASUREMENTS COLLECTED BY WBC ON DECEMBER 5, 2010.
3. OVERLINER SYSTEM COMPONENTS, FINAL COVER SYSTEM COMPONENTS, AND SLURRY WALL DESIGN SPECIFICATIONS ARE PROVIDED IN APPENDIX IIIA.
4. POINT OF COMPLIANCE AND MONITORING WELL LOCATIONS ARE PROVIDED IN APPENDIX IIIH. REFER TO APPENDIX IIIH FOR GROUNDWATER MONITORING, SAMPLING, AND ANALYSIS PLAN.
5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 28 IS SCREENED BETWEEN THE DEPTHS OF 433.3 FT-MSL AND 425.8 FT-MSL.
7. REFER TO FIGURE 5.1 FOR SECTION LOCATION.

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3-21-12

YEAR 2011-2069
(EXISTING SITE CONDITION TO END OF POSTCLOSURE)

0 30 60
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2039	OVERLINER CONSTRUCTION	CLOSURE	INTERMEDIATE COVER	130 MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2039	12/31/2069	CLOSURE	END OF POSTCLOSURE	FINAL COVER	6.5 MM/YR				

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FILE: 1339-351-11
CAD: FIGURE 7.3.DWG

DRAWN BY: SRF
DESIGN BY: RJS
REVIEWED BY: NT

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MAJOR PERMIT AMENDMENT OVERLINER POC DEMONSTRATION CASE I–SECTION C

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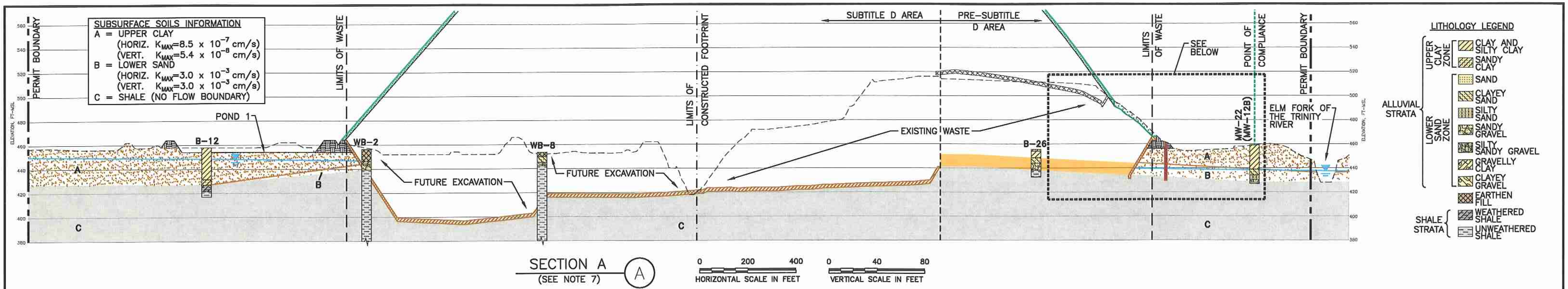
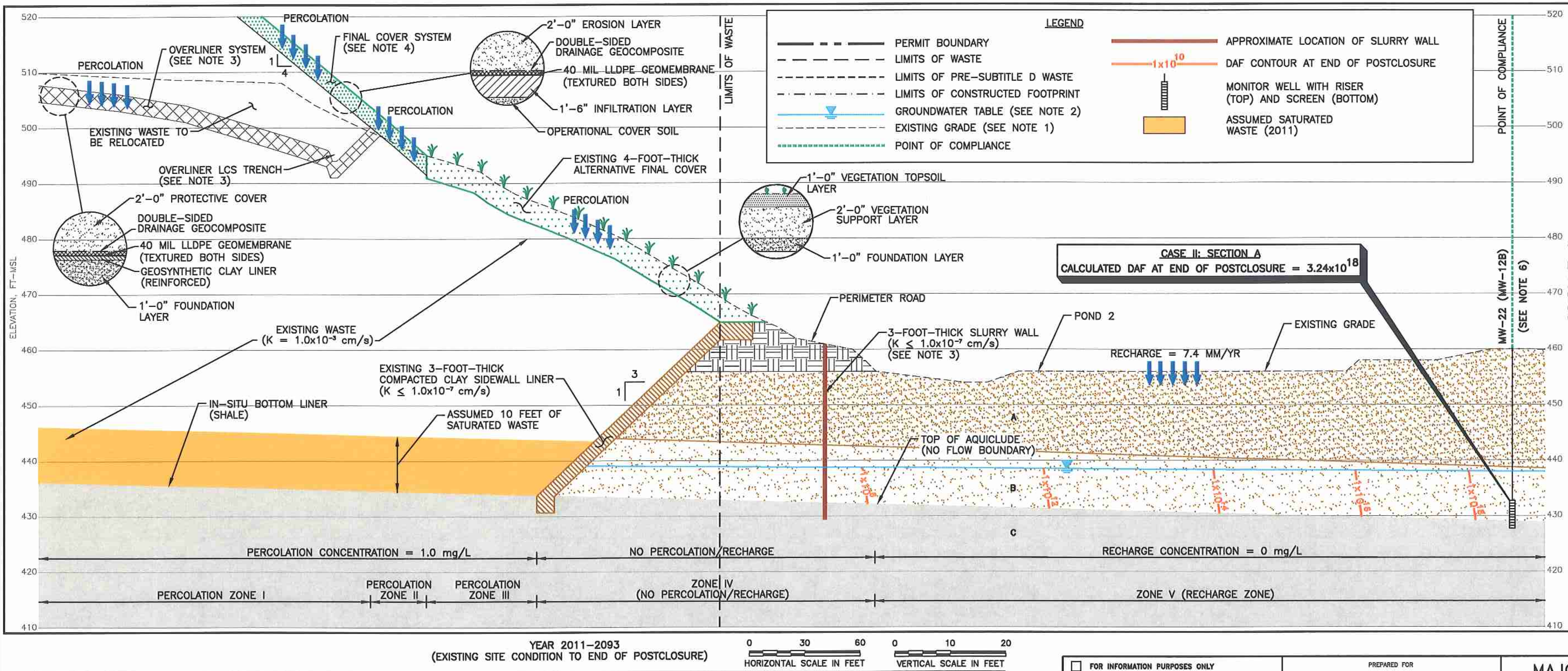
FIGURE 7.3

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIGURE 7.3 - SECTION C - CASE I.dwg, sford, 1:2





NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. WATER LEVEL MEASUREMENTS COLLECTED BY WBC ON DECEMBER 5, 2010.
3. OVERLINER SYSTEM COMPONENTS, FINAL COVER SYSTEM COMPONENTS, AND SLURRY WALL DESIGN SPECIFICATIONS ARE PROVIDED IN APPENDIX IIIA.
4. POINT OF COMPLIANCE AND MONITORING WELL LOCATIONS ARE PROVIDED IN APPENDIX IIIH. REFER TO APPENDIX IIIH FOR GROUNDWATER MONITORING, SAMPLING, AND ANALYSIS PLAN.
5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 22 IS SCREENED BETWEEN THE DEPTHS OF 432.7 FT-MSL AND 427.7 FT-MSL.
7. REFER TO FIGURE 5.1 FOR SECTION LOCATION.

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LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT									
TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2063	OVERLINER CONSTRUCTION	CLOSURE	OVERLINER	6.5 MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2063	12/31/2093	CLOSURE	END OF POSTCLOSURE	OVERLINER/FINAL COVER	6.5 MM/YR				

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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
OVERLINER POC DEMONSTRATION
CASE II–SECTION A

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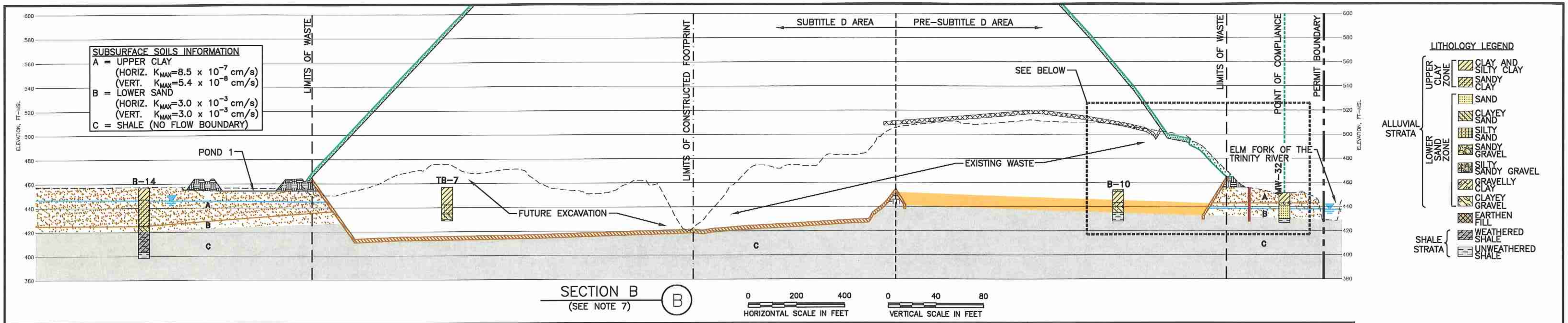
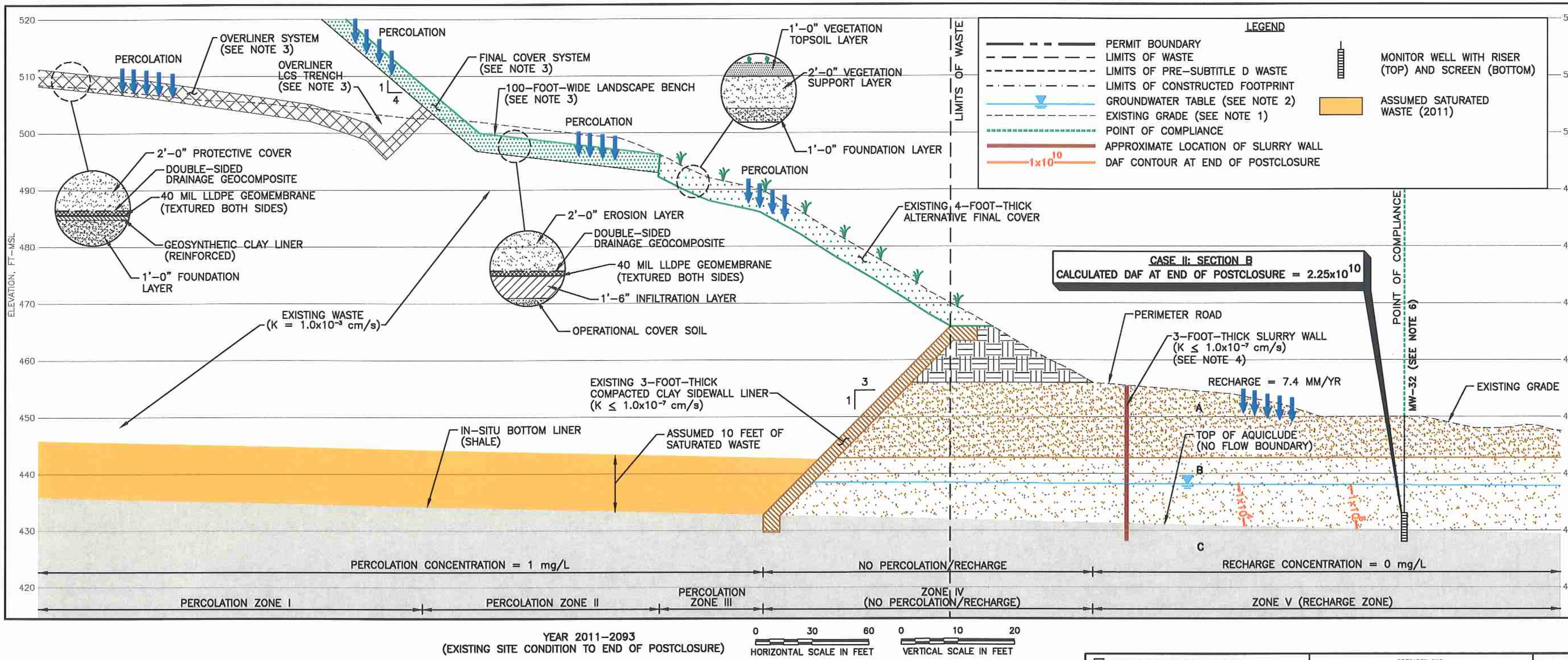
FIGURE 7.4

O:\1339\351\EXPANSION 2009\PART III–SDP\IIIH\FIGURE 7.4 – SECTION A – CASE II.dwg, sford, 1:2





NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. WATER LEVEL MEASUREMENTS COLLECTED BY WBC ON DECEMBER 5, 2010.
3. OVERLINER SYSTEM COMPONENTS, FINAL COVER SYSTEM COMPONENTS, AND SLURRY WALL DESIGN SPECIFICATIONS ARE PROVIDED IN APPENDIX IIIA.
4. POINT OF COMPLIANCE AND MONITORING WELL LOCATIONS ARE PROVIDED IN APPENDIX IIIH. REFER TO APPENDIX IIIH FOR GROUNDWATER MONITORING, SAMPLING, AND ANALYSIS PLAN.
5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 32 IS SCREENED BETWEEN THE DEPTHS OF 433.0 FT-MSL AND 428.0 FT-MSL.
7. REFER TO FIGURE 5.1 FOR SECTION LOCATION.

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LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT									
TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2063	OVERLINER CONSTRUCTION	CLOSURE	OVERLINER	6.5 MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2063	12/31/2093	CLOSURE	END OF POSTCLOSURE	OVERLINER/FINAL COVER	6.5 MM/YR				

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MAJOR PERMIT AMENDMENT
OVERLINER POC DEMONSTRATION
CASE II–SECTION B

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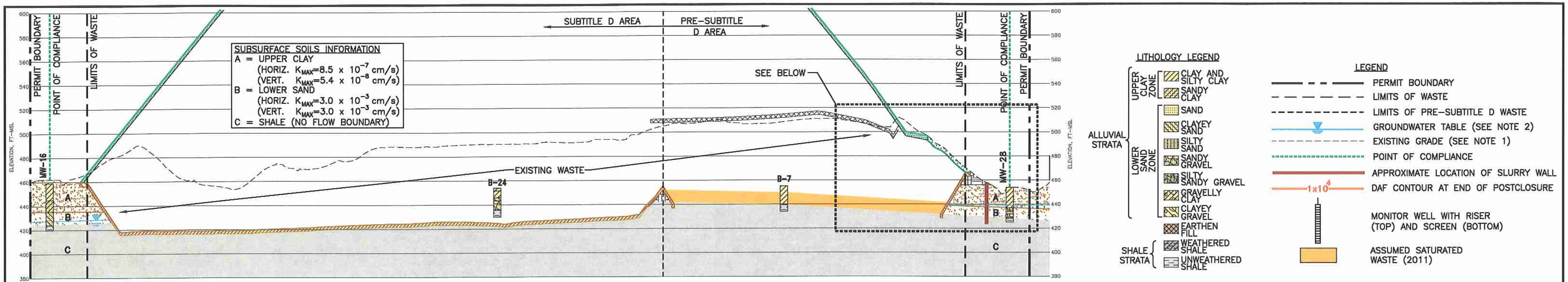
FIGURE 7.5

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIB\FIGURE 7.5 - SECTION B - CASE II.dwg, sford, 1:2



SECTION C

(SEE NOTE 7)

Ⓒ

0 200 400
HORIZONTAL SCALE IN FEET

0 40 80
VERTICAL SCALE IN FEET

NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8–28–2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. WATER LEVEL MEASUREMENTS COLLECTED BY WBC ON DECEMBER 5, 2010.
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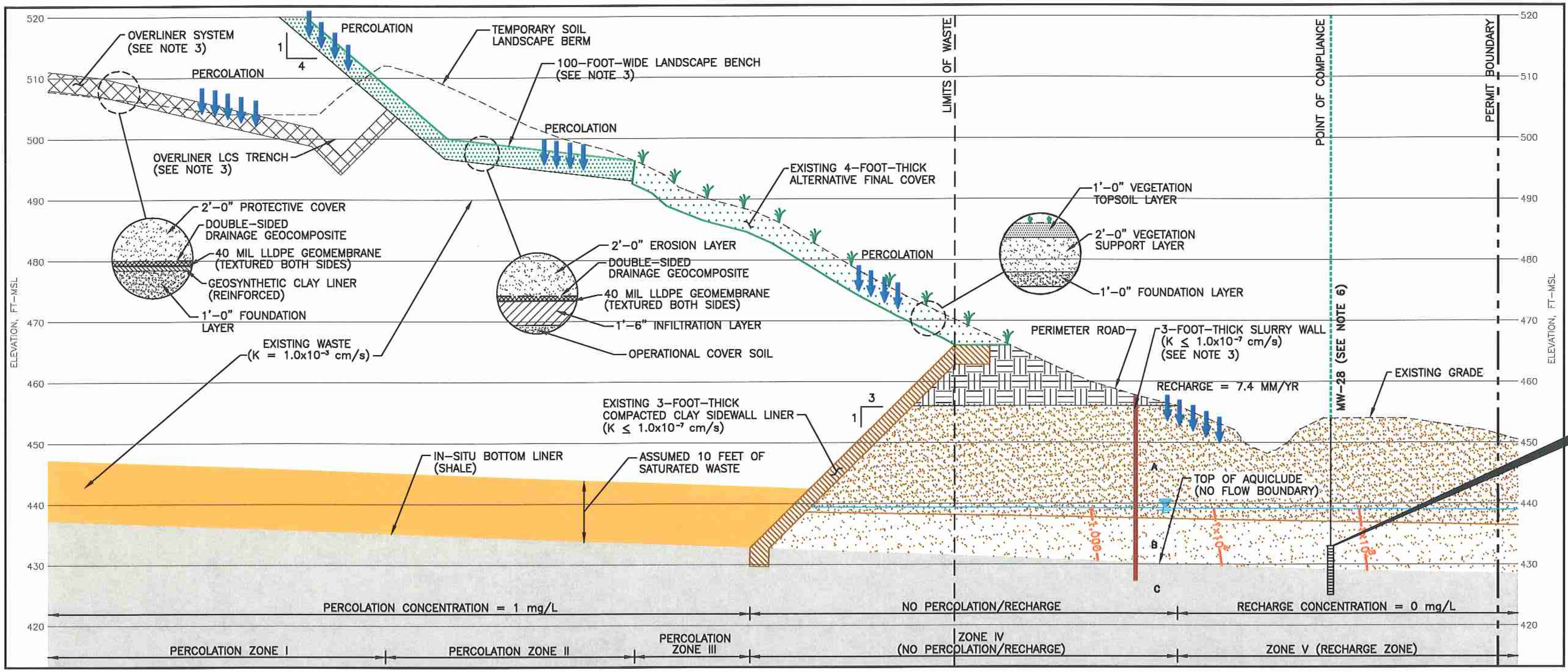
4. POINT OF COMPLIANCE AND MONITORING WELL LOCATIONS ARE PROVIDED IN APPENDIX IIIH. REFER TO APPENDIX IIIH FOR GROUNDWATER MONITORING, SAMPLING, AND ANALYSIS PLAN.
5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 28 IS SCREENED BETWEEN THE DEPTHS OF 433.3 FT–MSL AND 425.8 FT–MSL.
7. REFER TO FIGURE 5.1 FOR SECTION LOCATION.



CASE II: SECTION C

CALCULATED DAF AT END OF POSTCLOSURE = $4.21x10^7$

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84059
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YEAR 2011–2093

(EXISTING SITE CONDITION TO END OF POSTCLOSURE)

0 30 60
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II		PERCOLATION ZONE III	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2011	01/01/2028	EXISTING SITE CONDITION	OVERLINER CONSTRUCTION	INTERMEDIATE COVER	130 MM/YR	INTERMEDIATE COVER	130 MM/YR	ALTERNATIVE FINAL COVER	4 MM/YR
01/01/2028	12/31/2063	OVERLINER CONSTRUCTION	CLOSURE	OVERLINER	6.5 MM/YR	FINAL COVER	6.5 MM/YR		
12/31/2063	12/31/2093	CLOSURE	END OF POSTCLOSURE	OVERLINER/FINAL COVER	6.5 MM/YR				

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FILE: 1339–351–11
CAD: FIGURE 7.6.DWG

DRAWN BY: SRF
DESIGN BY: RJS
REVIEWED BY: NT

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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
OVERLINER POC DEMONSTRATION
CASE II–SECTION C

CAMELOT LANDFILL
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FIGURE 7.6

O:\1339\351\EXPANSION 2009\PART III–SDP\IIIB\FIGURE 7.6 – SECTION C – CASE II.dwg, sford, 1:2

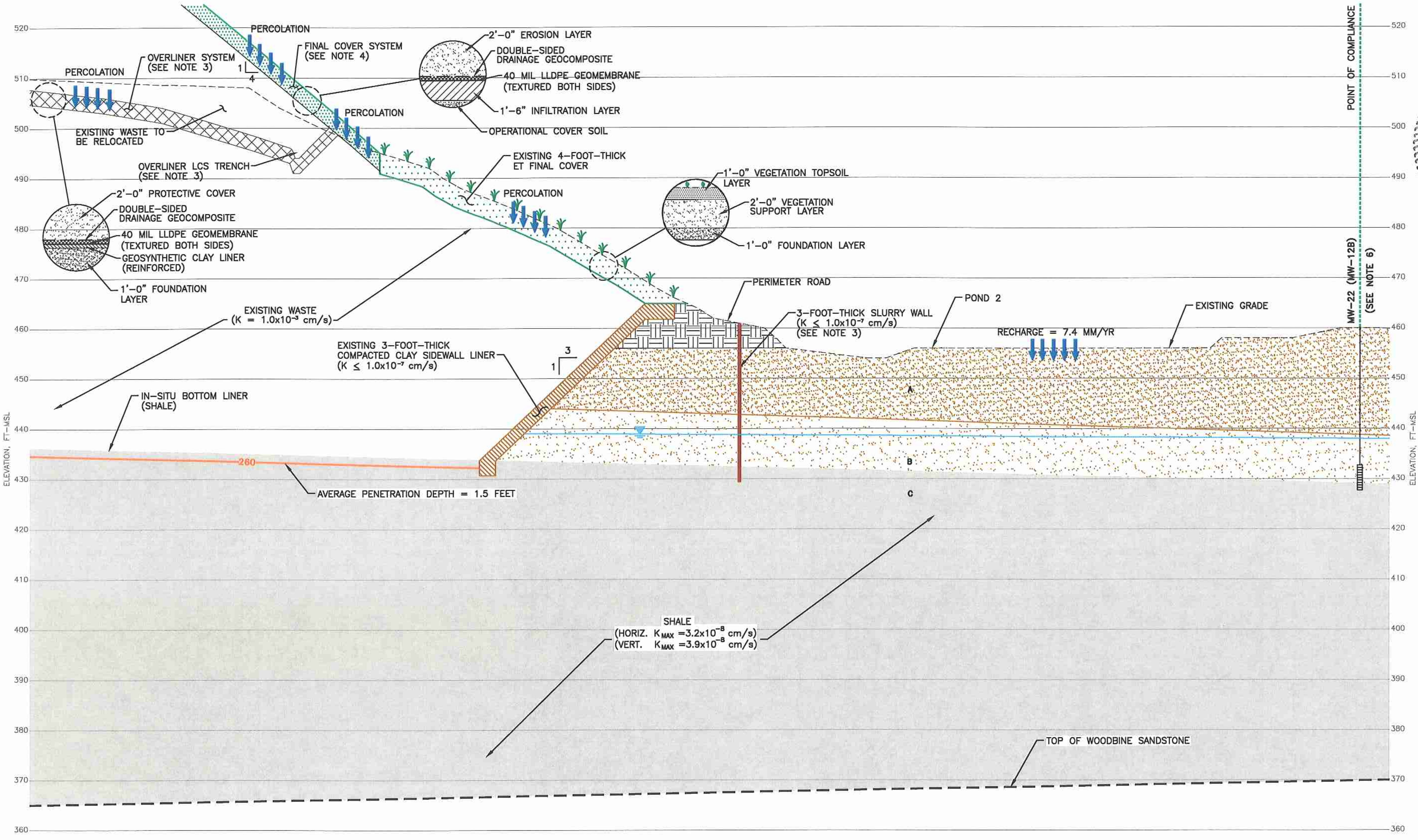
8 EFFECTIVENESS OF SHALE STRATA AS A BARRIER LAYER

This section has been developed to demonstrate that the unweathered Shale Strata layer is an effective barrier layer that separates the uppermost aquifer and the Woodbine Strata. This demonstration includes a fate and transport analysis using MODFLOW to demonstrate that in the unlikely event that there was a release from the waste disposal area, leachate constituents would be prevented from reaching the Woodbine Strata during the life of the site plus the 30-year postclosure period. The results of this analysis are provided on Figure 8.1.

This demonstration was completed by modifying the model discussed in Sections 2 through 5. The model geometry developed for the POC demonstration was modified by lowering the no-flow boundary to the bottom of Shale Strata, thereby allowing leachate from the bottom of the landfill to penetrate into the Shale Strata. For the POC demonstration, the no-flow boundary was set at the top of the Shale Strata to provide a conservative boundary condition (i.e., percolation from the landfill was forced to flow toward the POC through the alluvium). The Shale Strata are assumed to be saturated so that MODFLOW simulations can be performed. This is also a significant conservative assumption given that any potential flow from the landfill will be retarded through the unsaturated shale and thus will require a much longer time to progress than what is modeled. The Shale Strata below the pre-Subtitle D area has an average thickness of over 90 feet (refer to Figure IIIG-C-4 in Appendix IIIG-C).

The Shale Strata were modeled using the highest reported saturated hydraulic conductivity value of 3.9×10^{-8} cm/s and lowest reported porosity value of 27.2 percent.

As shown, at the end of the postclosure period the 260 DAF contour is modeled to be less than 2 feet below the landfill. Therefore, if there were a horizontal point of compliance monitoring system below the landfill, the constituent concentrations would reach the compliance level less than 2 feet below the landfill. This demonstrates that the Shale Strata effectively restrict potential downward flow from the site.



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SUBSURFACE SOILS INFORMATION

A = UPPER CLAY
(HORIZ. K_{MAX}=8.5 x 10^{-7} cm/s)
(VERT. K_{MAX}=5.4 x 10^{-8} cm/s)

B = LOWER SAND
(HORIZ. K_{MAX}=3.0 x 10^{-3} cm/s)
(VERT. K_{MAX}=3.0 x 10^{-3} cm/s)

C = SHALE
(HORIZ. K_{MAX}=3.2 x 10^{-8} cm/s)
(VERT. K_{MAX}=3.9 x 10^{-8} cm/s)

NOTES:

1. EXISTING GRADE ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8–28–2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. WATER LEVEL MEASUREMENTS COLLECTED BY WBC ON DECEMBER 5, 2010. GROUNDWATER TABLE WITHIN THE PRE–SUBTITLE D AREA IS APPROXIMATE.
3. OVERLINER SYSTEM COMPONENTS, FINAL COVER SYSTEM COMPONENTS, AND SLURRY WALL DESIGN SPECIFICATIONS ARE PROVIDED IN APPENDIX IIIA.
4. POINT OF COMPLIANCE AND MONITORING WELL LOCATIONS ARE PROVIDED IN APPENDIX IIIH. REFER TO APPENDIX IIIH FOR GROUNDWATER MONITORING, SAMPLING, AND ANALYSIS PLAN.
5. TOP OF SHALE ELEVATION, LOWER SAND THICKNESS, AND UPPER CLAY THICKNESS DATA FROM RONE, REED, AND WBC BOREHOLE LOGS. REFER TO APPENDIX IIIG FOR BORING INFORMATION AND SITE GEOLOGY REPORT.
6. MONITORING WELL 22 IS SCREENED BETWEEN THE DEPTHS OF 432.7 FT–MSL AND 427.7 FT–MSL.

FIGURE 1: YEAR 2011–2069
(EXISTING SITE CONDITION TO END OF POSTCLOSURE)

0 30 60
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

LEGEND

GROUNDWATER TABLE (SEE NOTE 2)
EXISTING GRADE (SEE NOTE 1)
POINT OF COMPLIANCE
APPROXIMATE LOCATION OF SLURRY WALL
260 DAF CONTOUR AT END OF POSTCLOSURE
MONITOR WELL WITH RISER (TOP) AND SCREEN (BOTTOM)
THE PERCOLATION CONDITIONS FOR THIS ANALYSIS ARE THE SAME AS PERCOLATION VALUES DESCRIBED IN SECTION 3

O:\1339\351\EXPANSION 2009\PART III–SDP\IIIB\FIG 8.1–BARRIER LAYER DEMONSTRATION.dwg, sford, 1:2

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DATE: 03/2012
FILE: 1339–351–11
CAD: 8.1 BARRIER LAYER.DWG

DRAWN BY: SRF
DESIGN BY: RJS
REVIEWED BY: NT

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PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
BARRIER LAYER DEMONSTRATION

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

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FIGURE 8.1

9 SUMMARY

9.1 POC Demonstration Summary

The POC demonstration described in Sections 2 through 5 is based on the waste containment system design that includes several barrier layers that work together to (1) minimize the percolation of leachate into the existing waste fill area and (2) to prevent migration of leachate constituents to the POC, in the unlikely event there is a release from the landfill.

The waste containment system design does not rely on just one containment system component, rather the various containment system components (e.g., overliner, slurry wall, final cover system) work together to provide for a redundant system that provides a high degree of environmental protection that exceeds the design criteria listed in Title 30 TAC §330.331(a)(1) for the waste containment system design.

The DAF results for the "Design Case" and each of the additional cases presented in Section 7 that demonstrate the effectiveness of the waste containment system design are summarized in Table 9-1.

Table 9-1
DAF Summary

Model Section	Design Case Calculated DAF	Case I – Same as Design Case With No Overliner	Case II – Artificially Increased Percolation Rate Assumptions
Section A	1.01×10^{33}	1.35×10^{29}	3.24×10^{18}
Section B	1.66×10^{22}	2.42×10^{20}	2.25×10^{10}
Section C	2.80×10^{20}	2.91×10^{11}	4.21×10^{7}

The results demonstrate that the proposed waste containment system design results in DAFs that are well in excess of the minimum required value of 260.

Based on the model simulation results, it is concluded that the "waste containment system design" included in this permit amendment application exceeds the requirements of Title 30 TAC §330.331(a)(1).

9.2 Liner Equivalency Demonstration Summary

The liner equivalency demonstration presented in Section 6 showed that the proposed alternative liners (which replace the prescriptive 2 feet of compacted clay liner with a geosynthetic clay liner) are more conservative based on calculated percolation rates through each liner. Therefore, the alternative composite liner is more protective than the composite liner specified in Title 30 TAC §330.331(a)(2).

The use of a GCL to replace the CCL component of the overliner system requires that a POC demonstration be completed consistent with §330.331(a)(1). However, a POC demonstration would not be required if the less protective CCL were included in the design.

9.3 Barrier Layer Demonstration Summary

The Shale Strata described in Section 8 were demonstrated as an effective barrier layer that separates the uppermost aquifer and the Woodbine Strata, thus restricting potential downward flow from the site.

APPENDIX IIIB-A

HELP MODEL OUTPUT – POC DEMONSTRATION

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3-21-12

Includes Pages IIIB-A-1 through IIIB-A-36

Prep By: NT
Date: 3/16/2012

Chkd By: RS
Date: 3/16/2012

CAMELOT LANDFILL
1339-351-11-02-6B.2
HELP VERSION 3.07 SUMMARY SHEET
POINT OF COMPLIANCE DEMONSTRATION

			ACTIVE EXISTING SITE CONDITION	INTERIM OVERLINER WITH 10 FEET OF WASTE	CLOSED OVERLINER/ FINAL COVER	CLOSED EXISTING ALTERNATIVE FINAL COVER[1]	OFFSITE AREAS (RECHARGE)
GENERAL INFORMATION		No. of Years	29	12	30	30	30
		Ground Cover	BARE	FAIR	GOOD	EXCELLENT	EXCELLENT
		SCS Runoff Curve No.	-	87.1	80.1	98.7	86.7
		Model Area (acre)	1	1	1	1	1
		Runoff Area (%)	95	70	100	100	95
		Maximum Leaf Area Index	3.5	3.0	4.5	5.0	5.0
		Evaporative Zone Depth (inch)	6	12	18	12	24
Final Cover	TOPSOIL LAYER (Texture = 10)	Thickness (in)	6		12	12	Upper Layer of Offsite Areas (see below)
		Porosity (vol/vol)	0.4640		0.3980	0.4253	
		Field Capacity (vol/vol)	0.3100		0.2440	-	
		Wilting Point (vol/vol)	0.1870		0.1360	0.2170	
		Init. Moisture Content (vol/vol)	0.3100		0.2440	-	
		Hyd. Conductivity (cm/s)	6.4E-05		1.2E-04	1.3E-05	
	EROSION LAYER (Texture = 10)	Thickness (in)			12	36	48
		Porosity (vol/vol)			0.3980	0.4253	0.4640
		Field Capacity (vol/vol)			0.2440	-	0.3100
		Wilting Point (vol/vol)			0.1360	0.2170	0.1870
		Init. Moisture Content (vol/vol)			0.2440	-	0.3100
		Hyd. Conductivity (cm/s)			1.2E-04	1.3E-05	1.8E-08
	FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)			0.04	See Note 1 For Referenced Information	Lower Layer of Offsite Areas Upper Clay Soil (see below)
		Hyd. Conductivity (cm/s)			4.0E-13		
		Pinhole Density (holes/acre)			1		
		Install. Defects (holes/acre)			4		
		Placement Quality			GOOD		
	INFILTRATION LAYER (Texture = 0)	Thickness (in)			18		72
		Porosity (vol/vol)			0.4270		0.4750
		Field Capacity (vol/vol)			0.4180		0.3780
		Wilting Point (vol/vol)			0.3670		0.2650
		Init. Moisture Content (vol/vol)			0.4270		0.4750
		Hyd. Conductivity (cm/s)			1.0E-05		1.8E-08
Intermediate Cover	INTERMEDIATE COVER (Texture = 11)	Thickness (in)	6	12	12		
		Porosity (vol/vol)	0.4750	0.4640	0.4640		
		Field Capacity (vol/vol)	0.3780	0.3100	0.3100		
		Wilting Point (vol/vol)	0.2650	0.1870	0.1870		
		Init. Moisture Content (vol/vol)	0.4750	0.3100	0.3100		
		Hyd. Conductivity (cm/s)	1.7E-05	6.4E-05	6.4E-05		
Waste	WASTE TOP[2] (Texture = 0)	Thickness (in)	600		1500		
		Porosity (vol/vol)	0.6376		0.6148		
		Field Capacity (vol/vol)	0.5185		0.5114		
		Wilting Point (vol/vol)	0.0770		0.0770		
		Init. Moisture Content (vol/vol)	0.2500		0.3800		
		Hyd. Conductivity (cm/s)	1.0E-03		1.0E-03		
	WASTE BOTTOM[2] (Texture = 0)	Thickness (in)		120	756		
		Porosity (vol/vol)		0.6376	0.5387		
		Field Capacity (vol/vol)		0.5185	0.4900		
		Wilting Point (vol/vol)		0.0770	0.0770		
		Init. Moisture Content (vol/vol)		0.2500	0.3800		
		Hyd. Conductivity (cm/s)		1.0E-03	1.0E-04		
Pre D Cover		Thickness (in)	36				
		Porosity (vol/vol)	0.4270				
		Field Capacity (vol/vol)	0.4180				
		Wilting Point (vol/vol)	0.3670				
		Init. Moisture Content (vol/vol)	0.4270				
		Hyd. Conductivity (cm/s)	1.0E-07				
Overliner	PROTECTIVE COVER (Texture = 10)	Thickness (in)		24	24		
		Porosity (vol/vol)		0.3980	0.3980		
		Field Capacity (vol/vol)		0.2440	0.2440		
		Wilting Point (vol/vol)		0.1360	0.1360		
		Init. Moisture Content (vol/vol)		0.2440	0.2440		
		Hyd. Conductivity (cm/s)		1.2E-04	1.2E-04		
	LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)		0.30	0.25		
		Porosity (vol/vol)		0.8500	0.8500		
		Field Capacity (vol/vol)		0.0100	0.0100		
		Wilting Point (vol/vol)		0.0050	0.0050		
		Init. Moisture Content (vol/vol)		0.0100	0.0100		
		Hyd. Conductivity (cm/s)		40.42	7.77		
		Slope (%)		1	1		
		Slope Length (ft)		700	700		
	FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)		0.04	0.04		
		Hyd. Conductivity (cm/s)		4.0E-13	4.0E-13		
		Pinhole Density (holes/acre)		1	1		
		Install. Defects (holes/acre)		4	20		
		Placement Quality		GOOD	GOOD		
	GEOSYNTHETIC CLAY LINER (Texture = 0)	Thickness (in)		0.25	0.25		
		Porosity (vol/vol)		0.7500	0.7500		
		Field Capacity (vol/vol)		0.7470	0.7470		
		Wilting Point (vol/vol)		0.4000	0.4000		
		Init. Moisture Content (vol/vol)		0.7500	0.7500		
		Hyd. Conductivity (cm/s)		5.0E-09	5.0E-09		
PRECIPITATION		Average Annual (in)	34.25	36.16	34.26	34.26	34.26
PERCOLATION		Through Layer	Int. Cover	Overliner	Overliner Final Cover	Alt. Final Cover[1]	Upper Clay
		Average Annual (in/year)	5.07635	0.00001	0.00002 0.2564	0.0106	0.2917
		Average Annual (mm/year)	130	0.00025	0.00051 6.5	0.3	7.4

[1] Existing alternative final cover information was reproduced from the Alternative Soil Final Cover System approved by TCEQ on August 5, 2011. This demonstration was completed using the UNSAT-H model and estimated a 0.3 mm/yr percolation rate for the existing alternative final cover. However, a percolation value of 4 mm/yr was used in lieu of 0.3 mm/yr for the existing alternative final cover in MODFLOW simulations for a more conservative approach.

HELP MODEL OUTPUT FILES

HELP MODEL OUTPUT FOR EXISTING SITE CONDITION (ACTIVE WITH INTERMEDIATE COVER)

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\CAMELOT\DESIGN\INTRM\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP\camelot\DESIGN\INTRM\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP\CAMELOT\DESIGN\INTRM\DATA13.D13
EVAPOTRANSPIRATION DATA:     c:\help\camelot\DESIGN\INTRM\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\camelot\DESIGN\INTRM\DATA10.D10
OUTPUT DATA FILE:            C:\HELP\camelot\DESIGN\INTRM\PRED-INT.OUT


TIME:  15:31     DATE:   7/22/2011


******************************************************************************

     TITLE:  CAMELOT LF PRE-D AREA WITH INT COVER - DESIGN 29 YRS

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4640 VOL/VOL
           FIELD CAPACITY             =      0.3100 VOL/VOL
           WILTING POINT              =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  15
THICKNESS                   =      6.00    INCHES
POROSITY                    =      0.4750 VOL/VOL
FIELD CAPACITY              =      0.3780 VOL/VOL
WILTING POINT               =      0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4750 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.170000003000E-04 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    600.00    INCHES
POROSITY                    =      0.6376 VOL/VOL
FIELD CAPACITY              =      0.5185 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     36.00    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
            ----------------------------------------

FRACTION OF AREA ALLOWING RUNOFF   =     95.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
EVAPORATIVE ZONE DEPTH             =      6.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      1.860  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      2.784  INCHES
```

```
     LOWER LIMIT OF EVAPORATIVE STORAGE =      1.122  INCHES
     INITIAL SNOW WATER                 =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS   =    170.082  INCHES
     TOTAL INITIAL WATER                =    170.082  INCHES
     TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR


                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               DALLAS                TEXAS

          STATION LATITUDE                         =  32.85 DEGREES
          MAXIMUM LEAF AREA INDEX                  =   3.50
          START OF GROWING SEASON (JULIAN DATE)    =     63
          END OF GROWING SEASON (JULIAN DATE)      =    329
          EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
          AVERAGE ANNUAL WIND SPEED                =  10.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  66.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  68.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  63.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  66.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

               NORMAL MEAN MONTHLY PRECIPITATION  (INCHES)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     1.90        2.37        3.06        3.20        5.15        3.23
     2.12        2.03        2.42        4.11        2.57        2.57


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
    44.10       49.40       57.40       65.00       73.10       80.90
    85.00       84.40       77.50       67.20       55.10       46.70


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS
                 AND STATION LATITUDE  =  32.85 DEGREES
```

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******************************************************************************

      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   29
------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                  1.43     2.22     2.83     3.07     4.63     3.29
                           2.78     1.91     2.77     4.21     2.37     2.75

   STD. DEVIATIONS         0.98     1.29     1.69     1.92     2.20     2.17
                           2.21     1.46     1.54     3.50     1.83     1.95

 RUNOFF
 ------
   TOTALS                  0.152    0.396    0.647    0.822    1.529    1.024
                           0.881    0.409    0.635    1.777    0.607    0.627

   STD. DEVIATIONS         0.229    0.401    0.706    0.915    1.247    0.950
                           1.127    0.474    0.554    2.134    0.777    0.619

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  1.135    1.352    1.699    1.853    2.592    2.053
                           1.798    1.404    1.795    1.625    1.123    1.245

   STD. DEVIATIONS         0.547    0.672    0.777    1.021    0.847    1.123
                           1.019    0.985    0.843    0.856    0.514    0.518

 PERCOLATION/LEAKAGE THROUGH LAYER  2
 ------------------------------------
   TOTALS                  0.2655   0.4823   0.4702   0.4182   0.4771   0.3422
                           0.1534   0.0855   0.1706   0.7672   0.5366   0.9077

   STD. DEVIATIONS         0.3922   0.4001   0.5774   0.4297   0.3849   0.3717
                           0.2802   0.1559   0.2310   0.7874   0.6221   0.9731

 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


------------------------------------------------------------------------------
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------
```

```
  DAILY AVERAGE HEAD ON TOP OF LAYER  2
  -------------------------------------
    AVERAGES                0.0107   0.0249   0.0221   0.0224   0.0239   0.0168
                            0.0077   0.0036   0.0066   0.0466   0.0244   0.0409

    STD. DEVIATIONS         0.0153   0.0233   0.0296   0.0279   0.0219   0.0199
                            0.0142   0.0071   0.0099   0.0597   0.0307   0.0461

  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES                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

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   29
-------------------------------------------------------------------------------
                                          INCHES            CU. FEET     PERCENT
                                    -------------------  -------------  ---------
 PRECIPITATION                       34.25    (   6.387)    124326.3     100.00

 RUNOFF                               9.507   (  3.0653)     34509.18     27.757

 EVAPOTRANSPIRATION                  19.673   (  2.9467)     71412.05     57.439

 PERCOLATION/LEAKAGE THROUGH          5.07635 (  1.59823)    18427.148    14.82160
   LAYER  2

 AVERAGE HEAD ON TOP                  0.021 (     0.008)
   OF LAYER  2

 PERCOLATION/LEAKAGE THROUGH          0.00000 (  0.00000)        0.000     0.00000
   LAYER  4

 AVERAGE HEAD ON TOP                  0.000 (     0.000)
   OF LAYER  4

 CHANGE IN WATER STORAGE              5.070   (  1.6292)     18405.02     14.804
*******************************************************************************
```

```
******************************************************************************

          PEAK DAILY VALUES FOR YEARS    1 THROUGH   29
 ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
  PRECIPITATION                                   6.00        21780.000

  RUNOFF                                          4.431       16083.0010

  PERCOLATION/LEAKAGE THROUGH LAYER  2            0.816628     2964.36060

  AVERAGE HEAD ON TOP OF LAYER  2                 2.694

  PERCOLATION/LEAKAGE THROUGH LAYER  4            0.000000        0.00000

  AVERAGE HEAD ON TOP OF LAYER  4                 0.000

  SNOW WATER                                      2.40         8713.1436


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4292

  MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.1870

******************************************************************************
```

```
******************************************************************************

               FINAL WATER STORAGE AT END OF YEAR   29
     ----------------------------------------------------------------------
                LAYER          (INCHES)          (VOL/VOL)
                -----          --------          ---------
                  1              1.6832            0.2805

                  2              2.8500            0.4750

                  3            297.2141            0.4954

                  4             15.3720            0.4270

               SNOW WATER        0.000

******************************************************************************
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```

HELP MODEL OUTPUT FOR OVERLINER WITH 10-FOOT-THICK WASTE (INTERIM)

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP 307\CAM\POC\ACTIV\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP 307\CAM\POC\ACTIV\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP 307\CAM\POC\ACTIV\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP 307\CAM\POC\ACTIV\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP 307\CAM\POC\ACTIV\DATA10.D10
OUTPUT DATA FILE:            C:\HELP 307\CAM\POC\ACTIV\ACTIVE.OUT


TIME:  10: 0     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER ACTIVE 10'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  11
           THICKNESS                 =     12.00   INCHES
           POROSITY                  =      0.4640 VOL/VOL
           FIELD CAPACITY            =      0.3100 VOL/VOL
           WILTING POINT             =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                        =     120.00    INCHES
POROSITY                         =       0.6376 VOL/VOL
FIELD CAPACITY                   =       0.5185 VOL/VOL
WILTING POINT                    =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT       =       0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =   0.100000005000E-02 CM/SEC


                              LAYER  3
                              --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  10
THICKNESS                        =      24.00    INCHES
POROSITY                         =       0.3980 VOL/VOL
FIELD CAPACITY                   =       0.2440 VOL/VOL
WILTING POINT                    =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT       =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =   0.119999997000E-03 CM/SEC


                              LAYER  4
                              --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                        =       0.30    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.        =    40.4199982000       CM/SEC
SLOPE                            =       1.00    PERCENT
DRAINAGE LENGTH                  =     700.0     FEET


                              LAYER  5
                              --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  36
THICKNESS                        =       0.04    INCHES
POROSITY                         =       0.0000 VOL/VOL
FIELD CAPACITY                   =       0.0000 VOL/VOL
WILTING POINT                    =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT       =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.        =   0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY              =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS         =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY            =   3 - GOOD
```

```
                                LAYER  6
                                --------

                      TYPE 3 - BARRIER SOIL LINER
                      MATERIAL TEXTURE NUMBER   0
      THICKNESS                    =       0.25   INCHES
      POROSITY                     =       0.7500 VOL/VOL
      FIELD CAPACITY               =       0.7470 VOL/VOL
      WILTING POINT                =       0.4000 VOL/VOL
      INITIAL SOIL WATER CONTENT   =       0.7500 VOL/VOL
      EFFECTIVE SAT. HYD. COND.    =   0.499999997000E-08 CM/SEC




                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

    NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
             SOIL DATA BASE USING SOIL TEXTURE #11 WITH A
             FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
             AND A SLOPE LENGTH OF  200. FEET.

   SCS RUNOFF CURVE NUMBER              =     87.10
   FRACTION OF AREA ALLOWING RUNOFF     =     70.0     PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
   EVAPORATIVE ZONE DEPTH               =     12.0     INCHES
   INITIAL WATER IN EVAPORATIVE ZONE    =      3.720   INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE   =      5.568   INCHES
   LOWER LIMIT OF EVAPORATIVE STORAGE   =      2.244   INCHES
   INITIAL SNOW WATER                   =      0.000   INCHES
   INITIAL WATER IN LAYER MATERIALS     =     39.766   INCHES
   TOTAL INITIAL WATER                  =     39.766   INCHES
   TOTAL SUBSURFACE INFLOW              =      0.00    INCHES/YEAR



                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             DALLAS                TEXAS

        STATION LATITUDE                        =  32.85 DEGREES
        MAXIMUM LEAF AREA INDEX                 =   3.00
        START OF GROWING SEASON (JULIAN DATE)   =     63
        END OF GROWING SEASON (JULIAN DATE)     =    329
        EVAPORATIVE ZONE DEPTH                  =  12.0  INCHES
        AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DALLAS                TEXAS

             NORMAL MEAN MONTHLY PRECIPITATION (INCHES)
```

```
 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
   1.90         2.37         3.06         3.20         5.15         3.23
   2.12         2.03         2.42         4.11         2.57         2.57


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS              TEXAS

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

 JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
 -------      -------      -------      -------      -------      -------
  44.00        48.50        56.10        65.90        73.70        82.00
  86.30        85.50        78.60        67.90        55.60        47.80


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS              TEXAS
                  AND STATION LATITUDE  =  32.85 DEGREES
```

```
******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   18 THROUGH   29
------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 1.79     2.08     2.62     3.08     4.16     3.95
                           3.63     1.67     3.52     3.40     2.52     3.74

    STD. DEVIATIONS        1.15     1.41     1.14     1.33     2.23     2.65
                           2.68     1.31     1.48     2.93     1.79     1.58

  RUNOFF
  ------
    TOTALS                 0.033    0.073    0.041    0.179    0.222    0.292
                           0.231    0.069    0.117    0.371    0.089    0.208

    STD. DEVIATIONS        0.056    0.144    0.057    0.305    0.245    0.418
                           0.354    0.126    0.134    0.835    0.186    0.247

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 1.877    1.644    2.235    2.833    3.516    2.979
                           3.079    1.652    2.791    1.949    1.411    1.537

    STD. DEVIATIONS        0.264    0.778    0.867    1.573    1.269    1.886
                           1.490    1.287    1.310    1.114    0.685    0.512

  LATERAL DRAINAGE COLLECTED FROM LAYER  4
  ----------------------------------------
    TOTALS                 0.4352   0.3547   0.4102   0.3768   0.4091   0.3836
                           0.3890   0.3840   0.3582   0.3759   0.3803   0.4418

    STD. DEVIATIONS        0.2889   0.1926   0.2344   0.2063   0.2296   0.2100
                           0.2045   0.1931   0.1837   0.1826   0.1971   0.2467

  PERCOLATION/LEAKAGE THROUGH LAYER  6
  ------------------------------------
    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


------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES               0.0043   0.0038   0.0040   0.0038   0.0040   0.0039
                           0.0038   0.0038   0.0036   0.0037   0.0039   0.0044

    STD. DEVIATIONS        0.0028   0.0021   0.0023   0.0021   0.0023   0.0021
                           0.0020   0.0019   0.0019   0.0018   0.0020   0.0024

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```

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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   18 THROUGH   29
------------------------------------------------------------------------------

                                    INCHES              CU. FEET       PERCENT
                              -------------------   -------------    ---------
  PRECIPITATION               36.16     (   4.969)    131278.9       100.00

  RUNOFF                       1.925    (  1.0804)      6985.99        5.321

  EVAPOTRANSPIRATION          27.503    (  3.2570)     99835.57       76.048

  LATERAL DRAINAGE COLLECTED   4.69889 (  2.49381)     17056.975     12.99293
    FROM LAYER  4

  PERCOLATION/LEAKAGE THROUGH  0.00001 (  0.00000)         0.019      0.00001
    LAYER  6

  AVERAGE HEAD ON TOP          0.004 (     0.002)
    OF LAYER  5

  CHANGE IN WATER STORAGE      2.039    (  3.0507)      7400.40        5.637

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            PEAK DAILY VALUES FOR YEARS   18 THROUGH   29
------------------------------------------------------------------------
                                             (INCHES)      (CU. FT.)
                                            ----------   -------------
   PRECIPITATION                               4.59         16661.701

   RUNOFF                                      1.580         5735.6289

   DRAINAGE COLLECTED FROM LAYER  4            0.07095        257.53546

   PERCOLATION/LEAKAGE THROUGH LAYER  6        0.000000         0.00008

   AVERAGE HEAD ON TOP OF LAYER  5             0.022

   MAXIMUM HEAD ON TOP OF LAYER  5             0.043

   LOCATION OF MAXIMUM HEAD IN LAYER  4
         (DISTANCE FROM DRAIN)                10.9 FEET

   SNOW WATER                                  1.93          7007.0430


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4510

   MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1870

    ***  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   29
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            3.8101         0.3175

                      2           53.6091         0.4467

                      3            6.6094         0.2754

                      4            0.0146         0.0485

                      5            0.0000         0.0000

                      6            0.1875         0.7500

                  SNOW WATER       0.000

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```

HELP MODEL OUTPUT FOR OVERLINER WITH FINAL COVER (CLOSED)

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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                 **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP 307\CAM\POC\CLOSD\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP 307\CAM\POC\CLOSD\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAM\POC\CLOSD\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP 307\CAM\POC\CLOSD\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAM\POC\CLOSD\DATA10.D10
OUTPUT DATA FILE:           C:\HELP 307\CAM\POC\CLOSD\CLOSED.OUT


TIME:  10:10     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER CLOSED

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
           THICKNESS                 =     12.00    INCHES
           POROSITY                  =      0.3980 VOL/VOL
           FIELD CAPACITY            =      0.2440 VOL/VOL
           WILTING POINT             =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  = 0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                          LAYER  2
                          --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  10
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.3980 VOL/VOL
FIELD CAPACITY               =     0.2440 VOL/VOL
WILTING POINT                =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                          LAYER  3
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  36
THICKNESS                    =     0.04   INCHES
POROSITY                     =     0.0000 VOL/VOL
FIELD CAPACITY               =     0.0000 VOL/VOL
WILTING POINT                =     0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =     1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =     4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER  4
                          --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    18.00   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.    =  0.999999975000E-05 CM/SEC


                          LAYER  5
                          --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  11
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.4640 VOL/VOL
FIELD CAPACITY               =     0.3100 VOL/VOL
WILTING POINT                =     0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
```

```
                          LAYER  6
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =   1500.00   INCHES
POROSITY                      =      0.6148 VOL/VOL
FIELD CAPACITY                =      0.5114 VOL/VOL
WILTING POINT                 =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                          LAYER  7
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =    756.00   INCHES
POROSITY                      =      0.5387 VOL/VOL
FIELD CAPACITY                =      0.4900 VOL/VOL
WILTING POINT                 =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-04 CM/SEC


                          LAYER  8
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.3980 VOL/VOL
FIELD CAPACITY                =      0.2440 VOL/VOL
WILTING POINT                 =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC


                          LAYER  9
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      0.25   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.     =   7.76999998000     CM/SEC
SLOPE                         =      1.00   PERCENT
DRAINAGE LENGTH               =    700.0    FEET
```

```
                              LAYER 10
                              --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  36
        THICKNESS                  =       0.04    INCHES
        POROSITY                   =       0.0000 VOL/VOL
        FIELD CAPACITY             =       0.0000 VOL/VOL
        WILTING POINT              =       0.0000 VOL/VOL
        INITIAL SOIL WATER CONTENT =       0.0000 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =   0.399999993000E-12 CM/SEC
        FML PINHOLE DENSITY        =       1.00    HOLES/ACRE
        FML INSTALLATION DEFECTS   =      20.00    HOLES/ACRE
        FML PLACEMENT QUALITY      =   3 - GOOD


                              LAYER 11
                              --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   0
        THICKNESS                  =       0.25    INCHES
        POROSITY                   =       0.7500 VOL/VOL
        FIELD CAPACITY             =       0.7470 VOL/VOL
        WILTING POINT              =       0.4000 VOL/VOL
        INITIAL SOIL WATER CONTENT =       0.7500 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =   0.499999997000E-08 CM/SEC


               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

      NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
               GOOD STAND OF GRASS, A SURFACE SLOPE OF   4.%
               AND A SLOPE LENGTH OF   500. FEET.

     SCS RUNOFF CURVE NUMBER                =     80.10
     FRACTION OF AREA ALLOWING RUNOFF       =    100.0     PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE     =      1.000   ACRES
     EVAPORATIVE ZONE DEPTH                 =     18.0     INCHES
     INITIAL WATER IN EVAPORATIVE ZONE      =      4.392   INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE     =      7.164   INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE     =      2.448   INCHES
     INITIAL SNOW WATER                     =      0.000   INCHES
     INITIAL WATER IN LAYER MATERIALS       =    880.588   INCHES
     TOTAL INITIAL WATER                    =    880.588   INCHES
     TOTAL SUBSURFACE INFLOW                =      0.00    INCHES/YEAR


                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               DALLAS                TEXAS
```

```
        STATION LATITUDE                            =  32.85 DEGREES
        MAXIMUM LEAF AREA INDEX                     =   4.50
        START OF GROWING SEASON (JULIAN DATE)       =     63
        END OF GROWING SEASON (JULIAN DATE)         =    329
        EVAPORATIVE ZONE DEPTH                      =  18.0  INCHES
        AVERAGE ANNUAL WIND SPEED                   =  10.80 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY       =  66.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY       =  68.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY       =  63.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY       =  66.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DALLAS              TEXAS

             NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.90        2.37        3.06        3.20        5.15        3.23
  2.12        2.03        2.42        4.11        2.57        2.57


    NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DALLAS              TEXAS

        NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 44.10       49.40       57.40       65.00       73.10       80.90
 85.00       84.40       77.50       67.20       55.10       46.70


    NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DALLAS              TEXAS
               AND STATION LATITUDE  =  32.85 DEGREES
```

```
*******************************************************************************

      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH   30
-------------------------------------------------------------------------------

                       JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                       -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS               1.49     2.20     2.80     3.08     4.59     3.29
                         2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS      1.02     1.27     1.67     1.89     2.17     2.13
                         2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS               0.231    0.154    0.318    0.189    0.352    0.106
                         0.124    0.016    0.022    0.847    0.537    0.879

    STD. DEVIATIONS      0.410    0.410    0.709    0.443    0.820    0.204
                         0.289    0.039    0.049    1.590    1.034    1.518

  EVAPOTRANSPIRATION
  ------------------
    TOTALS               1.673    1.770    2.669    4.424    4.729    3.465
                         2.959    1.935    2.408    1.751    1.035    1.400

    STD. DEVIATIONS      0.408    0.585    0.943    1.005    1.869    1.948
                         1.993    1.548    1.397    0.866    0.367    0.421

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS               0.0314   0.0274   0.0306   0.0241   0.0158   0.0134
                         0.0135   0.0123   0.0119   0.0195   0.0255   0.0309

    STD. DEVIATIONS      0.0126   0.0096   0.0093   0.0081   0.0061   0.0034
                         0.0036   0.0024   0.0025   0.0103   0.0141   0.0142

  LATERAL DRAINAGE COLLECTED FROM LAYER  9
  ----------------------------------------
    TOTALS               0.3260   0.3088   0.3367   0.3263   0.3353   0.3219
                         0.3332   0.3299   0.3195   0.3311   0.3188   0.3263

    STD. DEVIATIONS      0.0896   0.0998   0.1110   0.1037   0.1047   0.0988
                         0.1006   0.0990   0.0974   0.1013   0.0904   0.0958

  PERCOLATION/LEAKAGE THROUGH LAYER 11
  ------------------------------------
    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

-------------------------------------------------------------------------------
          AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
```

```
  AVERAGES                  15.3998  14.7275  15.0076  12.1243   7.5029   6.5148
                             6.3332   5.7299   5.7205   9.3725  12.8499  15.1297

  STD. DEVIATIONS            6.3262   5.3059   4.6271   4.1758   3.0544   1.7389
                             1.7835   1.1462   1.2067   5.1851   7.3282   7.1434

DAILY AVERAGE HEAD ON TOP OF LAYER 10
-------------------------------------
  AVERAGES                   0.0167   0.0174   0.0173   0.0173   0.0172   0.0171
                             0.0171   0.0169   0.0169   0.0170   0.0169   0.0167

  STD. DEVIATIONS            0.0046   0.0057   0.0057   0.0055   0.0054   0.0052
                             0.0052   0.0051   0.0052   0.0052   0.0048   0.0049

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   1 THROUGH   30
-------------------------------------------------------------------------------
                                         INCHES             CU. FEET      PERCENT
                                   -------------------   -------------   ---------
 PRECIPITATION                       34.26    (  6.276)     124371.1      100.00

 RUNOFF                               3.774   ( 2.9347)      13698.63      11.014

 EVAPOTRANSPIRATION                  30.216   ( 4.2443)     109684.16      88.191

 PERCOLATION/LEAKAGE THROUGH          0.25638 ( 0.06252)        930.642     0.74828
   LAYER  4

 AVERAGE HEAD ON TOP                 10.534 (    2.625)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED           3.91390 ( 1.16512)      14207.473   11.42345
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH          0.00002 ( 0.00000)          0.062     0.00005
   LAYER 11

 AVERAGE HEAD ON TOP                  0.017 (    0.005)
   OF LAYER 10

 CHANGE IN WATER STORAGE             -3.642   ( 2.3787)     -13219.24     -10.629

*******************************************************************************
```

```
******************************************************************************

             PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               6.00        21780.000

      RUNOFF                                      3.413       12389.1777

      PERCOLATION/LEAKAGE THROUGH LAYER  4        0.001567        5.68974

      AVERAGE HEAD ON TOP OF LAYER  3            24.000

      DRAINAGE COLLECTED FROM LAYER  9            0.02820       102.37544

      PERCOLATION/LEAKAGE THROUGH LAYER 11        0.000000        0.00035

      AVERAGE HEAD ON TOP OF LAYER 10             0.045

      MAXIMUM HEAD ON TOP OF LAYER 10             0.089

      LOCATION OF MAXIMUM HEAD IN LAYER  9
            (DISTANCE FROM DRAIN)                 4.2 FEET

      SNOW WATER                                  2.40         8713.1436


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3980

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1360


       ***  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   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            2.4409         0.2034

                      2            3.8913         0.3243

                      3            0.0000         0.0000

                      4            7.6860         0.4270

                      5            3.7200         0.3100

                      6          515.5693         0.3437

                      7          231.6745         0.3064

                      8            6.1575         0.2566

                      9            0.0107         0.0437

                     10            0.0000         0.0000

                     11            0.1875         0.7500

                  SNOW WATER       0.000

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```

HELP MODEL OUTPUT FOR OFF-SITE AREAS (RECHARGE)

```
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**              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               **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************

PRECIPITATION DATA FILE:    C:\HELP\CAMELOT\DESIGN\OFFSITE\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP\camelot\DESIGN\OFFSITE\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP\CAMELOT\DESIGN\OFFSITE\DATA13.D13
EVAPOTRANSPIRATION DATA:    c:\help\camelot\DESIGN\OFFSITE\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP\camelot\DESIGN\OFFSITE\DATA10.D10
OUTPUT DATA FILE:           C:\HELP\camelot\DESIGN\OFFSITE\OFFSITE.OUT

TIME:  11:36     DATE:   8/ 2/2011

*******************************************************************************

     TITLE:  CAMELOT LF OFFSITE AREA LANDFILL TO POC

*******************************************************************************

     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =     48.00   INCHES
           POROSITY                     =      0.4640 VOL/VOL
           FIELD CAPACITY               =      0.3100 VOL/VOL
           WILTING POINT                =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.179999997000E-07 CM/SEC


                                   LAYER  2
                                   --------

                         TYPE 3 - BARRIER SOIL LINER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =     72.00   INCHES
           POROSITY                     =      0.4750 VOL/VOL
           FIELD CAPACITY               =      0.3780 VOL/VOL
           WILTING POINT                =      0.2650 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.4750 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.179999997000E-07 CM/SEC




                   GENERAL DESIGN AND EVAPORATIVE ZONE DATA
```

```
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #16 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  2.%
          AND A SLOPE LENGTH OF  300. FEET.

 SCS RUNOFF CURVE NUMBER            =      86.70
 FRACTION OF AREA ALLOWING RUNOFF   =      95.0   PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE =       1.000 ACRES
 EVAPORATIVE ZONE DEPTH             =      24.0   INCHES
 INITIAL WATER IN EVAPORATIVE ZONE  =       7.440 INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE =      11.136 INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE =       4.488 INCHES
 INITIAL SNOW WATER                 =       0.000 INCHES
 INITIAL WATER IN LAYER MATERIALS   =      49.080 INCHES
 TOTAL INITIAL WATER                =      49.080 INCHES
 TOTAL SUBSURFACE INFLOW            =       0.00  INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DALLAS                TEXAS

      STATION LATITUDE                         = 32.85 DEGREES
      MAXIMUM LEAF AREA INDEX                  =  5.00
      START OF GROWING SEASON (JULIAN DATE)    =    63
      END OF GROWING SEASON (JULIAN DATE)      =   329
      EVAPORATIVE ZONE DEPTH                   = 24.0  INCHES
      AVERAGE ANNUAL WIND SPEED                = 10.80 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY    = 66.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY    = 68.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY    = 63.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY    = 66.00 %

 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.90        2.37        3.06        3.20        5.15        3.23
  2.12        2.03        2.42        4.11        2.57        2.57


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 44.10       49.40       57.40       65.00       73.10       80.90
 85.00       84.40       77.50       67.20       55.10       46.70


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS
            AND STATION LATITUDE  =  32.85 DEGREES
```

```
******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                  1.49     2.20     2.80     3.08     4.59     3.29
                            2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS         1.02     1.27     1.67     1.89     2.17     2.13
                            2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                  0.216    0.461    0.741    0.549    0.656    0.369
                            0.381    0.096    0.144    1.169    0.514    0.730

    STD. DEVIATIONS         0.296    0.522    0.888    0.727    0.886    0.505
                            0.708    0.141    0.188    1.756    0.889    0.957

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                  1.260    1.447    1.991    4.675    4.832    3.216
                            2.636    1.744    2.284    1.625    0.934    1.231

    STD. DEVIATIONS         0.433    0.574    0.708    0.783    1.679    1.786
                            1.657    1.282    1.281    0.794    0.308    0.401

  PERCOLATION/LEAKAGE THROUGH LAYER  2
  ------------------------------------
    TOTALS                  0.0242   0.0221   0.0240   0.0235   0.0245   0.0241
                            0.0251   0.0252   0.0244   0.0252   0.0243   0.0252

    STD. DEVIATIONS         0.0047   0.0042   0.0047   0.0045   0.0044   0.0017
                            0.0010   0.0004   0.0001   0.0003   0.0005   0.0007


------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  2
  -------------------------------------
    AVERAGES              22.1586  22.2186  21.3576  22.5567  23.1462  22.9845
                          23.0300  23.5159  23.6571  23.6862  23.2091  23.7080

    STD. DEVIATIONS         5.5297   5.0551   5.7924   5.2861   4.4649   4.1799
                            3.8229   1.5937   0.5327   0.9563   1.8668   2.5131

******************************************************************************
```

```
*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET     PERCENT
                              -------------------  -------------  ---------
 PRECIPITATION                 34.26     (   6.276)     124371.1    100.00

 RUNOFF                         6.024    (  2.8623)      21866.54     17.582

 EVAPOTRANSPIRATION            27.876    (  3.9874)     101189.33     81.361

 PERCOLATION/LEAKAGE THROUGH    0.29173 (  0.02529)      1058.986     0.85147
   LAYER  2

 AVERAGE HEAD ON TOP           22.936 (    2.754)
   OF LAYER  2

 CHANGE IN WATER STORAGE        0.071    (  2.5083)        256.21      0.206
*******************************************************************************
```

```
******************************************************************************

          PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
  ------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------    -------------
     PRECIPITATION                             6.00          21780.000

     RUNOFF                                    3.599         13064.1924

     PERCOLATION/LEAKAGE THROUGH LAYER  2      0.000884          3.21035

     AVERAGE HEAD ON TOP OF LAYER  2          32.000

     SNOW WATER                                2.40           8713.1436


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4557

     MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1870

******************************************************************************
```

```
******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1          16.9974          0.3541

                      2          34.2000          0.4750

                  SNOW WATER      0.000

******************************************************************************
******************************************************************************
```

APPENDIX IIIB-B

HELP MODEL OUTPUT – GCL/CCL COMPARISON

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

3-21-12

Includes pages IIIB-B-1 through IIIB-B-21

CAMELOT LANDFILL
1339-351-11-02-6B.2
HELP VERSION 3.07 SUMMARY SHEET
POINT OF COMPLIANCE DEMONSTRATION

			INTERIM OVERLINER WITH GEOSYNTHETIC CLAY LINER[1]	INTERIM OVERLINER WITH COMPACTED CLAY LINER	CLOSED OVERLINER WITH GEOSYNTHETIC CLAY LINER[1]	CLOSED OVERLINER WITH COMPACTED CLAY LINER
GENERAL INFORMATION		No. of Years	12	12	30	30
		Ground Cover	FAIR	FAIR	GOOD	GOOD
		SCS Runoff Curve No.	87.1	87.1	80.1	80.1
		Model Area (acre)	1	1	1	1
		Runoff Area (%)	70	70	100	100
		Maximum Leaf Area Index	3.0	3.0	4.5	4.5
		Evaporative Zone Depth (inch)	12	12	18	18
Final Cover	TOPSOIL LAYER (Texture = 10)	Thickness (in)			12	12
		Porosity (vol/vol)			0.3980	0.3980
		Field Capacity (vol/vol)			0.2440	0.2440
		Wilting Point (vol/vol)			0.1360	0.1360
		Init. Moisture Content (vol/vol)			0.2440	0.2440
		Hyd. Conductivity (cm/s)			1.2E-04	1.2E-04
	EROSION LAYER (Texture = 10)	Thickness (in)			12	12
		Porosity (vol/vol)			0.3980	0.3980
		Field Capacity (vol/vol)			0.2440	0.2440
		Wilting Point (vol/vol)			0.1360	0.1360
		Init. Moisture Content (vol/vol)			0.2440	0.2440
		Hyd. Conductivity (cm/s)			1.2E-04	1.2E-04
	FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)			0.04	0.04
		Hyd. Conductivity (cm/s)			4.0E-13	4.0E-13
		Pinhole Density (holes/acre)			1	1
		Install. Defects (holes/acre)			4	4
		Placement Quality			GOOD	GOOD
	INFILTRATION LAYER (Texture = 0)	Thickness (in)			18	18
		Porosity (vol/vol)			0.4270	0.4270
		Field Capacity (vol/vol)			0.4180	0.4180
		Wilting Point (vol/vol)			0.3670	0.3670
		Init. Moisture Content (vol/vol)			0.4270	0.4270
		Hyd. Conductivity (cm/s)			1.0E-05	1.0E-05
Intermediate Cover	INTERMEDIATE COVER (Texture = 11)	Thickness (in)	12	12	12	12
		Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640
		Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100
		Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870
		Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100
		Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05
Waste	WASTE TOP (Texture = 0)	Thickness (in)			1500	1500
		Porosity (vol/vol)			0.6148	0.6148
		Field Capacity (vol/vol)			0.5114	0.5114
		Wilting Point (vol/vol)			0.0770	0.0770
		Init. Moisture Content (vol/vol)			0.3800	0.3800
		Hyd. Conductivity (cm/s)			1.0E-03	1.0E-03
	WASTE BOTTOM (Texture = 0)	Thickness (in)	120	120	756	756
		Porosity (vol/vol)	0.6376	0.6376	0.5387	0.5387
		Field Capacity (vol/vol)	0.5185	0.5185	0.4900	0.4900
		Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770
		Init. Moisture Content (vol/vol)	0.2500	0.2500	0.3800	0.3800
		Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-04	1.0E-04
Pre D Cover		Thickness (in)				
		Porosity (vol/vol)				
		Field Capacity (vol/vol)				
		Wilting Point (vol/vol)				
		Init. Moisture Content (vol/vol)				
		Hyd. Conductivity (cm/s)				
Overliner	PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24	24
		Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980
		Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440
		Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360
		Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440
		Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04
	LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.30	0.30	0.25	0.25
		Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500
		Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100
		Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050
		Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100
		Hyd. Conductivity (cm/s)	40.42	40.42	7.77	7.77
		Slope (%)	1	1	1	1
		Slope Length (ft)	700	700	700	700
	FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)	0.04	0.04	0.04	0.04
		Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13
		Pinhole Density (holes/acre)	1	1	1	1
		Install. Defects (holes/acre)	4	4	20	20
		Placement Quality	GOOD	GOOD	GOOD	GOOD
	COMPACTED CLAY LINER (Texture = 0)	Thickness (in)		24		24
		Porosity (vol/vol)		0.4270		0.4270
		Field Capacity (vol/vol)		0.4180		0.4180
		Wilting Point (vol/vol)		0.3670		0.3670
		Init. Moisture Content (vol/vol)		0.4270		0.4270
		Hyd. Conductivity (cm/s)		1.0E-07		1.0E-07
	GEOSYNTHETIC CLAY LINER (Texture = 0)	Thickness (in)	0.25		0.25	
		Porosity (vol/vol)	0.7500		0.7500	
		Field Capacity (vol/vol)	0.7470		0.7470	
		Wilting Point (vol/vol)	0.4000		0.4000	
		Init. Moisture Content (vol/vol)	0.7500		0.7500	
		Hyd. Conductivity (cm/s)	5.0E-09		5.0E-09	
PRECIPITATION		Average Annual (in)	36.16	36.16	34.26	34.26
PERCOLATION		Through Layer	Overliner	Overliner	Overliner	Overliner
		Average Annual (in/year)	0.00001	0.00001	0.00002	0.00011
		Average Annual (mm/year)	0.00025	0.00025	0.00051	0.00279
		Average Annual (cf/year)	0.019	0.040	0.062	0.416

[1] HELP summary reproduced from Appendix IIIB-A.

HELP MODEL OUTPUT FOR OVERLINER WITH CCL (INTERIM)

```
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**              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               **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP 307\CAM\POC\ACTIV\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP 307\CAM\POC\ACTIV\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAM\POC\ACTIV\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP 307\CAM\POC\ACTIV\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAM\POC\ACTIV\DATA10.D10
OUTPUT DATA FILE:           C:\HELP 307\CAM\POC\ACTIV\ACTIVE.OUT


TIME:  10:17     DATE:   2/28/2012


*******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER ACTIVE 10'

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                    LAYER  1
                                    --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                    =      12.00   INCHES
           POROSITY                     =       0.4640 VOL/VOL
           FIELD CAPACITY               =       0.3100 VOL/VOL
           WILTING POINT                =       0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT   =       0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    120.00   INCHES
POROSITY                    =      0.6376 VOL/VOL
FIELD CAPACITY              =      0.5185 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  4
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.30   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.   =   40.4199982000     CM/SEC
SLOPE                       =      1.00   PERCENT
DRAINAGE LENGTH             =    700.0    FEET


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   INCHES
```

```
          POROSITY                     =       0.0000 VOL/VOL
          FIELD CAPACITY               =       0.0000 VOL/VOL
          WILTING POINT                =       0.0000 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
          FML INSTALLATION DEFECTS     =       4.00    HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD


                                 LAYER  6
                                 --------

                       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 #11 WITH A
                  FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
                  AND A SLOPE LENGTH OF  200. FEET.

       SCS RUNOFF CURVE NUMBER               =      87.10
       FRACTION OF AREA ALLOWING RUNOFF      =      70.0     PERCENT
       AREA PROJECTED ON HORIZONTAL PLANE    =       1.000   ACRES
       EVAPORATIVE ZONE DEPTH                =      12.0     INCHES
       INITIAL WATER IN EVAPORATIVE ZONE     =       3.720   INCHES
       UPPER LIMIT OF EVAPORATIVE STORAGE    =       5.568   INCHES
       LOWER LIMIT OF EVAPORATIVE STORAGE    =       2.244   INCHES
       INITIAL SNOW WATER                    =       0.000   INCHES
       INITIAL WATER IN LAYER MATERIALS      =      49.827   INCHES
       TOTAL INITIAL WATER                   =      49.827   INCHES
       TOTAL SUBSURFACE INFLOW               =       0.00    INCHES/YEAR


                     EVAPOTRANSPIRATION AND WEATHER DATA
                     -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  DALLAS                TEXAS
```

```
          STATION LATITUDE                          =  32.85 DEGREES
          MAXIMUM LEAF AREA INDEX                   =   3.00
          START OF GROWING SEASON (JULIAN DATE)     =     63
          END OF GROWING SEASON (JULIAN DATE)       =    329
          EVAPORATIVE ZONE DEPTH                    =  12.0  INCHES
          AVERAGE ANNUAL WIND SPEED                 =  10.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  66.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  68.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  63.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  66.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   1.90        2.37        3.06        3.20        5.15        3.23
   2.12        2.03        2.42        4.11        2.57        2.57


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   44.00       48.50       56.10       65.90       73.70       82.00
   86.30       85.50       78.60       67.90       55.60       47.80


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS
                 AND STATION LATITUDE  =  32.85 DEGREES




******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   18 THROUGH   29
------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 1.79     2.08     2.62     3.08     4.16     3.95
                           3.63     1.67     3.52     3.40     2.52     3.74
```

```
  STD. DEVIATIONS          1.15      1.41      1.14      1.33      2.23      2.65
                           2.68      1.31      1.48      2.93      1.79      1.58

RUNOFF
------
  TOTALS                   0.033     0.073     0.041     0.179     0.222     0.292
                           0.231     0.069     0.117     0.371     0.089     0.208

  STD. DEVIATIONS          0.056     0.144     0.057     0.305     0.245     0.418
                           0.354     0.126     0.134     0.835     0.186     0.247

EVAPOTRANSPIRATION
------------------
  TOTALS                   1.877     1.644     2.235     2.833     3.516     2.979
                           3.079     1.652     2.791     1.949     1.411     1.537

  STD. DEVIATIONS          0.264     0.778     0.867     1.573     1.269     1.886
                           1.490     1.287     1.310     1.114     0.685     0.512

LATERAL DRAINAGE COLLECTED FROM LAYER  4
----------------------------------------
  TOTALS                   0.4352    0.3547    0.4102    0.3768    0.4091    0.3836
                           0.3890    0.3840    0.3582    0.3759    0.3803    0.4418

  STD. DEVIATIONS          0.2889    0.1926    0.2344    0.2063    0.2296    0.2100
                           0.2045    0.1931    0.1837    0.1826    0.1971    0.2467

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  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


-------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


DAILY AVERAGE HEAD ON TOP OF LAYER  5
-------------------------------------
  AVERAGES                 0.0043    0.0038    0.0040    0.0038    0.0040    0.0039
                           0.0038    0.0038    0.0036    0.0037    0.0039    0.0044

  STD. DEVIATIONS          0.0028    0.0021    0.0023    0.0021    0.0023    0.0021
                           0.0020    0.0019    0.0019    0.0018    0.0020    0.0024

*******************************************************************************
```

```
*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   18 THROUGH   29
-------------------------------------------------------------------------------
                                    INCHES            CU. FEET        PERCENT
                              -------------------   -------------   ---------
 PRECIPITATION                36.16    (   4.969)     131278.9      100.00

 RUNOFF                        1.925   (  1.0804)       6985.99       5.321

 EVAPOTRANSPIRATION           27.503   (  3.2570)      99835.57      76.048

 LATERAL DRAINAGE COLLECTED    4.69889 (  2.49380)     17056.955     12.99291
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH   0.00001 (  0.00000)         0.040      0.00003
   LAYER  6

 AVERAGE HEAD ON TOP           0.004 (    0.002)
   OF LAYER  5

 CHANGE IN WATER STORAGE       2.039   (  3.0507)       7400.40       5.637

*******************************************************************************
```

```
******************************************************************************

          PEAK DAILY VALUES FOR YEARS   18 THROUGH   29
------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------    -------------
   PRECIPITATION                               4.59         16661.701

   RUNOFF                                      1.580         5735.6289

   DRAINAGE COLLECTED FROM LAYER  4            0.07095        257.53522

   PERCOLATION/LEAKAGE THROUGH LAYER  6        0.000000         0.00035

   AVERAGE HEAD ON TOP OF LAYER  5             0.022

   MAXIMUM HEAD ON TOP OF LAYER  5             0.043

   LOCATION OF MAXIMUM HEAD IN LAYER  4
         (DISTANCE FROM DRAIN)                10.2 FEET

   SNOW WATER                                  1.93          7007.0430


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.4510

   MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1870


    ***  Maximum heads are computed using McEnroe's equations.  ***

         Reference:  Maximum Saturated Depth over Landfill Liner
                     by Bruce M. McEnroe, University of Kansas
                     ASCE Journal of Environmental Engineering
                     Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR    29
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            3.8101         0.3175

                      2           53.6091         0.4467

                      3            6.6094         0.2754

                      4            0.0146         0.0485

                      5            0.0000         0.0000

                      6           10.2480         0.4270

                  SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

HELP MODEL OUTPUT FOR OVERLINER WITH CCL (CLOSED)

```
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**              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               **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP 307\CAM\POC\CLOSD\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP 307\CAM\POC\CLOSD\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAM\POC\CLOSD\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP 307\CAM\POC\CLOSD\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAM\POC\CLOSD\DATA10.D10
OUTPUT DATA FILE:           C:\HELP 307\CAM\POC\CLOSD\CLOSED.OUT


TIME:  10:14     DATE:   2/28/2012


*******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER CLOSED

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =     12.00   INCHES
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
THICKNESS                    =     12.00    INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                        LAYER  3
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
THICKNESS                    =      0.04    INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  4
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     18.00    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.    =  0.999999975000E-05 CM/SEC


                        LAYER  5
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  11
```

```
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4640 VOL/VOL
FIELD CAPACITY               =       0.3100 VOL/VOL
WILTING POINT                =       0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC


                         LAYER  6
                         --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    1500.00    INCHES
POROSITY                     =       0.6148 VOL/VOL
FIELD CAPACITY               =       0.5114 VOL/VOL
WILTING POINT                =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                         LAYER  7
                         --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     756.00    INCHES
POROSITY                     =       0.5387 VOL/VOL
FIELD CAPACITY               =       0.4900 VOL/VOL
WILTING POINT                =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                         LAYER  8
                         --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                    =      24.00    INCHES
POROSITY                     =       0.3980 VOL/VOL
FIELD CAPACITY               =       0.2440 VOL/VOL
WILTING POINT                =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                         LAYER  9
                         --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =     0.25   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.    =  7.76999998000     CM/SEC
  SLOPE                        =     1.00   PERCENT
  DRAINAGE LENGTH              =   700.0    FEET


                          LAYER 10
                          --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
  THICKNESS                    =     0.04   INCHES
  POROSITY                     =     0.0000 VOL/VOL
  FIELD CAPACITY               =     0.0000 VOL/VOL
  WILTING POINT                =     0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT   =     0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    = 0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY          =     1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS     =    20.00   HOLES/ACRE
  FML PLACEMENT QUALITY        = 3 - GOOD


                          LAYER 11
                          --------

                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 #10 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
         AND A SLOPE LENGTH OF  500. FEET.
```

```
SCS RUNOFF CURVE NUMBER                 =    80.10
FRACTION OF AREA ALLOWING RUNOFF        =   100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE      =     1.000  ACRES
EVAPORATIVE ZONE DEPTH                  =    18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE       =     4.392  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE      =     7.164  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE      =     2.448  INCHES
INITIAL SNOW WATER                      =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS        =   890.648  INCHES
TOTAL INITIAL WATER                     =   890.648  INCHES
TOTAL SUBSURFACE INFLOW                 =     0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DALLAS                 TEXAS

     STATION LATITUDE                           =  32.85 DEGREES
     MAXIMUM LEAF AREA INDEX                    =   4.50
     START OF GROWING SEASON (JULIAN DATE)      =     63
     END OF GROWING SEASON (JULIAN DATE)        =    329
     EVAPORATIVE ZONE DEPTH                     =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED                  =  10.80 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  66.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  68.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY      =  63.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY      =  66.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.90        2.37        3.06        3.20        5.15        3.23
  2.12        2.03        2.42        4.11        2.57        2.57


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 44.10       49.40       57.40       65.00       73.10       80.90
 85.00       84.40       77.50       67.20       55.10       46.70
```

```
          NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    DALLAS              TEXAS
                     AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                              JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                              -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                      1.49     2.20     2.80     3.08     4.59     3.29
                                2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS             1.02     1.27     1.67     1.89     2.17     2.13
                                2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                      0.231    0.154    0.318    0.189    0.352    0.106
                                0.124    0.016    0.022    0.847    0.537    0.879

    STD. DEVIATIONS             0.410    0.410    0.709    0.443    0.820    0.204
                                0.289    0.039    0.049    1.590    1.034    1.518

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                      1.673    1.770    2.669    4.424    4.729    3.465
                                2.959    1.935    2.408    1.751    1.035    1.400

    STD. DEVIATIONS             0.408    0.585    0.943    1.005    1.869    1.948
                                1.993    1.548    1.397    0.866    0.367    0.421

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                      0.0314   0.0274   0.0306   0.0241   0.0158   0.0134
                                0.0135   0.0123   0.0119   0.0195   0.0255   0.0309

    STD. DEVIATIONS             0.0126   0.0096   0.0093   0.0081   0.0061   0.0034
                                0.0036   0.0024   0.0025   0.0103   0.0141   0.0142

  LATERAL DRAINAGE COLLECTED FROM LAYER  9
  ----------------------------------------
    TOTALS                      0.3260   0.3088   0.3367   0.3262   0.3353   0.3219
                                0.3332   0.3299   0.3195   0.3311   0.3188   0.3263

    STD. DEVIATIONS             0.0896   0.0998   0.1110   0.1037   0.1047   0.0988
                                0.1006   0.0990   0.0974   0.1013   0.0904   0.0958
```

```
  PERCOLATION/LEAKAGE THROUGH LAYER 11
  ------------------------------------
    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


--------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
--------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
    AVERAGES                    15.3998  14.7275  15.0076  12.1243   7.5029   6.5148
                                 6.3332   5.7299   5.7205   9.3725  12.8499  15.1297

    STD. DEVIATIONS              6.3262   5.3059   4.6271   4.1758   3.0544   1.7389
                                 1.7835   1.1462   1.2067   5.1851   7.3282   7.1434

  DAILY AVERAGE HEAD ON TOP OF LAYER 10
  -------------------------------------
    AVERAGES                     0.0167   0.0174   0.0173   0.0173   0.0172   0.0171
                                 0.0171   0.0169   0.0169   0.0170   0.0169   0.0167

    STD. DEVIATIONS              0.0046   0.0057   0.0057   0.0055   0.0054   0.0052
                                 0.0052   0.0051   0.0052   0.0052   0.0048   0.0049

********************************************************************************
```

```
******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                               INCHES           CU. FEET       PERCENT
                         ------------------   -------------   ---------
 PRECIPITATION            34.26     (   6.276)    124371.1     100.00

 RUNOFF                    3.774    (  2.9347)     13698.63     11.014

 EVAPOTRANSPIRATION       30.216    (  4.2443)    109684.16     88.191

 PERCOLATION/LEAKAGE THROUGH   0.25638 (  0.06252)      930.642     0.74828
   LAYER  4

 AVERAGE HEAD ON TOP      10.534 (     2.625)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED    3.91381 (  1.16509)    14207.118   11.42317
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH   0.00011 (  0.00003)        0.416     0.00033
   LAYER 11

 AVERAGE HEAD ON TOP       0.017 (     0.005)
   OF LAYER 10

 CHANGE IN WATER STORAGE  -3.642    (  2.3787)    -13219.24    -10.629

******************************************************************************
```

```
******************************************************************************

          PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                               6.00         21780.000

      RUNOFF                                      3.413        12389.1777

      PERCOLATION/LEAKAGE THROUGH LAYER  4        0.001567         5.68974

      AVERAGE HEAD ON TOP OF LAYER  3            24.000

      DRAINAGE COLLECTED FROM LAYER  9            0.02820        102.37334

      PERCOLATION/LEAKAGE THROUGH LAYER 11        0.000001         0.00267

      AVERAGE HEAD ON TOP OF LAYER 10             0.045

      MAXIMUM HEAD ON TOP OF LAYER 10             0.089

      LOCATION OF MAXIMUM HEAD IN LAYER  9
            (DISTANCE FROM DRAIN)                 6.6 FEET

      SNOW WATER                                  2.40          8713.1436


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3980

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1360

       ***  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   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            2.4409         0.2034

                      2            3.8913         0.3243

                      3            0.0000         0.0000

                      4            7.6860         0.4270

                      5            3.7200         0.3100

                      6          515.5693         0.3437

                      7          231.6745         0.3064

                      8            6.1575         0.2566

                      9            0.0107         0.0437

                     10            0.0000         0.0000

                     11           10.2480         0.4270

                  SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

CAMELOT LANDFILL
CITY OF LEWISVILLE, DENTON COUNTY
TCEQ PERMIT NO. MSW-1312B

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIC
LEACHATE AND CONTAMINATED WATER MANAGEMENT PLAN

Prepared for

City of Farmers Branch

March 2012

JEFFREY P. YOUNG
79809

3-20-12

MARILYN D. MORRISON
102273

3.20.12

Prepared by

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TBPE Registration No. F-3727
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817-735-9770

WBC Project No. 1339-351-11-02-6B.3

This document is intended for permitting purposes only.

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STATE OF TEXAS
MARILYN D. MORRISON
102273
LICENSED PROFESSIONAL ENGINEER
3-20-12

CONTENTS (Continued)

STATE OF TEXAS
MARILYN D. MORRISON
102273
LICENSED
PROFESSIONAL ENGINEER

3.20.12

1 PURPOSE AND SCOPE

This appendix addresses §§330.177, 330.207 and 330.333.

This Leachate and Contaminated Water Management Plan for the Camelot Landfill was prepared consistent with Title 30 Texas Administrative Code (TAC) §§330.177, 330.207, and 330.333. This plan provides the details of the collection, storage, treatment and disposal of contaminated water, and leachate generated during the active and postclosure periods of the landfill. The design details for the liner, overliner, and final cover systems are included in Part III, Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. The top of liner plan and final contour plan are also included in Part III, Appendix IIIA-A. Additionally, Figure 3-1 includes the top of liner plan showing the leachate collection system layout including the leachate collection system forcemain and leachate storage tank.

2 LEACHATE AND CONTAMINATED WATER GENERATION

2.1 Generation Process

Leachate is generated when water percolates through the layers of solid waste as moisture is released from high moisture content waste. The capacity of solid waste to absorb moisture is known as field capacity. When the field capacity is exceeded, leachate is generated. However, leachate may also flow within the landfill through preferential pathways; therefore, some downward flow of leachate will occur before the field capacity of waste is reached. The quantity of leachate produced will depend upon the climate, site topography, type of cover, construction and landfilling procedures, and waste characteristics.

Contaminated water is defined in Title 30 TAC §330.3(36) as "leachate, gas condensate, or water that has come into contact with waste." Contaminated water is therefore generated when stormwater runoff has come into contact with solid waste at the working face of the landfill or any other area at the site where water contacts solid waste, leachate, or gas condensate.

2.2 Leachate Generation and Contaminated Stormwater Modeling

The Hydrologic Evaluation of Landfill Performance (HELP) model, Version 3.07, was used to estimate the amount of leachate that will be generated at the Camelot Landfill. The HELP model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of landfills. The model uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, soil-moisture storage, recirculation, evapotranspiration, and lateral drainage.

Leachate generation was evaluated for both active and closed landfill conditions. An explanation of the assumed conditions, methodologies, models and printouts of the results are included as Appendix IIIC-A. The leachate generation estimates produced by HELP are compared to actual generation rates in Section 6. As discussed in Section 6, the leachate generation rates produced by HELP and used for the leachate collection system design are much higher than the actual leachate generation rates experienced to date at the site.

The Rational Method was used to estimate the volume of contaminated water that must be contained around the working face. The design calculations and the size of the diversion and containment berms required around the working face for a 25-year, 24-hour storm event are provided in Appendix IIIC-C.

2.3 Stormwater Management

The Camelot Landfill will manage surface water throughout the active life of the landfill to minimize the amount of stormwater that will come in contact with waste or leachate. Contaminated water will be managed consistent with Title 30 TAC §330.207. Surface water will be controlled through the use of diversion berms, stormwater diversion ditches, and sumps. To promote runoff and prevent ponding, the operational cover will be graded and maintained. The use of drainage swales, diversion berms, and the containment berm is illustrated in Parts I/II, Appendix I/IIA, Drawings I/IIA.4 through I/IIA.8 – Sector Development Plans.

Stormwater that comes into contact with waste will be considered contaminated water and handled consistent with Title 30 TAC §330.207. Contaminated water will be contained by the containment berm at the working face as shown in Appendix IIIC-C. At no time will contaminated water be allowed to discharge into waters of the United States. Storage of contaminated water and its disposal are discussed in Section 4 and Section 5 of this appendix, respectively.

The final cover has been designed to minimize infiltration and promote runoff. Surface water will be managed throughout the active life of the landfill to minimize infiltration into the filled areas and to minimize contact with solid waste. Also, daily and intermediate cover will be graded and maintained to promote runoff and prevent ponding as described in Part IV – Site Operating Plan (SOP).

Procedures for verifying the adequacy of daily cover placement to cover all waste material is discussed in Part IV – SOP, Section 4.18.2. Runoff generated from fill areas covered with a minimum 6 inches of earthen daily cover having no exposed waste or 12 inches of intermediate cover will be considered as uncontaminated and allowed to drain to the perimeter drainage system. In the event that the 6 inches of daily cover does not prevent stormwater from contacting solid waste or leachate, this stormwater will be collected and managed as contaminated and disposed of in an authorized manner. Surface water runoff will be diverted around the working face as shown in Appendix IIIC-C.

3 LEACHATE COLLECTION SYSTEM

3.1 System Layout and Design Criteria

3.1.1 Introduction

The leachate collection system (LCS) for the Subtitle D area will consist of: (1) a collection layer placed over the liner system, (2) the leachate collection piping, and (3) the leachate collection sumps and pumps. An overliner leachate collection system will be placed above the overliner system geomembrane liner within the pre-Subtitle D area to collect leachate generated from the waste placed in the vertical expansion area. The plan for the overliner LCS piping and grading is also shown in Part III, Appendix IIIA-A, Drawing A.1 – Excavation Plan and Figure 3-1. LCS details are also provided in Part III, Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. The existing leachate collection system has also been analyzed to show that the proposed change in site configuration will not adversely impact the existing leachate collection system.

3.1.2 Design Criteria

The leachate management system is designed and operated to collect and remove leachate from each cell, maintain leachate levels below 12 inches (or 30 cm) above the liner systems, channel leachate to designated collection sumps, and effectively manage leachate through storage and disposal. The system is designed to eliminate potential migration of landfill leachate into the environment and to meet the requirements of 30 TAC §330.333, namely:

- constructed of materials that are chemically resistant to the leachate expected to be generated;
- of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by equipment used at the facility; and
- designed to function through the scheduled closure and post-closure period of the facility.

The LCS is designed to maintain the maximum leachate depth on the liner to less than 12 inches, in accordance with 30 TAC §330.331(a)(2) by the monitoring of head levels and timely recovery of leachate. This is accomplished by setting the control level for the automatic sump pumps at a level less than 12 inches above the lip of the sump. The drainage geocomposite leachate collection layer is designed to convey the estimated peak leachate flow rate without the leachate level within the geocomposite exceeding the thickness of the geocomposite. The operation of the leachate sump and the conveyance capacity of the geocomposite leachate collection layer work in tandem to maintain compliance with the design standard listed in Title 30 TAC §330.331(a)(2). The leachate collection system piping network is designed to convey collected leachate to the leachate collection sumps. The LCS piping is designed for post-settlement slopes and to meet each of the three criteria listed within the bullets on the previous page.

In addition, the leachate collection system for the undeveloped Subtitle D areas is also designed to manage leachate that will be recirculated at the working face. Section 5.2 includes a leachate recirculation plan. Also, Appendix IIIC-A (page IIIC-A-4) provides a discussion regarding how the estimated additional leachate load due to recirculation was determined.

The geotextiles used for the geocomposite drainage layer utilize 100% continuous-filament polyester or polypropylene. Extensive testing, including EPA 9090 for chemical resistance, has demonstrated that polyester and polypropylene are resistant to a wide range of chemical classes encountered in soil and to typical leachate. The LCS piping and the geonet portion of the geocomposite are constructed of polyethylene. Polyethylene is an industry standard material and is resistant to a wide range of chemical constituents, including those typically found in leachate.

3.1.3 Leachate Collection System Layout

3.1.3.1 Subtitle D Areas

The leachate collection system layout is shown on Figure 3-1. Cells 1 through 5, 8, and 9A have been constructed to date. For Cells 3, 4A, 8, and 9A, the leachate collection layer consists of 1 foot of tire chips placed over 1 foot of general fill to collect and transfer the leachate to the leachate collection pipes and sumps. For Cells 1 and 2 the leachate collection layer includes single-sided geocomposite, and for Cells 4B and 5 the leachate collection layer includes double-sided geocomposite placed over the liner system to collect and transfer leachate to the leachate collection pipes and sumps. The currently constructed leachate collection system has been evaluated considering the leachate collection layer and leachate collection header pipe grades under the proposed landfill expansion conditions (i.e., after landfill foundation settlement – refer to Appendix IIIJ). Leachate collection layer slopes and slope lengths have been estimated for the proposed closed landfill conditions. Table 3-1 provides a design summary for Cells 1 through 5, 8, and 9A. As shown in each case, the maximum depth of leachate that occurs in the liner system is less than 12 inches and the flow depth is less than the thickness of the drainage geocomposite.

For the undeveloped cells (Cells 6, 6A, 7, 7A, and 10 through 13), the leachate collection layer will also be placed directly over the liner system. The undeveloped cells have also been designed for the estimated overburden pressure that will be created by the proposed expansion. Material specifications are included in the following subsections for these cells. Table 3-1 shows that the maximum leachate depth for these cells is also less than 12 inches and the flow depth is less than the thickness of the drainage geocomposite.

Table 3-1
Subtitle D Leachate Collection System Design Summary
Maximum Depth of Leachate on Liner

Cells[3]	Location	Initial Slope	Post-Settlement Slope	Slope Used for Design	Maximum Depth of Leachate on Liner Using Peak Flow Rate Generated by HELP[1]	Maximum Depth of Leachate on Liner Using Actual Leachate Generation Information[1]	Flow Depth Less than Thickness of Drainage Geocomposite
1 and 2	Slope between cell ridgeline and leachate collection pipe	1.17%	1.16%	1.1%	0.009 inches	0.0029 inches	Yes
	Slope of leachate collection pipe	0.5%	0.36%	0.3%	Peak flow less than the capacity of the collection pipe[2]	Peak flow less than the capacity of the collection pipe[2]	
4B and 5	Slope between cell ridgeline and leachate collection pipe	1.17%	1.16%	1.1%	0.138 inches	0.0674 inches	Yes
	Slope of leachate collection pipe (minimum)	0.5%	0.47%	0.3%	Peak flow less than the capacity of the collection pipe[2]	Peak flow less than the capacity of the collection pipe[2]	
6, 6A, 7, 7A, and 10 through 13	Slope between cell ridgeline and leachate collection pipe (minimum)	0.92%	0.90%	0.9%	0.138 inches	0.0032 inches	Yes
	Slope of leachate collection pipe (minimum)	0.5%	0.37%	0.3%	Peak flow less than the capacity of the collection pipe[2]	Peak flow less than the capacity of the collection pipe[2]	

[1] Maximum depth of leachate on liner was determined using the design slope. Refer to Appendices IIIC-A, IIIC-B, and IIIC-E for additional information. Refer to Appendix IIIC-B (Maximum Head Calculations for Cells 3/4A/8/9A), which address Cells 3, 4A, 8, and 9A. A tire chip layer was used for the leachate collection system in these cells.

[2] The leachate collection pipe consists of a 6-inch-diameter HDPE pipe.

[3] The leachate collection layer is as follows: Cells 1 and 2 – 200-mil-thick single-sided geocomposite; Cells 4B and 5 – 200-mil-thick double-sided geocomposite; and Cells 6, 6A, 7, 7A, and 10 through 13 – 250-mil-thick single-sided geocomposite.

Figure 3-2 provides a summary of the post-settlement slopes that were estimated for each Subtitle D cells. Detailed settlement calculations are provided in Appendix IIIJ-B. As shown on Figure 3-2, the typical post-settlement slopes of the Subtitle D cells range from 0.90 percent to 1.16 percent. A slope of 1.1 percent was conservatively selected for Cells 1 through 5, 8, and 9A, and a slope of 0.9 percent was used for Cells 6, 6A, 7, 7A, and 10 through 13 for the LCS design of the Subtitle D area cells. Table 3-1 presents a summary of the initial and post-settlement slope for each Subtitle D cell and also the maximum depth of leachate over the liner based on the HELP generated peak flow and the actual leachate generation information.

3.1.3.2 Overliner Area

As shown on Figure 3-1, the overliner that will be installed in the pre-Subtitle D area is divided into six cells. The grades of the overliner will generally match existing grade. The leachate will drain to collection pipes and be conveyed to sumps located near the overliner/final cover tie-in.

The post-settlement slopes of the overliner were used to demonstrate that the overliner leachate collection system will maintain less than 12 inches of leachate above the liner. Figure 3-3 shows the overliner post-settlement slopes at the end of the postclosure period. The settlement analyses are discussed in detail in Appendix IIIJ-B. The post-settlement slope of the overliner ranges from 1.9 percent to 14.8 percent. To provide for a conservative analysis, a slope of 1.0 percent was used for the overliner in the HELP analysis included in Appendix IIIC-A. Table 3-2 presents a summary of the initial and post-settlement slopes for the overliner and the maximum depth of leachate on the overliner system.

Table 3-2
Overliner Leachate Collection System Design Summary
Maximum Depth of Leachate on Liner

Item	Location	Typical Initial Slope	Post-Settlement Slope	Slope Used for Design	Maximum Depth of Leachate on Liner Using Peak Flow Rate Generated by HELP[1]	Maximum Depth of Leachate on Liner Using Actual Leachate Generation Information[1]	Flow Depth Less than Thickness of Drainage Geocomposite
Overliner	Slope of overliner	2-20%	1.9-14.8%	1.0%	0.089 inches	0.0020 inches	Yes
	Slope of leachate collection pipe	0.6% (minimum)	0.5%	0.50%	Peak flow less than capacity of the collection pipe[2]	Peak flow less than capacity of the collection pipe[2]	

[1] Maximum depth of leachate on liner was determined using the design slope. Refer to Appendices IIIC-A and IIIC-E for additional information.

[2] The leachate collection pipe consists of a 6-inch-diameter HDPE pipe.

3.2 Leachate Collection Layer

3.2.1 Subtitle D Areas

The leachate collection layer for the undeveloped cells will be placed directly over the liner system to collect and transfer leachate to the leachate collection system pipes and sumps. The leachate collection layer placed over the floor grades for the undeveloped portion of the site will consist of a 250-mil-thick HDPE geonet with a 6 oz/sy non-woven geotextile heat bonded to the top side of the HDPE geonet. The geocomposite was selected to maintain less than 12 inches of head above the bottom liner. The leachate collection layer placed over the sideslopes will consist of an HDPE geonet with a geotextile heat bonded to both sides. Calculations indicating the required properties of the geocomposite drainage layer (after accounting for losses due to clogging) are presented in Appendix IIIC-A. The drainage geocomposite for the undeveloped cells will comply with the following specifications listed in Table 3-3.

An analysis of the existing Subtitle D areas is also included in Appendix IIIC-A. The existing cells include Cells 1 through 5, 8, and 9A. Cells 1 and 2 were constructed with a 200-mil-thick geonet heat bonded to an overlying 8 oz/sy non-woven geotextile (single-sided on the floor grades). Cells 4B and 5 were constructed with a 200-mil-thick geonet heat bonded to two 8 oz/sy non-woven geotextiles (double-sided on the floor grades). Cells 3, 4A, 8, and 9A were constructed with 1 foot of tire chips over 1 foot of general fill. The calculations included in Appendix IIIC-B address the maximum head on the liner in these cells.

3.2.2 Overliner Areas

In addition to the leachate collection layer for the Subtitle D area, an overliner leachate collection system will be placed above the overliner system geomembrane liner in the pre-Subtitle D area to collect and transfer leachate to the leachate collection system drainage pipes and sumps.

The leachate collection layer placed over the floor grades of the overliner area will consist of a 300-mil-thick HDPE geonet with a 6 oz/sy non-woven geotextile heat bonded to both sides of the HDPE geonet. Calculations indicating the required properties of the geocomposite drainage layer are presented in Appendix IIIC-A and summarized in Table 3-4. Estimated percolation rates used to demonstrate that the overliner design meets the requirements presented in Title 30 TAC §330.331(a)(1) are included in Appendix IIIB.

Table 3-3
Geotextile and Drainage Geocomposite Required Testing and Properties for Undeveloped Subtitle D Lined Area[1]

Responsible Party	Material	Test	Standard	Required Property[4]
Manufacturer	Geotextile	Unit Weight	ASTM D 5261	6 oz/sy
		Apparent Opening Size	ASTM D 4751	80 sieve
		Grab Strength	ASTM D 4632	157 lb
		Tear Strength	ASTM D 4533	56 lb
		Puncture Strength	ASTM D 4833	56 lb
		Permeability	ASTM D 4491	0.2 cm/s
Manufacturer	HDPE Geonet	Specific Gravity	ASTM D 1505	0.939 g/cm^3
		Thickness	ASTM D 5199	0.25 inch
		Carbon Black	ASTM D 1603	2%
		Tensile Strength	ASTM D 5035	45 lb/in (Peak)
Third Party Laboratory	Drainage Geocomposite	Transmissivity	ASTM D 4716	See Note 2
		Strength[3]	ASTM D 5321	Protective Cover/Geocomposite: Peak: C_a=100 psf, Δ=15°; Residual: C_a=60 psf, Δ=10° Single-sided Geocomposite/Smooth Geomembrane: Peak: C_a=0 psf, Δ=13°; Residual: C_a=0 psf, Δ=9° Double-sided Geocomposite/Textured Geomembrane: Peak: C_a=110 psf, Δ=23°; Residual: C_a=100 psf, Δ=10° Smooth Geomembrane/Clay Liner: Peak: C_a=100 psf, Δ=11°; Residual: C_a=0 psf, Δ=10° Textured Geomembrane/Clay Liner: Peak: C_a=200 psf, Δ=14°; Residual: C_a=100 psf, Δ=12° Clay Liner/Underdrain Geocomposite: Peak: C_a=100 psf, Δ=15°; Residual: C_a=60 psf, Δ=10° Clay Liner Internal: C_a=125 psf, Φ =13°
Manufacturer		Peel Adhesion	ASTM D 7005	1.0 lb/in

[1] The minimum testing frequency will be one test sample per 100,000 square feet.

[2] As noted in Appendix IIIC, Appendices IIIC-A and IIIC-B, the transmissivity of the bottom liner single-sided geocomposite will be measured at a gradient of 0.009 under normal pressures of 1,000, 15,000 and 23,421 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours will be run for the first 100,000 square feet of liner construction. For each additional 100,000 square feet liner single-sided geocomposite placement area, one additional transmissivity test will be run under the minimum normal stress (i.e., 23,421 psf) with all the other assumptions the same as the first three tests. The minimum transmissivity will be 9.94x10^{-4} m^2/s. The transmissivity of the bottom sidewall liner double-sided geocomposite shall be measured at a minimum gradient of 0.33 under a minimum normal pressure of 1,000, 10,000 and 18,748 or higher). Boundary conditions consist of soil/geocomposite/geomembrane with a minimum seating time of 100 hours. The minimum transmissivity will be 6.24x10^{-5} m^2/s. For each additional 100,000 square feet liner double-sided geocomposite placement area, one additional transmissivity test will be run under the minimum normal stress (i.e., 18,748 psf) with all the other assumptions the same as the first three tests.

[3] The adhesion and interface friction angle of the geocomposite components will be determined to verify they meet the values used in the slope stability analysis of Appendix IIIJ-A. This test may be performed using stack testing (i.e., performing a single test combining all components of the liner system).

[4] Minimum required property values for the geotextile and drainage geocomposite transmissivity are based on calculations provided in Appendix IIIC-A. The geonet properties are based on values specified in GRI standard GM-13. In addition, each material will be tested prior to construction to verify that it meets the minimum required properties.

Table 3-4
Geotextile and Drainage Geocomposite Requirements for the Overliner Areas[1]

Responsible Party	Material	Test	Standard	Required Property[4]
Manufacturer	Geotextile	Unit Weight	ASTM D 5261	6 oz/sy
		Apparent Opening Size	ASTM D 4751	80 sieve
		Grab Strength	ASTM D 4632	157 lb
		Tear Strength	ASTM D 4533	56 lb
		Puncture Strength	ASTM D 4833	56 lb
		Permeability	ASTM D 4491	0.2 cm/s
Manufacturer	HDPE Geonet	Specific Gravity	ASTM D 1505	0.939 g/cm^3
		Thickness	ASTM D 5199	0.30 inch
		Carbon Black	ASTM D 1603	2%
		Tensile Strength	ASTM D 5035	45 lb/in (Peak)
Third Party Laboratory	Drainage Geocomposite	Transmissivity	ASTM D 4716	See Note 2
		Strength[3]	ASTM D 5321	Protective Cover/Geocomposite: Peak: C_a=100 psf, Δ=15° Residual: C_a=60 psf, Δ=10° Geocomposite/Textured Geomembrane: Peak: C_a=110 psf, Δ=23° Residual: C_a=100 psf, Δ=10° Textured Geomembrane/Geosynthetic Clay Liner: Peak: C_a=100 psf, Δ=20° Residual: C_a=70 psf, Δ=15° Geosynthetic Clay Liner/Subgrade: Peak: C_a=80 psf, Δ=25° Residual: C_a=50 psf, Δ=16° Geosynthetic Clay Liner Internal: Peak: C_a=100 psf, Φ =24° Residual: C_a=50 psf, Φ =6°
Manufacturer		Peel Adhesion	ASTM D 7005	1.0 lb/in

[1] The minimum testing frequency will be one test sample per 100,000 square feet.

[2] As noted in Appendix IIIC, Appendices IIIC-A and IIIC-B, the transmissivity of the overliner double-sided geocomposite will be measured at a minimum gradient of 0.01 under a minimum normal pressure of 1,000, 10,000 and 13,720 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours. The minimum transmissivity will be $2.77x10^{-3}$ m^2/s. For each additional 100,000 square feet double-sided geocomposite placement area, one additional transmissivity test will be run under the minimum normal stress of 13,720 psf with all the same assumptions as the first three tests.

[3] The adhesion and interface friction angle of the geocomposite components will be determined to verify they meet the values used in the slope stability analysis of Appendix IIIJ-A. This test may be performed using stack testing (i.e., performing a single test combining all components of the overliner system).

[4] Minimum required property values for the geotextile and drainage geocomposite transmissivity are based on calculations provided in Appendix IIIC-A. The geonet properties are based on values specified in GRI standard GM-13. In addition, each material will be tested prior to construction to verify that it meets the minimum required properties.

3.2.3 Protective Cover

The chimney drains will be installed above the LCS pipes and the top of the chimney drain gravel will match the top of protective cover grades as shown on Drawing A.4, Detail L1, and Drawing A.9, Detail OL2, located in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. The chimney drains will be constructed with drainage material having a hydraulic conductivity of 1.0 cm/s or greater and will be covered by a geotextile to restrict migration of the protective cover soil into the LCS. The chimney drains will allow leachate to flow into the LCS without a buildup of head above the protective cover layer. Calculations showing the adequacy of the chimney drain are provided in Appendix IIIC-B.

3.3 Leachate Collection Piping

3.3.1 Subtitle D Areas

The liner and overlying leachate collection layer will slope to drain toward the LCS trenches, which will contain a perforated leachate collection pipe surrounded by drainage stone and separated from the adjacent protective cover and waste layers by a geotextile fabric. The leachate collection pipe will direct the leachate to the landfill sumps. The proposed leachate collection pipes will be SDR 17 HDPE smooth wall pipe (refer to Appendix IIIC-B for LCS pipe designs for the Subtitle D area). The existing leachate collection pipes for Cell 5 is a perforated 6-inch SDR 13.5 HDPE pipe and for Cells 1 through 4, 8, and 9A are perforated 6-inch SDR 11 HDPE smooth wall pipe. As shown in Table 3-1, the LCS pipes are designed for slopes that are equal to or less than the estimated post-settlement slope.

The geotextile fabric and pipe perforations are designed to prevent clogging of the fabric or pipe. The leachate collection system is designed with cleanout risers at the end of each of the collection pipes to allow cleaning. Proposed leachate collection pipe design calculations are provided in Appendix IIIC-B. These calculations demonstrate the adequacy of the pipes to convey leachate to the sumps, the structural stability of the pipes, and the satisfaction of the perforation requirements. Details of the LCS layer and pipe trench are shown in Part III, Appendix IIIA-A – Liner, Overliner, and Final Cover System Details.

3.3.2 Pre-Subtitle D Areas (Overliner)

The overliner leachate collection layer is designed with the same parameters as the Subtitle D areas. However, the maximum cleanout distance in the pre-Subtitle D areas is 570 feet. This distance is the maximum measured distance from the cleanout to the end of the longest leachate collection pipe. This distance is within the limits of recognized methods and manufacturer's information for cleaning of collection pipes through jetting and/or flushing. Proposed overliner leachate collection pipe design calculations are provided in Appendix IIIC-B. These calculations demonstrate the adequacy of the pipes to convey leachate to the sumps, the structural stability of the pipes, and the satisfaction of the perforation requirements. As shown in Table 3-2, the LCS pipes are designed for slopes that are equal to or less than the estimated post-settlement slope. Details of the overliner LCS layer and pipe trench are shown in Part III, Appendix IIIA-A – Liner, Overliner, and Final Cover System Details.

3.4 Leachate Sumps and Pumps

The leachate collection sumps and pumps have been sized to comply with the regulatory performance standard listed in §330.331(a)(2). The leachate collection sumps and pumps will maintain the maximum head above the liner system at less than 12 inches and provide a reasonable pump cycle time. Each leachate sump will be sized based on the amount of leachate generation. The minimum sump size for the undeveloped cells and the overliner cells will be 3 feet deep (and 2 feet, 4 inches below the pipe invert) with minimum dimensions of approximately 33 by 33 feet at the landfill floor and 15 by 15 feet at the sump base and will store a minimum of 1,809 cubic feet of leachate. The size and capacity of the sumps are presented in Appendix IIIC-B. Sumps will be backfilled with drainage stone meeting the gradation in accordance with ASTM D 448, size number 467 (nominal aggregate size is 2 inches to 3/16 inches). Each sump will be emptied by a submersible pump located in an 18-inch nominal diameter sidewall riser pipe which extends into the bottom of the sump and is perforated in the sump. Pumps will be operated either manually or automatically by pressure transducers. Control levels for an automatic pump will be set to maintain sump liquid levels at a level less than 12 inches above the lip of the sump. The objective of the pump operation is to ensure that a free-flowing condition is maintained in the LCS. If the pump malfunctions, the pump will be removed, repaired, and replaced, or a new pump will be used.

The leachate depth monitoring procedure and leachate removal will be the same for all disposal areas (undeveloped and developed Subtitle D and overliner). The depth of leachate in the sump will be monitored by the pressure transducer which will be calibrated to provide direct read-out of the leachate level in the sump (e.g., typically the leachate level is shown on a continuous digital display at the sump as the pressure transducers provide a constant determination of the leachate levels in the sump). These automatic control levels will be inspected every day the facility is in operation and accepting waste. As noted in Part IV – SOP, Section 4.23, the leachate levels for each sump will be recorded in the Site Operating Record once per week. If the pressure transducers are not functioning, the pumps will be operated manually (once per day) until the automatic system is repaired. Details of the leachate sump are provided in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details.

If the specified leachate sump pumps are not able to empty the sump and maintain less than 12 inches of head on the liner at reasonable cycle times, then a pump with more capacity will be used (refer to Section 4.1 for more information).

The specified pump will have the capacity to pump leachate at a rate of 25 gpm or 36,000 gpd. The maximum estimated flow to be pumped from the largest sector is 34,085 gpd. As noted in Section 6, the leachate generation rate predicted by the HELP model is much greater than the expected leachate generation rate that is based on site specific information.

3.5 Drainage Stone (Coarse Aggregate)

Granular drainage material around the leachate collection pipes and in the LCS sumps in the pre-subtitle D and Subtitle D areas will consist of typical (e.g., unit weight of 90 to 110 pcf) or lightweight (e.g., unit weight less than 70 pcf) materials that comply with the following criteria. The aggregate will have a loss of mass due to calcium carbonate of less than 15 percent (in accordance with JLT-S-105-89 or ASTM D3042 method modified to use a solution of hydrochloric acid having a pH of 5). The drainage stone will meet the following gradation in accordance with ASTM D448, size number 467.

Sieve Size Square Opening	Percent Passing
2 inches	100
1½ inches	95 - 100
¾ inch	35 - 70
3/8 inch	10 - 30
No. 4 (3/16 inch)	0 - 5

Drainage materials not complying with the above gradations may also be approved by the POR if demonstrated to have a hydraulic conductivity of at least 1.0 cm/s and meet the gradation requirements of the filter and leachate collection pipe (in no case will the maximum rock size be greater than 2 inches). At a minimum, the drainage stone will meet the following criteria:

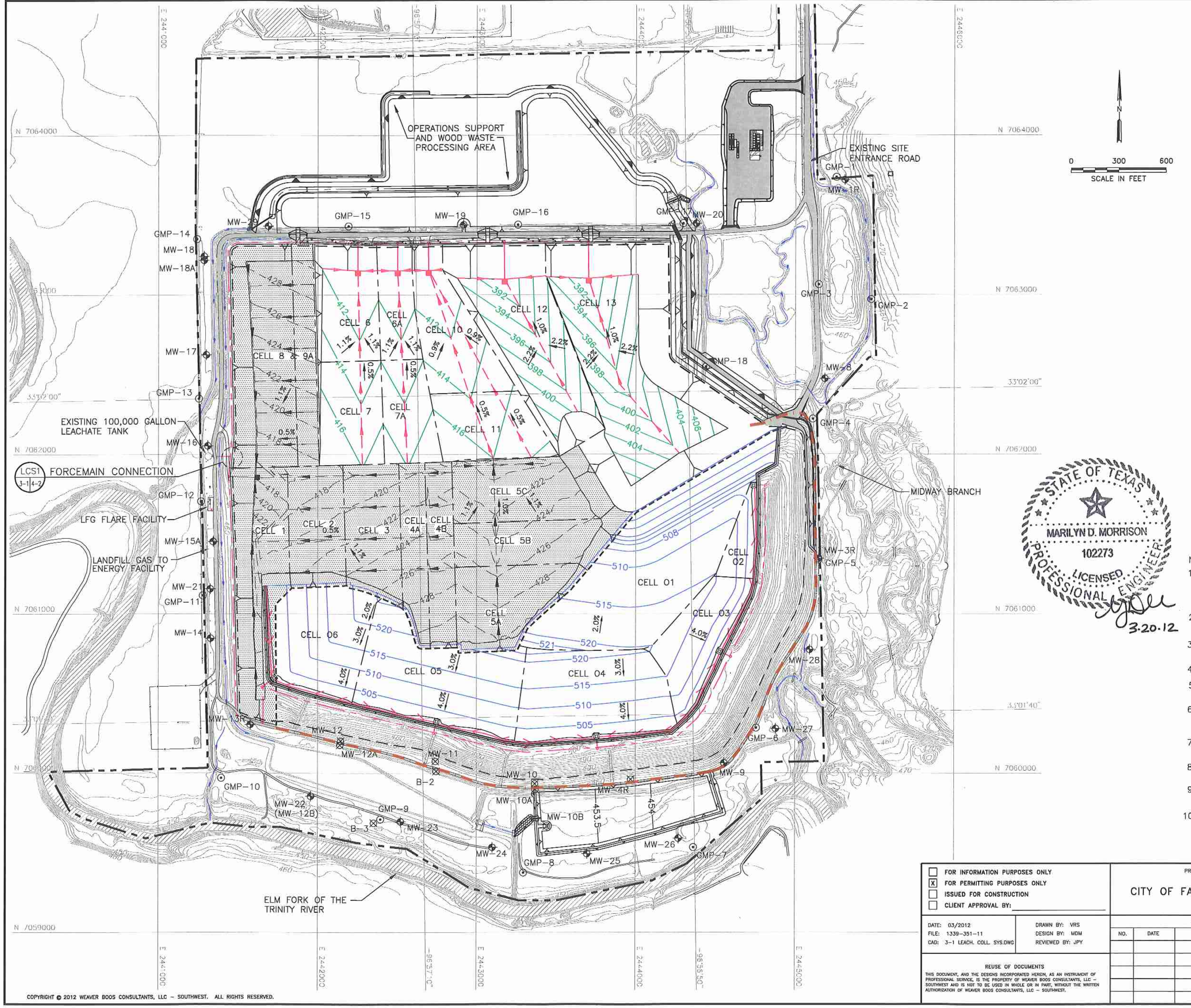
For circular holes in the leachate collection pipe:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Hole Diameter}} >1.7$$

For slots in the leachate collection pipe:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Slot Width}} >2.0$$

The drainage stone will be covered by a geotextile to maintain separation of drainage stone from the overlying layers. The geotextile will be resistant to commonly encountered chemicals, hydrocarbons and mildew, and will be rot resistant. Geotextile design calculations are presented in Appendix IIIC-B.



LEGEND

— - - —	PERMIT BOUNDARY
— — — —	LIMITS OF WASTE
- - - - - -	LIMITS OF PRE-SUBTITLE D WASTE
N 7064000	STATE PLANE COORDINATE SYSTEM
33°02'00"	GEODETIC COORDINATE SYSTEM
500	EXISTING CONTOUR
— · — · —	EASEMENT
——— — ———	CELL BOUNDARY
398	PROPOSED EXCAVATION CONTOUR
— —◄— —	PROPOSED LEACHATE LINE
■	PROPOSED LEACHATE COLLECTION SUMP
———●	PROPOSED LEACHATE RISER
— — —422— — —	AS-BUILT TOP OF SUBTITLE D CLAY LINER (SEE NOTE 8)
— —◄— —	EXISTING LEACHATE LINE
■	EXISTING LEACHATE COLLECTION SUMP
———○	EXISTING LEACHATE RISER
515	PROPOSED TOP OF OVERLINER CONTOUR
→→→	PROPOSED OVERLINER LEACHATE LINE
⊡	PROPOSED OVERLINER LEACHATE COLLECTION SUMP
— — —	LEACHATE FORCEMAIN
Y Y Y	3H:1V SLOPE (TYPICAL)
MW-8	GROUNDWATER MONITORING WELL
GMP-1	GAS MONITORING PROBE
MW-12	OBSERVATION WELL
▨	EXISTING SUBTITLE D COMPOSITE LINER AREA
— · — · —	APPROXIMATE LOCATION OF PROPOSED SLURRY WALL

MARILYN D. MORRISON
102273
3.20.12

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.
3. SEE APPENDIX IIIC-D FOR LEACHATE FORCEMAIN AND STORAGE TANK INFORMATION.
4. MINIMUM EXCAVATION ELEVATION AT LCS SUMP IS 387 FT-MSL.
5. LINER AND LEACHATE COLLECTION SYSTEM DETAILS ARE PRESENTED IN APPENDIX IIIA-A.
6. SUBTITLE D AREA LCS PIPES SLOPE WITH A MINIMUM OF 0.5% TO SUMPS. LCS LATERAL DRAINAGE SLOPE WITH A MINIMUM OF 0.9% ALONG THE FLOW PATH. OVERLINER LCS PIPES SLOPE WITH A MINIMUM OF 0.6% TO SUMPS.
7. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA.
8. NOTED CONTOURS REPRESENT THE TOP OF CLAY FOR THE EXISTING SUBTITLE D LINERS.
9. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (E.G. CHANNELS) ARE TYPICALLY 3(H):1(V).
10. THE LEACHATE FORCEMAIN FOR THE PRE-SUBTITLE D AND THE SUBTITLE D AREAS WILL BE A 3-INCH MINIMUM DIAMETER DUAL-CONTAINMENT PIPE (6-INCH MINIMUM OUTER CONTAINMENT PIPE).

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PREPARED FOR

CITY OF FARMERS BRANCH

MAJOR PERMIT AMENDMENT LEACHATE COLLECTION SYSTEM PLAN

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

DATE: 03/2012
FILE: 1339-351-11
CAD: 3-1 LEACH. COLL. SYS.DWG

DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

REVISIONS

NO.	DATE	DESCRIPTION

REUSE OF DOCUMENTS

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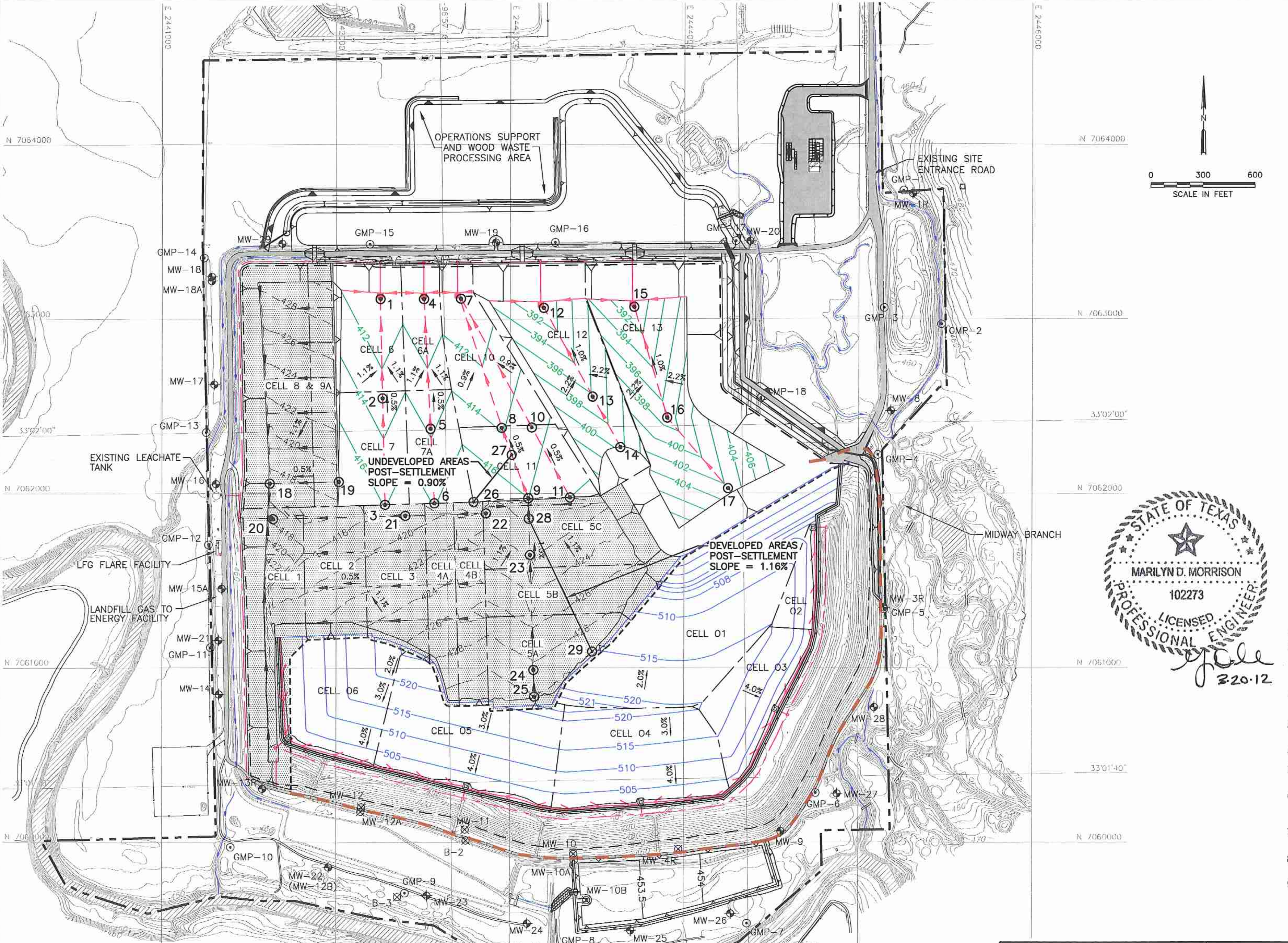
FIGURE 3-1

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIC\3-1 LEACHATE COLLECTION SYSTEM.dwg, 3/20/2012 3:01:47 PM, rsellers



MARILYN D. MORRISON
102273

3·20·12

LEGEND

— - - —	PERMIT BOUNDARY
— — — —	LMITS OF WASTE
- - - - - -	LIMITS OF PRE-SUBTITLE D WASTE
N 7064000	STATE PLANE COORDINATE SYSTEM
33°02'00"	GEODETIC COORDINATE SYSTEM
500	EXISTING CONTOUR
— · — · —	EASEMENT
— - —	CELL BOUNDARY
398	PROPOSED EXCAVATION CONTOUR
— —◄— —	PROPOSED LEACHATE LINE
■	PROPOSED LEACHATE COLLECTION SUMP
—•	PROPOSED LEACHATE RISER
— — 422 — —	AS-BUILT TOP OF SUBTITLE D CLAY LINER (SEE NOTE 8)
— —◄— —	EXISTING LEACHATE LINE
■	EXISTING LEACHATE COLLECTION SUMP
—∘	EXISTING LEACHATE RISER
515	PROPOSED TOP OF OVERLINER CONTOUR
—>—>—>	PROPOSED OVERLINER LEACHATE LINE
⊠	PROPOSED OVERLINER LEACHATE COLLECTION SUMP
— - —	LEACHATE FORCEMAIN
Y Y Y	3H:1V SLOPE (TYPICAL)
MW-8	GROUNDWATER MONITORING WELL
⊙ GMP-1	GAS MONITORING PROBE
⊠ MW-12	OBSERVATION WELL
▨	EXISTING SUBTITLE D COMPOSITE LINER AREA
◉4	SETTLEMENT EVALUATION POINT
▬ ▬ ▬	APPROXIMATE LOCATION OF PROPOSED SLURRY WALL

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
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3. SEE APPENDIX IIIC-D FOR LEACHATE FORCEMAIN AND STORAGE TANK INFORMATION.
4. MINIMUM EXCAVATION ELEVATION AT LCS SUMP IS 387 FT-MSL.
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7. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA.
8. NOTED CONTOURS REPRESENT THE TOP OF CLAY FOR THE EXISTING SUBTITLE D LINERS.
9. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (E.G. CHANNELS) ARE TYPICALLY 3(H):1(V).

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DATE: 03/2012
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DESIGN BY: MDM
REVIEWED BY: JPY

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CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
SUBTITLE D AREA
POST-SETTLEMENT SLOPES

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

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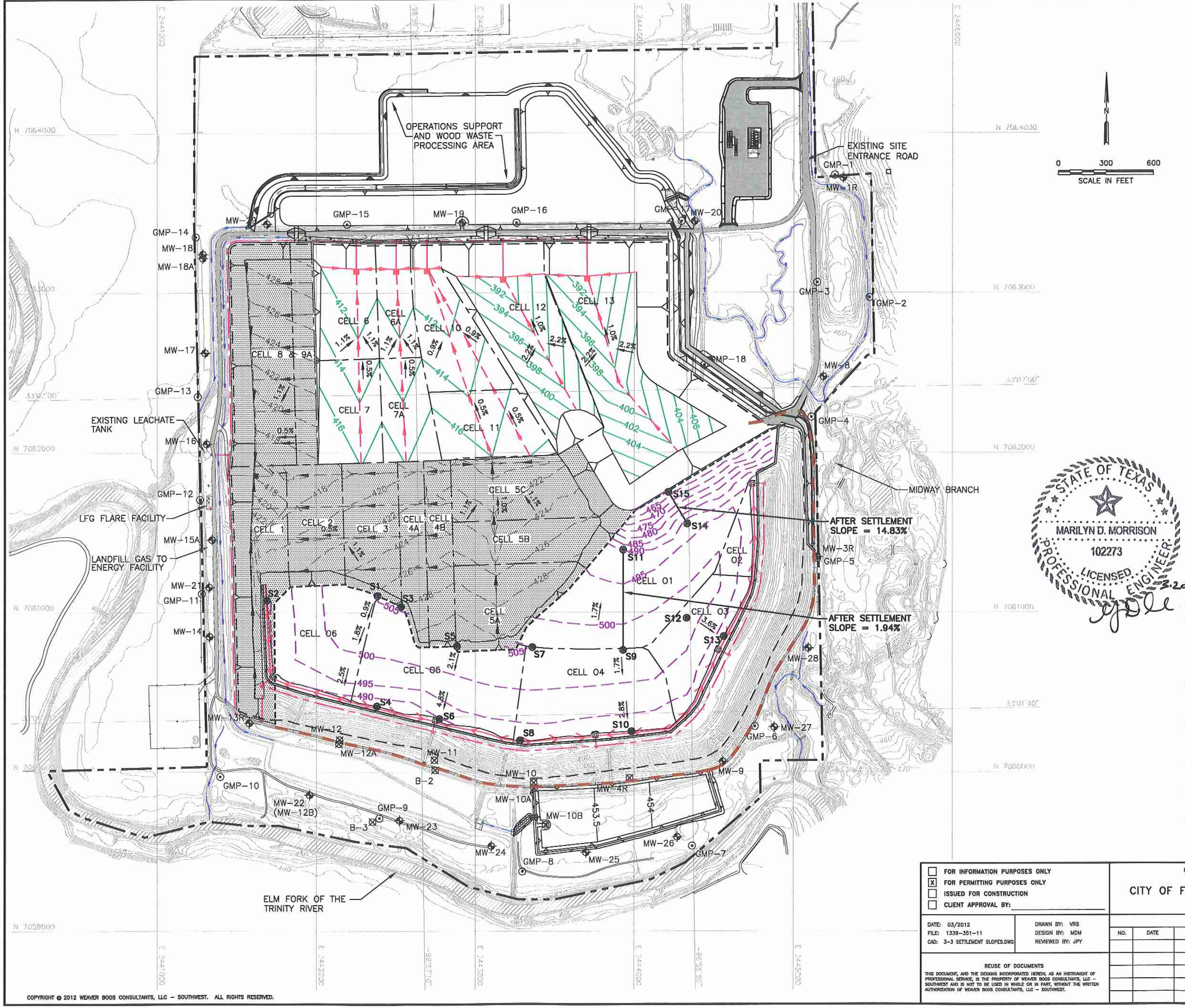
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE 3-2

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIC\3-2 SUB D AREA AFTER SETTLEMENT SLOPES.dwg, 3/20/2012 3:01:09 PM, rsellers



LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- LIMITS OF PRE-SUBTITLE D WASTE
- N 7064000 STATE PLANE COORDINATE SYSTEM
- 33°02'00" GEODETIC COORDINATE SYSTEM
- 500 EXISTING CONTOUR
- EASEMENT
- CELL BOUNDARY
- 398 PROPOSED EXCAVATION CONTOUR
- PROPOSED LEACHATE LINE
- ■ PROPOSED LEACHATE COLLECTION SUMP
- PROPOSED LEACHATE RISER
- 422 AS-BUILT TOP OF SUBTITLE D CLAY LINER (SEE NOTE 8)
- EXISTING LEACHATE LINE
- ■ EXISTING LEACHATE COLLECTION SUMP
- EXISTING LEACHATE RISER
- 500 OVERLINER POST SETTLEMENT CONTOURS
- PROPOSED OVERLINER LEACHATE LINE
- ⊠ PROPOSED OVERLINER LEACHATE COLLECTION SUMP
- LEACHATE FORCEMAIN
- 3H:1V SLOPE (TYPICAL)
- MW-8 GROUNDWATER MONITORING WELL
- GMP-1 GAS MONITORING PROBE
- ⊠ MW-12 OBSERVATION WELL
- ▨ EXISTING SUBTITLE D COMPOSITE LINER AREA
- ● S12 STRAIN/SLOPE EVALUATION POINT
- APPROXIMATE LOCATION OF PROPOSED SLURRY WALL

MARILYN D. MORRISON
102273
3.20.12

NOTES:

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4. MINIMUM EXCAVATION ELEVATION AT LCS SUMP IS 387 FT-MSL.
5. LINER AND LEACHATE COLLECTION SYSTEM DETAILS ARE PRESENTED IN APPENDIX IIIA-A.
6. THE OVERLINER DESIGN IS DETAILED IN PART III, APPENDIX IIIA-A.
7. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA.
8. NOTED CONTOURS REPRESENT THE TOP OF CLAY FOR THE EXISTING SUBTITLE D LINERS.
9. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (E.G. CHANNELS) ARE TYPICALLY 3(H):1(V).

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REVIEWED BY: JPY

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CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
OVERLINER
POST-SETTLEMENT SLOPES
CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

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SOUTH BEND, IN
SPRINGFIELD, IL
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FIGURE 3-3

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIC\3-3 OVERLINER AFTER SETTLEMENT SLOPES.dwg, jwilson, 1:2

4 LEACHATE AND CONTAMINATED WATER STORAGE

4.1 Leachate Storage

Temporary leachate storage will be provided in the leachate collection sumps. The leachate collection sumps have been sized based on the amount of leachate generated. Each cell and drainage area in the overliner area and undeveloped cells will have a sump which will provide at least 1,809 cubic feet of storage capacity. Additional storage will be provided in onsite above ground storage tanks as discussed in Section 4.3. Table 4-1 summarizes the estimated leachate flow into the sump and the daily pump operating time provided by three representative cells/areas. The estimated leachate generation rate is based on the average leachate generation produced by the HELP model analysis. As shown in Section 6, the average annual leachate generation rate produced by the HELP model analysis is greater than actual leachate generation values documented at the site. Therefore, the use of the average annual leachate generation rate produced by HELP to design the leachate collection sumps and forcemain provides for a conservative analysis. Table 4-1 also includes the expected leachate generation and pump operating time which are based on site specific leachate generation values. Sump volume calculations are provided in Appendix IIIC-B. Details of the leachate sumps are provided in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details.

Leachate levels in the sumps will be measured and recorded to evaluate leachate production and fluctuations. A form to record leachate measurements will be kept in the Site Operating Record and will be used to evaluate the effectiveness of leachate monitoring and control facilities. The sumps will be emptied by submersible pumps located within the sump section of the sidewall riser pipes to meet the design objective and to maintain leachate levels below 12 inches on the liner system. Disposal of leachate is discussed in Section 5. Leachate will be pumped to a leachate storage tank through a forcemain. The design and operation of the onsite storage tanks and the forcemain are discussed in Section 4.3. The existing forcemain consists of a 3-inch diameter pipe encased in a 6-inch diameter carrier pipe, and the proposed forcemain consists of a 3-inch minimum diameter pipe encased in a 6-inch minimum diameter carrier pipe. The carrier pipe will provide leak detection and containment. The forcemain will be extended to serve each cell and overliner area as landfill development progresses. The locations of the leachate forcemain and the storage tank after the site is completely developed are shown on Figure 4-1. Details of the connection between the 18-inch riser and forcemain are presented on Figure 4-2, and other forcemain details are provided on Figures 4-3 and 4-4. Figure 4-5 provides the layout of the existing forcemain. The forcemain and storage tank calculations are presented in Appendix IIIC-D.

Table 4-1
Sump Flow and Pump Operating Times

Condition	Sump Storage Summary														
	Sump for Cells 1, 2, 3, 4A, 4B, 8, and 9A[1]					Sump for Cells 5A, 5B, 5C, 10, and 11[1]					Sump for Overliner Cell O5[1]				
	Flow (gpd)		Pump Operating Time (hours/day)		Pump Capacity (gpm)	Flow (gpd)		Pump Operating Time (hours/day)		Pump Capacity (gpm)	Flow (gpd)		Pump Operating Time (hours/day)		Pump Capacity (gpm)
	Average[2]	Expected[3]	Average[2]	Expected[3]		Average[2]	Expected[3]	Average[2]	Expected[3]		Average[2]	Expected[3]	Average[2]	Expected[3]	
Active	2,374	1,328	1.6	0.9	25	21,363	1,202	14.2	0.8	25	4,688	345	5.2	0.4	15
Closed	2,023	1,328	1.3	0.9	25	19,441	1,202	13.0	0.8	25	3,669	345	4.1	0.4	15

[1] Sumps for the largest drainage areas are shown. Refer to Appendix IIIC-B, Sheet IIIC-B-41 – Sump Drainage Areas for sector layout and sump drainage areas.

[2] Refer to Appendix IIIC-B, pages IIIC-B-35 through IIIC-B-41 for sumps in the developed and undeveloped areas and Appendix IIIC-B, pages IIIC-B-60 through IIIC-B-64 for the sumps in the overliner area.

[3] The expected flow values are based on site specific leachate generation listed in Table 6-1. The average value listed in Table 6-1 was used (i.e., 9,991 gal/ac/yr).

4.2 Contaminated Water Storage

Contaminated water will be contained at the working face as shown in Appendix IIIC-C. A vacuum truck or similar vehicle will remove contaminated water from this area. Contaminated water will then be pumped to a sanitary sewer line, as discussed in Section 5. Contaminated water will be removed from behind the contaminated water containment berm as discussed in Part IV – SOP, Section 4.19.

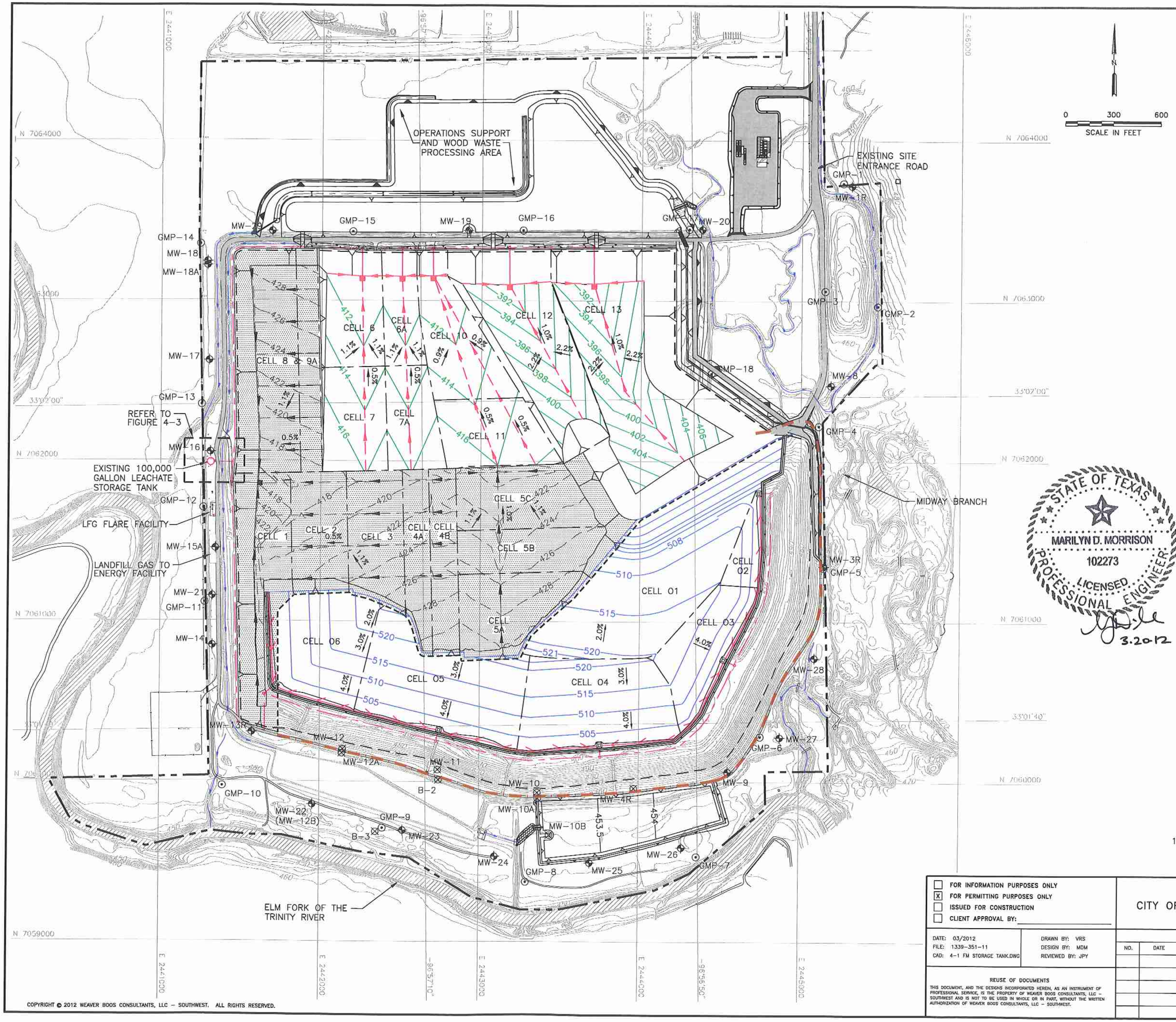
4.3 Onsite Storage Tanks

The existing 100,000-gallon leachate storage tank is located to the west of the existing Subtitle D area (see Figures 4-1 and 4-3). The 100,000-gallon leachate storage tank provides enough storage capacity for the leachate currently generated at the site. The storage tank will be emptied, as required, to maintain capacity for the leachate currently generated at the site. However, the leachate level in the tank will be managed to provide a minimum of 30,000 gallons of emergency backup storage capacity.

Leachate storage capacity calculations are provided in Appendix IIIC-D. The tank is equipped with a liquid-level sensor and a high-level alarm to prevent overfill. When the high level alarm is triggered, a light on the tank will start flashing, which will alert site personnel of the high level in the tank. Additionally, the alarm will activate an electronic signal that will be sent to the leachate sump pumps to shut them down until the issue is resolved. Site personnel will then take appropriate actions to reduce the leachate level in the tank. The storage tank will be emptied consistent with the leachate storage system operation plan detailed in Section 5.

The 100,000 gallon tank is a double-walled leachate tank made of steel that contains an inner tank ("storage vessel") consisting of a geomembrane liner. The tank is located over a concrete foundation to provide stability for the tank. The secondary geomembrane liner, attached to the inner surface of the steel tank, collects any leachate that may infiltrate through the primary geomembrane liner. Any leachate that migrates through the primary liner drains to a collection sump which is equipped with a witness riser pipe. The witness riser pipe extends under the tank and through the concrete foundation. As shown on Sheet IIIC-D-4 a clear visual inspection pipe is provided so that the integrity of the tank's primary HDPE geomembrane liner can be visually monitored by site personnel on a weekly basis. Leachate in the visual inspection tube indicates a leak of the primary HDPE geomembrane liner. If this occurs, the tank will be drained and repaired.

A concrete truck loading pad is located adjacent to the 100,000 gallon storage tank. The storage tank area is designed to contain spills and control contaminated water from leaving the facility. The design is sufficient to control and contain a worst case spill or release. The 100,000-gallon tank is an enclosed tank, so the 25-year, 24-hour storm event precipitation criteria does not apply to this tank. Also, the dual-contained forcemain will extend to the tank, as shown on Sheet IIIC-D-4 in Appendix IIIC-D. Valve boxes will be installed, as shown on Sheet IIIC-D-4, to provide secondary containment. Trucks will park on the loadout pad when leachate is transferred from the tanks to the trucks. The loadout pad is constructed of concrete and the pad slopes to drain to a concrete collection sump (note that this is not the same sump as the leachate storage tank sump discussed above). In the event of a spill while the truck is loading, leachate will be contained within the loadout pad and will drain to the sump. Collected leachate in the sump will be pumped back to the leachate storage tank.



LEGEND

— - - —	PERMIT BOUNDARY
— — — —	LMITS OF WASTE
- - - - - -	LIMITS OF PRE-SUBTITLE D WASTE
N 7064000	STATE PLANE COORDINATE SYSTEM
33°02'00"	GEODETIC COORDINATE SYSTEM
500	EXISTING CONTOUR
— · — · —	EASEMENT
—— – ——	CELL BOUNDARY
398	PROPOSED EXCAVATION CONTOUR
– – ◄ – –	PROPOSED LEACHATE LINE
■	PROPOSED LEACHATE COLLECTION SUMP
—•	PROPOSED LEACHATE RISER
422	AS-BUILT TOP OF SUBTITLE D CLAY LINER (SEE NOTE 8)
– – ◄ – –	EXISTING LEACHATE LINE
■	EXISTING LEACHATE COLLECTION SUMP
—∘	EXISTING LEACHATE RISER
515	PROPOSED TOP OF OVERLINER CONTOUR
→ → →	PROPOSED OVERLINER LEACHATE LINE
⊡	PROPOSED OVERLINER LEACHATE COLLECTION SUMP
—— – ——	LEACHATE FORCEMAIN
Y Y Y	3H:1V SLOPE (TYPICAL)
MW-8	GROUNDWATER MONITORING WELL
GMP-1	GAS MONITORING PROBE
MW-12	OBSERVATION WELL
▨	EXISTING SUBTITLE D COMPOSITE LINER AREA
○	EXISTING 100,000 GALLON LEACHATE STORAGE TANK
▬ · ▬ · ▬	APPROXIMATE LOCATION OF PROPOSED SLURRY WALL

MARILYN D. MORRISON
102273

3.20.12

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
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9. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (E.G. CHANNELS) ARE TYPICALLY 3(H):1(V).
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FILE: 1339-351-11
CAD: 4-1 FM STORAGE TANK.DWG

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DESIGN BY: MDM
REVIEWED BY: JPY

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PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT FORCEMAIN AND STORAGE TANK PLAN

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

FORT WORTH, TX
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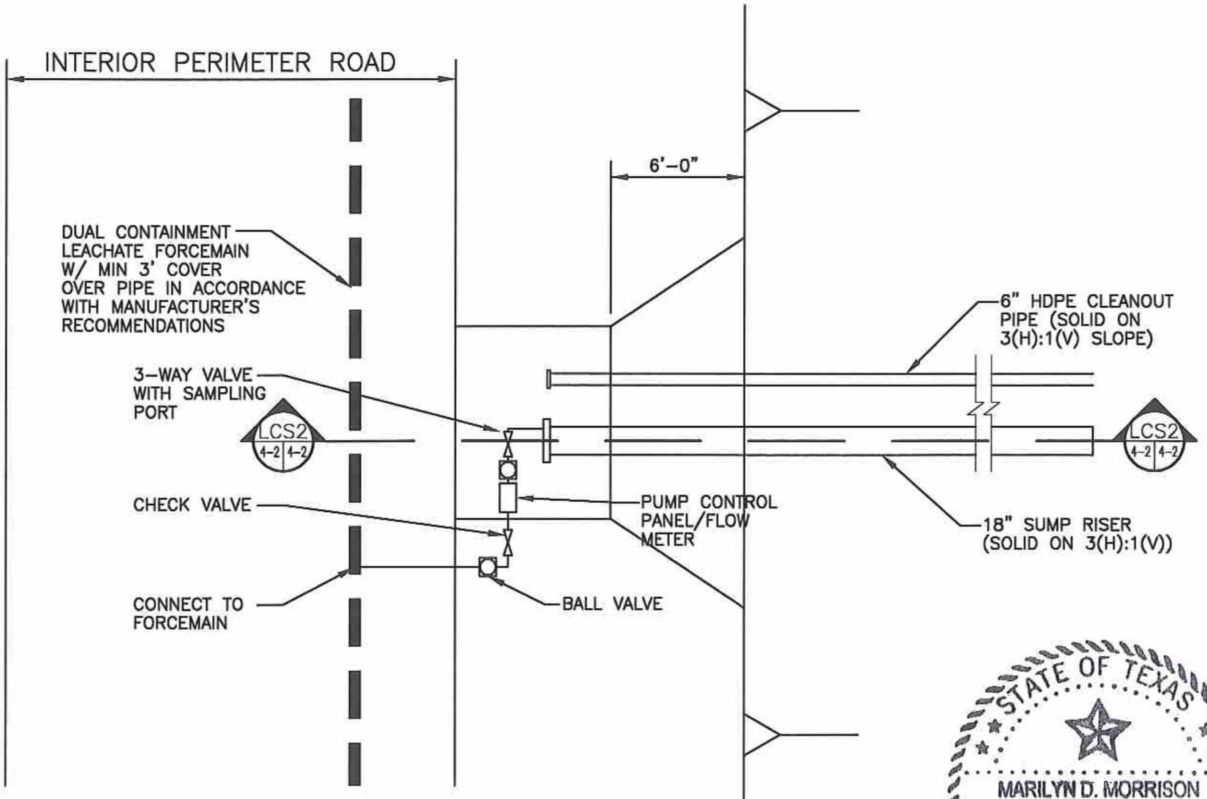
GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

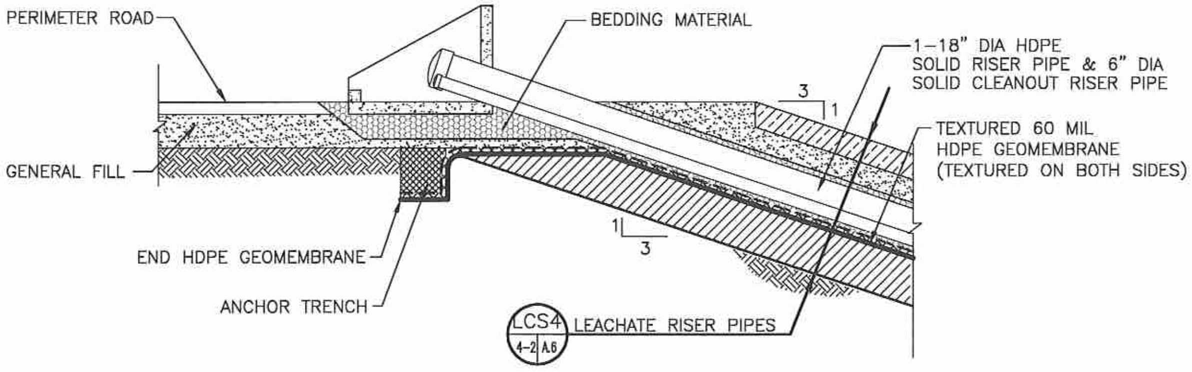
FIGURE 4-1

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIC\4-1 FORCEMAIN_STORAGE TANK PLAN.dwg, 3/20/2012 2:58:10 PM, rsellers

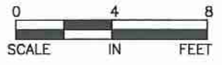


FORCEMAIN CONNECTION (LCS1 3-1 4-2)
N.T.S.

STATE OF TEXAS
MARILYN D. MORRISON
102273
LICENSED PROFESSIONAL ENGINEER
3.20.12



LEACHATE RISER/CLEANOUT (LCS2 4-2 4-2)



NOTE:

1. REFER TO APPENDIX IIIA-A-LINER, OVERLINER, AND FINAL COVER SYSTEM DETAILS FOR LINER INFORMATION.

MAJOR PERMIT AMENDMENT
LEACHATE FORCEMAIN DETAILS

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

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SOUTH BEND, IN
SPRINGFIELD, IL

DRAWN BY: VRS	DATE: 03/2012	FILE: 1339-351-11
REVIEWED BY: JPY	CAD: 4-2 FORCEMAIN DTLS.DWG	FIGURE 4-2

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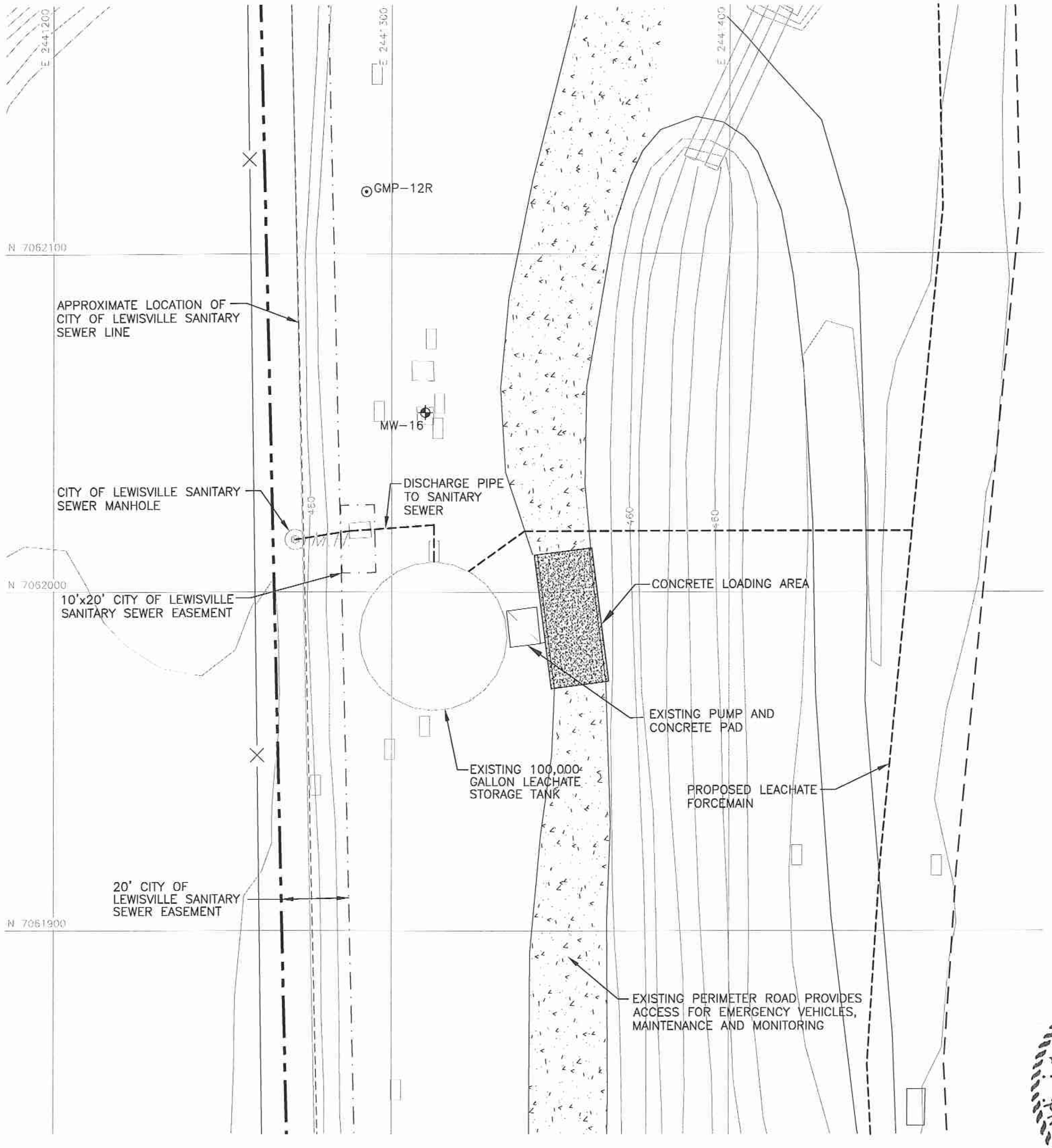
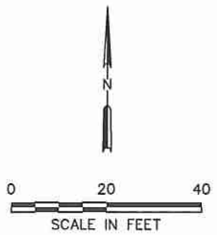


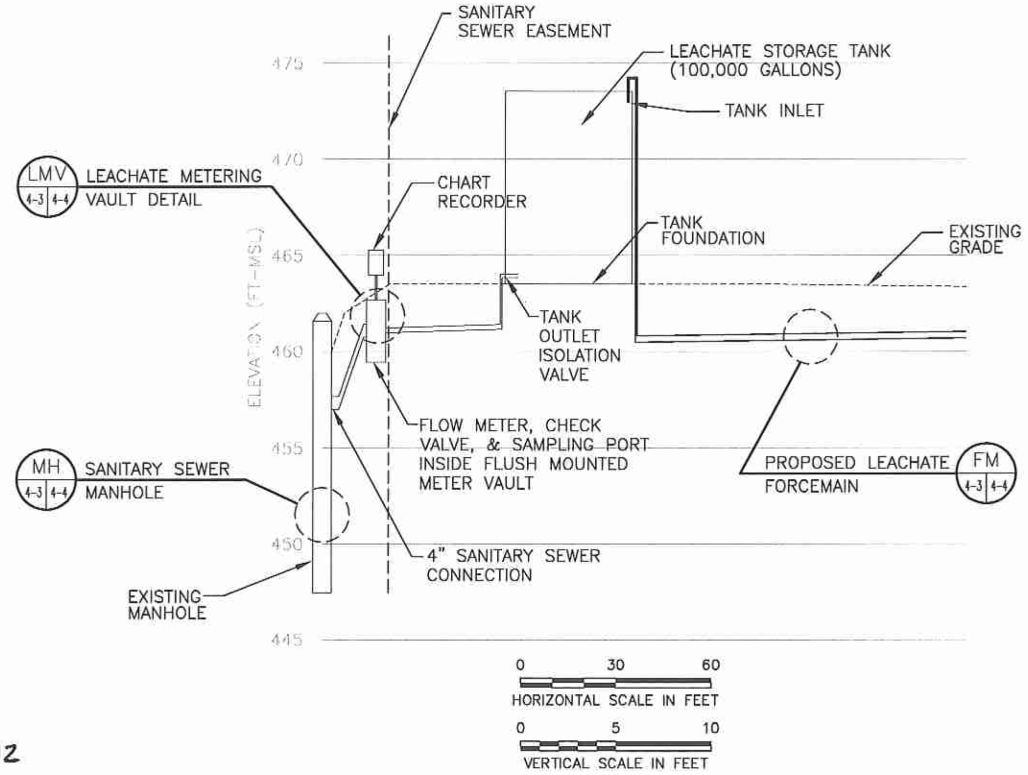


LEGEND

- ▬ ▬ · ▬ PERMIT BOUNDARY (SEE NOTE 2)
- — — — LIMIT OF WASTE
- N 7062000 STATE PLANE COORDINATE SYSTEM
- 500 EXISTING CONTOUR
- — · — · EASEMENT
- ⊙ GMP-12R PERMITTED GAS MONITORING PROBE
- ⊕ MW-16 PERMITTED GAS MONITORING PROBE
- PERIMETER ACCESS ROAD
- —×— PERIMETER FENCE
- - - - - PROPOSED FORCEMAIN

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.



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DESIGN BY: MDM
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CITY OF FARMERS BRANCH

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MAJOR PERMIT AMENDMENT PROPOSED FORCEMAIN AND STORAGE TANK DETAILS

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DENTON COUNTY, TEXAS

Weaver Boos Consultants
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GRIFFITH, IN
SOUTH BEND, IN
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ST. LOUIS, MO

FIGURE 4-3

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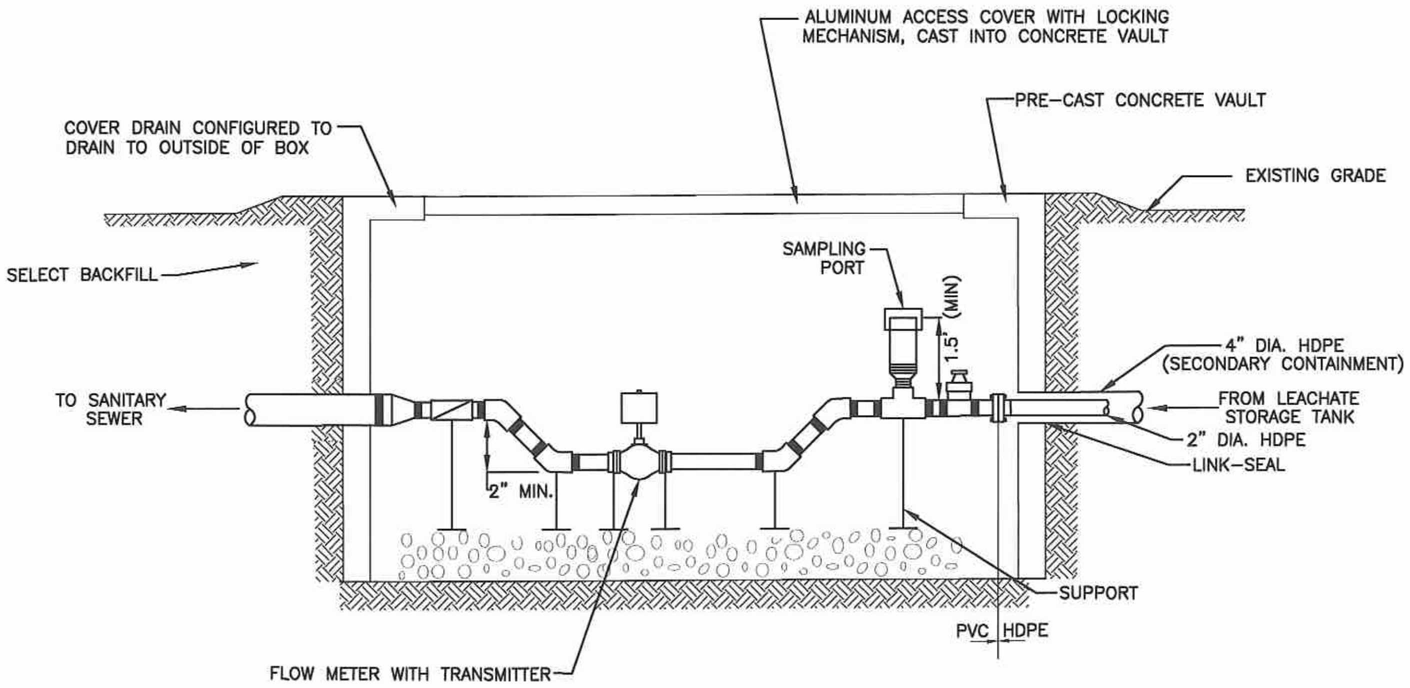
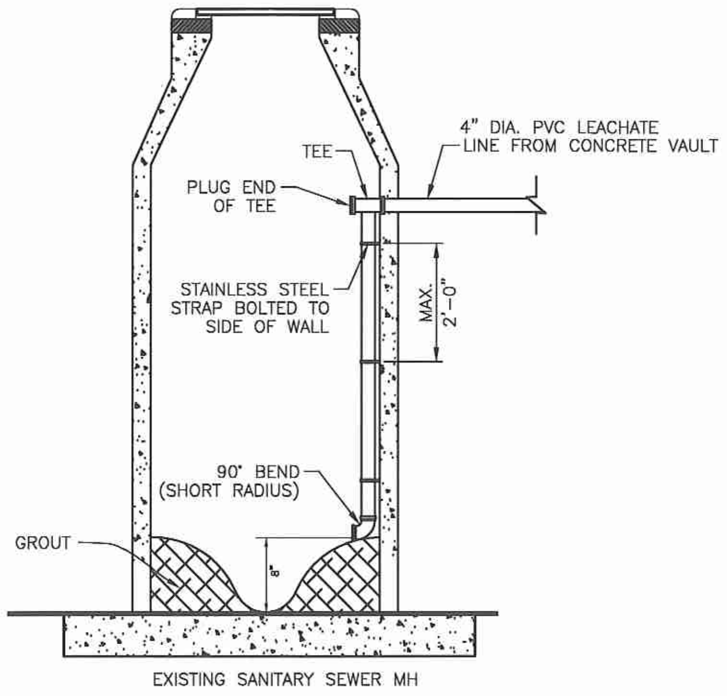


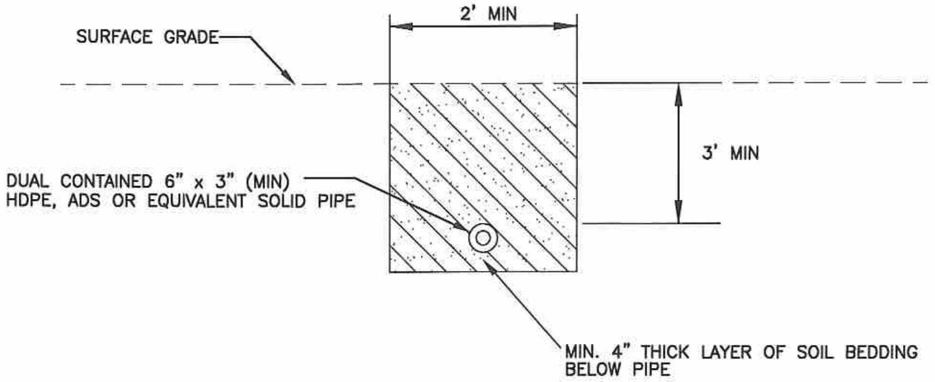
LEACHATE METERING VAULT-DETAIL LMV 4-3 | 4-4

N.T.S.



SANITARY SEWER MANHOLE MH 4-3 | 4-4

N.T.S.



PROPOSED LEACHATE FORCEMAIN FM 4-3 | 4-4

N.T.S.

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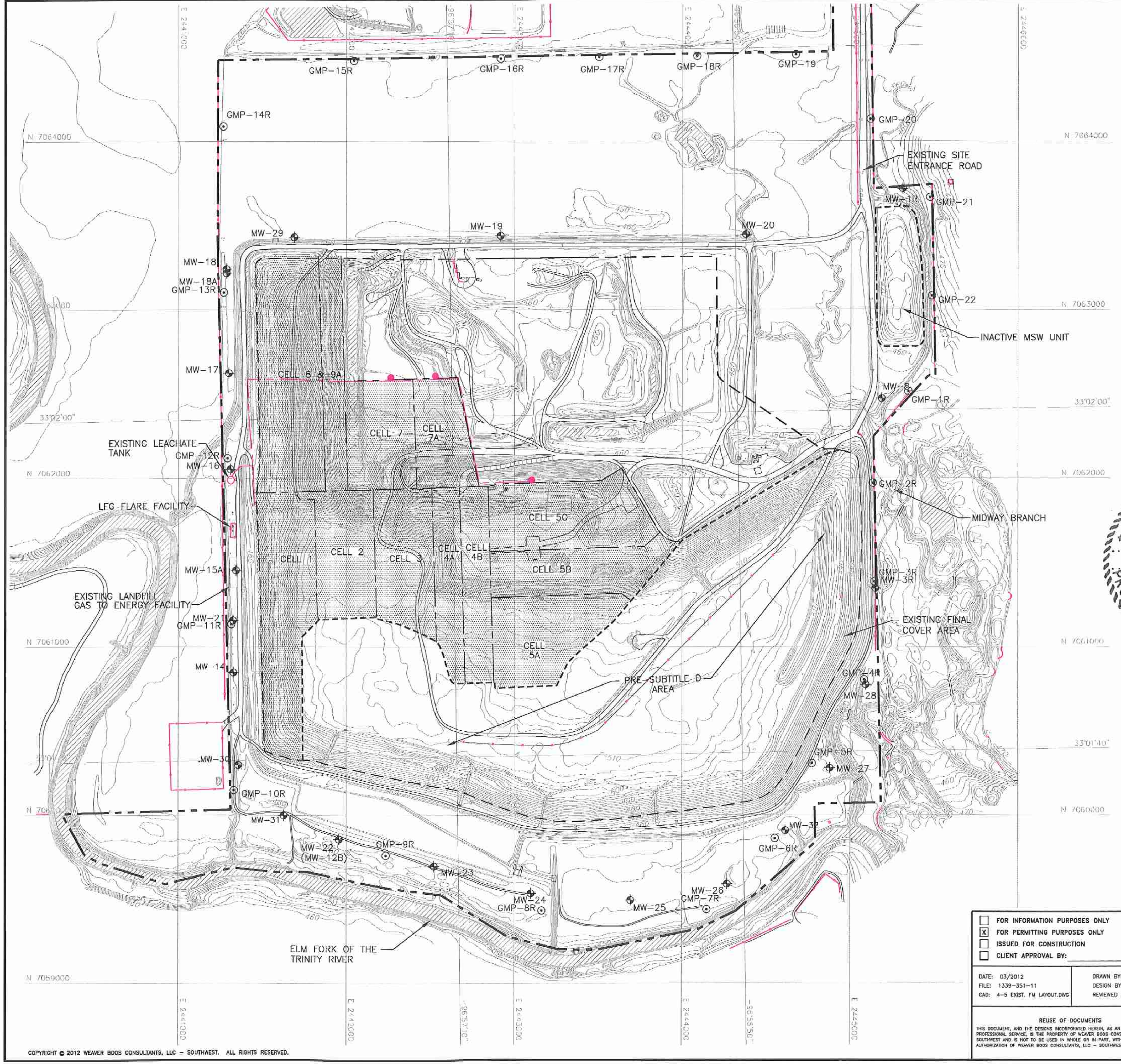
FIGURE 4-4



N

0 300 600
SCALE IN FEET

LEGEND

——— – – ———	PERMIT BOUNDARY
— — — — — —	LMITS OF WASTE
- - - - - - - - - -	LIMITS OF PRE–SUBTITLE D WASTE
N 7064000	STATE PLANE COORDINATE SYSTEM
33°02'00"	GEODETIC COORDINATE SYSTEM
500	EXISTING CONTOUR
— · — · —	EASEMENT
——— – ———	CELL BOUNDARY
——— – ———	EXISTING LEACHATE FORCEMAIN
●	TEMPORAY LEACHATE SUMP
—•—•—	EXISTING FENCE
⌖ MW–8	GROUNDWATER MONITORING WELL
⊙ GMP–1	GAS MONITORING PROBE
☒ MW–12	OBSERVATION WELL
▨	EXISTING SUBTITLE D COMPOSITE LINER AREA
○	EXISTING 100,000 GALLON LEACHATE STORAGE TANK

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3·20·12

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8–28–2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.
3. SEE APPENDIX IIIC–D FOR LEACHATE FORCEMAIN AND STORAGE TANK INFORMATION.
4. THE EXISTING LEACHATE FORCEMAIN IS A 3–INCH MINIMUM DIAMETER DUAL–CONTAINMENT PIPE (6–INCH MINIMUM OUTER CONTAINMENT PIPE).

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FIGURE 4–5

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5 LEACHATE AND CONTAMINATED WATER DISPOSAL

5.1 Leachate Storage System Operation and Disposal

Leachate that is generated at the site will be conveyed to the leachate collection sumps. Leachate levels in the sumps are measured and recorded to evaluate leachate production and fluctuations. A form to record leachate measurements is kept in the Site Operating Record and is used to evaluate the effectiveness of the leachate monitoring and control facilities. The depth of leachate in the sump will be monitored by the pressure transducer which will be calibrated to provide direct read-out of the leachate level in the sump (e.g., typically the leachate level is shown on a continuous digital display at the sump, as the pressure transducers provide a constant determination of the leachate levels in the sump). As noted in Part IV – SOP, Section 4.24, the leachate levels for each sump will be recorded in the Site Operating Record once per week.

Leachate will be pumped from the leachate sumps within the landfill via a forcemain (which consists of a 3-inch minimum diameter pipe contained in a 6-inch minimum diameter carrier pipe) to the leachate storage tank. The forcemain location is shown on Figure 4-1. The forcemain calculations are included in Appendix IIIC-D.

The storage tank area management plan is presented in Appendix IIIC-D. The storage tank will be operated so that leachate will either be recirculated (refer to Section 5.2) or discharged to the sanitary sewer system. The location of the 100,000-gallon tank and the connection to the adjacent POTW line is shown on Figure 4-3. As noted in Appendix IIIC-D, the leachate levels in the 100,000-gallon storage tank will be maintained so that a minimum of 30,000 gallons of emergency backup leachate storage capacity will be provided.

Leachate levels in the storage tanks will be measured once per day, if used, to verify that the system is operating in conformance with this plan. The quantity of leachate pumped from the system is also recorded on a monthly basis. This information is maintained in the Site Operating Record. The tank is equipped with a liquid-level sensor and a high-level alarm to prevent overfill. When the high level alarm is triggered, a light on the tank will start flashing, which will alert site personnel of the high level in the tank. Additionally, the alarm will activate an electronic signal that will be sent to the leachate sump pumps to shut them down until the issue is resolved. Site personnel will then take appropriate actions to reduce the leachate level in the tank.

5.2 Leachate Recirculation Plan

The main purpose of recirculating leachate at this facility is to enhance the ability to manage and control leachate. Additionally, in an effort to promote an increase in waste compaction, leachate recirculation will provide the opportunity to create a uniform moisture content throughout the waste at the working face. The additional moisture will help stabilize the waste mass, thus providing for an increased compaction of the waste. The leachate will be better managed because the recirculation of leachate through the waste mass allows for treatment of the leachate to occur through physical, biological, and chemical interactions with the organic and some inorganic portions of the waste. This increases the rate of waste decomposition and stabilization, as well as increasing the rate of landfill gas recovery. Recirculation of leachate also facilitates dust control at the working face.

Consistent with Title 30 TAC §330.177, recirculation of leachate will only occur over future areas underlain by a Subtitle D liner system (i.e., Cells 6, 6A, 7, 7A, and 10 through 13). Leachate will be recirculated by surface spraying at the working face. Leachate will be distributed from a water truck or other comparable equipment using a spray bar or hose to distribute leachate back to the working face (i.e., within the active waste fill area that is contained by the containment berm).

As discussed in Appendix IIIC-A (Leachate Collection System section on page IIIC-A-4) and Section 6.0, the percent of leachate recirculation at the site varies. The average leachate generation rate is about 10,000 gal/acre/year. As summarized on Figure 6-1, the leachate collection system is conservatively modeled producing a peak leachate generation rate of over 50,000 gal/acre/year.

The following performance standards will govern the application rate of leachate recirculation.

- The rate of leachate recirculation will not exceed the moisture holding capacity of the landfill. For example, the application rate will be applied so that no seeps or ponding is observed in the vicinity of the recirculation area. In addition, leachate recirculation over a specific cell will cease if the leachate flow rate to a sump approaches the capacity of the pump within the sump. For the purposes of this plan, if the leachate pump is constantly having to pump leachate more than 22 hours in a day, then the capacity of the sump has been reached. The quantity of leachate pumped from each sump will be monitored on a monthly basis. If the pump begins to operate near capacity (36,000 gpd), then the pump operating time will be monitored on a daily basis to determine if leachate recirculation needs to be reduced over the phase that flows to the sump which contains the pump that is operating near capacity. If this occurs, recirculation activities will move to another cell.

- Leachate recirculation will not occur immediately before, during, or immediately after rainfall events, or during freezing temperatures that could affect the holding-capacity of the waste.
- Leachate recirculation will not occur during high wind events.
- Refer to Part IV – SOP, Section 4.10 for additional information regarding the plan to be followed if odors due to leachate recirculation become an issue.

Sampling and analysis is not proposed for the recirculated leachate. Contaminated stormwater will not be recirculated into the waste.

The leachate generated from the landfill will be recirculated to the landfill working face, and excess quantities of leachate will be directed to the leachate storage facilities.

5.3 Contaminated Water Disposal

Contaminated water that collects behind the containment berm will be pumped into tanker trucks and transported to a properly permitted privately-owned treatment facility or a POTW for treatment. Contaminated water will be removed as soon as practicable from the area behind the contaminated water containment berm (refer to Section 4.23 of the SOP for additional information and record keeping requirements). Contaminated water may also be transported to the leachate storage tanks. When contaminated water is stored in the leachate storage tanks, no leachate recirculation will occur, and a sign will be posted on the tank stating "No Recirculation." When the tank containing the contaminated water is emptied, the sign will be removed. Also, a record will be placed in the Site Operating Record noting that contaminated water is being stored in the leachate storage tank.

5.4 Landfill Gas Condensate

Consistent with 30 TAC §330.177 and §330.207(e), landfill gas condensate will be pumped to the permanent on-site leachate storage tank. It will then be recirculated per Section 5.2 or discharged to the sanitary sewer system.

6 LEACHATE GENERATION SUMMARY

6.1 Purpose

The purpose of this section is to summarize the leachate generation rates developed in Appendix IIIC-A and compare them to leachate generation rates developed from actual leachate generation information obtained at the Camelot Landfill and other published sources.

The following sections discuss (1) leachate information that has been obtained from the site, (2) a comparison between actual leachate generation rates and the leachate generation rates provided by the HELP model, and (3) an evaluation of the leachate depth on the liner system.

6.2 Existing Site Leachate Collection Information

Table 6-1 summarizes the leachate generation information that has been obtained for the existing site in 2008, 2009, and 2010. Supporting information for this data is included in Appendix IIIC-E. This information was used to calculate the "leachate generated per acre" value in Table 6-1. As shown in Table 6-1, the average leachate generation at the site is 9,991 gal/acre/year and the maximum leachate generation has been 17,414 gal/acre/year. The average percent of leachate recirculated was 48 percent, with a maximum of 100 percent in 2010 (see Table 6-1).

Table 6-1
Existing Site Leachate Generation Summary

Year	Annual Rainfall[1] (in)	Total Leachate Generated Per Year (gallons)	Amount Recirculated Per Year (gallons)	Percent Leachate Recirculated (%)	Total Subtitle D Lined Area (acres)	Average Waste Column Thickness (feet)	Leachate Generated Per Acre (gallons/ac/year)
2008	33.54	290,312	55,766	19.2%	58	60	5,005
2009	43.64	1,149,300	277,855	24.2%	66	70	17,414
2010	32.12	498,527	525,913	100%	66	76	7,553
Average	36.43	646,046	286,511	48%	63	69	9,991

[1] The rainfall data was obtained from site personnel.

6.3 Leachate Generation Comparison

The existing site leachate generation rates and the estimated leachate generation rates provided by HELP are presented on Figure 6-1. As shown, the leachate generation rates estimated by the HELP model are higher than the actual leachate generation rates. This demonstration shows that the HELP model analysis is based on conservative assumptions and the estimated leachate generation rate modeled in the application is greater than the expected actual leachate generation rate.

Figure 6-2 presents a comparison between the leachate generation volume over the life of the site and the postclosure period. The following three estimates are shown.

- HELP Analysis – Peak Value. This estimate was obtained from the HELP analysis included in Appendix IIIC-A. The estimate is based on using the peak average leachate generation information for undeveloped cells, overliner, and developed cells and the Sector Development Plans included in Parts I/II of the application.
- HELP Analysis – Average Value. Similar to the above, this estimate was obtained from the HELP analysis included in Appendix IIIC-A. The estimate is based on using the average leachate generation information for the undeveloped cells, overliner and developed cells and the Sector Development Plans included in Parts I/II of the application.
- Estimate of Actual Leachate Generation Values. The leachate generation rate was estimated using information obtained from site personnel for the Camelot Landfill for 2008-2010 time frame. For the postclosure period, the leachate generated was estimated based on the EPA study "Assessment and Recommendations for Improving the Performance of Waste Containment Systems" by Rudolph Bonaparte, David E. Daniel, and Robert M. Koener in December 2002. This study indicates that the leachate generation within a closed landfill decreases by a factor of four in one year after closure and by one order of magnitude in two to four years after closure. This study also indicated the flow was almost negligible after nine years of closure. Based on the above EPA study, for the first 10 years of the postclosure period the flow was assumed to be 10 percent of the closed case; for the second and third 10-year postclosure periods, the flow was assumed to be 2 percent of the closed case leachate flow.

As shown on Figure 6-2, the leachate generation rate over the life of the site that was determined from actual leachate generation information is less than both the average and the peak values estimated by the HELP model.

6.4 Comparison of Leachate Thickness on Liner System

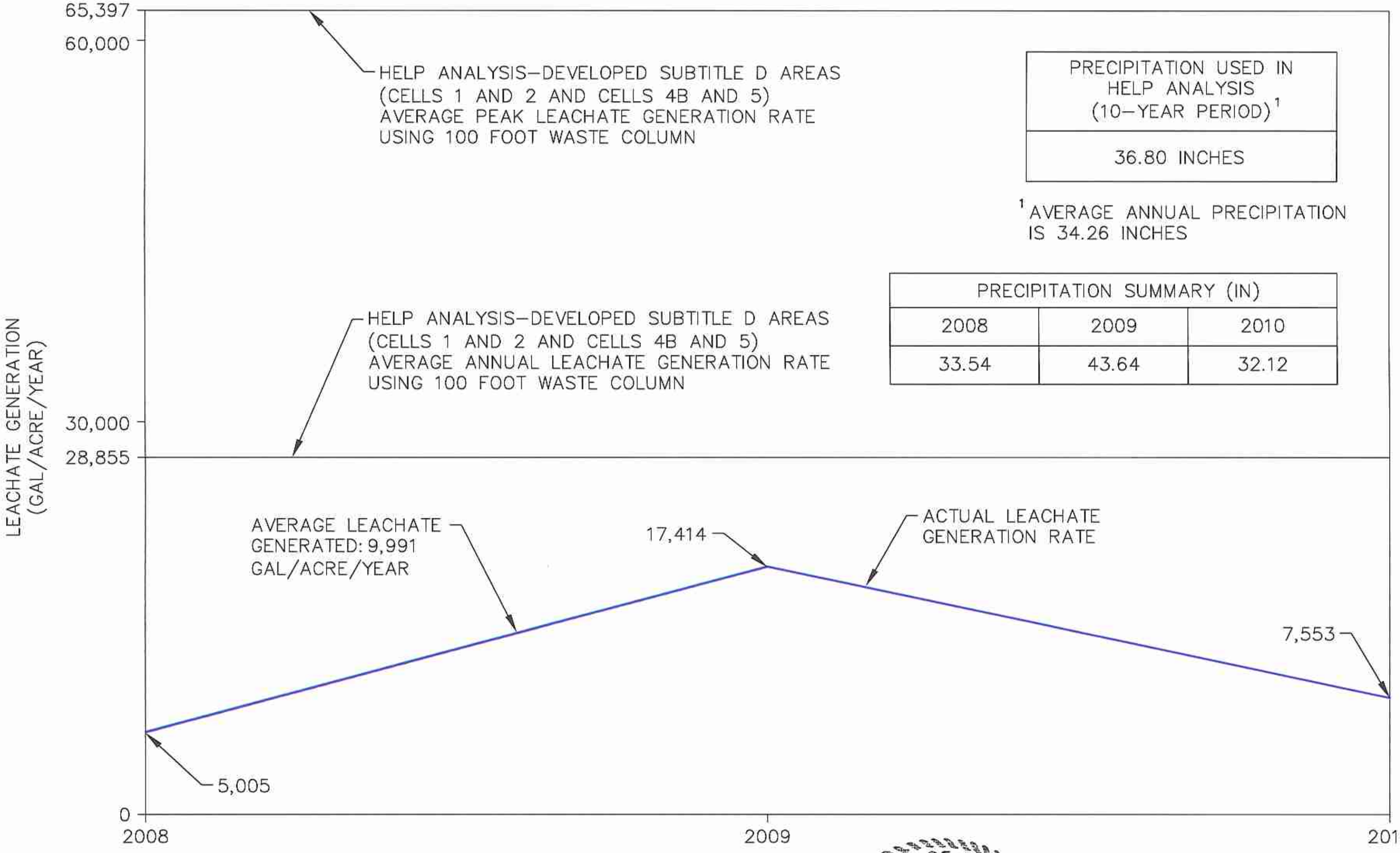
Figures 6-3 through 6-6 show that when flow rates based on actual leachate generation rates are used the depth of leachate on the liner system is much less than the design depth.

Figures 6-3 through 6-6 show that when actual flows are used, the depth of leachate on the liner system is much less than the design flows. Figures 6-3 through 6-6 provide leachate depth information for each Subtitle D cells and the overliner system that includes a geocomposite. The leachate depths for each cell are also compared to the compressed thickness of the geocomposite.

As shown in Figures 6-3 through 6-6, in each case the peak head on the liner using the flow rates produced by HELP is contained within the thickness of the geocomposite. When the actual flow rates are used the depth of the leachate within the drainage geocomposite utilizes only a fraction of the capacity of the drainage geocomposite. The supporting information for Figures 6-3 through 6-6 is included in Appendix IIIC-E.

6.5 Summary

As noted in Appendices IIIC-A and IIIC-B, the design of the leachate collection system components is based on the peak flow rate provided by the HELP model. As shown in this appendix, this approach results in a conservative design given that the expected actual leachate generation rates are much less than the design values.



PRECIPITATION USED IN HELP ANALYSIS (10–YEAR PERIOD)[1]
36.80 INCHES

[1] AVERAGE ANNUAL PRECIPITATION IS 34.26 INCHES

PRECIPITATION SUMMARY (IN)		
2008	2009	2010
33.54	43.64	32.12

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LEACHATE GENERATION RATE COMPARISON

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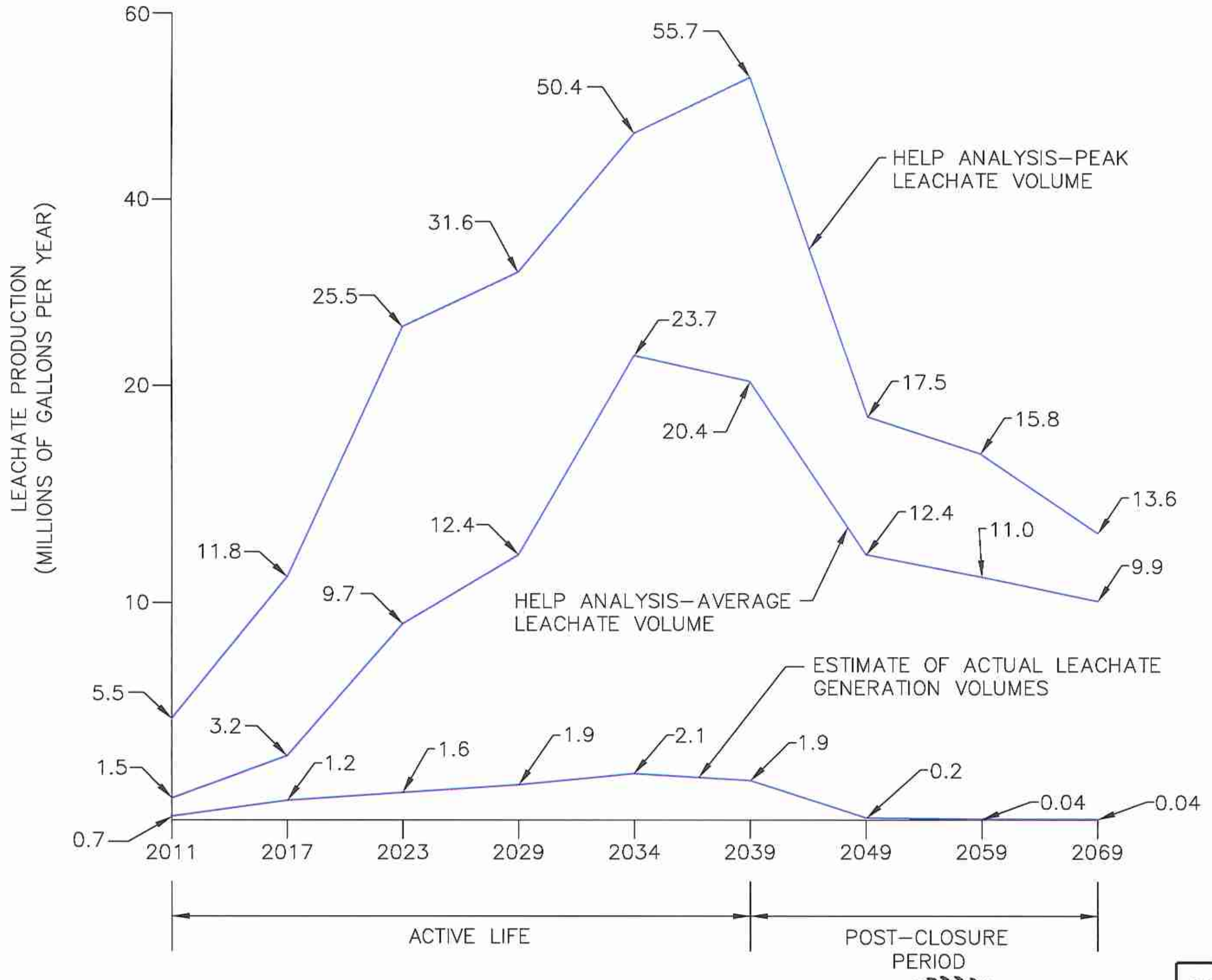

NOTE:

1. REFER TO APPENDIX IIIC–E FOR SUPPORTING INFORMATION.

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LEACHATE GENERATION VOLUME ESTIMATION

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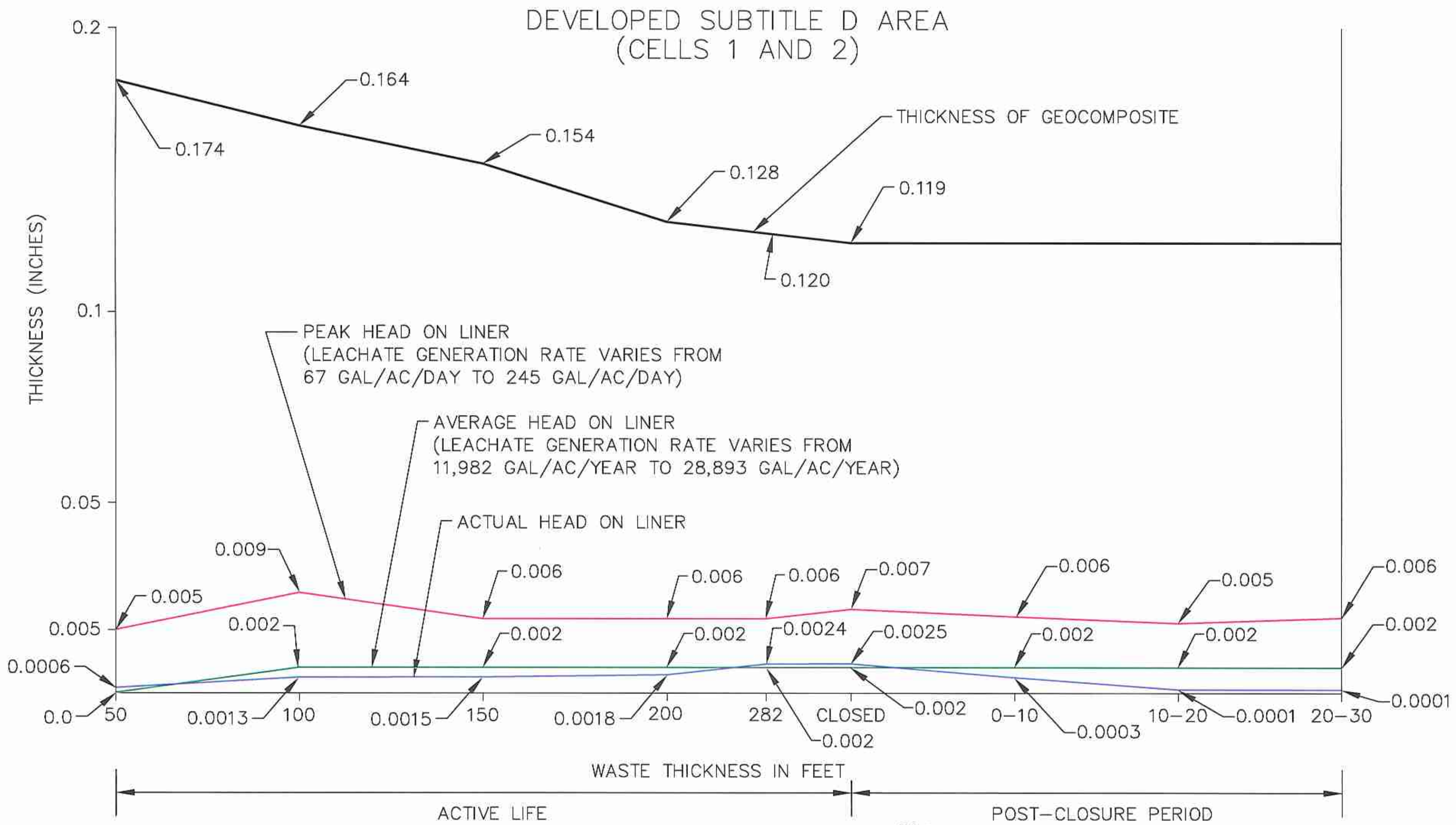
O:\1339\351\EXPANSION 2009\PART III–SDP\IIIC\FIGURE 6–2.dwg, 3/12/2012 9:47:34 AM, rsellers



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ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

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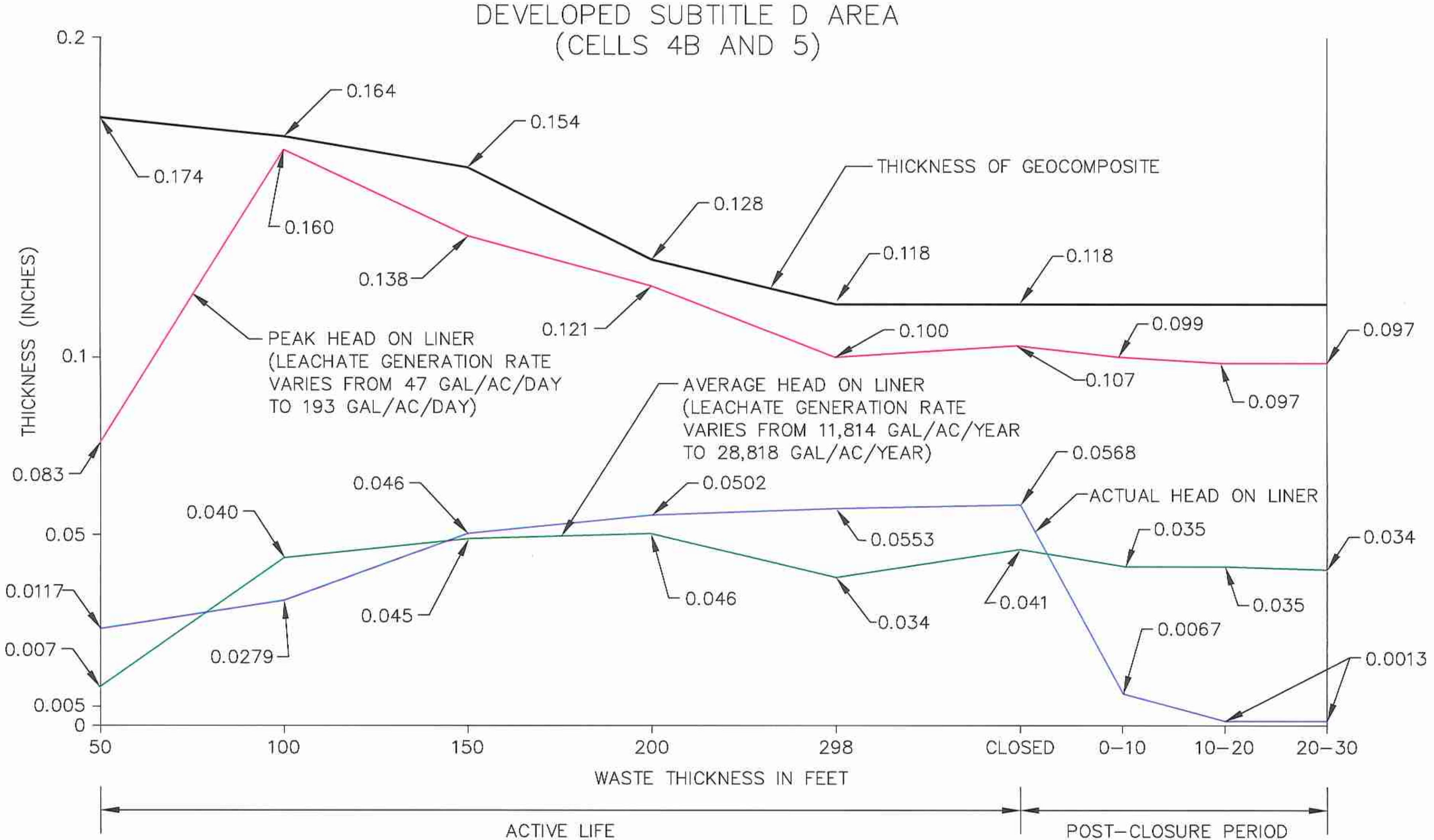
REVIEWED BY: JPY	CAD: FIG 6-3.DWG	FIGURE 6-3



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ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

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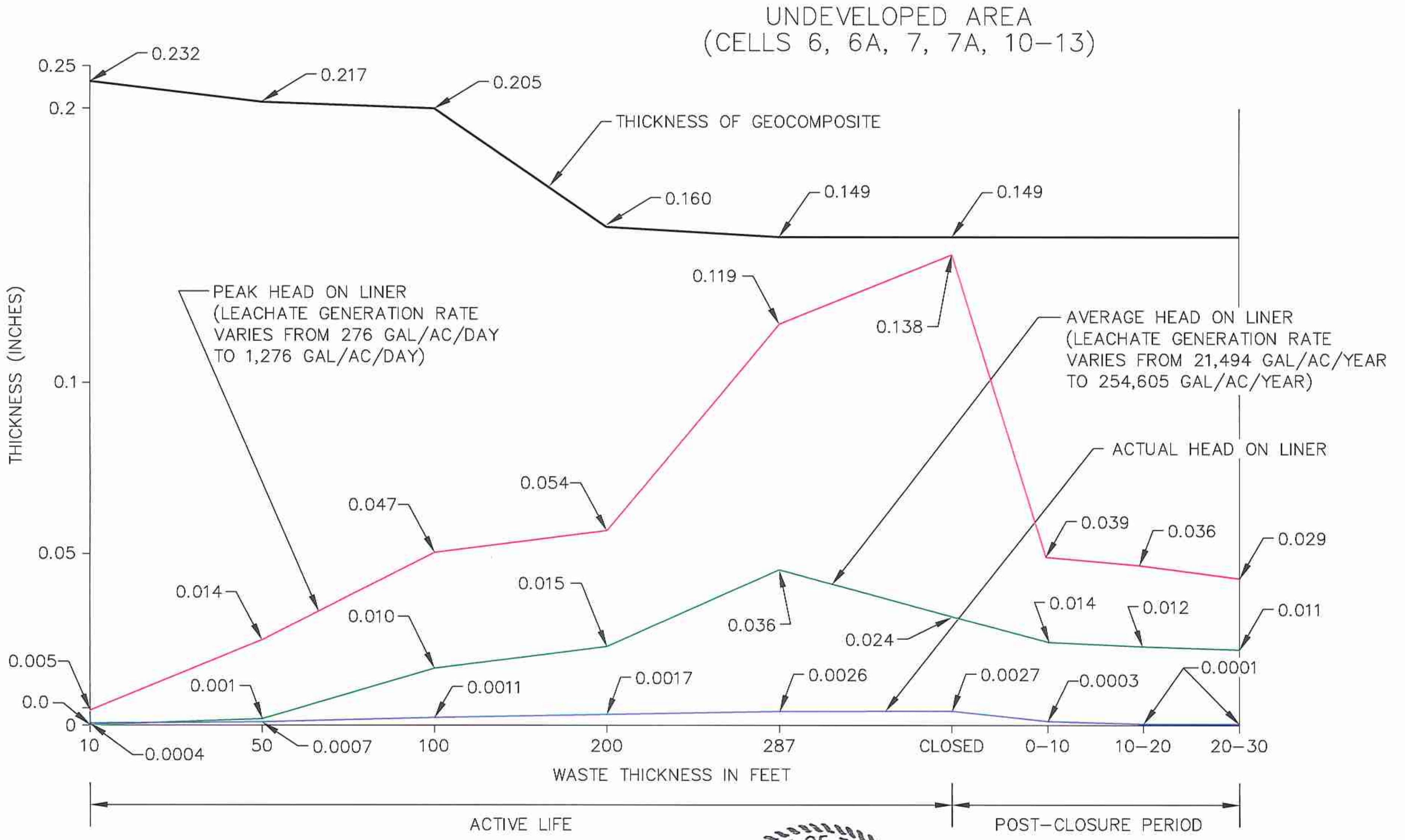
REVIEWED BY: JPY	CAD: FIG 6-4.DWG	FIGURE 6-4



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ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

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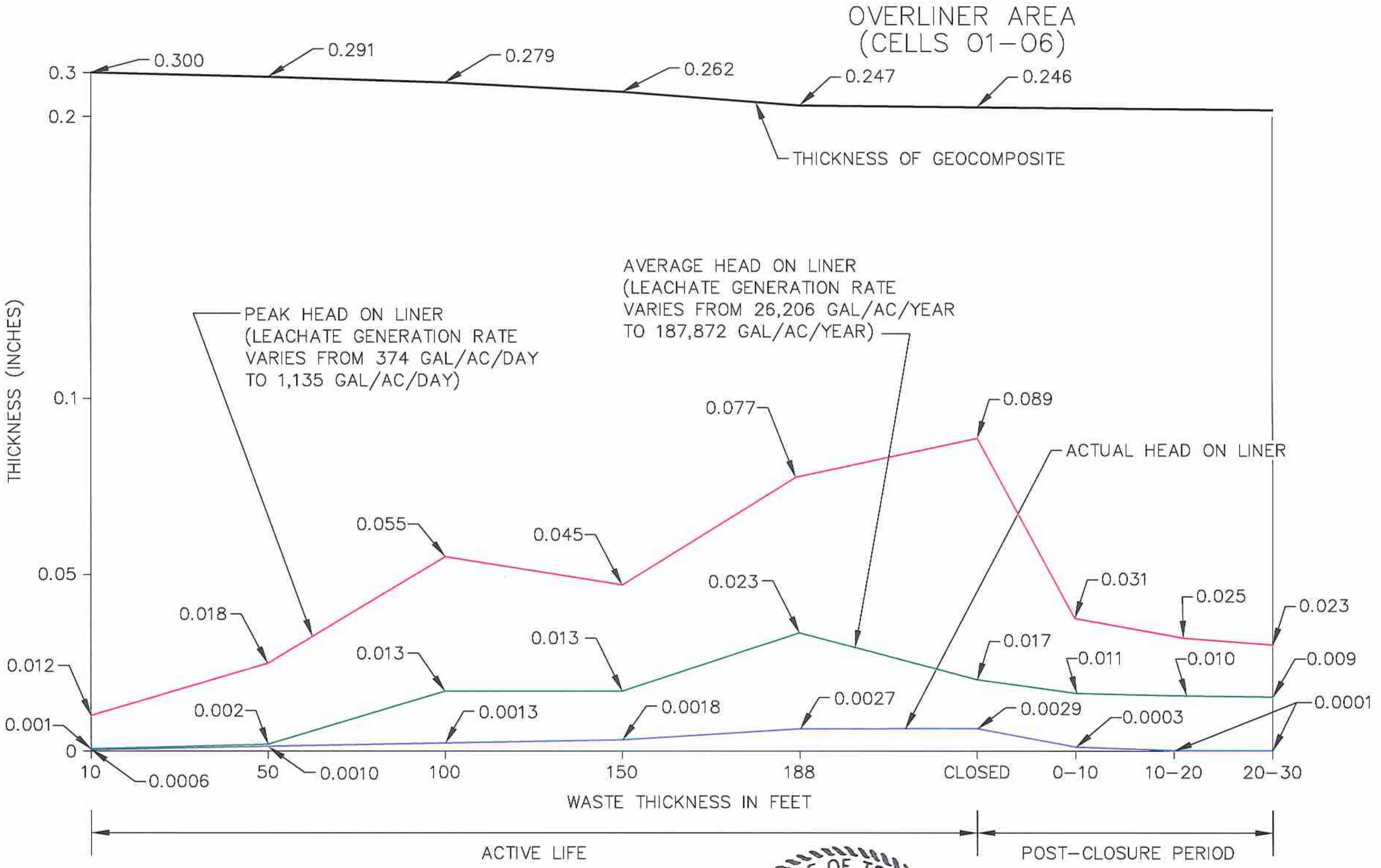
REVIEWED BY: JPY	CAD: FIG 6–5.DWG	FIGURE 6–5

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIC\FIGURE 6-5.dwg, 3/12/2012 8:28:46 AM, rsellers



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ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

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REVIEWED BY: JPY	CAD: FIG 6-6.DWG	FIGURE 6-6

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APPENDIX IIIC-A

LEACHATE GENERATION MODEL

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Includes pages IIIC-A-1 through IIIC-A-236

LEACHATE GENERATION MODEL

HELP MODEL

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 was used to estimate quantity of leachate that will be generated during the active life and postclosure period of the Camelot Landfill. The HELP Model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of the landfill. The model uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage.

MODEL SETUP

The site was modeled as a 1-acre unit area for the following stages of landfill development in undeveloped Subtitle D areas:

- Working face with 10 feet of waste
- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 200 feet of waste with intermediate cover
- 287 feet of waste with intermediate cover
- 287 feet of waste with final cover

The site was modeled as a 1-acre unit area for the following stages of landfill development in developed Cells 1 and 2:

- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 150 feet of waste with intermediate cover
- 200 feet of waste with intermediate cover
- 282 feet of waste with intermediate cover
- 282 feet of waste with final cover

The site was modeled as a 1-acre unit area for the following stages of landfill development in developed Cells 4B and 5:

- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 150 feet of waste with intermediate cover
- 200 feet of waste with intermediate cover
- 298 feet of waste with intermediate cover
- 298 feet of waste with final cover

No HELP models were developed for Cells 3, 4A, 8, and 9A since they used tire chips as the drainage layer. However, calculations addressing the maximum head on the liner for these cells are provided in Appendix IIIC-B.

The overliner pre-Subtitle D area maximum waste column thicknesses represent the thickness of waste above the overliner system. Each area was modeled as a 1-acre unit area for the following stages of landfill development:

- Working face with 10 feet of waste
- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 150 feet of waste with intermediate cover
- 188 feet of waste with intermediate cover
- 188 feet of waste with final cover

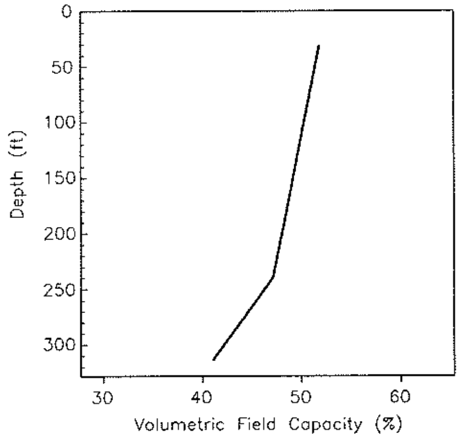
The active stage was modeled for 1 year with initial moisture contents initialized at 25 percent. The interim stages with intermediate cover were modeled for various lengths of time selected based on the projected duration each condition is likely to occur. The closed landfill condition was modeled for 30 years. The evaporative zone depth was selected to be 10 inches for the active and interim cases and 18 inches for the closed case. The leaf area index was selected to be 0 for the active case, 2 for the interim cases and 4.5 for the closed case based on the selected ground area. The Soil Conservation Service (SCS) runoff curve numbers were calculated by HELP based on soil data and expected ground cover, surface slope, and slope length. The active case models a curve number of 80.3 and percent runoff area of zero, which is representative given that this condition assumes complete infiltration (minus evapotranspiration). The interim cases utilize the default curve number assigned by the HELP model which is 87.1 and corresponds to "fair" ground cover. The percent runoff area used varies between 70 to 90. This is representative of the intermediate cover, which will be 12 inches of compacted soil with 60 percent or more vegetation coverage. The final case models a curve number of 80.1 and percent runoff area of 100, which corresponds to "good" ground cover. This is representative of the final cover, which will have a minimum 90 percent vegetation coverage.

MOISTURE CONTENT AND FIELD CAPACITY

For a conservative analysis, the initial moisture content was set at field capacity for all profile layers except the compacted clay barrier layer and the waste layer. HELP automatically sets the initial moisture content for a compacted clay barrier layer at porosity (i.e., fully saturated). The initial moisture content for the waste layer was selected to be 25 percent for the 10-foot-thick and 50-foot-thick waste column cases. A moisture content of 25 percent is typical for recently placed waste. For the remaining cases, the initial moisture content for the waste layer was selected to be 38 percent to account for the fact that the waste will be in place for a longer period of time and the moisture content could increase.

Default values for the field capacity of each profile layer, other than the waste layer, were used. The field capacity values for the waste layer were obtained from "Retention of Free Liquids in Landfills Undergoing Vertical Expansion" (Zornberg, Jorge G., et al., 1999) and varies based on average waste column thickness. The relationship used is shown in the graph below.

VOLUMETRIC FIELD CAPACITY
AS A FUNCTION OF
WASTE DEPTH



CLIMATE DATA INPUT

Precipitation data was synthetically generated by the HELP model program using normal mean monthly precipitation data from the NOAA for DFW, Texas. The average annual precipitation over the modeled 30-year period was 34.26 inches. Temperature and solar radiation data were synthetically generated by the HELP model using program defaults for Dallas, Texas.

LANDFILL PROFILE

The landfill profiles for various stages of the landfill development are presented in the attached HELP Model summary sheets. The profile presented below includes a composite liner with a standard Subtitle D final cover system, as well as the overliner.

Liner Systems

The Subtitle D composite liner designed for developed and undeveloped cells consists of a 60-mil high-density polyethylene (HDPE) geomembrane placed over a 24-inch-thick compacted clay liner with a hydraulic conductivity of $1\text{x}10^{-7}$ cm/s. The geomembrane liner was modeled for good installation quality, with no defects or pinholes to produce the largest leachate flow rate (which is a conservative assumption because it will produce a conservative leachate head value). Default characteristics from the HELP model were selected for the HDPE geomembrane hydraulic conductivity. Default soil characteristics from the HELP model also were selected for the 24-inch-thick compacted clay liner.

The pre-Subtitle D overliner consists of a 40-mil LLDPE geomembrane and GCL. The geomembrane liner was modeled for good installation quality, with no defects or pinholes to produce the greatest head on the liner. Default soil characteristics from the HELP model were selected for the HDPE geomembrane hydraulic conductivity. The geomembrane will be placed on a GCL with a permeability of $5\text{x}10^{-9}$ cm/s.

Leachate Collection System

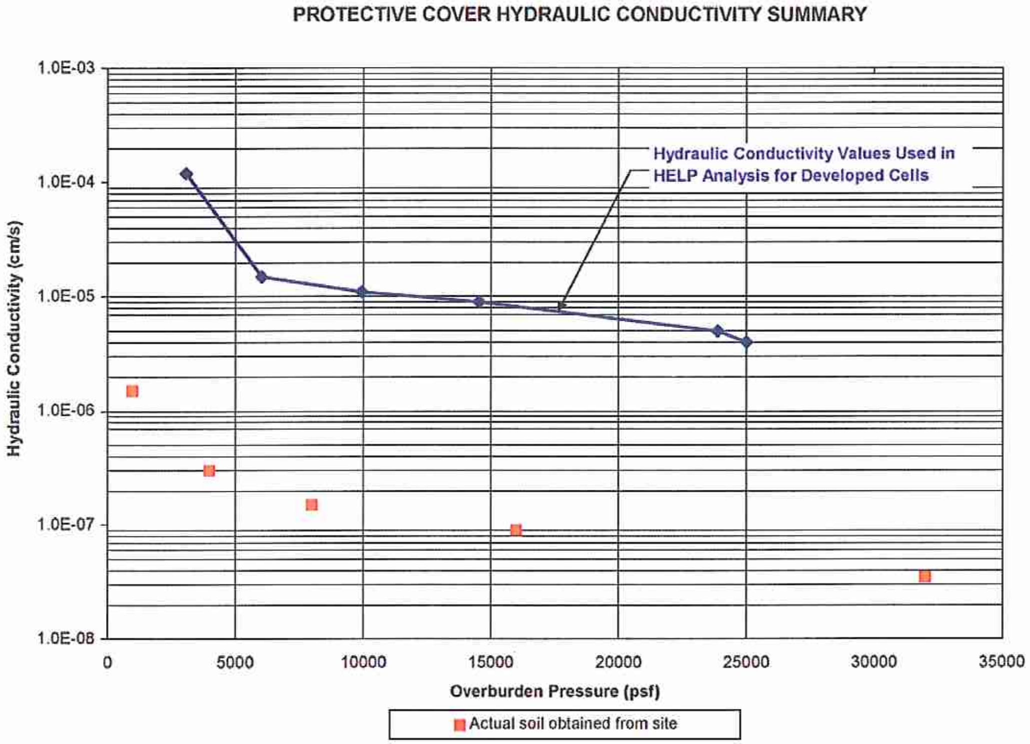
The developed Subtitle D LCS includes a drainage geocomposite collection layer consisting of a 200 mil geonet heat bonded to an overlying 8 oz/sy non-woven geotextile (single-sided for Cells 1 and 2 and double-sided for Cells 4B and 5). The geocomposite is 250 mil geonet heat bonded to an overlying 6 oz/sy non-woven geotextile for undeveloped cells (single-sided on floor grades and double-sided on sideslopes). The calculations for determining the hydraulic conductivity of the geocomposite are shown on pages IIIC-A-7 through IIIC-A-18. In HELP model demonstrations 10 percent recirculation is used for the undeveloped cells (leachate will not be recirculated over pre-Subtitle D areas). This is a conservative assumption since that recirculation will only occur at the working face, which will move on a daily basis. For example, the HELP Model analysis is based on a 1-acre "unit" area. As discussed in Section 5.2, recirculation will only occur at the working face. Therefore, the area that receives additional leachate due to recirculation is limited to the working face area which constantly moves within the area defined by the waste fill footprint. As a result, the majority of the time most of the waste footprint area does not experience any recirculation, and for the purpose of this analysis it is assumed that the "unit" acre will experience recirculation 10 percent of the time (this is a conservative assumption given that the site currently recirculates almost all the leachate that is produced). Refer to Appendix IIIC, Section 5.2 for specific guidance regarding leachate recirculation. Consistent with Subtitle D regulations, leachate will only be recirculated over areas underlain by a Subtitle D compliant liner system that is consistent with 30 TAC §330.331(b).

The pre-Subtitle D overliner LCS includes a drainage geocomposite collection layer consisting of a 300-mil geonet heat bonded on both sides with a 6 oz/sy non-woven geotextile. The calculations for determining the hydraulic conductivity of the geocomposite are shown on pages III-C-A-19 through IIIC-A-22.

Protective Cover

The undeveloped Subtitle D and pre-Subtitle D overliner protective cover consists of a 24-inch-thick layer of soil placed over the leachate collection system. The hydraulic conductivity of the protective cover was modeled as $1.2\text{x}10^{-4}$ cm/s. The hydraulic conductivity of $1.2\text{x}10^{-4}$ cm/s was used to provide a conservative analysis. The hydraulic conductivity of the protective cover layer is expected to decrease as the overburden pressure increases.

For the developed cells, a range of hydraulic conductivity values was used based on the following graph.



The graph showing the relationship between the hydraulic conductivity and overburden pressure for the soil protective cover was developed based on laboratory tests performed on a composite soil sample obtained from the site. These soils have been utilized and are expected to be utilized for the liner construction events. The composite sample was created by mixing the soils recovered from the site's future excavation areas at depths between 6 feet and 30 feet below ground surface.

The samples were first consolidated at 1,000 psf, 4,000 psf, 8,000 psf, 16,000 psf, and 32,000 psf normal stresses. Falling-head hydraulic conductivity tests were run on the consolidated soil samples. The figure above shows the change of protective cover hydraulic conductivity under varying over burden pressures. As shown on the figure, even under low overburden pressure, the hydraulic conductivity of the proposed cover is well below the hydraulic conductivity values used for the HELP model demonstrations. As the waste column thickness increases, the additional overburden pressure decreases the hydraulic conductivity of the protective cover.

The reduced hydraulic conductivity of the protective cover results in reduced flux of leachate into the leachate collection system, thus the hydraulic head on the liner is expected to be lower than what is estimated in the HELP Model using the hydraulic conductivities shown on the graph for the soil protective cover. As noted in Appendix IIIC-B, the chimney drains installed over the leachate collection pipes provide a passage for the leachate that may be retained above soil protective cover. As designed, the chimney drains convey the entire leachate flow to the leachate collection pipe in the event that the protective cover does not transmit leachate.

Waste Layers

Waste layers of 10, 50, 100, 150, 200, 282, 287 and 298 feet were used to represent the various stages of landfill development in the Subtitle D areas, while the pre-Subtitle D overliner areas had waste layers of 10, 50, 100, 150, and 188 feet. A default wilting point was selected from HELP to represent municipal solid waste. The waste column was split into two layers. The top 125-foot layer was modeled with a hydraulic conductivity of 1×10^{-3} cm/s. A lower hydraulic conductivity of 1×10^{-4} cm/s was used for the bottom layer because the additional overburden pressure will cause additional consolidation to this layer that will likely lower the hydraulic conductivity. The moisture content, field capacity, and porosity values were selected as discussed previously.

Intermediate Cover

The intermediate cover consists of a 12-inch-thick layer of soil placed over the waste. Default soil characteristics were selected from HELP to represent the available onsite soils.

Final Cover

The final cover over the Subtitle D and pre-Subtitle D areas consists of a 24-inch erosion layer with the top 6 inches capable of sustaining growth of vegetation, a geocomposite drainage layer (to be conservative this layer is not considered in HELP modeling), a 40-mil LLDPE geomembrane liner, and an 18-inch infiltration layer. The geomembrane liner was modeled for good installation quality, 4 construction defects per acre, and a pinhole density of 1 hole per acre. The infiltration layer consists of compacted soil with a hydraulic conductivity of 1×10^{-5} cm/sec.

HELP MODEL OUTPUT

The HELP summary table and output files for the various stages of the landfill development are presented on pages IIIC-A-27 through IIIC-A-236.

CAMELOT LANDFILL
1339-351-11-02
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
DEVELOPED SUBTITLE D AREAS (CELLS 1 AND 2)

Required:

Estimate the properties of the 200 mil geocomposite leachate collection layer for the developed Subtitle D cells (1and 2).

Method:

1. Determine the 200 mil geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the 200 mil thick double-sided geocomposite collection layer.
4. Compute the transmissivity of the 200 mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

CAMELOT LANDFILL
1339-351-11-02
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
DEVELOPED SUBTITLE D AREAS (CELLS 1 AND 2)

Solution:

1. Geocomposite Leachate Collection Layer Thickness:

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (200 mil)= 0.20 in
Unit Weight of Soil = 115 pcf

Table 1 - Geocomposite Thickness (200 mil) for Cells 1 and 2

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Interim - 50'	50	3	55	3,095	0.174	0.004
Interim - 100'	100	3	57	6,045	0.164	0.004
Interim - 150'	150	3	64	9,945	0.154	0.004
Interim - 200'	200	3	71	14,545	0.128	0.003
Interim - 282'	282	3	78	22,341	0.120	0.003
Closed	282	6.5	78	22,744	0.119	0.003

[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, overliner foundation, and final cover) above the geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below adapted from Reference 4.

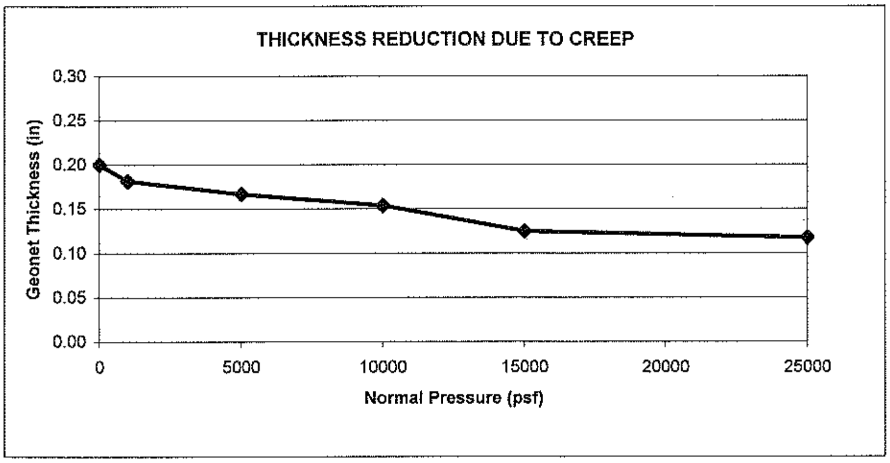


Table 2 - Reduction Factors and Factor of Safety

		Fill Condition					
		Interim (50' Waste)	Interim (100' Waste)	Interim (150' Waste)	Interim (200' Waste)	Interim (282' Waste)	Closed Final Cover
Reduction Factors[1]							
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.5	1.6	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.1	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.82	1.94	2.38	2.51	2.86

Overall Factor of Safety to Account For Uncertainties	2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]	2.20	3.63	3.87	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Transmissivity Data

The transmissivity for the 200-mil-thick single sided geocomposite with 8 oz/sy is shown on Sheet IIIC-A-23.

4. Compute the Transmissivity (T) of the Geocomposite Leachate Collection Layer:

Table 3 - Estimate the As-built Transmissivity (200 mil and 8 oz/sy for Cells 1 and 2)

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	3,095	0.174	1.15E-03	2.20	5.23E-04	11.83
Interim - 100'	100	6,045	0.164	8.54E-04	3.63	2.35E-04	5.65
Interim - 150'	150	9,945	0.154	7.02E-04	3.87	1.81E-04	4.63
Interim - 200'	200	14,545	0.128	6.08E-04	4.75	1.28E-04	3.94
Interim - 282'	282	22,341	0.120	4.50E-04	5.02	8.97E-05	2.94
Closed	282	22,744	0.119	4.42E-04	5.72	7.73E-05	2.56

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Table 1.

[3] t is the calculated geocomposite leachate collection layer thickness from Table 1 for 200 mil drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer (200-mil-thick geonet and 8 oz/sy polypropylene geotextile) as shown on Sheet IIIC-A-23.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

CAMELOT LANDFILL
1339-351-11-02
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
DEVELOPED SUBTITLE D AREAS (CELLS 4B AND 5)

Required:

Estimate the properties of the 200 mil geocomposite leachate collection layer for the developed Subtitle D cells (4B and 5).

Method:

1. Determine the 200 mil geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the 200 mil thick double-sided geocomposite collection layer.
4. Compute the transmissivity of the 200 mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

<u>Solution:</u>

I. <u>Geocomposite Leachate Collection Layer Thickness:</u>

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (200 mil)= 0.20 in
Unit Weight of Soil = 115 pcf

Table 1 - Geocomposite Thickness (200 mil) for Sectors 4B, and 5

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Interim - 50'	50	3	55	3,095	0.174	0.004
Interim - 100'	100	3	57	6,045	0.164	0.004
Interim - 150'	150	3	64	9,945	0.154	0.004
Interim - 200'	200	3	71	14,545	0.128	0.003
Interim - 298'	298	3	79	23,887	0.118	0.003
Closed	298	6.5	79	24,290	0.118	0.003

[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, overliner foundation, and final cover) above the geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below adapted from Reference 4.

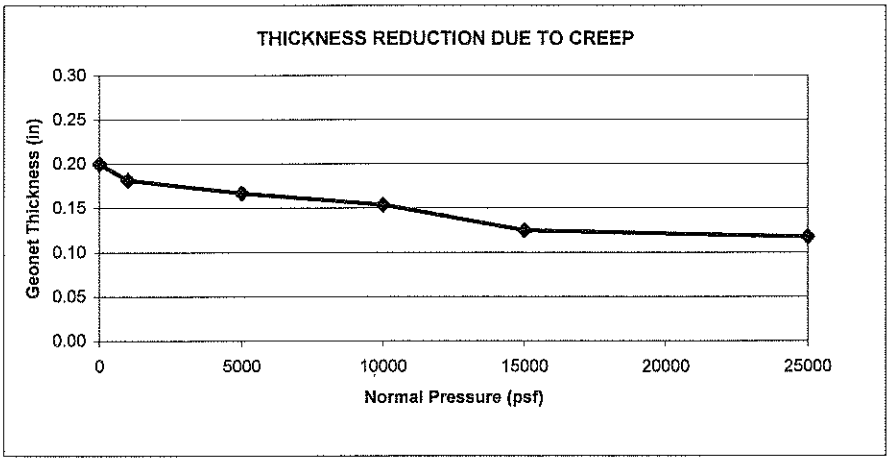


Table 2 - Reduction Factors and Factor of Safety

		Fill Condition					
Reduction Factors[1]		Interim (50' Waste)	Interim (100' Waste)	Interim (150' Waste)	Interim (200' Waste)	Interim (298' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.5	1.6	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.1	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.82	1.94	2.38	2.51	2.86

Overall Factor of Safety to Account For Uncertainties	2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]	2.20	3.63	3.87	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Transmissivity Data

The transmissivity for the 200-mil-thick double sided geocomposite with 8 oz/sy is shown on Sheet IIIC-A-24.

4. Compute the Transmissivity (T) of the Geocomposite Leachate Collection Layer:

Table 3 - Estimate the As-built Transmissivity (200 mil and 8 oz/sy for Sectors 4B, 5)

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	3,095	0.174	2.30E-04	2.20	1.05E-04	2.37
Interim - 100'	100	6,045	0.164	1.49E-04	3.63	4.10E-05	0.99
Interim - 150'	150	9,945	0.154	9.06E-05	3.87	2.34E-05	0.60
Interim - 200'	200	14,545	0.128	8.54E-05	4.75	1.80E-05	0.55
Interim - 298'	298	23,887	0.118	7.57E-05	5.02	1.51E-05	0.50
Closed	298	24,290	0.118	7.54E-05	5.72	1.32E-05	0.44

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Table 1.

[3] t is the calculated geocomposite leachate collection layer thickness from Table 1 for 200 mil drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer (200-mil-thick geonet and 8 oz/sy polypropylene geotextile) as shown on Sheet IIIC-A-24.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

CAMELOT LANDFILL
1339-351-11-02
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
UNDEVELOPED SUBTITLE D AREAS

Required:

Determine the minimum requirements of the 250 mil geocomposite leachate collection layer for the undeveloped Subtitle D sectors.

Method:

1. Determine the 250 mil geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum required transmissivity for the 250 mil thick single-sided geocomposite collection layer.
4. Compute the design transmissivity of the 250 mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.
5. Specify the geocomposite properties for the leachate collection layer.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Geocomposite Leachate Collection Layer Thickness:

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (250 mil)=	0.25	in
Unit Weight of Soil =	115	pcf

Table 1 - Geocomposite Thickness (250 mil) for Undeveloped Areas

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Active - 10'	10	2	55	780	0.232	0.006
Interim - 50'	50	3	55	3,095	0.217	0.006
Interim - 100'	100	3	57	6,045	0.205	0.005
Interim - 200'	200	3	71	14,545	0.160	0.004
Interim - 287'	287	3	79	23,018	0.149	0.004
Closed	287	6.5	79	23,421	0.149	0.004

[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover and final cover) above the geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below adapted from Reference 4.

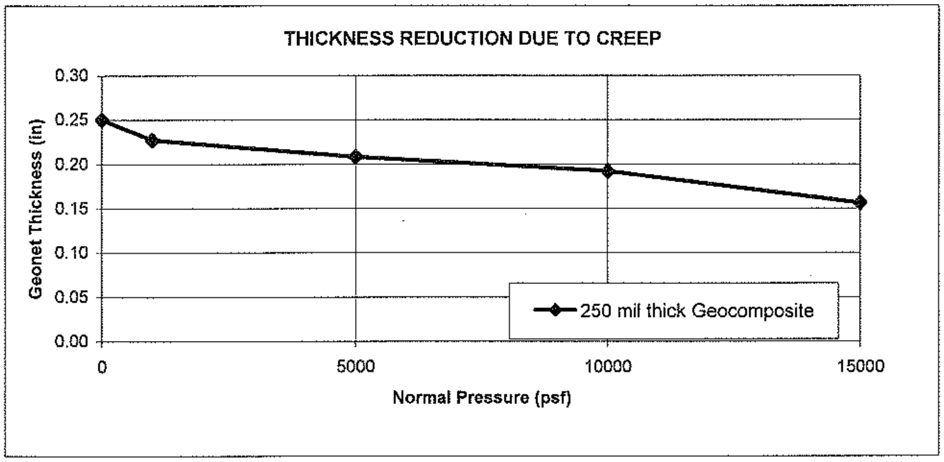


Table 2 - Reduction Factors and Factor of Safety

		Fill Condition					
Reduction Factors[1]		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (287' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.38	2.51	2.86

Overall Factor of Safety to Account For Uncertainties	2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]	2.20	3.15	3.96	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Transmissivity Data

The required minimum transmissivity for the 250-mil-thick single sided geocomposite with 6 oz/sy is shown on Sheet IIIC-A-25.

4. Compute the Design Transmissivity (T) of the Geocomposite Leachate Collection Layer:

Table 3 - Calculate the Required Transmissivity (250 mil and 6oz/sy for Undeveloped Area)

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active	10	780	0.232	4.07E-03	2.20	1.85E-03	31.38
Interim - 50'	50	3,095	0.217	3.40E-03	3.15	1.08E-03	19.63
Interim - 100'	100	6,045	0.205	2.71E-03	3.96	6.85E-04	13.15
Interim - 200'	200	14,545	0.160	1.54E-03	4.75	3.24E-04	7.97
Interim - 287'	287	23,018	0.149	1.02E-03	5.02	2.03E-04	5.37
Closed	287	23,421	0.149	9.94E-04	5.72	1.74E-04	4.59

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Table 1.

[3] t is the calculated geocomposite leachate collection layer thickness from Table 1 for 250 mil drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer (250-mil-thick geonet and 6 oz/sy polypropylene geotextile) as shown on Sheet IIIC-A-25.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

5. Specify drainage geocomposite properties for undeveloped areas

As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the graph shown on IIIC-A-24 will provide a drainage layer that will maintain less than twelve inches of head on the liner system.

The drainage geocomposite required transmissivity values will be measured at a gradient of 0.009 under normal pressures of 1,000, 15,000 and 23,421 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours and will be run for the first 100,000 square feet of liner construction. For each additional 100,000 square feet of single-sided geocomposite placement area, one additional transmissivity test will be run under the minimum normal stress (i.e., 23,421 psf) with all the same assumptions as the first three tests. The minimum transmissivity will be 9.94 x10^{-4} m^2/s.

CAMELOT LANDFILL
1339-351-11-02
OVERLINER GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES

Required:

Determine the minimum requirements of the 300 mil geocomposite overliner leachate collection layer.

Method:

1. Determine the 300-mil geocomposite overliner leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum required transmissivity for the 300 mil thick double-sided geocomposite overliner leachate collection layer.
4. Compute the design transmissivity of the 300 mil geocomposite overliner leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.
5. Specify the geocomposite properties for the overliner leachate collection layer.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Overliner Geocomposite Leachate Collection Layer Thickness:

Assume the overliner geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (300 mil)=	0.30	in
Unit Weight of Soil =	115	pcf

Table 1 - Overliner Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (psf)	P[4] (psf)	t[5] (in)	t[5] (m)
Active - 10'	10	2	55	780	0.300	0.008
Interim - 50'	50	3	55	3,095	0.291	0.007
Interim - 100'	100	3	57	6,045	0.279	0.007
Interim - 150'	150	3	64	9,945	0.262	0.007
Interim - 188'	188	3	69	13,317	0.247	0.006
Closed	188	6.5	69	13,720	0.246	0.006

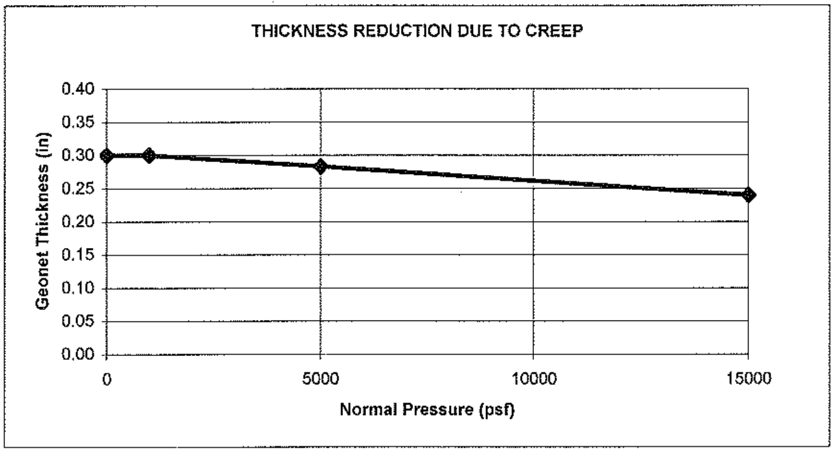
[1] d_W is the depth of waste and daily cover soil above the overliner geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, or final cover) above the overliner geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the overliner geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the overliner geocomposite leachate collection layer after being subjected to compression based on the following chart adapted from Reference 4.



2. Reduction Factors and Factor of Safety for Strength and Environmental Conditions

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (150' Waste)	Interim (188' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.38	2.51	2.86

Overall Factor of Safety to Account For Uncertainties	2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]	2.20	3.15	3.96	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Transmissivity Data

The required minimum transmissivity for the 300-mil-thick double-sided geocomposite is shown on Sheet IIIC-A-26.

4. Compute the Design Transmissivity (T) of the Overliner Geocomposite Leachate Collection Layer:

Table 3 - Required Transmissivity for Overliner

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7,8] (cm/s)
Active - 10'	10	780	0.300	6.82E-03	2.20	3.10E-03	40.65
Interim - 50'	50	3,095	0.291	6.07E-03	3.15	1.93E-03	26.10
Interim - 100'	100	6,045	0.279	5.24E-03	3.96	1.32E-03	18.70
Interim - 150'	150	9,945	0.262	4.31E-03	4.75	9.07E-04	13.65
Interim - 188'	188	13,317	0.247	2.91E-03	5.02	5.79E-04	9.22
Closed	188	13,720	0.246	2.77E-03	5.72	4.84E-04	7.77

[1] d_W is the depth of waste above the overliner geocomposite leachate collection layer.

[2] P is the pressure on the overliner geocomposite leachate collection layer due to the weight of the waste and soil from Table 1.

[3] t is the calculated overliner geocomposite leachate collection layer thickness from Table 1 for a 300 mil drainage geocomposite.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer (6 oz/sy polypropylene geotextile with 300-mil-thick geonet) as shown on Sheet IIIC-A-26.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

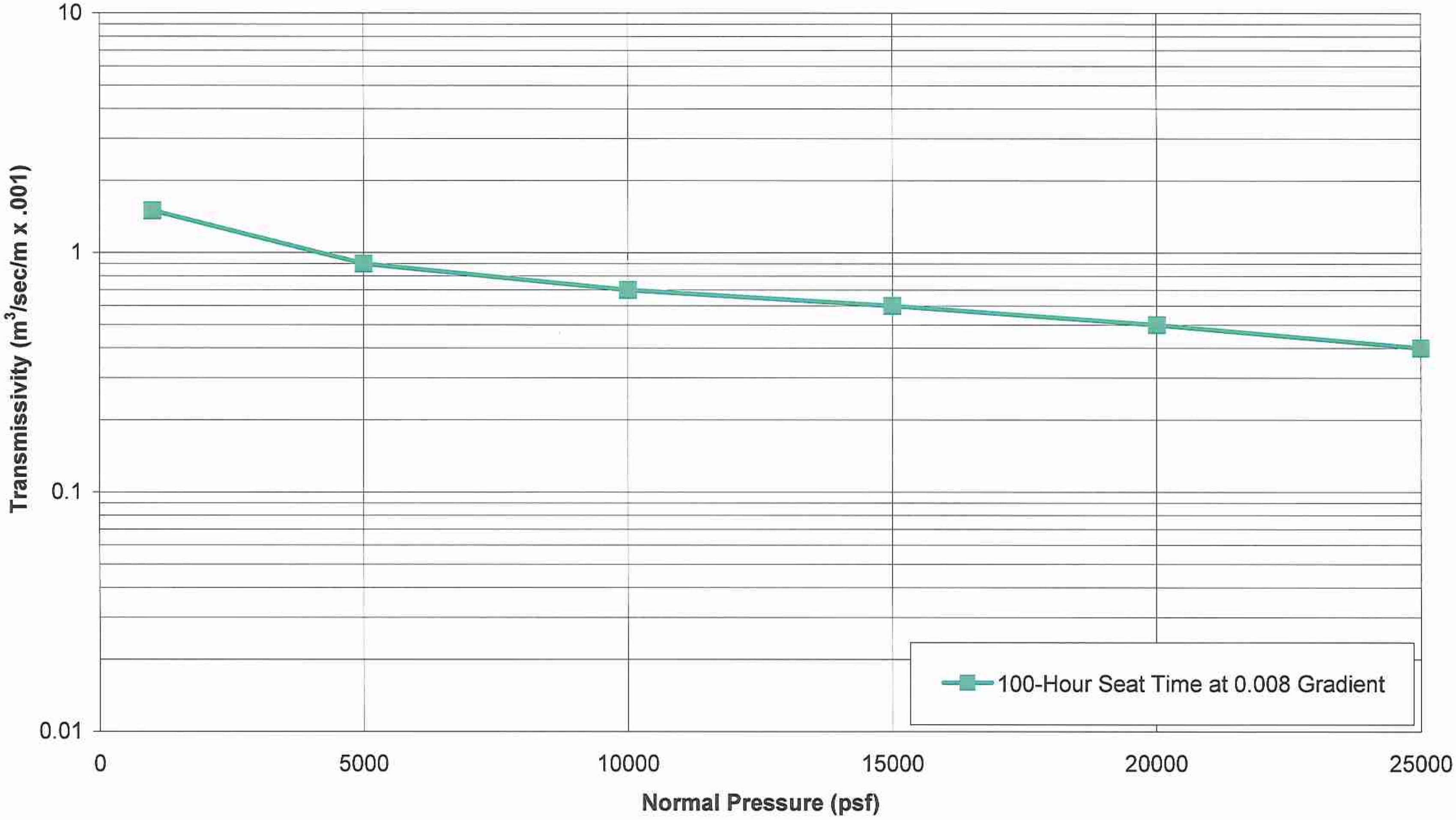
[8] The calculated hydraulic conductivity values for the 300 mil geocomposite are used in the overliner HELP Model demonstration for the fill conditions shown in this table.

5. Specify drainage geocomposite properties for undeveloped areas.

As shown on the HELP model summary sheet, a geocomposite with characteristics similar to the graphs shown on IIIC-A-25 will provide a drainage layer that will maintain less than twelve inches of head on the liner system.

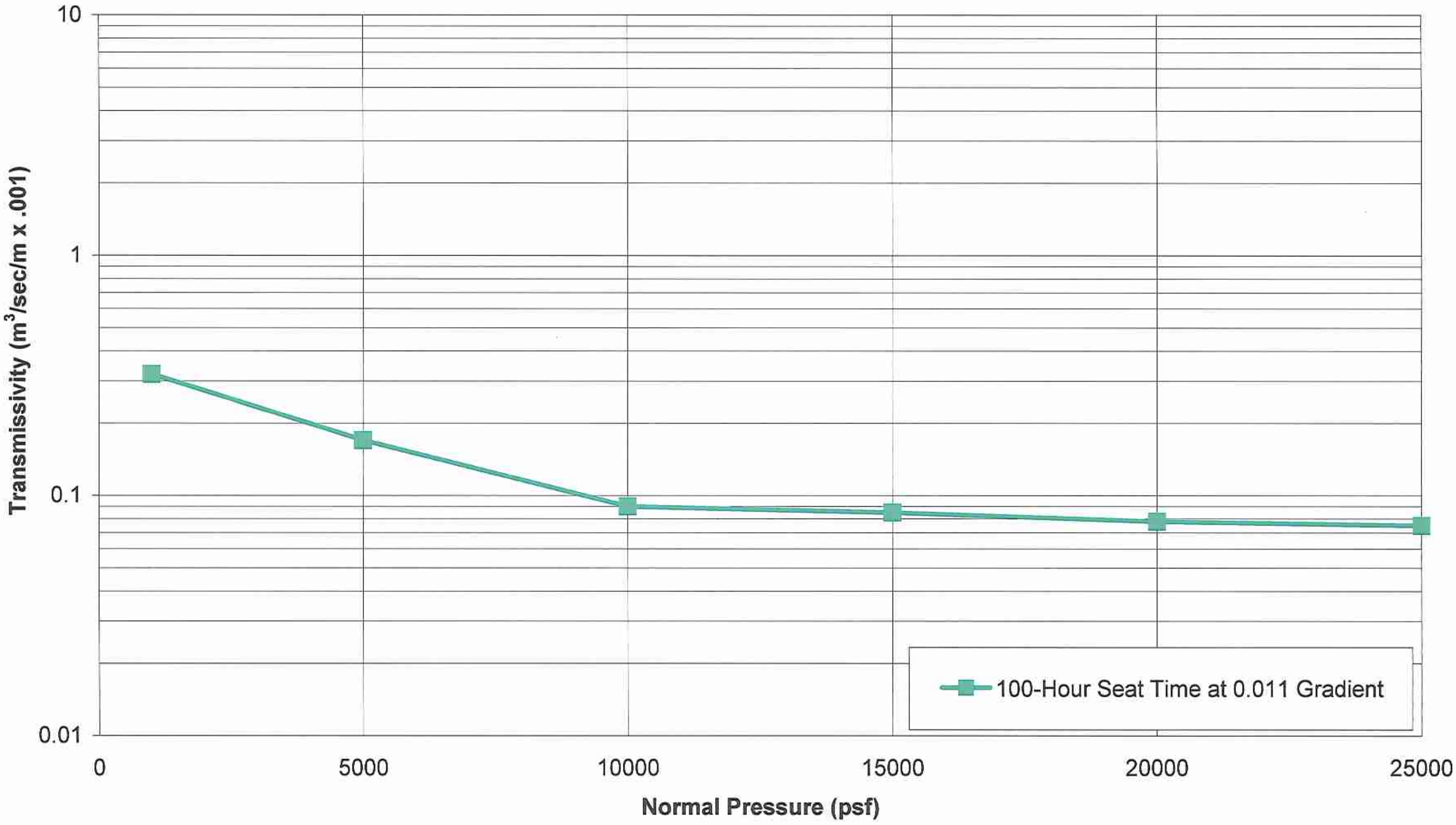
The transmissivity of the overliner double-sided geocomposite will be measured at a minimum gradient of 0.01 under a minimum normal pressure of 1,000, 10,000 and 13,720 (or higher) psf, boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours. The minimum transmissivity will be 2.77×10^{-3} m^2/s. For each additional 100,000 square feet liner geocomposite placement area, one additional transmissivity test will be run under the minimum normal stress of 13,720 psf with all the same assumptions as the first three tests.

TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE
8 oz/sy Polypropylene Geotextile with 200 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



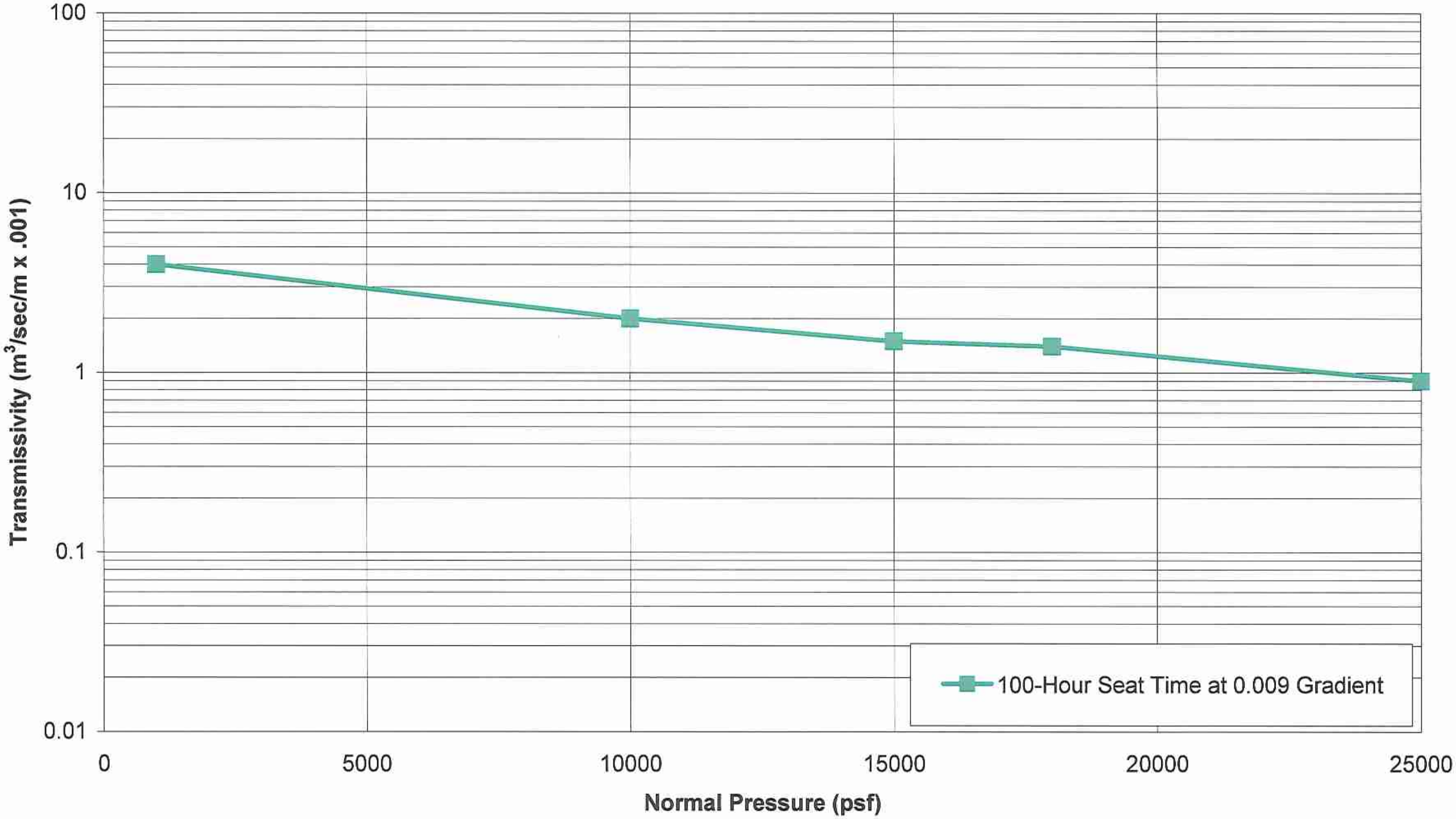
TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE

8 oz/sy Polypropylene Geotextile with 200 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



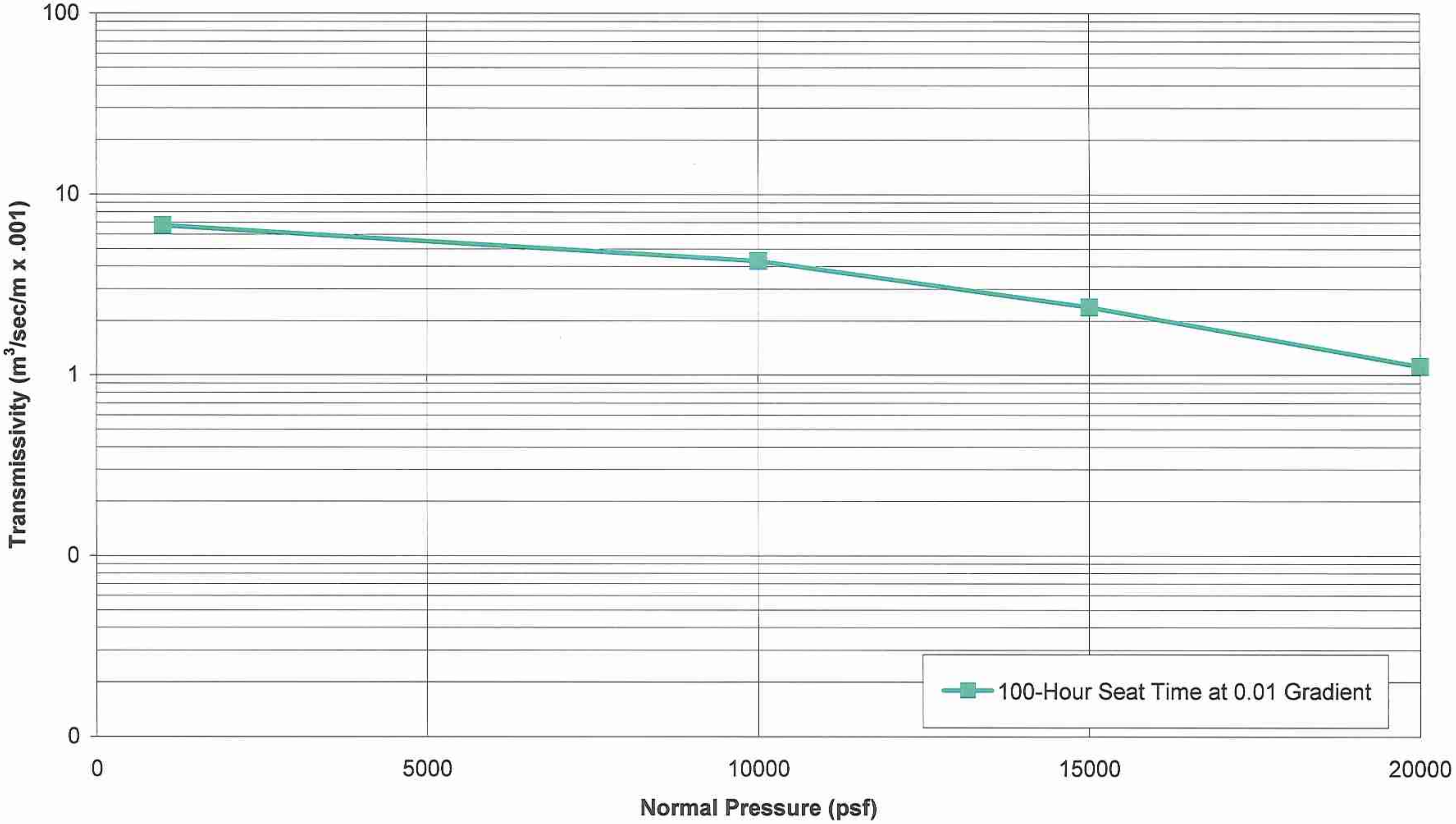
TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE

6 oz/sy Polypropylene Geotextile with 250 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE

6 oz/sy Polypropylene Geotextile with 300 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



Prep By: JLG
Date: 2/29/2012

Chkd By: mDm
Date: 3.20.12

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY SHEET
DEVELOPED SUBTITLE D AREA (CELLS 1 AND 2)

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (150 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (282 FT WASTE)	CLOSED (282 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	5	10	15	10	5	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	87.1	87.1	87.1	87.1	88.1	82.4
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	70	70	80	80	90	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	18
TOPSOIL	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						18
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-05
INTERMEDIATE	Thickness (in)	12	12	12	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	600	1200	1500	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6247	0.6148	0.6148	0.6148	0.6148
	Field Capacity (vol/vol)	0.5185	0.5144	0.5114	0.5114	0.5114	0.5114
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			300	900	1884	1884
(Texture = 0)	Porosity (vol/vol)			0.5539	0.5337	0.5007	0.5007
	Field Capacity (vol/vol)			0.4945	0.4886	0.4793	0.4793
	Wilting Point (vol/vol)			0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.5E-05	1.1E-05	9.0E-06	5.7E-06	5.5E-06
LEACHATE	Thickness (in)	0.174	0.164	0.154	0.128	0.120	0.119
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	11.83	5.65	4.63	3.94	2.94	2.56
	Slope[1] (%)	1.1	1.1	1.1	1.1	1.1	1.1
	Slope Length (ft)	220	220	220	220	220	220
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	38.98	36.80	35.60	36.80	38.98	34.26
RUNOFF	Average Annual (in)	3.26	1.98	2.50	2.25	4.52	3.96
EVAPOTRANSPIRATION	Average Annual (in)	25.31	27.01	25.51	27.03	25.21	30.03
LATERAL	Average Annual (cf/year)	1,601.6	3,862.2	2,651.2	2,484.3	1,935.7	2,035.8
DRAINAGE COLLECTED	Peak Daily (cf/day)	32.7	26.7	15.0	11.5	9.9	8.9
HEAD ON LINER	Average Annual (in)	0.000	0.002	0.002	0.002	0.002	0.002
	Peak Daily (in)	0.005	0.009	0.006	0.006	0.006	0.007

[1] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the developed area presented in Appendix IIIJ-B.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

Prep By: JLG
Date: 2/29/2012

Chkd By: mDm
Date: 3.20.12

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY SHEET
DEVELOPED SUBTITLE D AREA (CELLS 4B, 5)

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (150 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (298 FT WASTE)	CLOSED (298 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	5	10	15	10	5	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	87.1	87.1	87.1	87.1	86.7	80.1
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	70	70	80	80	90	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	18
TOPSOIL	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						18
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-05
INTERMEDIATE	Thickness (in)	12	12	12	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	600	1200	1500	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6247	0.6148	0.6148	0.6148	0.6148
	Field Capacity (vol/vol)	0.5185	0.5144	0.5114	0.5114	0.5114	0.5114
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			300	900	2076	2076
(Texture = 0)	Porosity (vol/vol)			0.5539	0.5337	0.4941	0.4941
	Field Capacity (vol/vol)			0.4945	0.4886	0.4775	0.4775
	Wilting Point (vol/vol)			0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.5E-05	1.1E-05	9.0E-06	5.0E-06	4.6E-06
LEACHATE	Thickness (in)	0.174	0.164	0.154	0.128	0.118	0.118
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	2.37	0.99	0.60	0.55	0.50	0.44
	Slope[1] (%)	1.1	1.1	1.1	1.1	1.1	1.1
	Slope Length (ft)	855	855	855	855	855	855
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	38.98	36.80	35.60	36.80	38.98	34.26
RUNOFF	Average Annual (in)	3.26	1.98	2.50	2.25	3.84	3.77
EVAPOTRANSPIRATION	Average Annual (in)	25.31	27.01	25.51	27.03	25.19	30.22
LATERAL	Average Annual (cf/year)	1,579.2	3,852.1	2,639.1	2,470.6	1,661.7	1,743.3
DRAINAGE COLLECTED	Peak Daily (cf/day)	25.8	21.2	11.1	8.8	6.6	6.3
HEAD ON LINER	Average Annual (in)	0.007	0.040	0.045	0.046	0.034	0.041
	Peak Daily (in)	0.083	0.160	0.138	0.121	0.100	0.107

[1] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the developed area presented in Appendix IIIJ-B.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

Prep By: JLG
Date: 2/28/2012

Chkd By: mDm
Date: 7·20·12

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY
UNDEVELOPED AREA

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (287 FT WASTE)	CLOSED (287 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	1	10	15	10	5	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	87.1	87.1	87.1	86.7	80.1
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	0	70	80	80	90	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	18
TOPSOIL	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						18
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-05
INTERMEDIATE	Thickness (in)		12	12	12	12	12
COVER	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	120	600	1200	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6376	0.6247	0.6148	0.6148	0.6148
	Field Capacity (vol/vol)	0.5185	0.5185	0.5144	0.5114	0.5114	0.5114
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.2500	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)				900	1944	1944
(Texture = 0)	Porosity (vol/vol)				0.5337	0.4985	0.4985
	Field Capacity (vol/vol)				0.4886	0.4790	0.4790
	Wilting Point (vol/vol)				0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)				0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)				1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.232	0.217	0.205	0.160	0.149	0.149
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	31.38	19.63	13.15	7.97	5.37	4.59
	Slope[1] (%)	0.9	0.9	0.9	0.9	0.9	0.9
	Slope Length (ft)	350	350	350	350	350	350
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	45.93	36.80	35.60	36.80	38.98	34.26
RUNOFF	Average Annual (in)	0.00	1.98	2.50	2.25	3.84	3.77
EVAPOTRANSPIRATION	Average Annual (in)	32.90	27.01	25.51	27.03	25.19	30.22
LATERAL	Average Annual (cf/year)	2,873.2	4,559.7	23,742.8	20,879.6	34,033.5	21,609.7
DRAINAGE COLLECTED[3]	Peak Daily (cf/day)	36.9	66.4	147.9	104.0	154.1	170.5
LATERAL	Average Annual (cf/year)	0.0	506.6	2,638.1	2,320.0	3,781.5	0.0
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	0.0	7.4	16.4	11.6	17.1	0.0
HEAD ON LINER	Average Annual (in)	0.000	0.001	0.010	0.015	0.036	0.024
	Peak Daily (in)	0.005	0.014	0.047	0.054	0.119	0.138

[1] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the undeveloped area presented in Appendix IIIJ-B.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

[3] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

Prep By: JLG
Date: 2/28/2012

Chkd By: MDM
Date: 3.20.12

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY SHEET
OVERLINER DESIGN

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (150 FT WASTE)	INTERIM (188 FT WASTE)	CLOSED (188 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	1	10	15	10	5	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	87.1	87.1	87.1	86.7	80.1
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	0	70	80	80	90	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	18
TOPSOIL	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						18
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-05
INTERMEDIATE	Thickness (in)		12	12	12	12	12
COVER	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	120	600	1200	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6376	0.6247	0.6148	0.6148	0.6148
	Field Capacity (vol/vol)	0.5185	0.5185	0.5144	0.5114	0.5114	0.5114
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.2500	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)				300	756	756
(Texture = 0)	Porosity (vol/vol)				0.5539	0.5387	0.5387
	Field Capacity (vol/vol)				0.4945	0.4900	0.4900
	Wilting Point (vol/vol)				0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)				0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)				1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.300	0.291	0.279	0.262	0.247	0.246
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	40.65	26.10	18.70	13.65	9.22	7.77
	Slope[1] (%)	1	1	1	1	1	1
	Slope Length (ft)	700	700	700	700	700	700
FLEXIBLE	Thickness (in)	0.04	0.04	0.04	0.04	0.04	0.04
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 36)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
GEOSYNTHETIC	Thickness (in)	0.25	0.25	0.25	0.25	0.25	0.25
CLAY LINER	Porosity (vol/vol)	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500
(Texture = 0)	Field Capacity (vol/vol)	0.7470	0.7470	0.7470	0.7470	0.7470	0.7470
	Wilting Point (vol/vol)	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
	Init. Moisture Content (vol/vol)	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500
	Hyd. Conductivity (cm/s)	5.0E-09	5.0E-09	5.0E-09	5.0E-09	5.0E-09	5.0E-09
PRECIPITATION	Average Annual (in)	45.93	36.80	35.60	36.80	38.98	34.26
RUNOFF	Average Annual (in)	0.00	1.98	2.50	2.25	3.84	3.77
EVAPOTRANSPIRATION	Average Annual (in)	32.32	26.99	25.51	27.03	25.19	30.22
LATERAL	Average Annual (cf/year)	3,503.0	4,961.5	25,113.2	19,406.4	23,103.6	14,207.5
DRAINAGE COLLECTED	Peak Daily (cf/day)	50.0	72.8	151.8	89.9	104.2	102.4
HEAD ON LINER	Average Annual (in)	0.001	0.002	0.013	0.013	0.023	0.017
	Peak Daily (in)	0.012	0.018	0.055	0.045	0.077	0.089

[1] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the overliner presented in Appendix IIIJ-B.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

HELP MODELS FOR CELLS 1 AND 2

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    d:\DATA4.D4
TEMPERATURE DATA FILE:      d:\DATA7.D7
SOLAR RADIATION DATA FILE:  d:\DATA13.D13
EVAPOTRANSPIRATION DATA:    d:\DATA11.D11
SOIL AND DESIGN DATA FILE:  d:\DATA10.D10
OUTPUT DATA FILE:           d:\I50.OUT


TIME:  14:41     DATE:  11/ 7/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELL 1 AND 2 INTERIM 50'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                   =      12.00   INCHES
           POROSITY                    =       0.4640 VOL/VOL
           FIELD CAPACITY              =       0.3100 VOL/VOL
           WILTING POINT               =       0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT  =       0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                        LAYER  2
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          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    600.00   INCHES
POROSITY                    =      0.6376 VOL/VOL
FIELD CAPACITY              =      0.5185 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  4
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.17   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.   =   11.8299999000     CM/SEC
SLOPE                       =      1.10   PERCENT
DRAINAGE LENGTH             =    220.0    FEET


                        LAYER  5
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            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   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   =      0.00   HOLES/ACRE
          FML PLACEMENT QUALITY      =  3 - GOOD


                                  LAYER  6
                                  --------

                         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 #11 WITH A
                  FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
                  AND A SLOPE LENGTH OF  200. FEET.

       SCS RUNOFF CURVE NUMBER            =     87.10
       FRACTION OF AREA ALLOWING RUNOFF   =     70.0    PERCENT
       AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
       EVAPORATIVE ZONE DEPTH             =     10.0    INCHES
       INITIAL WATER IN EVAPORATIVE ZONE  =      3.100  INCHES
       UPPER LIMIT OF EVAPORATIVE STORAGE =      4.640  INCHES
       LOWER LIMIT OF EVAPORATIVE STORAGE =      1.870  INCHES
       INITIAL SNOW WATER                 =      0.000  INCHES
       INITIAL WATER IN LAYER MATERIALS   =    169.826  INCHES
       TOTAL INITIAL WATER                =    169.826  INCHES
       TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR


                      EVAPOTRANSPIRATION AND WEATHER DATA
                      -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  DALLAS                TEXAS

            STATION LATITUDE                       =  32.85 DEGREES
```

```
        MAXIMUM LEAF AREA INDEX                 =   2.00
        START OF GROWING SEASON (JULIAN DATE)   =     63
        END OF GROWING SEASON (JULIAN DATE)     =    329
        EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
        AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DALLAS              TEXAS

             NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    1.90        2.37        3.06        3.20        5.15        3.23
    2.12        2.03        2.42        4.11        2.57        2.57


    NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DALLAS              TEXAS

        NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   44.10       49.40       57.40       65.00       73.10       80.90
   85.00       84.40       77.50       67.20       55.10       46.70


    NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    DALLAS              TEXAS
               AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

    AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------

                      JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                      -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS              1.19     2.92     2.56     3.32     5.03     3.09
                        3.21     2.21     2.74     5.78     3.54     3.38
```

```
    STD. DEVIATIONS          0.70      1.06      1.38      2.23      3.28      2.03
                             2.38      1.68      1.48      3.85      2.95      2.55

  RUNOFF
  ------
    TOTALS                   0.000     0.076     0.099     0.206     0.558     0.180
                             0.582     0.108     0.095     0.836     0.407     0.115

    STD. DEVIATIONS          0.000     0.040     0.148     0.238     0.896     0.169
                             0.816     0.110     0.132     1.099     0.606     0.137

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                   1.472     2.017     2.456     2.550     2.565     2.930
                             1.629     1.734     2.201     2.438     1.661     1.659

    STD. DEVIATIONS          0.350     0.712     0.937     1.106     1.280     1.079
                             0.779     1.379     1.278     1.028     0.692     0.641

  LATERAL DRAINAGE COLLECTED FROM LAYER  4
  ----------------------------------------
    TOTALS                   0.0313    0.0271    0.0329    0.0326    0.0330    0.0324
                             0.0358    0.0386    0.0316    0.0406    0.0426    0.0627

    STD. DEVIATIONS          0.0701    0.0606    0.0736    0.0728    0.0739    0.0725
                             0.0800    0.0862    0.0707    0.0908    0.0758    0.0897

  PERCOLATION/LEAKAGE THROUGH LAYER  6
  ------------------------------------
    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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES                 0.0003    0.0003    0.0003    0.0003    0.0003    0.0003
                             0.0003    0.0004    0.0003    0.0004    0.0004    0.0006

    STD. DEVIATIONS          0.0007    0.0006    0.0007    0.0007    0.0007    0.0007
                             0.0008    0.0008    0.0007    0.0009    0.0008    0.0009

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------
```

```
                                 INCHES            CU. FEET      PERCENT
                          -------------------   -------------   ---------
PRECIPITATION               38.98    (   7.188)    141490.1     100.00

RUNOFF                       3.261   (  1.0329)     11837.35      8.366

EVAPOTRANSPIRATION          25.310   (  3.0580)     91877.08     64.935

LATERAL DRAINAGE COLLECTED   0.44121 (  0.90106)     1601.609    1.13196
  FROM LAYER  4

PERCOLATION/LEAKAGE THROUGH  0.00000 (  0.00000)        0.002    0.00000
  LAYER  6

AVERAGE HEAD ON TOP          0.000 (    0.001)
  OF LAYER  5

CHANGE IN WATER STORAGE      9.965   (  3.5680)     36174.11     25.567

*******************************************************************************
```

```
******************************************************************************

            PEAK DAILY VALUES FOR YEARS    6 THROUGH   10
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              4.72         17133.600

      RUNOFF                                     1.738         6310.6831

      DRAINAGE COLLECTED FROM LAYER  4           0.00902         32.74840

      PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00002

      AVERAGE HEAD ON TOP OF LAYER  5            0.003

      MAXIMUM HEAD ON TOP OF LAYER  5            0.005

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)                3.9 FEET

      SNOW WATER                                 0.86          3135.2500


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4640

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1870


       ***  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    10
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1           3.7197          0.3100

                      2         199.6272          0.3327

                      3           6.0545          0.2523

                      4           0.0029          0.0165

                      5           0.0000          0.0000

                      6          10.2480          0.4270

                  SNOW WATER      0.000

*******************************************************************************
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```

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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP 307\CAM\1AND2\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP 307\CAM\1AND2\I100\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAM\1AND2\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP 307\CAM\1AND2\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAM\1AND2\I100\DATA10.D10
OUTPUT DATA FILE:            C:\HELP 307\CAM\1AND2\I100\I100.OUT


TIME:   7:56     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELLS 1 AND 2 INTERIM 100'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                     =      12.00   INCHES
           POROSITY                      =       0.4640 VOL/VOL
           FIELD CAPACITY                =       0.3100 VOL/VOL
           WILTING POINT                 =       0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT    =       0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                         LAYER  2
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =   1200.00   INCHES
POROSITY                      =      0.6247 VOL/VOL
FIELD CAPACITY                =      0.5144 VOL/VOL
WILTING POINT                 =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.3980 VOL/VOL
FIELD CAPACITY                =      0.2440 VOL/VOL
WILTING POINT                 =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.149999996000E-04 CM/SEC


                         LAYER  4
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      0.16   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.     =   5.65000010000      CM/SEC
SLOPE                         =      1.10   PERCENT
DRAINAGE LENGTH               =    220.0    FEET


                         LAYER  5
                         --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                     =      0.06   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       =      0.00   HOLES/ACRE
          FML PLACEMENT QUALITY          =  3 - GOOD


                                  LAYER  6
                                  --------

                         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 #11 WITH A
                 FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
                 AND A SLOPE LENGTH OF  200. FEET.

       SCS RUNOFF CURVE NUMBER            =     87.10
       FRACTION OF AREA ALLOWING RUNOFF   =     70.0     PERCENT
       AREA PROJECTED ON HORIZONTAL PLANE =      1.000   ACRES
       EVAPORATIVE ZONE DEPTH             =     10.0     INCHES
       INITIAL WATER IN EVAPORATIVE ZONE  =      3.100   INCHES
       UPPER LIMIT OF EVAPORATIVE STORAGE =      4.640   INCHES
       LOWER LIMIT OF EVAPORATIVE STORAGE =      1.870   INCHES
       INITIAL SNOW WATER                 =      0.000   INCHES
       INITIAL WATER IN LAYER MATERIALS   =    475.826   INCHES
       TOTAL INITIAL WATER                =    475.826   INCHES
       TOTAL SUBSURFACE INFLOW            =      0.00    INCHES/YEAR


                    EVAPOTRANSPIRATION AND WEATHER DATA
                    -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                 DALLAS                TEXAS
```

```
            STATION LATITUDE                          =  32.85 DEGREES
            MAXIMUM LEAF AREA INDEX                   =   2.00
            START OF GROWING SEASON (JULIAN DATE)     =    63
            END OF GROWING SEASON (JULIAN DATE)       =   329
            EVAPORATIVE ZONE DEPTH                    =  10.0  INCHES
            AVERAGE ANNUAL WIND SPEED                 =  10.80 MPH
            AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  66.00 %
            AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  68.00 %
            AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  63.00 %
            AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  66.00 %


        NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DALLAS              TEXAS

                 NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
      1.90        2.37        3.06        3.20        5.15        3.23
      2.12        2.03        2.42        4.11        2.57        2.57


        NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DALLAS              TEXAS

            NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
     44.10       49.40       57.40       65.00       73.10       80.90
     85.00       84.40       77.50       67.20       55.10       46.70


        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DALLAS              TEXAS
                   AND STATION LATITUDE  =  32.85 DEGREES



*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS                  1.93     2.15     2.72     3.17     4.26     3.50
                            4.03     1.92     3.59     3.31     2.63     3.58
```

```
   STD. DEVIATIONS           1.28      1.01      1.14      1.17      2.39      2.30
                             3.13      1.41      1.53      3.11      1.73      1.82

 RUNOFF
 ------
   TOTALS                    0.027     0.084     0.052     0.070     0.284     0.270
                             0.336     0.087     0.132     0.429     0.049     0.161

   STD. DEVIATIONS           0.033     0.149     0.063     0.089     0.287     0.310
                             0.492     0.139     0.147     0.947     0.094     0.209

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    1.831     1.787     2.171     2.969     3.170     2.475
                             3.064     1.743     2.615     2.133     1.390     1.663

   STD. DEVIATIONS           0.394     0.780     0.576     1.255     1.210     1.627
                             1.457     1.215     1.236     1.279     0.652     0.491

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                    0.0972    0.0833    0.0848    0.0667    0.0897    0.0905
                             0.0816    0.0887    0.0872    0.0998    0.0999    0.0945

   STD. DEVIATIONS           0.0413    0.0364    0.0356    0.0225    0.0317    0.0332
                             0.0356    0.0351    0.0179    0.0332    0.0371    0.0241

 PERCOLATION/LEAKAGE THROUGH LAYER  6
 ------------------------------------
   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


-------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  5
 -------------------------------------
   AVERAGES                  0.0020    0.0018    0.0017    0.0014    0.0018    0.0019
                             0.0016    0.0018    0.0018    0.0020    0.0021    0.0019

   STD. DEVIATIONS           0.0008    0.0008    0.0007    0.0005    0.0006    0.0007
                             0.0007    0.0007    0.0004    0.0007    0.0008    0.0005

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
```

```
-------------------------------------------------------------------------------
                                     INCHES           CU. FEET       PERCENT
                              -------------------  -------------   ---------
 PRECIPITATION                36.80     (   4.383)     133573.1     100.00

 RUNOFF                        1.980    (  0.8397)       7188.30     5.382

 EVAPOTRANSPIRATION           27.011    (  2.9394)      98050.70    73.406

 LATERAL DRAINAGE COLLECTED    1.06395 (  0.29691)       3862.150   2.89141
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH   0.00000 (  0.00000)          0.009    0.00001
   LAYER  6

 AVERAGE HEAD ON TOP           0.002 (    0.001)
   OF LAYER  5

 CHANGE IN WATER STORAGE       6.742    (  2.5848)      24471.94    18.321
*******************************************************************************
```

```
******************************************************************************

             PEAK DAILY VALUES FOR YEARS   21 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               4.59        16661.701

      RUNOFF                                      1.735        6297.2578

      DRAINAGE COLLECTED FROM LAYER  4            0.00736        26.70811

      PERCOLATION/LEAKAGE THROUGH LAYER  6        0.000000        0.00002

      AVERAGE HEAD ON TOP OF LAYER  5             0.005

      MAXIMUM HEAD ON TOP OF LAYER  5             0.009

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)                 3.8 FEET

      SNOW WATER                                  1.29         4675.1299


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.4617

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1870


       ***  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   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            2.8678         0.2390

                      2          523.3007         0.4361

                      3            6.8214         0.2842

                      4            0.0035         0.0212

                      5            0.0000         0.0000

                      6           10.2480         0.4270

                  SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

```
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**              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               **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP 307\CAM\1AND2\I150\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP 307\CAM\1AND2\I150\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAM\1AND2\I150\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP 307\CAM\1AND2\I150\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAM\1AND2\I150\DATA10.D10
OUTPUT DATA FILE:           C:\HELP 307\CAM\1AND2\I150\I150.OUT


TIME:   8:19     DATE:   2/28/2012


*******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELLS 1 AND 2 INTERIM 150'

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                    =     12.00    INCHES
           POROSITY                     =      0.4640 VOL/VOL
           FIELD CAPACITY               =      0.3100 VOL/VOL
           WILTING POINT                =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    = 0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =   1500.00   INCHES
     POROSITY                     =      0.6148 VOL/VOL
     FIELD CAPACITY               =      0.5114 VOL/VOL
     WILTING POINT                =      0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                              LAYER  3
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =    300.00   INCHES
     POROSITY                     =      0.5539 VOL/VOL
     FIELD CAPACITY               =      0.4945 VOL/VOL
     WILTING POINT                =      0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                              LAYER  4
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =     24.00   INCHES
     POROSITY                     =      0.3980 VOL/VOL
     FIELD CAPACITY               =      0.2440 VOL/VOL
     WILTING POINT                =      0.1360 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.110000001000E-04 CM/SEC


                              LAYER  5
                              --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =      0.15   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.   =   4.63000011000     CM/SEC
        SLOPE                       =     1.10   PERCENT
        DRAINAGE LENGTH             =   220.0    FEET


                                LAYER  6
                                --------

                    TYPE 4 - FLEXIBLE MEMBRANE LINER
                      MATERIAL TEXTURE NUMBER  35
        THICKNESS                   =     0.06   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    =     0.00   HOLES/ACRE
        FML PLACEMENT QUALITY       = 3 - GOOD


                                LAYER  7
                                --------

                      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 #11 WITH A
               FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
               AND A SLOPE LENGTH OF  200. FEET.

     SCS RUNOFF CURVE NUMBER             =     87.10
     FRACTION OF AREA ALLOWING RUNOFF    =     80.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
     EVAPORATIVE ZONE DEPTH              =     10.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =      3.100  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE  =      4.640  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.870  INCHES
```

```
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    703.826  INCHES
TOTAL INITIAL WATER                  =    703.826  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DALLAS                 TEXAS

      STATION LATITUDE                        =  32.85 DEGREES
      MAXIMUM LEAF AREA INDEX                 =   2.00
      START OF GROWING SEASON (JULIAN DATE)   =     63
      END OF GROWING SEASON (JULIAN DATE)     =    329
      EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
      AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS                TEXAS

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  1.90        2.37        3.06        3.20        5.15        3.23
  2.12        2.03        2.42        4.11        2.57        2.57


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS                TEXAS

      NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 44.10       49.40       57.40       65.00       73.10       80.90
 85.00       84.40       77.50       67.20       55.10       46.70


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS                TEXAS
            AND STATION LATITUDE  =  32.85 DEGREES
```

```
******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   16 THROUGH   30
------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 1.71     2.22     2.45     3.35     4.37     3.64
                           3.65     1.61     3.28     3.60     2.37     3.34

    STD. DEVIATIONS        1.20     1.32     1.18     1.53     2.20     2.56
                           2.72     1.24     1.50     3.28     1.73     1.75

  RUNOFF
  ------
    TOTALS                 0.023    0.093    0.041    0.208    0.460    0.327
                           0.314    0.067    0.137    0.555    0.099    0.173

    STD. DEVIATIONS        0.037    0.162    0.064    0.329    0.780    0.464
                           0.477    0.137    0.160    1.096    0.196    0.251

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 1.660    1.591    2.083    2.584    3.349    2.590
                           2.982    1.436    2.586    1.794    1.248    1.610

    STD. DEVIATIONS        0.550    0.690    0.994    1.456    1.123    1.741
                           1.535    1.098    1.201    1.093    0.661    0.486

  LATERAL DRAINAGE COLLECTED FROM LAYER  5
  ----------------------------------------
    TOTALS                 0.0581   0.0561   0.0598   0.0589   0.0603   0.0622
                           0.0604   0.0616   0.0617   0.0647   0.0601   0.0665

    STD. DEVIATIONS        0.0187   0.0180   0.0179   0.0167   0.0172   0.0179
                           0.0124   0.0124   0.0103   0.0110   0.0085   0.0115

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    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


------------------------------------------------------------------------------
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  6
```

```
 -------------------------------------
   AVERAGES                  0.0014   0.0015   0.0015   0.0015   0.0015   0.0016
                             0.0015   0.0015   0.0016   0.0016   0.0015   0.0016

   STD. DEVIATIONS           0.0005   0.0005   0.0004   0.0004   0.0004   0.0005
                             0.0003   0.0003   0.0003   0.0003   0.0002   0.0003

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   16 THROUGH   30
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET      PERCENT
                                  -------------------  ------------   ---------
 PRECIPITATION                     35.60    (   4.934)    129225.6     100.00

 RUNOFF                             2.499   (  1.2777)      9071.59      7.020

 EVAPOTRANSPIRATION                25.512   (  3.2612)     92609.22     71.665

 LATERAL DRAINAGE COLLECTED         0.73037 (  0.15166)     2651.225     2.05163
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH        0.00000 (  0.00000)        0.009      0.00001
   LAYER  7

 AVERAGE HEAD ON TOP                0.002 (    0.000)
   OF LAYER  6

 CHANGE IN WATER STORAGE            6.858   (  2.4263)     24893.53     19.264
*******************************************************************************
```

```
*******************************************************************************

           PEAK DAILY VALUES FOR YEARS   16 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
     PRECIPITATION                                6.00         21780.000

     RUNOFF                                       2.948        10699.7725

     DRAINAGE COLLECTED FROM LAYER  5             0.00414         15.03596

     PERCOLATION/LEAKAGE THROUGH LAYER  7         0.000000         0.00002

     AVERAGE HEAD ON TOP OF LAYER  6              0.003

     MAXIMUM HEAD ON TOP OF LAYER  6              0.006

     LOCATION OF MAXIMUM HEAD IN LAYER  5
           (DISTANCE FROM DRAIN)                  0.0 FEET

     SNOW WATER                                   2.56          9295.1191


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4577

     MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1870


      ***  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   30
    ----------------------------------------------------------------------
                 LAYER         (INCHES)       (VOL/VOL)
                 -----         --------       ---------
                   1             2.7479         0.2290

                   2           666.0279         0.4440

                   3           120.9820         0.4033

                   4             6.6821         0.2784

                   5             0.0034         0.0219

                   6             0.0000         0.0000

                   7            10.2480         0.4270

               SNOW WATER        0.000

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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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP 307\CAM\1AND2\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP 307\CAM\1AND2\I200\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP 307\CAM\1AND2\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP 307\CAM\1AND2\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP 307\CAM\1AND2\I200\DATA10.D10
OUTPUT DATA FILE:            C:\HELP 307\CAM\1AND2\I200\I200.OUT


TIME:   8:43     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELLS 1 AND 2 INTERIM 200'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                    =      12.00    INCHES
           POROSITY                     =       0.4640 VOL/VOL
           FIELD CAPACITY               =       0.3100 VOL/VOL
           WILTING POINT                =       0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT   =       0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                     =   1500.00   INCHES
     POROSITY                      =      0.6148 VOL/VOL
     FIELD CAPACITY                =      0.5114 VOL/VOL
     WILTING POINT                 =      0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                              LAYER  3
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                     =    900.00   INCHES
     POROSITY                      =      0.5337 VOL/VOL
     FIELD CAPACITY                =      0.4886 VOL/VOL
     WILTING POINT                 =      0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-04 CM/SEC


                              LAYER  4
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                     =     24.00   INCHES
     POROSITY                      =      0.3980 VOL/VOL
     FIELD CAPACITY                =      0.2440 VOL/VOL
     WILTING POINT                 =      0.1360 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.900000032000E-05 CM/SEC


                              LAYER  5
                              --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER   0
     THICKNESS                     =      0.13   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.   =    3.94000006000     CM/SEC
   SLOPE                       =       1.10   PERCENT
   DRAINAGE LENGTH             =     220.0    FEET


                        LAYER  6
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
   THICKNESS                   =       0.06   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    =       0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =   3 - GOOD


                        LAYER  7
                        --------

                  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 #11 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
          AND A SLOPE LENGTH OF  200. FEET.

 SCS RUNOFF CURVE NUMBER            =      87.10
 FRACTION OF AREA ALLOWING RUNOFF   =      80.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE =       1.000  ACRES
 EVAPORATIVE ZONE DEPTH             =      10.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE  =       3.100  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE =       4.640  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE =       1.870  INCHES
```

```
INITIAL SNOW WATER                     =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS       =    931.825  INCHES
TOTAL INITIAL WATER                    =    931.825  INCHES
TOTAL SUBSURFACE INFLOW                =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DALLAS                TEXAS

     STATION LATITUDE                        =  32.85 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   2.00
     START OF GROWING SEASON (JULIAN DATE)   =     63
     END OF GROWING SEASON (JULIAN DATE)     =    329
     EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
     AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.90         2.37         3.06         3.20         5.15         3.23
  2.12         2.03         2.42         4.11         2.57         2.57


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 44.10        49.40        57.40        65.00        73.10        80.90
 85.00        84.40        77.50        67.20        55.10        46.70


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS
            AND STATION LATITUDE  =  32.85 DEGREES
```

```
*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                 1.93     2.15     2.72     3.17     4.26     3.50
                          4.03     1.92     3.59     3.31     2.63     3.58

   STD. DEVIATIONS        1.28     1.01     1.14     1.17     2.39     2.30
                          3.13     1.41     1.53     3.11     1.73     1.82

 RUNOFF
 ------
   TOTALS                 0.030    0.096    0.059    0.080    0.323    0.308
                          0.381    0.100    0.151    0.479    0.056    0.184

   STD. DEVIATIONS        0.038    0.171    0.071    0.102    0.326    0.355
                          0.559    0.158    0.168    1.052    0.107    0.237

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                 1.830    1.785    2.184    2.965    3.161    2.484
                          3.071    1.737    2.609    2.138    1.397    1.664

   STD. DEVIATIONS        0.393    0.777    0.581    1.251    1.207    1.637
                          1.473    1.218    1.226    1.275    0.647    0.491

 LATERAL DRAINAGE COLLECTED FROM LAYER  5
 ----------------------------------------
   TOTALS                 0.0590   0.0517   0.0556   0.0560   0.0531   0.0547
                          0.0556   0.0579   0.0583   0.0628   0.0592   0.0604

   STD. DEVIATIONS        0.0209   0.0175   0.0187   0.0187   0.0190   0.0177
                          0.0157   0.0132   0.0064   0.0059   0.0080   0.0059

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ------------------------------------
   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


-------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  6
```

```
  -------------------------------------
   AVERAGES                0.0017   0.0016   0.0016   0.0017   0.0015   0.0016
                           0.0016   0.0017   0.0017   0.0018   0.0018   0.0017

   STD. DEVIATIONS         0.0006   0.0006   0.0005   0.0006   0.0005   0.0005
                           0.0005   0.0004   0.0002   0.0002   0.0002   0.0002

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES              CU. FEET     PERCENT
                                 -------------------   -------------  ---------
 PRECIPITATION                  36.80    (   4.383)      133573.1     100.00

 RUNOFF                          2.248   (  0.9387)        8161.14      6.110

 EVAPOTRANSPIRATION             27.025   (  2.9312)       98101.46     73.444

 LATERAL DRAINAGE COLLECTED      0.68438 (  0.13606)       2484.316     1.85989
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)          0.009     0.00001
   LAYER  7

 AVERAGE HEAD ON TOP             0.002 (    0.000)
   OF LAYER  6

 CHANGE IN WATER STORAGE         6.839   (  2.4898)       24826.22     18.586
*******************************************************************************
```

```
******************************************************************************

          PEAK DAILY VALUES FOR YEARS   21 THROUGH   30
------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
  PRECIPITATION                                4.59        16661.701

  RUNOFF                                       1.884        6839.5244

  DRAINAGE COLLECTED FROM LAYER  5             0.00315        11.45214

  PERCOLATION/LEAKAGE THROUGH LAYER  7         0.000000        0.00002

  AVERAGE HEAD ON TOP OF LAYER  6              0.003

  MAXIMUM HEAD ON TOP OF LAYER  6              0.006

  LOCATION OF MAXIMUM HEAD IN LAYER  5
        (DISTANCE FROM DRAIN)                  0.0 FEET

  SNOW WATER                                   1.29         4675.1299


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4565

  MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1870


   ***  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   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            2.8603         0.2384

                      2          642.0176         0.4280

                      3          338.4471         0.3761

                      4            6.6412         0.2767

                      5            0.0028         0.0216

                      6            0.0000         0.0000

                      7           10.2480         0.4270

                  SNOW WATER       0.000

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP 307\CAM\1AND2\I282\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP 307\CAM\1AND2\I282\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP 307\CAM\1AND2\I282\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP 307\CAM\1AND2\I282\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP 307\CAM\1AND2\I282\DATA10.D10
OUTPUT DATA FILE:            C:\HELP 307\CAM\1AND2\I282\I282.OUT


TIME:   8:50     DATE:   2/28/2012


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     TITLE:  CAMELOT LANDFILL-CELLS 1 AND 2 INTERIM 282'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  11
           THICKNESS                     =     12.00    INCHES
           POROSITY                      =      0.4640 VOL/VOL
           FIELD CAPACITY                =      0.3100 VOL/VOL
           WILTING POINT                 =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =   1500.00   INCHES
POROSITY                     =      0.6148 VOL/VOL
FIELD CAPACITY               =      0.5114 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =   1884.00   INCHES
POROSITY                     =      0.5007 VOL/VOL
FIELD CAPACITY               =      0.4793 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.570000020000E-05 CM/SEC


                    LAYER  5
                    --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.12   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
```

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   INITIAL SOIL WATER CONTENT  =       0.0100 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =   2.94000006000      CM/SEC
   SLOPE                       =       1.10   PERCENT
   DRAINAGE LENGTH             =     220.0    FEET


                           LAYER  6
                           --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
   THICKNESS                   =       0.06   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    =       0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                           LAYER  7
                           --------

                  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 #11 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF 20.%
          AND A SLOPE LENGTH OF  120. FEET.

 SCS RUNOFF CURVE NUMBER            =      88.10
 FRACTION OF AREA ALLOWING RUNOFF   =      90.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE =       1.000  ACRES
 EVAPORATIVE ZONE DEPTH             =      10.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE  =       3.100  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE =       4.640  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE =       1.870  INCHES
```

```
INITIAL SNOW WATER                   =       0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    1305.745  INCHES
TOTAL INITIAL WATER                  =    1305.745  INCHES
TOTAL SUBSURFACE INFLOW              =       0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DALLAS                 TEXAS

     STATION LATITUDE                        =  32.85 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   2.00
     START OF GROWING SEASON (JULIAN DATE)   =     63
     END OF GROWING SEASON (JULIAN DATE)     =    329
     EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
     AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.90         2.37         3.06         3.20         5.15         3.23
  2.12         2.03         2.42         4.11         2.57         2.57


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 44.10        49.40        57.40        65.00        73.10        80.90
 85.00        84.40        77.50        67.20        55.10        46.70


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS
            AND STATION LATITUDE  =  32.85 DEGREES
```

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        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     6 THROUGH    10
------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                  1.19     2.92     2.56     3.32     5.03     3.09
                           3.21     2.21     2.74     5.78     3.54     3.38

   STD. DEVIATIONS         0.70     1.06     1.38     2.23     3.28     2.03
                           2.38     1.68     1.48     3.85     2.95     2.55

 RUNOFF
 ------
   TOTALS                  0.000    0.127    0.154    0.306    0.781    0.268
                           0.717    0.171    0.145    1.130    0.540    0.184

   STD. DEVIATIONS         0.000    0.066    0.215    0.340    1.202    0.246
                           0.973    0.166    0.200    1.410    0.772    0.216

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  1.477    2.007    2.453    2.568    2.562    2.888
                           1.609    1.712    2.189    2.425    1.649    1.671

   STD. DEVIATIONS         0.364    0.712    0.943    1.109    1.288    1.075
                           0.754    1.369    1.260    1.040    0.692    0.672

 LATERAL DRAINAGE COLLECTED FROM LAYER  5
 ----------------------------------------
   TOTALS                  0.0446   0.0374   0.0442   0.0442   0.0423   0.0376
                           0.0467   0.0486   0.0437   0.0447   0.0474   0.0517

   STD. DEVIATIONS         0.0255   0.0214   0.0268   0.0250   0.0213   0.0233
                           0.0217   0.0211   0.0197   0.0175   0.0084   0.0142

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ------------------------------------
   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


------------------------------------------------------------------------------
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  6
```

```
  -------------------------------------
   AVERAGES                     0.0017   0.0016   0.0017   0.0018   0.0016   0.0015
                                0.0018   0.0019   0.0018   0.0017   0.0019   0.0020

   STD. DEVIATIONS              0.0010   0.0009   0.0010   0.0010   0.0008   0.0009
                                0.0008   0.0008   0.0008   0.0007   0.0003   0.0005

*******************************************************************************


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    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET      PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                  38.98    (   7.188)    141490.1     100.00

 RUNOFF                          4.521   (  1.4578)     16411.19     11.599

 EVAPOTRANSPIRATION             25.210   (  3.0807)     91511.17     64.677

 LATERAL DRAINAGE COLLECTED      0.53325 (  0.22880)     1935.697    1.36808
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.009     0.00001
   LAYER  7

 AVERAGE HEAD ON TOP             0.002 (    0.001)
   OF LAYER  6

 CHANGE IN WATER STORAGE         8.714   (  3.2899)     31632.13     22.356

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              PEAK DAILY VALUES FOR YEARS     6 THROUGH   10
------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------    -------------
   PRECIPITATION                                4.72        17133.600

   RUNOFF                                       1.960        7115.2412

   DRAINAGE COLLECTED FROM LAYER  5             0.00273         9.92614

   PERCOLATION/LEAKAGE THROUGH LAYER  7         0.000000        0.00002

   AVERAGE HEAD ON TOP OF LAYER  6              0.003

   MAXIMUM HEAD ON TOP OF LAYER  6              0.006

   LOCATION OF MAXIMUM HEAD IN LAYER  5
         (DISTANCE FROM DRAIN)                 15.6 FEET

   SNOW WATER                                   0.86         3135.2500


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4482

   MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1870

    ***  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   10
    -----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            3.7213         0.3101

                      2          616.2353         0.4108

                      3          712.3192         0.3781

                      4            6.7883         0.2828

                      5            0.0034         0.0287

                      6            0.0000         0.0000

                      7           10.2480         0.4270

                  SNOW WATER       0.000

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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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP 307\CAM\1AND2\CLOSD\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP 307\CAM\1AND2\CLOSD\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP 307\CAM\1AND2\CLOSD\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP 307\CAM\1AND2\CLOSD\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP 307\CAM\1AND2\CLOSD\DATA10.D10
OUTPUT DATA FILE:            C:\HELP 307\CAM\1AND2\CLOSD\CLOSD.OUT


TIME:   8:53     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELLS 1 AND 2 CLOSED 282'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  10
           THICKNESS                    =     12.00    INCHES
           POROSITY                     =      0.3980 VOL/VOL
           FIELD CAPACITY               =      0.2440 VOL/VOL
           WILTING POINT                =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                           LAYER  2
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.3980 VOL/VOL
FIELD CAPACITY               =       0.2440 VOL/VOL
WILTING POINT                =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                           LAYER  3
                           --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
THICKNESS                    =       0.04    INCHES
POROSITY                     =       0.0000 VOL/VOL
FIELD CAPACITY               =       0.0000 VOL/VOL
WILTING POINT                =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                           LAYER  4
                           --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      18.00    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.    =  0.999999975000E-05 CM/SEC


                           LAYER  5
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  11
THICKNESS                    =      12.00    INCHES
```

```
          POROSITY                  =      0.4640 VOL/VOL
          FIELD CAPACITY            =      0.3100 VOL/VOL
          WILTING POINT             =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT =     0.3100 VOL/VOL
          EFFECTIVE SAT. HYD. COND. =  0.639999998000E-04 CM/SEC


                                    LAYER  6
                                    --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   0
          THICKNESS                 =    1500.00   INCHES
          POROSITY                  =      0.6148 VOL/VOL
          FIELD CAPACITY            =      0.5114 VOL/VOL
          WILTING POINT             =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT =     0.3800 VOL/VOL
          EFFECTIVE SAT. HYD. COND. =  0.100000005000E-02 CM/SEC


                                    LAYER  7
                                    --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   0
          THICKNESS                 =    1884.00   INCHES
          POROSITY                  =      0.5007 VOL/VOL
          FIELD CAPACITY            =      0.4793 VOL/VOL
          WILTING POINT             =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT =     0.3800 VOL/VOL
          EFFECTIVE SAT. HYD. COND. =  0.999999975000E-04 CM/SEC


                                    LAYER  8
                                    --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   0
          THICKNESS                 =      24.00   INCHES
          POROSITY                  =      0.3980 VOL/VOL
          FIELD CAPACITY            =      0.2440 VOL/VOL
          WILTING POINT             =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =     0.2440 VOL/VOL
          EFFECTIVE SAT. HYD. COND. =  0.550000004000E-05 CM/SEC


                                    LAYER  9
                                    --------
```

```
                  TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   0
      THICKNESS                    =       0.12   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.    =    2.55999994000      CM/SEC
      SLOPE                        =       1.10   PERCENT
      DRAINAGE LENGTH              =     220.0    FEET


                              LAYER 10
                              --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
      THICKNESS                    =       0.06   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     =       0.00   HOLES/ACRE
      FML PLACEMENT QUALITY        =  3 - GOOD


                              LAYER 11
                              --------

                    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 #10 WITH A
             GOOD STAND OF GRASS, A SURFACE SLOPE OF 20.%
             AND A SLOPE LENGTH OF  120. FEET.

   SCS RUNOFF CURVE NUMBER            =      82.40
```

```
     FRACTION OF AREA ALLOWING RUNOFF     =     100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE   =       1.000  ACRES
     EVAPORATIVE ZONE DEPTH               =      18.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE    =       4.392  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE   =       7.164  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE   =       2.448  INCHES
     INITIAL SNOW WATER                   =       0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS     =    1319.287  INCHES
     TOTAL INITIAL WATER                  =    1319.287  INCHES
     TOTAL SUBSURFACE INFLOW              =       0.00   INCHES/YEAR


                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               DALLAS                TEXAS

          STATION LATITUDE                          = 32.85 DEGREES
          MAXIMUM LEAF AREA INDEX                   =  4.50
          START OF GROWING SEASON (JULIAN DATE)     =    63
          END OF GROWING SEASON (JULIAN DATE)       =   329
          EVAPORATIVE ZONE DEPTH                    = 18.0  INCHES
          AVERAGE ANNUAL WIND SPEED                 = 10.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY     = 66.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY     = 68.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY     = 63.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY     = 66.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     1.90        2.37        3.06        3.20        5.15        3.23
     2.12        2.03        2.42        4.11        2.57        2.57


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
    44.10       49.40       57.40       65.00       73.10       80.90
    85.00       84.40       77.50       67.20       55.10       46.70
```

```
        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DALLAS              TEXAS
                   AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 1.49     2.20     2.80     3.08     4.59     3.29
                           2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS        1.02     1.27     1.67     1.89     2.17     2.13
                           2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                 0.229    0.159    0.319    0.211    0.394    0.152
                           0.170    0.027    0.039    0.863    0.520    0.881

    STD. DEVIATIONS        0.407    0.408    0.694    0.448    0.804    0.263
                           0.366    0.062    0.075    1.578    1.008    1.509

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 1.672    1.775    2.663    4.407    4.685    3.411
                           2.907    1.918    2.392    1.756    1.037    1.403

    STD. DEVIATIONS        0.410    0.586    0.944    1.001    1.848    1.911
                           1.926    1.514    1.379    0.871    0.371    0.422

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                 0.0313   0.0272   0.0304   0.0240   0.0157   0.0132
                           0.0133   0.0123   0.0119   0.0192   0.0253   0.0308

    STD. DEVIATIONS        0.0126   0.0096   0.0092   0.0080   0.0060   0.0032
                           0.0033   0.0023   0.0024   0.0101   0.0139   0.0142

  LATERAL DRAINAGE COLLECTED FROM LAYER  9
  ----------------------------------------
    TOTALS                 0.0457   0.0441   0.0476   0.0449   0.0466   0.0458
                           0.0480   0.0503   0.0438   0.0485   0.0451   0.0503

    STD. DEVIATIONS        0.0118   0.0107   0.0120   0.0103   0.0114   0.0103
                           0.0106   0.0101   0.0096   0.0111   0.0077   0.0101

  PERCOLATION/LEAKAGE THROUGH LAYER 11
```

```
 -------------------------------------
   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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
   AVERAGES              15.3355  14.6313  14.9179  12.0426   7.4335   6.3967
                          6.2349   5.7141   5.7131   9.2092  12.7119  15.0495

   STD. DEVIATIONS        6.3426   5.3131   4.6169   4.1564   3.0030   1.6034
                          1.6241   1.0930   1.1600   5.0768   7.2484   7.1537

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   AVERAGES               0.0020   0.0022   0.0021   0.0021   0.0021   0.0021
                          0.0021   0.0022   0.0020   0.0022   0.0021   0.0022

   STD. DEVIATIONS        0.0005   0.0005   0.0005   0.0005   0.0005   0.0005
                          0.0005   0.0004   0.0004   0.0005   0.0004   0.0004

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES             CU. FEET      PERCENT
                               -------------------   -------------   ---------
  PRECIPITATION                 34.26    (   6.276)    124371.1      100.00

  RUNOFF                         3.964   (  2.9031)     14390.76      11.571

  EVAPOTRANSPIRATION            30.028   (  4.1461)    109001.06      87.642

  PERCOLATION/LEAKAGE THROUGH    0.25443 (  0.06134)       923.564     0.74259
    LAYER  4

  AVERAGE HEAD ON TOP           10.449 (     2.581)
    OF LAYER  3

  LATERAL DRAINAGE COLLECTED     0.56083 (  0.09058)      2035.812    1.63689
    FROM LAYER  9

  PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)         0.009     0.00001
    LAYER 11
```

```
 AVERAGE HEAD ON TOP                0.002 (    0.000)
   OF LAYER 10

 CHANGE IN WATER STORAGE           -0.291    (  2.1683)      -1056.59     -0.850

*******************************************************************************
```

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              6.00         21780.000

      RUNOFF                                     3.429        12448.3271

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.001567         5.68974

      AVERAGE HEAD ON TOP OF LAYER  3           24.000

      DRAINAGE COLLECTED FROM LAYER  9           0.00246          8.94342

      PERCOLATION/LEAKAGE THROUGH LAYER 11       0.000000         0.00002

      AVERAGE HEAD ON TOP OF LAYER 10            0.003

      MAXIMUM HEAD ON TOP OF LAYER 10            0.007

      LOCATION OF MAXIMUM HEAD IN LAYER  9
            (DISTANCE FROM DRAIN)                0.0 FEET

      SNOW WATER                                 2.40          8713.1436


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3980

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1360


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
******************************************************************************

           FINAL WATER STORAGE AT END OF YEAR   30
      ----------------------------------------------------------------------
              LAYER          (INCHES)       (VOL/VOL)
              -----          --------       ---------
                1             2.4319          0.2027

                2             3.8842          0.3237

                3             0.0000          0.0000

                4             7.6860          0.4270

                5             3.7200          0.3100

                6           577.6328          0.3851

                7           698.2209          0.3706

                8             6.7280          0.2803

                9             0.0034          0.0282

               10             0.0000          0.0000

               11            10.2480          0.4270

            SNOW WATER        0.000

******************************************************************************
******************************************************************************
```

HELP MODELS FOR CELLS 4B AND 5

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     d:\DATA4.D4
TEMPERATURE DATA FILE:       d:\DATA7.D7
SOLAR RADIATION DATA FILE:   d:\DATA13.D13
EVAPOTRANSPIRATION DATA:     d:\DATA11.D11
SOIL AND DESIGN DATA FILE:   d:\DATA10.D10
OUTPUT DATA FILE:            d:\I50.OUT


TIME:  10:53     DATE:   3/ 1/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELL 4B AND 5 INTERIM 50'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  11
           THICKNESS                    =     12.00    INCHES
           POROSITY                     =      0.4640 VOL/VOL
           FIELD CAPACITY               =      0.3100 VOL/VOL
           WILTING POINT                =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                         LAYER  2
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =    600.00   INCHES
 POROSITY                     =      0.6376 VOL/VOL
 FIELD CAPACITY               =      0.5185 VOL/VOL
 WILTING POINT                =      0.0770 VOL/VOL
 INITIAL SOIL WATER CONTENT   =      0.2500 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =     24.00   INCHES
 POROSITY                     =      0.3980 VOL/VOL
 FIELD CAPACITY               =      0.2440 VOL/VOL
 WILTING POINT                =      0.1360 VOL/VOL
 INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                         LAYER  4
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =      0.17   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.    =   2.36999989000     CM/SEC
 SLOPE                        =      1.10   PERCENT
 DRAINAGE LENGTH              =    855.0    FEET


                         LAYER  5
                         --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
 THICKNESS                    =      0.06   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     =      0.00    HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD


                                 LAYER  6
                                 --------

                       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 #11 WITH A
                 FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
                 AND A SLOPE LENGTH OF  200. FEET.

       SCS RUNOFF CURVE NUMBER              =      87.10
       FRACTION OF AREA ALLOWING RUNOFF     =      70.0     PERCENT
       AREA PROJECTED ON HORIZONTAL PLANE   =       1.000   ACRES
       EVAPORATIVE ZONE DEPTH               =      10.0     INCHES
       INITIAL WATER IN EVAPORATIVE ZONE    =       3.100   INCHES
       UPPER LIMIT OF EVAPORATIVE STORAGE   =       4.640   INCHES
       LOWER LIMIT OF EVAPORATIVE STORAGE   =       1.870   INCHES
       INITIAL SNOW WATER                   =       0.000   INCHES
       INITIAL WATER IN LAYER MATERIALS     =     169.826   INCHES
       TOTAL INITIAL WATER                  =     169.826   INCHES
       TOTAL SUBSURFACE INFLOW              =       0.00    INCHES/YEAR


                   EVAPOTRANSPIRATION AND WEATHER DATA
                   -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                 DALLAS                   TEXAS

            STATION LATITUDE                          =  32.85 DEGREES
```

```
          MAXIMUM LEAF AREA INDEX                    =   2.00
          START OF GROWING SEASON (JULIAN DATE)      =     63
          END OF GROWING SEASON (JULIAN DATE)        =    329
          EVAPORATIVE ZONE DEPTH                     =  10.0  INCHES
          AVERAGE ANNUAL WIND SPEED                  =  10.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  66.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  68.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY      =  63.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY      =  66.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    1.90        2.37        3.06        3.20        5.15        3.23
    2.12        2.03        2.42        4.11        2.57        2.57


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   44.10       49.40       57.40       65.00       73.10       80.90
   85.00       84.40       77.50       67.20       55.10       46.70


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS
                 AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------

                             JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                             -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS                     1.19     2.92     2.56     3.32     5.03     3.09
                               3.21     2.21     2.74     5.78     3.54     3.38
```

```
   STD. DEVIATIONS         0.70     1.06     1.38     2.23     3.28     2.03
                           2.38     1.68     1.48     3.85     2.95     2.55

 RUNOFF
 ------
   TOTALS                  0.000    0.076    0.099    0.206    0.558    0.180
                           0.582    0.108    0.095    0.836    0.407    0.115

   STD. DEVIATIONS         0.000    0.040    0.148    0.238    0.896    0.169
                           0.816    0.110    0.132    1.099    0.606    0.137

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  1.472    2.017    2.456    2.550    2.565    2.930
                           1.629    1.734    2.201    2.438    1.661    1.659

   STD. DEVIATIONS         0.350    0.712    0.937    1.106    1.280    1.079
                           0.779    1.379    1.278    1.028    0.692    0.641

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                  0.0311   0.0279   0.0319   0.0317   0.0331   0.0341
                           0.0342   0.0382   0.0333   0.0389   0.0398   0.0609

   STD. DEVIATIONS         0.0696   0.0624   0.0712   0.0709   0.0741   0.0762
                           0.0764   0.0855   0.0745   0.0869   0.0751   0.0886

 PERCOLATION/LEAKAGE THROUGH LAYER  6
 ------------------------------------
   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


-------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  5
 -------------------------------------
   AVERAGES                0.0058   0.0058   0.0059   0.0061   0.0062   0.0066
                           0.0064   0.0071   0.0064   0.0073   0.0077   0.0114

   STD. DEVIATIONS         0.0130   0.0129   0.0133   0.0137   0.0138   0.0147
                           0.0143   0.0160   0.0144   0.0162   0.0145   0.0165

*******************************************************************************


*******************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------
```

```
                               INCHES             CU. FEET      PERCENT
                         -------------------   -------------   ---------
PRECIPITATION              38.98    (   7.188)    141490.1      100.00

RUNOFF                      3.261   (  1.0329)     11837.35       8.366

EVAPOTRANSPIRATION         25.310   (  3.0580)     91877.08      64.935

LATERAL DRAINAGE COLLECTED  0.43503 (  0.89857)     1579.176      1.11610
  FROM LAYER  4

PERCOLATION/LEAKAGE THROUGH 0.00000 (  0.00000)        0.002      0.00000
  LAYER  6

AVERAGE HEAD ON TOP         0.007 (    0.014)
  OF LAYER  5

CHANGE IN WATER STORAGE     9.971   (  3.5718)     36196.54      25.582

*******************************************************************************
```

```
******************************************************************************

          PEAK DAILY VALUES FOR YEARS     6 THROUGH   10
   ------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------    -------------
      PRECIPITATION                              4.72         17133.600

      RUNOFF                                     1.738         6310.6831

      DRAINAGE COLLECTED FROM LAYER  4           0.00709         25.75262

      PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00002

      AVERAGE HEAD ON TOP OF LAYER  5            0.041

      MAXIMUM HEAD ON TOP OF LAYER  5            0.083

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)                0.0 FEET

      SNOW WATER                                 0.86          3135.2500


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4640

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1870

       ***  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    10
       ----------------------------------------------------------------------

                 LAYER          (INCHES)        (VOL/VOL)
                 -----          --------        ---------

                   1              3.7197          0.3100

                   2            199.6272          0.3327

                   3              6.0545          0.2523

                   4              0.0338          0.1941

                   5              0.0000          0.0000

                   6             10.2480          0.4270

               SNOW WATER         0.000

*******************************************************************************
*******************************************************************************
```

```
*****************************************************************************
*****************************************************************************
**                                                                         **
**                                                                         **
**              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            **
**                                                                         **
**                                                                         **
*****************************************************************************
*****************************************************************************


PRECIPITATION DATA FILE:     C:\HELP 307\CAM\4BAND5\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP 307\CAM\4BAND5\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP 307\CAM\4BAND5\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP 307\CAM\4BAND5\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP 307\CAM\4BAND5\I100\DATA10.D10
OUTPUT DATA FILE:            C:\HELP 307\CAM\4BAND5\I100\I100.OUT


TIME:   7:10     DATE:   2/28/2012


*****************************************************************************

     TITLE:  CAMELOT LANDFILL-CELL 4B AND 5 INTERIM 100'

*****************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                  =     12.00    INCHES
           POROSITY                   =      0.4640 VOL/VOL
           FIELD CAPACITY             =      0.3100 VOL/VOL
           WILTING POINT              =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =   1200.00   INCHES
POROSITY                    =      0.6247 VOL/VOL
FIELD CAPACITY              =      0.5144 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.149999996000E-04 CM/SEC


                        LAYER  4
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.16   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.   =  0.990000010000     CM/SEC
SLOPE                       =      1.10   PERCENT
DRAINAGE LENGTH             =    855.0    FEET


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   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   =       0.00   HOLES/ACRE
          FML PLACEMENT QUALITY      =  3 - GOOD


                                LAYER  6
                                --------

                      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 #11 WITH A
                  FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
                  AND A SLOPE LENGTH OF  200. FEET.

        SCS RUNOFF CURVE NUMBER             =     87.10
        FRACTION OF AREA ALLOWING RUNOFF    =     70.0     PERCENT
        AREA PROJECTED ON HORIZONTAL PLANE  =      1.000   ACRES
        EVAPORATIVE ZONE DEPTH              =     10.0     INCHES
        INITIAL WATER IN EVAPORATIVE ZONE   =      3.100   INCHES
        UPPER LIMIT OF EVAPORATIVE STORAGE  =      4.640   INCHES
        LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.870   INCHES
        INITIAL SNOW WATER                  =      0.000   INCHES
        INITIAL WATER IN LAYER MATERIALS    =    475.826   INCHES
        TOTAL INITIAL WATER                 =    475.826   INCHES
        TOTAL SUBSURFACE INFLOW             =      0.00    INCHES/YEAR


                   EVAPOTRANSPIRATION AND WEATHER DATA
                   -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  DALLAS                    TEXAS

           STATION LATITUDE                        =  32.85 DEGREES
```

```
          MAXIMUM LEAF AREA INDEX                   =   2.00
          START OF GROWING SEASON (JULIAN DATE)     =     63
          END OF GROWING SEASON (JULIAN DATE)       =    329
          EVAPORATIVE ZONE DEPTH                    =  10.0  INCHES
          AVERAGE ANNUAL WIND SPEED                 =  10.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  66.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  68.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  63.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  66.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

               NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   1.90        2.37        3.06        3.20        5.15        3.23
   2.12        2.03        2.42        4.11        2.57        2.57


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   44.10       49.40       57.40       65.00       73.10       80.90
   85.00       84.40       77.50       67.20       55.10       46.70


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
               COEFFICIENTS FOR    DALLAS              TEXAS
                 AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS                1.93     2.15     2.72     3.17     4.26     3.50
                          4.03     1.92     3.59     3.31     2.63     3.58
```

```
   STD. DEVIATIONS          1.28      1.01      1.14      1.17      2.39      2.30
                            3.13      1.41      1.53      3.11      1.73      1.82

 RUNOFF
 ------
   TOTALS                   0.027     0.084     0.052     0.070     0.284     0.270
                            0.336     0.087     0.132     0.429     0.049     0.161

   STD. DEVIATIONS          0.033     0.149     0.063     0.089     0.287     0.310
                            0.492     0.139     0.147     0.947     0.094     0.209

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   1.831     1.787     2.171     2.969     3.170     2.475
                            3.064     1.743     2.615     2.133     1.390     1.663

   STD. DEVIATIONS          0.394     0.780     0.576     1.255     1.210     1.627
                            1.457     1.215     1.236     1.279     0.652     0.491

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                   0.0925    0.0862    0.0877    0.0727    0.0818    0.0887
                            0.0874    0.0841    0.0860    0.0957    0.1024    0.0961

   STD. DEVIATIONS          0.0374    0.0377    0.0335    0.0267    0.0254    0.0315
                            0.0347    0.0328    0.0233    0.0252    0.0316    0.0289

 PERCOLATION/LEAKAGE THROUGH LAYER  6
 ------------------------------------
   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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  5
 -------------------------------------
   AVERAGES                 0.0413    0.0424    0.0392    0.0335    0.0365    0.0410
                            0.0390    0.0376    0.0397    0.0427    0.0473    0.0429

   STD. DEVIATIONS          0.0167    0.0187    0.0150    0.0123    0.0113    0.0146
                            0.0155    0.0146    0.0108    0.0113    0.0146    0.0129

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------
```

```
                                     INCHES            CU. FEET       PERCENT
                               --------------------  -------------   ---------
 PRECIPITATION                  36.80    (    4.383)     133573.1     100.00

 RUNOFF                          1.980   (  0.8397)        7188.30      5.382

 EVAPOTRANSPIRATION             27.011   (  2.9394)       98050.70     73.406

 LATERAL DRAINAGE COLLECTED      1.06119 (  0.30569)       3852.113    2.88390
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)          0.009     0.00001
   LAYER  6

 AVERAGE HEAD ON TOP             0.040 (    0.012)
   OF LAYER  5

 CHANGE IN WATER STORAGE         6.744   (  2.5902)       24481.97     18.329

*******************************************************************************
```

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS   21 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              4.59         16661.701

      RUNOFF                                     1.735         6297.2578

      DRAINAGE COLLECTED FROM LAYER  4           0.00585         21.24792

      PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00003

      AVERAGE HEAD ON TOP OF LAYER  5            0.081

      MAXIMUM HEAD ON TOP OF LAYER  5            0.160

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)                9.2 FEET

      SNOW WATER                                 1.29          4675.1299


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4617

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1870


       ***  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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```

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******************************************************************************

                FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                 LAYER          (INCHES)          (VOL/VOL)
                 -----          --------          ---------
                   1              2.8678            0.2390

                   2            523.3007            0.4361

                   3              6.8214            0.2842

                   4              0.0311            0.1897

                   5              0.0000            0.0000

                   6             10.2480            0.4270

                SNOW WATER        0.000

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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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP 307\CAM\4BAND5\I150\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP 307\CAM\4BAND5\I150\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP 307\CAM\4BAND5\I150\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP 307\CAM\4BAND5\I150\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP 307\CAM\4BAND5\I150\DATA10.D10
OUTPUT DATA FILE:            C:\HELP 307\CAM\4BAND5\I150\I150.OUT


TIME:   7:25     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELLS 4B AND 5 INTERIM 150'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                  =      12.00   INCHES
           POROSITY                   =       0.4640 VOL/VOL
           FIELD CAPACITY             =       0.3100 VOL/VOL
           WILTING POINT              =       0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =   1500.00   INCHES
POROSITY                    =      0.6148 VOL/VOL
FIELD CAPACITY              =      0.5114 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    300.00   INCHES
POROSITY                    =      0.5539 VOL/VOL
FIELD CAPACITY              =      0.4945 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.110000001000E-04 CM/SEC


                        LAYER  5
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.15    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.    =  0.600000024000     CM/SEC
    SLOPE                        =      1.10   PERCENT
    DRAINAGE LENGTH              =    855.0    FEET


                             LAYER  6
                             --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
    THICKNESS                    =      0.06   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     =      0.00   HOLES/ACRE
    FML PLACEMENT QUALITY        =  3 - GOOD


                             LAYER  7
                             --------

                    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 #11 WITH A
           FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
           AND A SLOPE LENGTH OF  200. FEET.

 SCS RUNOFF CURVE NUMBER            =     87.10
 FRACTION OF AREA ALLOWING RUNOFF   =     80.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
 EVAPORATIVE ZONE DEPTH             =     10.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE  =      3.100  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE =      4.640  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE =      1.870  INCHES
```

```
        INITIAL SNOW WATER                     =        0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS       =      703.826  INCHES
        TOTAL INITIAL WATER                    =      703.826  INCHES
        TOTAL SUBSURFACE INFLOW                =        0.00   INCHES/YEAR


                    EVAPOTRANSPIRATION AND WEATHER DATA
                    -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  DALLAS                 TEXAS

              STATION LATITUDE                        =  32.85 DEGREES
              MAXIMUM LEAF AREA INDEX                 =   2.00
              START OF GROWING SEASON (JULIAN DATE)   =     63
              END OF GROWING SEASON (JULIAN DATE)     =    329
              EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
              AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
              AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
              AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
              AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
              AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS              TEXAS

                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        1.90        2.37        3.06        3.20        5.15        3.23
        2.12        2.03        2.42        4.11        2.57        2.57


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS              TEXAS

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       44.10       49.40       57.40       65.00       73.10       80.90
       85.00       84.40       77.50       67.20       55.10       46.70


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS              TEXAS
                    AND STATION LATITUDE  =  32.85 DEGREES
```

```
******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   16 THROUGH   30
------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                  1.71     2.22     2.45     3.35     4.37     3.64
                            3.65     1.61     3.28     3.60     2.37     3.34

    STD. DEVIATIONS         1.20     1.32     1.18     1.53     2.20     2.56
                            2.72     1.24     1.50     3.28     1.73     1.75

  RUNOFF
  ------
    TOTALS                  0.023    0.093    0.041    0.208    0.460    0.327
                            0.314    0.067    0.137    0.555    0.099    0.173

    STD. DEVIATIONS         0.037    0.162    0.064    0.329    0.780    0.464
                            0.477    0.137    0.160    1.096    0.196    0.251

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                  1.660    1.591    2.083    2.584    3.349    2.590
                            2.982    1.436    2.586    1.794    1.248    1.610

    STD. DEVIATIONS         0.550    0.690    0.994    1.456    1.123    1.741
                            1.535    1.098    1.201    1.093    0.661    0.486

  LATERAL DRAINAGE COLLECTED FROM LAYER  5
  ----------------------------------------
    TOTALS                  0.0589   0.0546   0.0606   0.0584   0.0599   0.0608
                            0.0617   0.0615   0.0600   0.0644   0.0614   0.0646

    STD. DEVIATIONS         0.0188   0.0166   0.0188   0.0169   0.0164   0.0170
                            0.0146   0.0114   0.0096   0.0106   0.0093   0.0095

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    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


------------------------------------------------------------------------------
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  6
```

```
 ------------------------------------
   AVERAGES                 0.0435   0.0442   0.0447   0.0445   0.0442   0.0463
                            0.0455   0.0453   0.0457   0.0475   0.0468   0.0476

   STD. DEVIATIONS          0.0139   0.0134   0.0138   0.0129   0.0121   0.0130
                            0.0108   0.0084   0.0073   0.0078   0.0071   0.0070

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   16 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET     PERCENT
                                -------------------   -------------  ---------
 PRECIPITATION                   35.60    (   4.934)    129225.6     100.00

 RUNOFF                           2.499   (  1.2777)      9071.59      7.020

 EVAPOTRANSPIRATION              25.512   (  3.2612)     92609.22     71.665

 LATERAL DRAINAGE COLLECTED       0.72702 (  0.15680)     2639.091     2.04224
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)        0.009     0.00001
   LAYER  7

 AVERAGE HEAD ON TOP              0.045 (     0.010)
   OF LAYER  6

 CHANGE IN WATER STORAGE          6.861   (  2.4244)     24905.68     19.273
*******************************************************************************
```

```
*******************************************************************************

             PEAK DAILY VALUES FOR YEARS   16 THROUGH   30
    --------------------------------------------------------------------------
                                                  (INCHES)      (CU. FT.)
                                                 ----------    -------------
     PRECIPITATION                                  6.00         21780.000

     RUNOFF                                         2.948        10699.7725

     DRAINAGE COLLECTED FROM LAYER  5               0.00306         11.10699

     PERCOLATION/LEAKAGE THROUGH LAYER  7           0.000000         0.00003

     AVERAGE HEAD ON TOP OF LAYER  6                0.070

     MAXIMUM HEAD ON TOP OF LAYER  6                0.138

     LOCATION OF MAXIMUM HEAD IN LAYER  5
           (DISTANCE FROM DRAIN)                    9.7 FEET

     SNOW WATER                                     2.56          9295.1191


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4577

     MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.1870


      ***  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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```

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********************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            2.7479         0.2290

                      2          666.0279         0.4440

                      3          120.9820         0.4033

                      4            6.6821         0.2784

                      5            0.0535         0.3476

                      6            0.0000         0.0000

                      7           10.2480         0.4270

                  SNOW WATER       0.000

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```

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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP 307\CAM\4BAND5\I200\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP 307\CAM\4BAND5\I200\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAM\4BAND5\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP 307\CAM\4BAND5\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAM\4BAND5\I200\DATA10.D10
OUTPUT DATA FILE:           C:\HELP 307\CAM\4BAND5\I200\I200.OUT


TIME:   7:29     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELLS 4B AND 5 INTERIM 200'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4640 VOL/VOL
          FIELD CAPACITY               =      0.3100 VOL/VOL
          WILTING POINT                =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                         LAYER  2
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =   1500.00    INCHES
POROSITY                     =      0.6148 VOL/VOL
FIELD CAPACITY               =      0.5114 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    900.00    INCHES
POROSITY                     =      0.5337 VOL/VOL
FIELD CAPACITY               =      0.4886 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                         LAYER  4
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00    INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.900000032000E-05 CM/SEC


                         LAYER  5
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.13    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.    =  0.550000012000     CM/SEC
            SLOPE                        =     1.10   PERCENT
            DRAINAGE LENGTH              =   855.0    FEET


                                   LAYER  6
                                   --------

                      TYPE 4 - FLEXIBLE MEMBRANE LINER
                        MATERIAL TEXTURE NUMBER  35
            THICKNESS                    =     0.06   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     =     0.00   HOLES/ACRE
            FML PLACEMENT QUALITY        =  3 - GOOD


                                   LAYER  7
                                   --------

                        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 #11 WITH A
                    FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
                    AND A SLOPE LENGTH OF  200. FEET.

          SCS RUNOFF CURVE NUMBER              =     87.10
          FRACTION OF AREA ALLOWING RUNOFF     =     80.0    PERCENT
          AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
          EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
          INITIAL WATER IN EVAPORATIVE ZONE    =      3.100  INCHES
          UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.640  INCHES
          LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.870  INCHES
```

```
INITIAL SNOW WATER                    =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS      =    931.825  INCHES
TOTAL INITIAL WATER                   =    931.825  INCHES
TOTAL SUBSURFACE INFLOW               =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DALLAS                 TEXAS

      STATION LATITUDE                           =  32.85 DEGREES
      MAXIMUM LEAF AREA INDEX                    =   2.00
      START OF GROWING SEASON (JULIAN DATE)      =     63
      END OF GROWING SEASON (JULIAN DATE)        =    329
      EVAPORATIVE ZONE DEPTH                     =  10.0  INCHES
      AVERAGE ANNUAL WIND SPEED                  =  10.80 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  66.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  68.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY      =  63.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY      =  66.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.90         2.37         3.06         3.20         5.15         3.23
  2.12         2.03         2.42         4.11         2.57         2.57


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS

      NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 44.10        49.40        57.40        65.00        73.10        80.90
 85.00        84.40        77.50        67.20        55.10        46.70


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS              TEXAS
            AND STATION LATITUDE  =  32.85 DEGREES
```

```
********************************************************************************

       AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   21 THROUGH   30
--------------------------------------------------------------------------------

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                1.93     2.15     2.72     3.17     4.26     3.50
                          4.03     1.92     3.59     3.31     2.63     3.58

    STD. DEVIATIONS       1.28     1.01     1.14     1.17     2.39     2.30
                          3.13     1.41     1.53     3.11     1.73     1.82

  RUNOFF
  ------
    TOTALS                0.030    0.096    0.059    0.080    0.323    0.308
                          0.381    0.100    0.151    0.479    0.056    0.184

    STD. DEVIATIONS       0.038    0.171    0.071    0.102    0.326    0.355
                          0.559    0.158    0.168    1.052    0.107    0.237

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                1.830    1.785    2.184    2.965    3.161    2.484
                          3.071    1.737    2.609    2.138    1.397    1.664

    STD. DEVIATIONS       0.393    0.777    0.581    1.251    1.207    1.637
                          1.473    1.218    1.226    1.275    0.647    0.491

  LATERAL DRAINAGE COLLECTED FROM LAYER  5
  ----------------------------------------
    TOTALS                0.0565   0.0527   0.0569   0.0549   0.0547   0.0541
                          0.0555   0.0565   0.0574   0.0607   0.0602   0.0604

    STD. DEVIATIONS       0.0202   0.0180   0.0185   0.0177   0.0192   0.0171
                          0.0167   0.0137   0.0093   0.0050   0.0063   0.0055

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    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

--------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
--------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  6
```

```
  -------------------------------------
    AVERAGES                0.0455   0.0466   0.0458   0.0456   0.0440   0.0450
                            0.0447   0.0454   0.0477   0.0488   0.0500   0.0486

    STD. DEVIATIONS         0.0162   0.0159   0.0149   0.0147   0.0154   0.0142
                            0.0134   0.0110   0.0077   0.0041   0.0052   0.0044

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------
                                        INCHES            CU. FEET     PERCENT
                                   ------------------  ------------  ---------
  PRECIPITATION                    36.80    (   4.383)    133573.1    100.00

  RUNOFF                            2.248   (  0.9387)      8161.14     6.110

  EVAPOTRANSPIRATION               27.025   (  2.9312)     98101.46    73.444

  LATERAL DRAINAGE COLLECTED        0.68061 (  0.14952)     2470.615    1.84964
    FROM LAYER  5

  PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)        0.009    0.00001
    LAYER  7

  AVERAGE HEAD ON TOP               0.046 (    0.010)
    OF LAYER  6

  CHANGE IN WATER STORAGE           6.843   (  2.4914)     24839.93    18.597
*******************************************************************************
```

```
*******************************************************************************

             PEAK DAILY VALUES FOR YEARS   21 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               4.59        16661.701

      RUNOFF                                      1.884        6839.5244

      DRAINAGE COLLECTED FROM LAYER  5            0.00243         8.80945

      PERCOLATION/LEAKAGE THROUGH LAYER  7        0.000000        0.00002

      AVERAGE HEAD ON TOP OF LAYER  6             0.061

      MAXIMUM HEAD ON TOP OF LAYER  6             0.121

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)                 0.1 FEET

      SNOW WATER                                  1.29         4675.1299


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.4565

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1870


       ***  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   30
      ----------------------------------------------------------------------
               LAYER          (INCHES)         (VOL/VOL)
               -----          --------         ---------
                 1             2.8603           0.2384

                 2           642.0176           0.4280

                 3           338.4471           0.3761

                 4             6.6412           0.2767

                 5             0.0405           0.3163

                 6             0.0000           0.0000

                 7            10.2480           0.4270

             SNOW WATER        0.000

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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP 307\CAM\4BAND5\I298\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP 307\CAM\4BAND5\I298\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAM\4BAND5\I298\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP 307\CAM\4BAND5\I298\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAM\4BAND5\I298\DATA10.D10
OUTPUT DATA FILE:           C:\HELP 307\CAM\4BAND5\I298\I298.OUT


TIME:   7:34     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELLS 4B AND 5 INTERIM 298'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  11
           THICKNESS                 =     12.00   INCHES
           POROSITY                  =      0.4640 VOL/VOL
           FIELD CAPACITY            =      0.3100 VOL/VOL
           WILTING POINT             =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT  =    0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =   1500.00   INCHES
POROSITY                    =      0.6148 VOL/VOL
FIELD CAPACITY              =      0.5114 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =   2076.00   INCHES
POROSITY                    =      0.4941 VOL/VOL
FIELD CAPACITY              =      0.4775 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999987000E-05 CM/SEC


                        LAYER  5
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.12   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.     =  0.500000000000      CM/SEC
      SLOPE                         =       1.10    PERCENT
      DRAINAGE LENGTH               =     855.0     FEET


                                   LAYER  6
                                   --------

                         TYPE 4 - FLEXIBLE MEMBRANE LINER
                           MATERIAL TEXTURE NUMBER  35
      THICKNESS                     =       0.06    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      =       0.00    HOLES/ACRE
      FML PLACEMENT QUALITY         =  3 - GOOD


                                   LAYER  7
                                   --------

                           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 #11 WITH A
             FAIR STAND OF GRASS, A SURFACE SLOPE OF  4.%
             AND A SLOPE LENGTH OF  500. FEET.

   SCS RUNOFF CURVE NUMBER              =      86.70
   FRACTION OF AREA ALLOWING RUNOFF     =      90.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE   =       1.000  ACRES
   EVAPORATIVE ZONE DEPTH               =      10.0    INCHES
   INITIAL WATER IN EVAPORATIVE ZONE    =       3.100  INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE   =       4.640  INCHES
   LOWER LIMIT OF EVAPORATIVE STORAGE   =       1.870  INCHES
```

```
      INITIAL SNOW WATER                   =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS     =   1378.705  INCHES
      TOTAL INITIAL WATER                  =   1378.705  INCHES
      TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


                  EVAPOTRANSPIRATION AND WEATHER DATA
                  -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DALLAS                 TEXAS

           STATION LATITUDE                       =  32.85 DEGREES
           MAXIMUM LEAF AREA INDEX                =   2.00
           START OF GROWING SEASON (JULIAN DATE)  =     63
           END OF GROWING SEASON (JULIAN DATE)    =    329
           EVAPORATIVE ZONE DEPTH                 =  10.0  INCHES
           AVERAGE ANNUAL WIND SPEED              =  10.80 MPH
           AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  66.00 %
           AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  68.00 %
           AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  63.00 %
           AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  66.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS                TEXAS

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     1.90        2.37        3.06        3.20        5.15        3.23
     2.12        2.03        2.42        4.11        2.57        2.57


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS                TEXAS

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
    44.10       49.40       57.40       65.00       73.10       80.90
    85.00       84.40       77.50       67.20       55.10       46.70


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS                TEXAS
                  AND STATION LATITUDE  =  32.85 DEGREES
```

```
*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 1.19     2.92     2.56     3.32     5.03     3.09
                           3.21     2.21     2.74     5.78     3.54     3.38

    STD. DEVIATIONS        0.70     1.06     1.38     2.23     3.28     2.03
                           2.38     1.68     1.48     3.85     2.95     2.55

  RUNOFF
  ------
    TOTALS                 0.000    0.087    0.118    0.252    0.682    0.213
                           0.667    0.127    0.112    0.977    0.474    0.134

    STD. DEVIATIONS        0.000    0.047    0.181    0.294    1.106    0.200
                           0.925    0.132    0.155    1.267    0.697    0.160

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 1.473    2.016    2.397    2.581    2.527    2.908
                           1.612    1.724    2.207    2.428    1.656    1.662

    STD. DEVIATIONS        0.351    0.710    0.968    1.152    1.287    1.081
                           0.751    1.364    1.288    1.022    0.691    0.646

  LATERAL DRAINAGE COLLECTED FROM LAYER  5
  ----------------------------------------
    TOTALS                 0.0334   0.0326   0.0367   0.0367   0.0400   0.0378
                           0.0396   0.0378   0.0384   0.0411   0.0416   0.0421

    STD. DEVIATIONS        0.0213   0.0205   0.0196   0.0191   0.0220   0.0196
                           0.0199   0.0202   0.0190   0.0170   0.0124   0.0089

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    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

-------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  6
```

```
 -------------------------------------
   AVERAGES                0.0296   0.0316   0.0324   0.0336   0.0353   0.0346
                           0.0350   0.0334   0.0351   0.0364   0.0381   0.0372

   STD. DEVIATIONS         0.0188   0.0197   0.0174   0.0174   0.0195   0.0179
                           0.0176   0.0179   0.0173   0.0150   0.0114   0.0079

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET     PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    38.98     (   7.188)    141490.1    100.00

 RUNOFF                            3.843    (  1.2223)     13950.84     9.860

 EVAPOTRANSPIRATION               25.190    (  3.1191)     91438.16    64.625

 LATERAL DRAINAGE COLLECTED        0.45778 (  0.21027)      1661.743    1.17446
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)         0.009    0.00001
   LAYER  7

 AVERAGE HEAD ON TOP               0.034 (    0.016)
   OF LAYER  6

 CHANGE IN WATER STORAGE           9.487    (  3.4977)     34439.36    24.340
*******************************************************************************
```

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS     6 THROUGH   10
          ------------------------------------------------------------------------
                                                    (INCHES)      (CU. FT.)
                                                   ----------    -------------
   PRECIPITATION                                     4.72         17133.600

   RUNOFF                                            1.917         6957.3447

   DRAINAGE COLLECTED FROM LAYER  5                  0.00182          6.61715

   PERCOLATION/LEAKAGE THROUGH LAYER  7              0.000000         0.00002

   AVERAGE HEAD ON TOP OF LAYER  6                   0.050

   MAXIMUM HEAD ON TOP OF LAYER  6                   0.100

   LOCATION OF MAXIMUM HEAD IN LAYER  5
         (DISTANCE FROM DRAIN)                       0.0 FEET

   SNOW WATER                                        0.86          3135.2500


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                        0.4613

   MINIMUM VEG. SOIL WATER (VOL/VOL)                        0.1870


    ***  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   10
    ----------------------------------------------------------------------

                LAYER         (INCHES)        (VOL/VOL)
                -----         --------        ---------
                  1             3.7169          0.3097

                  2           619.7291          0.4132

                  3           785.6407          0.3784

                  4             6.7774          0.2824

                  5             0.0302          0.2556

                  6             0.0000          0.0000

                  7            10.2480          0.4270

              SNOW WATER        0.000

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```

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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP 307\CAM\4BAND5\CLOSD\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP 307\CAM\4BAND5\CLOSD\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP 307\CAM\4BAND5\CLOSD\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP 307\CAM\4BAND5\CLOSD\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP 307\CAM\4BAND5\CLOSD\DATA10.D10
OUTPUT DATA FILE:            C:\HELP 307\CAM\4BAND5\CLOSD\CLOSD.OUT


TIME:   7:41     DATE:   2/28/2012


******************************************************************************

     TITLE:  CAMELOT LANDFILL-CELLS 4B AND 5 CLOSED 298'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =     12.00   INCHES
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                   =      12.00    INCHES
POROSITY                    =       0.3980 VOL/VOL
FIELD CAPACITY              =       0.2440 VOL/VOL
WILTING POINT               =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  3
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =       0.04    INCHES
POROSITY                    =       0.0000 VOL/VOL
FIELD CAPACITY              =       0.0000 VOL/VOL
WILTING POINT               =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS    =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      18.00    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.   =  0.999999975000E-05 CM/SEC


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  11
THICKNESS                   =      12.00    INCHES
```

```
          POROSITY                     =      0.4640 VOL/VOL
          FIELD CAPACITY               =      0.3100 VOL/VOL
          WILTING POINT                =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC


                                LAYER  6
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =   1500.00    INCHES
          POROSITY                     =      0.6148 VOL/VOL
          FIELD CAPACITY               =      0.5114 VOL/VOL
          WILTING POINT                =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                LAYER  7
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =   2076.00    INCHES
          POROSITY                     =      0.4941 VOL/VOL
          FIELD CAPACITY               =      0.4775 VOL/VOL
          WILTING POINT                =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                                LAYER  8
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     24.00    INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.460000001000E-05 CM/SEC


                                LAYER  9
                                --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
   THICKNESS                  =       0.12    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.  =   0.439999998000      CM/SEC
   SLOPE                      =       1.10    PERCENT
   DRAINAGE LENGTH            =     855.0     FEET


                          LAYER 10
                          --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
   THICKNESS                  =       0.06    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   =       0.00    HOLES/ACRE
   FML PLACEMENT QUALITY      =   3 - GOOD


                          LAYER 11
                          --------

                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 #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  500. FEET.

 SCS RUNOFF CURVE NUMBER           =      80.10
```

```
     FRACTION OF AREA ALLOWING RUNOFF      =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE    =      1.000  ACRES
     EVAPORATIVE ZONE DEPTH                =     18.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE     =      4.392  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE    =      7.164  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE    =      2.448  INCHES
     INITIAL SNOW WATER                    =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS      =   1392.247  INCHES
     TOTAL INITIAL WATER                   =   1392.247  INCHES
     TOTAL SUBSURFACE INFLOW               =      0.00   INCHES/YEAR


                  EVAPOTRANSPIRATION AND WEATHER DATA
                  -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              DALLAS                TEXAS

          STATION LATITUDE                              =  32.85 DEGREES
          MAXIMUM LEAF AREA INDEX                       =   4.50
          START OF GROWING SEASON (JULIAN DATE)         =     63
          END OF GROWING SEASON (JULIAN DATE)           =    329
          EVAPORATIVE ZONE DEPTH                        =  18.0  INCHES
          AVERAGE ANNUAL WIND SPEED                     =  10.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY         =  66.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY         =  68.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY         =  63.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY         =  66.00 %


     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
  -------      -------      -------      -------      -------      -------
    1.90         2.37         3.06         3.20         5.15         3.23
    2.12         2.03         2.42         4.11         2.57         2.57


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
  -------      -------      -------      -------      -------      -------
   44.10        49.40        57.40        65.00        73.10        80.90
   85.00        84.40        77.50        67.20        55.10        46.70
```

```
          NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    DALLAS              TEXAS
                     AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 1.49     2.20     2.80     3.08     4.59     3.29
                           2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS        1.02     1.27     1.67     1.89     2.17     2.13
                           2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                 0.231    0.154    0.318    0.189    0.352    0.106
                           0.124    0.016    0.022    0.847    0.537    0.879

    STD. DEVIATIONS        0.410    0.410    0.709    0.443    0.820    0.204
                           0.289    0.039    0.049    1.590    1.034    1.518

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 1.673    1.770    2.669    4.424    4.729    3.465
                           2.959    1.935    2.408    1.751    1.035    1.400

    STD. DEVIATIONS        0.408    0.585    0.943    1.005    1.869    1.948
                           1.993    1.548    1.397    0.866    0.367    0.421

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                 0.0314   0.0274   0.0306   0.0241   0.0158   0.0134
                           0.0135   0.0123   0.0119   0.0195   0.0255   0.0309

    STD. DEVIATIONS        0.0126   0.0096   0.0093   0.0081   0.0061   0.0034
                           0.0036   0.0024   0.0025   0.0103   0.0141   0.0142

  LATERAL DRAINAGE COLLECTED FROM LAYER  9
  ----------------------------------------
    TOTALS                 0.0396   0.0363   0.0405   0.0387   0.0407   0.0404
                           0.0427   0.0417   0.0392   0.0407   0.0389   0.0408

    STD. DEVIATIONS        0.0091   0.0081   0.0084   0.0085   0.0085   0.0083
                           0.0079   0.0077   0.0079   0.0083   0.0073   0.0068

  PERCOLATION/LEAKAGE THROUGH LAYER 11
```

```
 ------------------------------------
   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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
   AVERAGES                15.3998   14.7275   15.0076   12.1243    7.5029    6.5148
                            6.3332    5.7299    5.7205    9.3725   12.8499   15.1297

   STD. DEVIATIONS          6.3262    5.3059    4.6271    4.1758    3.0544    1.7389
                            1.7835    1.1462    1.2067    5.1851    7.3282    7.1434

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   AVERAGES                 0.0398    0.0401    0.0407    0.0402    0.0410    0.0420
                            0.0429    0.0419    0.0407    0.0410    0.0404    0.0410

   STD. DEVIATIONS          0.0091    0.0089    0.0085    0.0089    0.0085    0.0086
                            0.0080    0.0078    0.0082    0.0084    0.0076    0.0068

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET       PERCENT
                               -------------------  --------------   ---------
PRECIPITATION                   34.26     (   6.276)   124371.1      100.00

RUNOFF                           3.774    (  2.9347)    13698.63      11.014

EVAPOTRANSPIRATION              30.216    (  4.2443)   109684.16      88.191

PERCOLATION/LEAKAGE THROUGH      0.25638 (  0.06252)      930.642      0.74828
  LAYER  4

AVERAGE HEAD ON TOP             10.534 (     2.625)
  OF LAYER  3

LATERAL DRAINAGE COLLECTED       0.48024 (  0.08566)     1743.281     1.40168
  FROM LAYER  9

PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)        0.009      0.00001
  LAYER 11
```

```
 AVERAGE HEAD ON TOP                0.041 (     0.007)
   OF LAYER 10

 CHANGE IN WATER STORAGE           -0.208    (  2.1814)          -755.05      -0.607

********************************************************************************
```

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------    -------------
      PRECIPITATION                             6.00          21780.000

      RUNOFF                                    3.413         12389.1777

      PERCOLATION/LEAKAGE THROUGH LAYER  4      0.001567          5.68974

      AVERAGE HEAD ON TOP OF LAYER  3          24.000

      DRAINAGE COLLECTED FROM LAYER  9          0.00173           6.29779

      PERCOLATION/LEAKAGE THROUGH LAYER 11      0.000000          0.00002

      AVERAGE HEAD ON TOP OF LAYER 10           0.054

      MAXIMUM HEAD ON TOP OF LAYER 10           0.107

      LOCATION OF MAXIMUM HEAD IN LAYER  9
            (DISTANCE FROM DRAIN)               8.2 FEET

      SNOW WATER                                2.40           8713.1436


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3980

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1360


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
****************************************************************************

               FINAL WATER STORAGE AT END OF YEAR   30
       ----------------------------------------------------------------------
                LAYER         (INCHES)         (VOL/VOL)
                -----         --------         ---------
                  1            2.4409            0.2034

                  2            3.8913            0.3243

                  3            0.0000            0.0000

                  4            7.6860            0.4270

                  5            3.7200            0.3100

                  6          577.6912            0.3851

                  7          773.5363            0.3726

                  8            6.7537            0.2814

                  9            0.0398            0.3372

                 10            0.0000            0.0000

                 11           10.2480            0.4270

               SNOW WATER      0.000

****************************************************************************
****************************************************************************
```

HELP MODELS FOR UNDEVELOPED CELLS

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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                 **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     d:\DATA4.D4
TEMPERATURE DATA FILE:       d:\DATA7.D7
SOLAR RADIATION DATA FILE:   d:\DATA13.D13
EVAPOTRANSPIRATION DATA:     d:\DATA11.D11
SOIL AND DESIGN DATA FILE:   d:\DATA10.D10
OUTPUT DATA FILE:            d:\ACTIVE.OUT


TIME:   8:36     DATE:  11/ 3/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-UNDEV AREA ACTIVE 10'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  0
           THICKNESS                    =    120.00    INCHES
           POROSITY                     =      0.6376 VOL/VOL
           FIELD CAPACITY               =      0.5185 VOL/VOL
           WILTING POINT                =      0.0770 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.2500 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
```

```
                              LAYER  2
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  10
    THICKNESS                    =     24.00   INCHES
    POROSITY                     =      0.3980 VOL/VOL
    FIELD CAPACITY               =      0.2440 VOL/VOL
    WILTING POINT                =      0.1360 VOL/VOL
    INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
    EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                              LAYER  3
                              --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER   0
    THICKNESS                    =      0.23   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.    =   31.3799992000      CM/SEC
    SLOPE                        =      0.90   PERCENT
    DRAINAGE LENGTH              =    350.0    FEET


                              LAYER  4
                              --------

                   TYPE 4 - FLEXIBLE MEMBRANE LINER
                     MATERIAL TEXTURE NUMBER  35
    THICKNESS                    =      0.06   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     =      0.00   HOLES/ACRE
    FML PLACEMENT QUALITY        =  3 - GOOD


                              LAYER  5
                              --------

                     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 #18 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
          A SLOPE LENGTH OF  200. FEET.

 SCS RUNOFF CURVE NUMBER              =    80.30
 FRACTION OF AREA ALLOWING RUNOFF     =     0.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE   =     1.000  ACRES
 EVAPORATIVE ZONE DEPTH               =    10.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE    =     2.500  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE   =     6.376  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE   =     0.770  INCHES
 INITIAL SNOW WATER                   =     0.000  INCHES
 INITIAL WATER IN LAYER MATERIALS     =    46.106  INCHES
 TOTAL INITIAL WATER                  =    46.106  INCHES
 TOTAL SUBSURFACE INFLOW              =     0.00   INCHES/YEAR



           EVAPOTRANSPIRATION AND WEATHER DATA
           -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DALLAS                TEXAS

      STATION LATITUDE                        =  32.85 DEGREES
      MAXIMUM LEAF AREA INDEX                 =   0.00
      START OF GROWING SEASON (JULIAN DATE)   =     63
      END OF GROWING SEASON (JULIAN DATE)     =    329
      EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
      AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    DALLAS             TEXAS

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)
```

```
   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     1.90        2.37        3.06        3.20        5.15        3.23
     2.12        2.03        2.42        4.11        2.57        2.57


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS              TEXAS

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
    44.10       49.40       57.40       65.00       73.10       80.90
    85.00       84.40       77.50       67.20       55.10       46.70


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS              TEXAS
                  AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     9 THROUGH     9
-------------------------------------------------------------------------------

                            JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                            -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                    1.30     3.02     3.80     4.33     7.68     2.52
                              5.79     0.00     4.02     2.40     7.68     3.39

    STD. DEVIATIONS           0.00     0.00     0.00     0.00     0.00     0.00
                              0.00     0.00     0.00     0.00     0.00     0.00

  RUNOFF
  ------
    TOTALS                    0.000    0.000    0.000    0.000    0.000    0.000
                              0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS           0.000    0.000    0.000    0.000    0.000    0.000
                              0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                    2.188    3.083    3.785    2.329    4.697    3.700
                              2.789    0.095    2.699    1.800    3.426    2.305

    STD. DEVIATIONS           0.000    0.000    0.000    0.000    0.000    0.000
```

```
                          0.000    0.000    0.000    0.000    0.000    0.000

  LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS                0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0547   0.1145   0.1242   0.1345   0.1310   0.2326

    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

  PERCOLATION/LEAKAGE THROUGH LAYER  5
  ------------------------------------
    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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0004   0.0008   0.0009   0.0009   0.0010   0.0016

    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

*******************************************************************************


*******************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS     9 THROUGH     9
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                ------------------   ------------   ---------
 PRECIPITATION                   45.93    (   0.000)    166725.9     100.00

 RUNOFF                           0.000   (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION              32.896   (  0.0000)    119413.28     71.623

 LATERAL DRAINAGE COLLECTED       0.79150 (  0.00000)     2873.162    1.72328
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)        0.004    0.00000
   LAYER  5

 AVERAGE HEAD ON TOP              0.000 (     0.000)
   OF LAYER  4
```

```
 CHANGE IN WATER STORAGE          12.242    (  0.0000)       44439.50     26.654
*******************************************************************************
```

```
*******************************************************************************

            PEAK DAILY VALUES FOR YEARS     9 THROUGH     9
  -------------------------------------------------------------------------
                                              (INCHES)     (CU. FT.)
                                             ----------   -------------
    PRECIPITATION                               2.98        10817.400

    RUNOFF                                      0.000           0.0000

    DRAINAGE COLLECTED FROM LAYER  3            0.01017        36.89970

    PERCOLATION/LEAKAGE THROUGH LAYER  5        0.000000        0.00002

    AVERAGE HEAD ON TOP OF LAYER  4             0.002

    MAXIMUM HEAD ON TOP OF LAYER  4             0.005

    LOCATION OF MAXIMUM HEAD IN LAYER  3
          (DISTANCE FROM DRAIN)                 0.0 FEET

    SNOW WATER                                  1.09          3951.7917


    MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3972

    MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0770

     ***  Maximum heads are computed using McEnroe's equations.  ***

          Reference:  Maximum Saturated Depth over Landfill Liner
                      by Bruce M. McEnroe, University of Kansas
                      ASCE Journal of Environmental Engineering
                      Vol. 119, No. 2, March 1993, pp. 262-270.

*******************************************************************************
```

```
******************************************************************************

              FINAL WATER STORAGE AT END OF YEAR    9
       ----------------------------------------------------------------------
               LAYER          (INCHES)        (VOL/VOL)
               -----          --------        ---------
                 1             41.8910          0.3491

                 2              6.2043          0.2585

                 3              0.0053          0.0229

                 4              0.0000          0.0000

                 5             10.2480          0.4270

             SNOW WATER         0.000

******************************************************************************
******************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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                **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    d:\DATA4.D4
TEMPERATURE DATA FILE:      d:\DATA7.D7
SOLAR RADIATION DATA FILE:  d:\DATA13.D13
EVAPOTRANSPIRATION DATA:    d:\DATA11.D11
SOIL AND DESIGN DATA FILE:  d:\DATA10.D10
OUTPUT DATA FILE:           d:\I50.OUT


TIME:   8:35     DATE:  11/ 3/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-UNDEV AREA INTERIM 50'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  11
           THICKNESS                    =     12.00   INCHES
           POROSITY                     =      0.4640 VOL/VOL
           FIELD CAPACITY               =      0.3100 VOL/VOL
           WILTING POINT                =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                          LAYER  2
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =    600.00    INCHES
  POROSITY                     =      0.6376 VOL/VOL
  FIELD CAPACITY               =      0.5185 VOL/VOL
  WILTING POINT                =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2500 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
NOTE:    10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
          IS RECIRCULATED INTO THIS LAYER.


                          LAYER  3
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  10
  THICKNESS                    =     24.00    INCHES
  POROSITY                     =      0.3980 VOL/VOL
  FIELD CAPACITY               =      0.2440 VOL/VOL
  WILTING POINT                =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                          LAYER  4
                          --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =      0.22    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.    =   19.6299992000       CM/SEC
  SLOPE                        =      0.90    PERCENT
  DRAINAGE LENGTH              =    350.0     FEET
NOTE:    10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
          LAYER IS RECIRCULATED INTO LAYER #  2.


                          LAYER  5
                          --------
```

```
             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.06    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     =       0.00    HOLES/ACRE
FML PLACEMENT QUALITY        =   3 - GOOD


                         LAYER  6
                         --------

               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 #11 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
          AND A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER            =     87.10
FRACTION OF AREA ALLOWING RUNOFF   =     70.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =      1.000   ACRES
EVAPORATIVE ZONE DEPTH             =     10.0     INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      3.100   INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      4.640   INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      1.870   INCHES
INITIAL SNOW WATER                 =      0.000   INCHES
INITIAL WATER IN LAYER MATERIALS   =    169.826   INCHES
TOTAL INITIAL WATER                =    169.826   INCHES
TOTAL SUBSURFACE INFLOW            =      0.00    INCHES/YEAR


           EVAPOTRANSPIRATION AND WEATHER DATA
           -----------------------------------
```

```
     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              DALLAS                TEXAS

         STATION LATITUDE                        =  32.85 DEGREES
         MAXIMUM LEAF AREA INDEX                 =   2.00
         START OF GROWING SEASON (JULIAN DATE)   =     63
         END OF GROWING SEASON (JULIAN DATE)     =    329
         EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
         AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     1.90        2.37        3.06        3.20        5.15        3.23
     2.12        2.03        2.42        4.11        2.57        2.57


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
    44.10       49.40       57.40       65.00       73.10       80.90
    85.00       84.40       77.50       67.20       55.10       46.70


     NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS
                AND STATION LATITUDE  =  32.85 DEGREES



*******************************************************************************

     AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------

  PRECIPITATION
```

```
-------------
  TOTALS                  1.93     2.15     2.72     3.17     4.26     3.50
                          4.03     1.92     3.59     3.31     2.63     3.58

  STD. DEVIATIONS         1.28     1.01     1.14     1.17     2.39     2.30
                          3.13     1.41     1.53     3.11     1.73     1.82

RUNOFF
------
  TOTALS                  0.027    0.084    0.052    0.070    0.284    0.270
                          0.336    0.087    0.132    0.429    0.049    0.161

  STD. DEVIATIONS         0.033    0.149    0.063    0.089    0.287    0.310
                          0.492    0.139    0.147    0.947    0.094    0.208

EVAPOTRANSPIRATION
------------------
  TOTALS                  1.830    1.787    2.171    2.964    3.181    2.459
                          3.071    1.741    2.615    2.133    1.396    1.664

  STD. DEVIATIONS         0.394    0.779    0.577    1.248    1.210    1.611
                          1.464    1.213    1.234    1.281    0.651    0.491

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                  0.0103   0.0109   0.0112   0.0108   0.0116   0.0119
                          0.0115   0.0121   0.0125   0.0114   0.0126   0.0126

  STD. DEVIATIONS         0.0127   0.0133   0.0127   0.0124   0.0133   0.0142
                          0.0134   0.0143   0.0152   0.0129   0.0148   0.0135

LATERAL DRAINAGE COLLECTED FROM LAYER  4
----------------------------------------
  TOTALS                  0.0931   0.0981   0.1010   0.0974   0.1044   0.1074
                          0.1036   0.1091   0.1125   0.1026   0.1136   0.1132

  STD. DEVIATIONS         0.1144   0.1194   0.1144   0.1112   0.1198   0.1279
                          0.1210   0.1285   0.1365   0.1165   0.1335   0.1219

LATERAL DRAINAGE RECIRCULATED FROM LAYER  4
-------------------------------------------
  TOTALS                  0.0103   0.0109   0.0112   0.0108   0.0116   0.0119
                          0.0115   0.0121   0.0125   0.0114   0.0126   0.0126

  STD. DEVIATIONS         0.0127   0.0133   0.0127   0.0124   0.0133   0.0142
                          0.0134   0.0143   0.0152   0.0129   0.0148   0.0135

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  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

-------------------------------------------------------------------------------
```

```
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES                 0.0012   0.0014   0.0013   0.0013   0.0013   0.0014
                             0.0013   0.0014   0.0015   0.0013   0.0015   0.0014

    STD. DEVIATIONS          0.0014   0.0016   0.0014   0.0014   0.0015   0.0017
                             0.0015   0.0016   0.0018   0.0015   0.0017   0.0015

*******************************************************************************



*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------
                                       INCHES           CU. FEET      PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    36.80   (   4.383)     133573.1     100.00

 RUNOFF                            1.980  (  0.8400)      7188.26       5.382

 EVAPOTRANSPIRATION               27.013  (  2.9291)     98055.80      73.410

 DRAINAGE RECIRCULATED             0.13957 (  0.16190)     506.629     0.37929
   INTO LAYER  2

 LATERAL DRAINAGE COLLECTED        1.25611 (  1.45712)    4559.665     3.41361
   FROM LAYER  4

 DRAINAGE RECIRCULATED             0.13957 (  0.16190)     506.629     0.37929
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)       0.005      0.00000
   LAYER  6

 AVERAGE HEAD ON TOP               0.001 (    0.002)
   OF LAYER  5

 CHANGE IN WATER STORAGE           6.548  (  2.9695)     23768.89      17.795
*******************************************************************************
```

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS   21 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              4.59         16661.701

      RUNOFF                                     1.735         6297.4575

      DRAINAGE RECIRCULATED INTO LAYER  2        0.00203          7.37332

      DRAINAGE COLLECTED FROM LAYER  4           0.01828         66.35985

      DRAINAGE RECIRCULATED FROM LAYER  4        0.00203          7.37332

      PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00002

      AVERAGE HEAD ON TOP OF LAYER  5            0.007

      MAXIMUM HEAD ON TOP OF LAYER  5            0.014

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)               16.6 FEET

      SNOW WATER                                 1.29          4675.1299


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4617

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1870


       ***  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   30
    ----------------------------------------------------------------------

                LAYER          (INCHES)        (VOL/VOL)
                -----          --------        ---------

                  1              2.8442          0.2370

                  2            215.9214          0.3599

                  3              6.2864          0.2619

                  4              0.0051          0.0236

                  5              0.0000          0.0000

                  6             10.2480          0.4270

              SNOW WATER         0.000

*******************************************************************************
*******************************************************************************
```

```
****************************************************************************
****************************************************************************
**                                                                        **
**                                                                        **
**              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            **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************


PRECIPITATION DATA FILE:    d:\DATA4.D4
TEMPERATURE DATA FILE:      d:\DATA7.D7
SOLAR RADIATION DATA FILE:  d:\DATA13.D13
EVAPOTRANSPIRATION DATA:    d:\DATA11.D11
SOIL AND DESIGN DATA FILE:  d:\DATA10.D10
OUTPUT DATA FILE:           d:\I100.OUT


TIME:   8:43     DATE:  11/ 3/2011


****************************************************************************

     TITLE:  CAMELOT LANDFILL-UNDEV AREA-INTERIM 100'

****************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  11
          THICKNESS                  =     12.00    INCHES
          POROSITY                   =      0.4640 VOL/VOL
          FIELD CAPACITY             =      0.3100 VOL/VOL
          WILTING POINT              =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.3100 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  = 0.639999998000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                         LAYER  2
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                  =    1200.00   INCHES
  POROSITY                   =       0.6247 VOL/VOL
  FIELD CAPACITY             =       0.5144 VOL/VOL
  WILTING POINT              =       0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT =       0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC
NOTE:    10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
          IS RECIRCULATED INTO THIS LAYER.


                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                  =      24.00   INCHES
  POROSITY                   =       0.3980 VOL/VOL
  FIELD CAPACITY             =       0.2440 VOL/VOL
  WILTING POINT              =       0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT =       0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC


                         LAYER  4
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
  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.  =   13.1499996000     CM/SEC
  SLOPE                      =       0.90   PERCENT
  DRAINAGE LENGTH            =     350.0    FEET
NOTE:    10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
          LAYER IS RECIRCULATED INTO LAYER #  2.


                         LAYER  5
                         --------
```

```
                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
   THICKNESS                  =      0.06   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   =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY      =  3 - GOOD


                            LAYER  6
                            --------

                  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 #11 WITH A
           FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
           AND A SLOPE LENGTH OF  200. FEET.

 SCS RUNOFF CURVE NUMBER            =    87.10
 FRACTION OF AREA ALLOWING RUNOFF   =    80.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE =     1.000  ACRES
 EVAPORATIVE ZONE DEPTH             =    10.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE  =     3.100  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE =     4.640  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE =     1.870  INCHES
 INITIAL SNOW WATER                 =     0.000  INCHES
 INITIAL WATER IN LAYER MATERIALS   =   475.826  INCHES
 TOTAL INITIAL WATER                =   475.826  INCHES
 TOTAL SUBSURFACE INFLOW            =     0.00   INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------
```

```
          NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                   DALLAS                TEXAS

              STATION LATITUDE                          =  32.85 DEGREES
              MAXIMUM LEAF AREA INDEX                   =   2.00
              START OF GROWING SEASON (JULIAN DATE)     =     63
              END OF GROWING SEASON (JULIAN DATE)       =    329
              EVAPORATIVE ZONE DEPTH                    =  10.0  INCHES
              AVERAGE ANNUAL WIND SPEED                 =  10.80 MPH
              AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  66.00 %
              AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  68.00 %
              AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  63.00 %
              AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  66.00 %


          NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    DALLAS              TEXAS

                   NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        1.90        2.37        3.06        3.20        5.15        3.23
        2.12        2.03        2.42        4.11        2.57        2.57


          NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    DALLAS              TEXAS

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       44.10       49.40       57.40       65.00       73.10       80.90
       85.00       84.40       77.50       67.20       55.10       46.70


          NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    DALLAS              TEXAS
                     AND STATION LATITUDE  =  32.85 DEGREES



*******************************************************************************

          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   16 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
```

```
PRECIPITATION
-------------
  TOTALS                     1.71     2.22     2.45     3.35     4.37     3.64
                             3.65     1.61     3.28     3.60     2.37     3.34

  STD. DEVIATIONS            1.20     1.32     1.18     1.53     2.20     2.56
                             2.72     1.24     1.50     3.28     1.73     1.75

RUNOFF
------
  TOTALS                     0.023    0.093    0.041    0.208    0.460    0.327
                             0.314    0.067    0.137    0.555    0.099    0.173

  STD. DEVIATIONS            0.037    0.162    0.064    0.329    0.780    0.464
                             0.477    0.137    0.160    1.096    0.196    0.251

EVAPOTRANSPIRATION
------------------
  TOTALS                     1.660    1.591    2.083    2.584    3.349    2.590
                             2.982    1.436    2.586    1.794    1.248    1.610

  STD. DEVIATIONS            0.550    0.690    0.994    1.456    1.123    1.741
                             1.535    1.098    1.201    1.093    0.661    0.486

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                     0.0587   0.0568   0.0639   0.0578   0.0635   0.0599
                             0.0618   0.0652   0.0602   0.0601   0.0577   0.0611

  STD. DEVIATIONS            0.0098   0.0065   0.0076   0.0067   0.0108   0.0068
                             0.0105   0.0087   0.0102   0.0055   0.0064   0.0063

LATERAL DRAINAGE COLLECTED FROM LAYER  4
----------------------------------------
  TOTALS                     0.5284   0.5114   0.5750   0.5198   0.5715   0.5395
                             0.5559   0.5871   0.5419   0.5413   0.5194   0.5495

  STD. DEVIATIONS            0.0880   0.0589   0.0680   0.0599   0.0974   0.0609
                             0.0946   0.0784   0.0915   0.0497   0.0576   0.0565

LATERAL DRAINAGE RECIRCULATED FROM LAYER  4
-------------------------------------------
  TOTALS                     0.0587   0.0568   0.0639   0.0578   0.0635   0.0599
                             0.0618   0.0652   0.0602   0.0601   0.0577   0.0611

  STD. DEVIATIONS            0.0098   0.0065   0.0076   0.0067   0.0108   0.0068
                             0.0105   0.0087   0.0102   0.0055   0.0064   0.0063

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  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
```

```
-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES                  0.0099   0.0105   0.0108   0.0100   0.0107   0.0104
                              0.0104   0.0110   0.0105   0.0101   0.0100   0.0103

    STD. DEVIATIONS           0.0016   0.0013   0.0013   0.0012   0.0018   0.0012
                              0.0018   0.0015   0.0018   0.0009   0.0011   0.0011

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   16 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES              CU. FEET     PERCENT
                               -------------------     -------------  ---------
 PRECIPITATION                  35.60     (   4.934)     129225.6     100.00

 RUNOFF                          2.499    (  1.2777)       9071.59      7.020

 EVAPOTRANSPIRATION             25.512    (  3.2612)      92609.22     71.665

 DRAINAGE RECIRCULATED           0.72675 (  0.05964)      2638.084     2.04146
   INTO LAYER  2

 LATERAL DRAINAGE COLLECTED      6.54070 (  0.53678)     23742.754    18.37311
   FROM LAYER  4

 DRAINAGE RECIRCULATED           0.72675 (  0.05964)      2638.084     2.04146
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.009     0.00001
   LAYER  6

 AVERAGE HEAD ON TOP             0.010 (    0.001)
   OF LAYER  5

 CHANGE IN WATER STORAGE         1.047    (  2.5308)       3802.04      2.942

*******************************************************************************
```

```
*******************************************************************************

             PEAK DAILY VALUES FOR YEARS   16 THROUGH   30
  ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
     PRECIPITATION                                6.00         21780.000

     RUNOFF                                       2.948        10699.7725

     DRAINAGE RECIRCULATED INTO LAYER  2          0.00453         16.43365

     DRAINAGE COLLECTED FROM LAYER  4             0.04074        147.90286

     DRAINAGE RECIRCULATED FROM LAYER  4          0.00453         16.43365

     PERCOLATION/LEAKAGE THROUGH LAYER  6         0.000000         0.00002

     AVERAGE HEAD ON TOP OF LAYER  5              0.024

     MAXIMUM HEAD ON TOP OF LAYER  5              0.047

     LOCATION OF MAXIMUM HEAD IN LAYER  4
           (DISTANCE FROM DRAIN)                  2.1 FEET

     SNOW WATER                                   2.56          9295.1191


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4577

     MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1870


      ***  Maximum heads are computed using McEnroe's equations.  ***

           Reference:  Maximum Saturated Depth over Landfill Liner
                       by Bruce M. McEnroe, University of Kansas
                       ASCE Journal of Environmental Engineering
                       Vol. 119, No. 2, March 1993, pp. 262-270.

*******************************************************************************
```

```
******************************************************************************

            FINAL WATER STORAGE AT END OF YEAR   30
     ----------------------------------------------------------------------
             LAYER         (INCHES)       (VOL/VOL)
             -----         --------       ---------
               1            2.7479          0.2290

               2          472.0331          0.3934

               3            6.4997          0.2708

               4            0.0082          0.0400

               5            0.0000          0.0000

               6           10.2480          0.4270

           SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    d:\DATA4.D4
TEMPERATURE DATA FILE:      d:\DATA7.D7
SOLAR RADIATION DATA FILE:  d:\DATA13.D13
EVAPOTRANSPIRATION DATA:    d:\DATA11.D11
SOIL AND DESIGN DATA FILE:  d:\DATA10.D10
OUTPUT DATA FILE:           d:\I200.OUT


TIME:   8:32     DATE:  11/ 3/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-UNDEV AREA INTERIM 200'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                   =     12.00    INCHES
           POROSITY                    =      0.4640 VOL/VOL
           FIELD CAPACITY              =      0.3100 VOL/VOL
           WILTING POINT               =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                           LAYER  2
                           --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   0
   THICKNESS                     =   1500.00   INCHES
   POROSITY                      =      0.6148 VOL/VOL
   FIELD CAPACITY                =      0.5114 VOL/VOL
   WILTING POINT                 =      0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
   EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC
 NOTE:    10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
          IS RECIRCULATED INTO THIS LAYER.


                           LAYER  3
                           --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   0
   THICKNESS                     =    900.00   INCHES
   POROSITY                      =      0.5337 VOL/VOL
   FIELD CAPACITY                =      0.4886 VOL/VOL
   WILTING POINT                 =      0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
   EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-04 CM/SEC


                           LAYER  4
                           --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  10
   THICKNESS                     =     24.00   INCHES
   POROSITY                      =      0.3980 VOL/VOL
   FIELD CAPACITY                =      0.2440 VOL/VOL
   WILTING POINT                 =      0.1360 VOL/VOL
   INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
   EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC


                           LAYER  5
                           --------

                  TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   0
   THICKNESS                     =      0.16   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.  =   7.96999979000     CM/SEC
   SLOPE                      =      0.90    PERCENT
   DRAINAGE LENGTH            =    350.0     FEET
 NOTE:    10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
          LAYER IS RECIRCULATED INTO LAYER #  2.


                           LAYER  6
                           --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
   THICKNESS                  =      0.06    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   =      0.00    HOLES/ACRE
   FML PLACEMENT QUALITY      =  3 - GOOD


                           LAYER  7
                           --------

                 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 #11 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
          AND A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER            =     87.10
FRACTION OF AREA ALLOWING RUNOFF   =     80.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =      1.000   ACRES
```

```
        EVAPORATIVE ZONE DEPTH                 =     10.0    INCHES
        INITIAL WATER IN EVAPORATIVE ZONE      =      3.100  INCHES
        UPPER LIMIT OF EVAPORATIVE STORAGE     =      4.640  INCHES
        LOWER LIMIT OF EVAPORATIVE STORAGE     =      1.870  INCHES
        INITIAL SNOW WATER                     =      0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS       =    931.826  INCHES
        TOTAL INITIAL WATER                    =    931.826  INCHES
        TOTAL SUBSURFACE INFLOW                =      0.00   INCHES/YEAR


                    EVAPOTRANSPIRATION AND WEATHER DATA
                    -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  DALLAS                 TEXAS

             STATION LATITUDE                      =  32.85 DEGREES
             MAXIMUM LEAF AREA INDEX               =   2.00
             START OF GROWING SEASON (JULIAN DATE) =     63
             END OF GROWING SEASON (JULIAN DATE)   =    329
             EVAPORATIVE ZONE DEPTH                =  10.0  INCHES
             AVERAGE ANNUAL WIND SPEED             =  10.80 MPH
             AVERAGE 1ST QUARTER RELATIVE HUMIDITY =  66.00 %
             AVERAGE 2ND QUARTER RELATIVE HUMIDITY =  68.00 %
             AVERAGE 3RD QUARTER RELATIVE HUMIDITY =  63.00 %
             AVERAGE 4TH QUARTER RELATIVE HUMIDITY =  66.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS                TEXAS

                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        1.90        2.37        3.06        3.20        5.15        3.23
        2.12        2.03        2.42        4.11        2.57        2.57


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS                TEXAS

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       44.10       49.40       57.40       65.00       73.10       80.90
       85.00       84.40       77.50       67.20       55.10       46.70


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS                TEXAS
```

```
                AND STATION LATITUDE  =  32.85 DEGREES



*******************************************************************************

    AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------

                       JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                       -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                 1.93     2.15     2.72     3.17     4.26     3.50
                          4.03     1.92     3.59     3.31     2.63     3.58

   STD. DEVIATIONS        1.28     1.01     1.14     1.17     2.39     2.30
                          3.13     1.41     1.53     3.11     1.73     1.82

 RUNOFF
 ------
   TOTALS                0.030    0.096    0.059    0.080    0.323    0.308
                         0.381    0.100    0.151    0.479    0.056    0.184

   STD. DEVIATIONS       0.038    0.171    0.071    0.102    0.326    0.355
                         0.559    0.158    0.168    1.052    0.107    0.237

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                1.830    1.785    2.184    2.965    3.161    2.484
                         3.071    1.737    2.609    2.138    1.397    1.664

   STD. DEVIATIONS       0.393    0.777    0.581    1.251    1.207    1.637
                         1.473    1.218    1.226    1.275    0.647    0.491

 LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
 ------------------------------------------
   TOTALS               0.0513   0.0506   0.0558   0.0537   0.0551   0.0528
                        0.0536   0.0540   0.0518   0.0538   0.0524   0.0542

   STD. DEVIATIONS      0.0098   0.0077   0.0083   0.0071   0.0075   0.0077
                        0.0075   0.0068   0.0058   0.0064   0.0060   0.0062

 LATERAL DRAINAGE COLLECTED FROM LAYER  5
 ----------------------------------------
   TOTALS               0.4615   0.4555   0.5020   0.4829   0.4961   0.4749
                        0.4826   0.4862   0.4666   0.4839   0.4716   0.4882

   STD. DEVIATIONS      0.0880   0.0697   0.0743   0.0637   0.0672   0.0690
                        0.0675   0.0609   0.0525   0.0572   0.0543   0.0559

 LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
 ------------------------------------------
   TOTALS               0.0513   0.0506   0.0558   0.0537   0.0551   0.0528
```

```
                          0.0536   0.0540   0.0518   0.0538   0.0524   0.0542

    STD. DEVIATIONS       0.0098   0.0077   0.0083   0.0071   0.0075   0.0077
                          0.0075   0.0068   0.0058   0.0064   0.0060   0.0062

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  6
  -------------------------------------
    AVERAGES              0.0142   0.0155   0.0155   0.0154   0.0153   0.0151
                          0.0149   0.0150   0.0149   0.0149   0.0150   0.0151

    STD. DEVIATIONS       0.0027   0.0024   0.0023   0.0020   0.0021   0.0022
                          0.0021   0.0019   0.0017   0.0018   0.0017   0.0017

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET      PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    36.80    (   4.383)    133573.1     100.00

 RUNOFF                            2.248   (  0.9387)      8161.14      6.110

 EVAPOTRANSPIRATION               27.025   (  2.9312)     98101.46     73.444

 DRAINAGE RECIRCULATED             0.63911 (  0.07269)     2319.955     1.73684
   INTO LAYER  2

 LATERAL DRAINAGE COLLECTED        5.75196 (  0.65417)    20879.598    15.63159
   FROM LAYER  5

 DRAINAGE RECIRCULATED             0.63911 (  0.07269)     2319.955     1.73684
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)        0.009     0.00001
   LAYER  7

 AVERAGE HEAD ON TOP               0.015 (    0.002)
   OF LAYER  6
```

```
 CHANGE IN WATER STORAGE           1.772   (  2.6272)        6430.95      4.815

*******************************************************************************
```

```
*******************************************************************************

          PEAK DAILY VALUES FOR YEARS   21 THROUGH   30
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
      PRECIPITATION                                4.59        16661.701

      RUNOFF                                       1.884        6839.5244

      DRAINAGE RECIRCULATED INTO LAYER  2          0.00318        11.55449

      DRAINAGE COLLECTED FROM LAYER  5             0.02865       103.99039

      DRAINAGE RECIRCULATED FROM LAYER  5          0.00318        11.55449

      PERCOLATION/LEAKAGE THROUGH LAYER  7         0.000000        0.00002

      AVERAGE HEAD ON TOP OF LAYER  6              0.027

      MAXIMUM HEAD ON TOP OF LAYER  6              0.054

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)                  2.5 FEET

      SNOW WATER                                   1.29         4675.1299


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4565

      MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1870


       ***  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   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            2.8603         0.2384

                      2          608.7083         0.4058

                      3          321.2263         0.3569

                      4            6.4846         0.2702

                      5            0.0142         0.0886

                      6            0.0000         0.0000

                      7           10.2480         0.4270

                  SNOW WATER       0.000

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```

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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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     d:\DATA4.D4
TEMPERATURE DATA FILE:       d:\DATA7.D7
SOLAR RADIATION DATA FILE:   d:\DATA13.D13
EVAPOTRANSPIRATION DATA:     d:\DATA11.D11
SOIL AND DESIGN DATA FILE:   d:\DATA10.D10
OUTPUT DATA FILE:            d:\I287.OUT


TIME:   9:20     DATE:  11/ 3/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-UNDEV AREA INTERIM 287'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  11
           THICKNESS                   =     12.00    INCHES
           POROSITY                    =      0.4640 VOL/VOL
           FIELD CAPACITY              =      0.3100 VOL/VOL
           WILTING POINT               =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                         LAYER  2
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
 THICKNESS                     =   1500.00   INCHES
 POROSITY                      =      0.6148 VOL/VOL
 FIELD CAPACITY                =      0.5114 VOL/VOL
 WILTING POINT                 =      0.0770 VOL/VOL
 INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
 EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC
NOTE:    10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
          IS RECIRCULATED INTO THIS LAYER.


                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
 THICKNESS                     =   1944.00   INCHES
 POROSITY                      =      0.4985 VOL/VOL
 FIELD CAPACITY                =      0.4790 VOL/VOL
 WILTING POINT                 =      0.0770 VOL/VOL
 INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
 EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-04 CM/SEC


                         LAYER  4
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
 THICKNESS                     =     24.00   INCHES
 POROSITY                      =      0.3980 VOL/VOL
 FIELD CAPACITY                =      0.2440 VOL/VOL
 WILTING POINT                 =      0.1360 VOL/VOL
 INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
 EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC


                         LAYER  5
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
 THICKNESS                     =      0.15   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.    =   5.36999989000     CM/SEC
   SLOPE                        =      0.90   PERCENT
   DRAINAGE LENGTH              =    350.0    FEET
 NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                            LAYER  6
                            --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
   THICKNESS                    =      0.06   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     =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY        =  3 - GOOD


                            LAYER  7
                            --------

                    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 #11 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  500. FEET.

 SCS RUNOFF CURVE NUMBER            =      86.70
 FRACTION OF AREA ALLOWING RUNOFF   =      90.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE =       1.000  ACRES
```

```
          EVAPORATIVE ZONE DEPTH                 =      10.0    INCHES
          INITIAL WATER IN EVAPORATIVE ZONE      =       3.100  INCHES
          UPPER LIMIT OF EVAPORATIVE STORAGE     =       4.640  INCHES
          LOWER LIMIT OF EVAPORATIVE STORAGE     =       1.870  INCHES
          INITIAL SNOW WATER                     =       0.000  INCHES
          INITIAL WATER IN LAYER MATERIALS       =    1328.545  INCHES
          TOTAL INITIAL WATER                    =    1328.545  INCHES
          TOTAL SUBSURFACE INFLOW                =       0.00   INCHES/YEAR


                    EVAPOTRANSPIRATION AND WEATHER DATA
                    -----------------------------------

           NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                    DALLAS                 TEXAS

               STATION LATITUDE                        =  32.85 DEGREES
               MAXIMUM LEAF AREA INDEX                 =   2.00
               START OF GROWING SEASON (JULIAN DATE)   =    63
               END OF GROWING SEASON (JULIAN DATE)     =   329
               EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
               AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
               AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
               AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
               AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
               AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


           NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                    COEFFICIENTS FOR    DALLAS               TEXAS

                    NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

        JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
        -------      -------      -------      -------      -------      -------
          1.90         2.37         3.06         3.20         5.15         3.23
          2.12         2.03         2.42         4.11         2.57         2.57


           NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                    COEFFICIENTS FOR    DALLAS               TEXAS

               NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

        JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
        -------      -------      -------      -------      -------      -------
         44.10        49.40        57.40        65.00        73.10        80.90
         85.00        84.40        77.50        67.20        55.10        46.70


           NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                    COEFFICIENTS FOR    DALLAS               TEXAS
```

```
                 AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                1.19     2.92     2.56     3.32     5.03     3.09
                          3.21     2.21     2.74     5.78     3.54     3.38

    STD. DEVIATIONS       0.70     1.06     1.38     2.23     3.28     2.03
                          2.38     1.68     1.48     3.85     2.95     2.55

  RUNOFF
  ------
    TOTALS                0.000    0.087    0.118    0.252    0.682    0.213
                          0.667    0.127    0.112    0.977    0.474    0.134

    STD. DEVIATIONS       0.000    0.047    0.181    0.294    1.106    0.200
                          0.925    0.132    0.155    1.267    0.697    0.160

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                1.473    2.016    2.397    2.581    2.527    2.908
                          1.612    1.724    2.207    2.428    1.656    1.662

    STD. DEVIATIONS       0.351    0.710    0.968    1.152    1.287    1.081
                          0.751    1.364    1.288    1.022    0.691    0.646

  LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
  ------------------------------------------
    TOTALS                0.0813   0.0875   0.0927   0.0881   0.0889   0.0855
                          0.0887   0.0873   0.0855   0.0861   0.0849   0.0852

    STD. DEVIATIONS       0.0173   0.0136   0.0134   0.0137   0.0113   0.0121
                          0.0138   0.0134   0.0117   0.0121   0.0113   0.0120

  LATERAL DRAINAGE COLLECTED FROM LAYER  5
  ----------------------------------------
    TOTALS                0.7316   0.7877   0.8343   0.7927   0.8003   0.7692
                          0.7986   0.7861   0.7699   0.7747   0.7639   0.7664

    STD. DEVIATIONS       0.1556   0.1226   0.1206   0.1231   0.1020   0.1091
                          0.1244   0.1202   0.1050   0.1087   0.1018   0.1080

  LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
  ------------------------------------------
    TOTALS                0.0813   0.0875   0.0927   0.0881   0.0889   0.0855
```

```
                        0.0887    0.0873    0.0855    0.0861    0.0849    0.0852

  STD. DEVIATIONS       0.0173    0.0136    0.0134    0.0137    0.0113    0.0121
                        0.0138    0.0134    0.0117    0.0121    0.0113    0.0120

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ------------------------------------
  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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  6
 -------------------------------------
  AVERAGES              0.0335    0.0397    0.0382    0.0375    0.0366    0.0364
                        0.0366    0.0360    0.0364    0.0355    0.0361    0.0351

  STD. DEVIATIONS       0.0071    0.0063    0.0055    0.0058    0.0047    0.0052
                        0.0057    0.0055    0.0050    0.0050    0.0048    0.0049

*******************************************************************************


*******************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------
                                    INCHES            CU. FEET       PERCENT
                               -------------------  -------------   ---------
PRECIPITATION                   38.98     (   7.188)    141490.1      100.00

RUNOFF                           3.843    (  1.2223)     13950.84      9.860

EVAPOTRANSPIRATION              25.190    (  3.1191)     91438.16     64.625

DRAINAGE RECIRCULATED            1.04174 (  0.13080)      3781.502    2.67263
  INTO LAYER  2

LATERAL DRAINAGE COLLECTED       9.37563 (  1.17720)     34033.520   24.05364
  FROM LAYER  5

DRAINAGE RECIRCULATED            1.04174 (  0.13080)      3781.502    2.67263
  FROM LAYER  5

PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)         0.009    0.00001
  LAYER  7

AVERAGE HEAD ON TOP              0.036 (    0.005)
  OF LAYER  6
```

```
 CHANGE IN WATER STORAGE         0.570   (  3.6116)       2067.49      1.461

*******************************************************************************
```

```
******************************************************************************

             PEAK DAILY VALUES FOR YEARS     6 THROUGH    10
        ------------------------------------------------------------------------
                                                      (INCHES)      (CU. FT.)
                                                     ----------   -------------
        PRECIPITATION                                   4.72       17133.600

        RUNOFF                                          1.917       6957.3447

        DRAINAGE RECIRCULATED INTO LAYER  2             0.00472       17.12068

        DRAINAGE COLLECTED FROM LAYER  5                0.04245      154.08614

        DRAINAGE RECIRCULATED FROM LAYER  5             0.00472       17.12068

        PERCOLATION/LEAKAGE THROUGH LAYER  7            0.000000       0.00003

        AVERAGE HEAD ON TOP OF LAYER  6                 0.060

        MAXIMUM HEAD ON TOP OF LAYER  6                 0.119

        LOCATION OF MAXIMUM HEAD IN LAYER  5
              (DISTANCE FROM DRAIN)                     5.5 FEET

        SNOW WATER                                      0.86        3135.2500


        MAXIMUM VEG. SOIL WATER (VOL/VOL)                       0.4613

        MINIMUM VEG. SOIL WATER (VOL/VOL)                       0.1870


         ***  Maximum heads are computed using McEnroe's equations.  ***

              Reference:  Maximum Saturated Depth over Landfill Liner
                          by Bruce M. McEnroe, University of Kansas
                          ASCE Journal of Environmental Engineering
                          Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
********************************************************************************

               FINAL WATER STORAGE AT END OF YEAR   10
    ----------------------------------------------------------------------
                LAYER          (INCHES)         (VOL/VOL)
                -----          --------         ---------
                  1              3.7169           0.3097

                  2            624.7405           0.4165

                  3            686.0540           0.3529

                  4              6.6046           0.2752

                  5              0.0291           0.1955

                  6              0.0000           0.0000

                  7             10.2480           0.4270

               SNOW WATER        0.000

********************************************************************************
********************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     d:\DATA4.D4
TEMPERATURE DATA FILE:       d:\DATA7.D7
SOLAR RADIATION DATA FILE:   d:\DATA13.D13
EVAPOTRANSPIRATION DATA:     d:\DATA11.D11
SOIL AND DESIGN DATA FILE:   d:\DATA10.D10
OUTPUT DATA FILE:            d:\CLOSED.OUT


TIME:   9:18     DATE:  11/ 3/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-UNDEV AREA CLOSED

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
           THICKNESS                    =     12.00    INCHES
           POROSITY                     =      0.3980 VOL/VOL
           FIELD CAPACITY               =      0.2440 VOL/VOL
           WILTING POINT                =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  10
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.3980 VOL/VOL
FIELD CAPACITY               =       0.2440 VOL/VOL
WILTING POINT                =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.119999997000E-03 CM/SEC


                              LAYER  3
                              --------

                   TYPE 4 - FLEXIBLE MEMBRANE LINER
                     MATERIAL TEXTURE NUMBER  36
THICKNESS                    =       0.04    INCHES
POROSITY                     =       0.0000 VOL/VOL
FIELD CAPACITY               =       0.0000 VOL/VOL
WILTING POINT                =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY        =   3 - GOOD


                              LAYER  4
                              --------

                     TYPE 3 - BARRIER SOIL LINER
                     MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      18.00    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.    =   0.999999975000E-05 CM/SEC


                              LAYER  5
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  11
THICKNESS                    =      12.00    INCHES
```

```
POROSITY                     =      0.4640 VOL/VOL
FIELD CAPACITY               =      0.3100 VOL/VOL
WILTING POINT                =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC


                      LAYER  6
                      --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =   1500.00    INCHES
POROSITY                     =      0.6148 VOL/VOL
FIELD CAPACITY               =      0.5114 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                      LAYER  7
                      --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =   1944.00    INCHES
POROSITY                     =      0.4985 VOL/VOL
FIELD CAPACITY               =      0.4790 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                      LAYER  8
                      --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                    =     24.00    INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                      LAYER  9
                      --------
```

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
    THICKNESS                    =       0.15    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.    =    4.59000015000       CM/SEC
    SLOPE                        =       0.90    PERCENT
    DRAINAGE LENGTH              =     350.0     FEET


                            LAYER 10
                            --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
    THICKNESS                    =       0.06    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     =       0.00    HOLES/ACRE
    FML PLACEMENT QUALITY        =   3 - GOOD


                            LAYER 11
                            --------

                  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 #10 WITH A
           GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
           AND A SLOPE LENGTH OF  500. FEET.

 SCS RUNOFF CURVE NUMBER                =     80.10
```

```
  FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
  AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
  EVAPORATIVE ZONE DEPTH               =     18.0    INCHES
  INITIAL WATER IN EVAPORATIVE ZONE    =      4.392  INCHES
  UPPER LIMIT OF EVAPORATIVE STORAGE   =      7.164  INCHES
  LOWER LIMIT OF EVAPORATIVE STORAGE   =      2.448  INCHES
  INITIAL SNOW WATER                   =      0.000  INCHES
  INITIAL WATER IN LAYER MATERIALS     =   1342.087  INCHES
  TOTAL INITIAL WATER                  =   1342.087  INCHES
  TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


              EVAPOTRANSPIRATION AND WEATHER DATA
              -----------------------------------

   NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
            DALLAS                TEXAS

       STATION LATITUDE                         =  32.85 DEGREES
       MAXIMUM LEAF AREA INDEX                  =   4.50
       START OF GROWING SEASON (JULIAN DATE)    =     63
       END OF GROWING SEASON (JULIAN DATE)      =    329
       EVAPORATIVE ZONE DEPTH                   =  18.0  INCHES
       AVERAGE ANNUAL WIND SPEED                =  10.80 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  66.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  68.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  63.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  66.00 %


   NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    DALLAS              TEXAS

            NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  1.90         2.37         3.06         3.20         5.15         3.23
  2.12         2.03         2.42         4.11         2.57         2.57


   NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    DALLAS              TEXAS

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
 44.10        49.40        57.40        65.00        73.10        80.90
 85.00        84.40        77.50        67.20        55.10        46.70
```

```
         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS              TEXAS
                    AND STATION LATITUDE  =  32.85 DEGREES




******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------------

                           JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                           -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                   1.49     2.20     2.80     3.08     4.59     3.29
                             2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS          1.02     1.27     1.67     1.89     2.17     2.13
                             2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                   0.231    0.154    0.318    0.189    0.352    0.106
                             0.124    0.016    0.022    0.847    0.537    0.879

    STD. DEVIATIONS          0.410    0.410    0.709    0.443    0.820    0.204
                             0.289    0.039    0.049    1.590    1.034    1.518

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                   1.673    1.770    2.669    4.424    4.729    3.465
                             2.959    1.935    2.408    1.751    1.035    1.400

    STD. DEVIATIONS          0.408    0.585    0.943    1.005    1.869    1.948
                             1.993    1.548    1.397    0.866    0.367    0.421

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                   0.0314   0.0274   0.0306   0.0241   0.0158   0.0134
                             0.0135   0.0123   0.0119   0.0195   0.0255   0.0309

    STD. DEVIATIONS          0.0126   0.0096   0.0093   0.0081   0.0061   0.0034
                             0.0036   0.0024   0.0025   0.0103   0.0141   0.0142

  LATERAL DRAINAGE COLLECTED FROM LAYER  9
  ----------------------------------------
    TOTALS                   0.4992   0.4742   0.5194   0.4954   0.5069   0.4873
                             0.5063   0.5008   0.4881   0.4998   0.4803   0.4953

    STD. DEVIATIONS          0.1882   0.2126   0.2181   0.2083   0.2064   0.1993
                             0.2091   0.2006   0.1951   0.1973   0.1951   0.1937

  PERCOLATION/LEAKAGE THROUGH LAYER 11
```

```
   ------------------------------------
     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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


   DAILY AVERAGE HEAD ON TOP OF LAYER  3
   -------------------------------------
     AVERAGES                 15.3998  14.7275  15.0076  12.1243   7.5029   6.5148
                               6.3332   5.7299   5.7205   9.3725  12.8499  15.1297

     STD. DEVIATIONS           6.3262   5.3059   4.6271   4.1758   3.0544   1.7389
                               1.7835   1.1462   1.2067   5.1851   7.3282   7.1434

   DAILY AVERAGE HEAD ON TOP OF LAYER 10
   -------------------------------------
     AVERAGES                  0.0241   0.0251   0.0250   0.0247   0.0244   0.0243
                               0.0244   0.0241   0.0243   0.0241   0.0239   0.0239

     STD. DEVIATIONS           0.0091   0.0113   0.0105   0.0104   0.0100   0.0099
                               0.0101   0.0097   0.0097   0.0095   0.0097   0.0093

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                       INCHES              CU. FEET      PERCENT
                               -------------------      -------------   ---------
 PRECIPITATION                  34.26     (   6.276)      124371.1      100.00

 RUNOFF                          3.774    (  2.9347)       13698.63      11.014

 EVAPOTRANSPIRATION             30.216    (  4.2443)      109684.16      88.191

 PERCOLATION/LEAKAGE THROUGH     0.25638 (  0.06252)          930.642     0.74828
   LAYER  4

 AVERAGE HEAD ON TOP            10.534 (     2.625)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED      5.95309 (  2.39718)       21609.734   17.37521
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)           0.009     0.00001
   LAYER 11
```

```
 AVERAGE HEAD ON TOP             0.024 (    0.010)
   OF LAYER 10

 CHANGE IN WATER STORAGE        -5.681   (  3.0871)     -20621.45    -16.581

*******************************************************************************
```

```
*******************************************************************************

            PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                               6.00          21780.000

      RUNOFF                                      3.413         12389.1777

      PERCOLATION/LEAKAGE THROUGH LAYER  4        0.001567          5.68974

      AVERAGE HEAD ON TOP OF LAYER  3            24.000

      DRAINAGE COLLECTED FROM LAYER  9            0.04698         170.53845

      PERCOLATION/LEAKAGE THROUGH LAYER 11        0.000000          0.00003

      AVERAGE HEAD ON TOP OF LAYER 10             0.070

      MAXIMUM HEAD ON TOP OF LAYER 10             0.138

      LOCATION OF MAXIMUM HEAD IN LAYER  9
            (DISTANCE FROM DRAIN)                 6.1 FEET

      SNOW WATER                                  2.40           8713.1436


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3980

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1360


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

*******************************************************************************
```

```
******************************************************************************

               FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                LAYER         (INCHES)        (VOL/VOL)
                -----         --------        ---------
                  1             2.4409          0.2034

                  2             3.8913          0.3243

                  3             0.0000          0.0000

                  4             7.6860          0.4270

                  5             3.7200          0.3100

                  6           547.8275          0.3652

                  7           589.5682          0.3033

                  8             6.2666          0.2611

                  9             0.0135          0.0906

                 10             0.0000          0.0000

                 11            10.2480          0.4270

               SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

HELP MODEL FOR OVERLINER

```
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**              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               **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************



PRECIPITATION DATA FILE:    d:\DATA4.D4
TEMPERATURE DATA FILE:      d:\DATA7.D7
SOLAR RADIATION DATA FILE:  d:\DATA13.D13
EVAPOTRANSPIRATION DATA:    d:\DATA11.D11
SOIL AND DESIGN DATA FILE:  d:\DATA10.D10
OUTPUT DATA FILE:           d:\ACTIVE.OUT


TIME:  15:40     DATE:  11/ 2/2011


*******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER ACTIVE 10'

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    120.00   INCHES
           POROSITY                    =      0.6376 VOL/VOL
           FIELD CAPACITY              =      0.5185 VOL/VOL
           WILTING POINT               =      0.0770 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2500 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
                         LAYER  2
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
THICKNESS                   =      24.00    INCHES
POROSITY                    =       0.3980 VOL/VOL
FIELD CAPACITY              =       0.2440 VOL/VOL
WILTING POINT               =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                         LAYER  3
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =       0.30    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.   =   40.6500015000      CM/SEC
SLOPE                       =       1.00    PERCENT
DRAINAGE LENGTH             =     700.0     FEET


                         LAYER  4
                         --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
THICKNESS                   =       0.04    INCHES
POROSITY                    =       0.0000 VOL/VOL
FIELD CAPACITY              =       0.0000 VOL/VOL
WILTING POINT               =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =       0.00    HOLES/ACRE
FML INSTALLATION DEFECTS    =       0.00    HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                         LAYER  5
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =       0.25    INCHES
```

```
          POROSITY                      =      0.7500 VOL/VOL
          FIELD CAPACITY                =      0.7470 VOL/VOL
          WILTING POINT                 =      0.4000 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.7500 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.499999997000E-08 CM/SEC


                  GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                  ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                 SOIL DATA BASE USING SOIL TEXTURE #18 WITH BARE
                 GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
                 A SLOPE LENGTH OF  200. FEET.

       SCS RUNOFF CURVE NUMBER              =     80.30
       FRACTION OF AREA ALLOWING RUNOFF     =      0.0     PERCENT
       AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
       EVAPORATIVE ZONE DEPTH               =     10.0     INCHES
       INITIAL WATER IN EVAPORATIVE ZONE    =      2.500   INCHES
       UPPER LIMIT OF EVAPORATIVE STORAGE   =      6.376   INCHES
       LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.770   INCHES
       INITIAL SNOW WATER                   =      0.000   INCHES
       INITIAL WATER IN LAYER MATERIALS     =     36.046   INCHES
       TOTAL INITIAL WATER                  =     36.046   INCHES
       TOTAL SUBSURFACE INFLOW              =      0.00    INCHES/YEAR


                   EVAPOTRANSPIRATION AND WEATHER DATA
                   -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                 DALLAS                TEXAS

            STATION LATITUDE                        =  32.85 DEGREES
            MAXIMUM LEAF AREA INDEX                 =   0.00
            START OF GROWING SEASON (JULIAN DATE)   =     63
            END OF GROWING SEASON (JULIAN DATE)     =    329
            EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
            AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
            AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
            AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
            AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
            AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


        NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DALLAS              TEXAS

                 NORMAL MEAN MONTHLY PRECIPITATION (INCHES)
```

```
        JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
        -------     -------     -------     -------     -------     -------
          1.90        2.37        3.06        3.20        5.15        3.23
          2.12        2.03        2.42        4.11        2.57        2.57


            NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                     COEFFICIENTS FOR    DALLAS             TEXAS

                NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

        JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
        -------     -------     -------     -------     -------     -------
         44.10       49.40       57.40       65.00       73.10       80.90
         85.00       84.40       77.50       67.20       55.10       46.70


            NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                     COEFFICIENTS FOR    DALLAS             TEXAS
                       AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    9 THROUGH    9
-------------------------------------------------------------------------------

                           JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                           -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                   1.30     3.02     3.80     4.33     7.68     2.52
                             5.79     0.00     4.02     2.40     7.68     3.39

    STD. DEVIATIONS          0.00     0.00     0.00     0.00     0.00     0.00
                             0.00     0.00     0.00     0.00     0.00     0.00

  RUNOFF
  ------
    TOTALS                   0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
                             0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                   2.197    3.017    3.846    2.357    4.697    3.536
                             2.515    0.000    2.714    1.828    3.478    2.135

    STD. DEVIATIONS          0.000    0.000    0.000    0.000    0.000    0.000
```

```
                         0.000    0.000    0.000    0.000    0.000    0.000

  LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0509   0.1387   0.1323   0.1625   0.1800   0.3007

    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

  PERCOLATION/LEAKAGE THROUGH LAYER  5
  ------------------------------------
    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


-------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES             0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0005   0.0014   0.0013   0.0016   0.0018   0.0029

    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

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    9 THROUGH    9
-------------------------------------------------------------------------------
                                    INCHES           CU. FEET      PERCENT
                              -------------------  -------------  ---------
 PRECIPITATION                  45.93   (   0.000)    166725.9     100.00

 RUNOFF                          0.000  (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION             32.320  (  0.0000)    117320.87     70.368

 LATERAL DRAINAGE COLLECTED      0.96501 (  0.00000)     3502.998    2.10105
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.008    0.00001
   LAYER  5

 AVERAGE HEAD ON TOP             0.001 (    0.000)
   OF LAYER  4
```

```
 CHANGE IN WATER STORAGE          12.645    (  0.0000)        45902.06     27.531

*******************************************************************************
```

```
******************************************************************************

             PEAK DAILY VALUES FOR YEARS    9 THROUGH    9
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              2.98         10817.400

      RUNOFF                                     0.000            0.0000

      DRAINAGE COLLECTED FROM LAYER  3           0.01377         49.97608

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000000         0.00005

      AVERAGE HEAD ON TOP OF LAYER  4            0.004

      MAXIMUM HEAD ON TOP OF LAYER  4            0.012

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)                0.0 FEET

      SNOW WATER                                 1.09          3951.7917


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4133

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0770


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
******************************************************************************

           FINAL WATER STORAGE AT END OF YEAR    9
    ----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          42.2483         0.3521

                2           6.2517         0.2605

                3           0.0042         0.0141

                4           0.0000         0.0000

                5           0.1875         0.7500

             SNOW WATER     0.000

******************************************************************************
******************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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                **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     d:\DATA4.D4
TEMPERATURE DATA FILE:       d:\DATA7.D7
SOLAR RADIATION DATA FILE:   d:\DATA13.D13
EVAPOTRANSPIRATION DATA:     d:\DATA11.D11
SOIL AND DESIGN DATA FILE:   d:\DATA10.D10
OUTPUT DATA FILE:            d:\I50.OUT


TIME:  15:39     DATE:  11/ 2/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER INTERIM 50'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  11
           THICKNESS                    =      12.00    INCHES
           POROSITY                     =       0.4640 VOL/VOL
           FIELD CAPACITY               =       0.3100 VOL/VOL
           WILTING POINT                =       0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT   =       0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                          LAYER  2
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                  =    600.00   INCHES
POROSITY                   =      0.6376 VOL/VOL
FIELD CAPACITY             =      0.5185 VOL/VOL
WILTING POINT              =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.3980 VOL/VOL
FIELD CAPACITY             =      0.2440 VOL/VOL
WILTING POINT              =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC


                          LAYER  4
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                  =      0.29   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.  =   26.1000004000      CM/SEC
SLOPE                      =      1.00   PERCENT
DRAINAGE LENGTH            =    700.0    FEET


                          LAYER  5
                          --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
THICKNESS                  =      0.04   INCHES
POROSITY                   =      0.0000 VOL/VOL
```

```
        FIELD CAPACITY            =       0.0000 VOL/VOL
        WILTING POINT             =       0.0000 VOL/VOL
        INITIAL SOIL WATER CONTENT =      0.0000 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =  0.399999993000E-12 CM/SEC
        FML PINHOLE DENSITY        =       0.00   HOLES/ACRE
        FML INSTALLATION DEFECTS   =       0.00   HOLES/ACRE
        FML PLACEMENT QUALITY      =  3 - GOOD


                               LAYER  6
                               --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   0
        THICKNESS                  =       0.25   INCHES
        POROSITY                   =       0.7500 VOL/VOL
        FIELD CAPACITY             =       0.7470 VOL/VOL
        WILTING POINT              =       0.4000 VOL/VOL
        INITIAL SOIL WATER CONTENT =       0.7500 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =  0.499999997000E-08 CM/SEC


                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

       NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                SOIL DATA BASE USING SOIL TEXTURE #11 WITH A
                FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
                AND A SLOPE LENGTH OF  200. FEET.

      SCS RUNOFF CURVE NUMBER              =     87.10
      FRACTION OF AREA ALLOWING RUNOFF     =     70.0    PERCENT
      AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
      EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
      INITIAL WATER IN EVAPORATIVE ZONE    =      3.100  INCHES
      UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.640  INCHES
      LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.870  INCHES
      INITIAL SNOW WATER                   =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS     =    159.766  INCHES
      TOTAL INITIAL WATER                  =    159.766  INCHES
      TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DALLAS                TEXAS

         STATION LATITUDE                         =  32.85 DEGREES
```

```
           MAXIMUM LEAF AREA INDEX                  =   2.00
           START OF GROWING SEASON (JULIAN DATE)    =     63
           END OF GROWING SEASON (JULIAN DATE)      =    329
           EVAPORATIVE ZONE DEPTH                   =  10.0  INCHES
           AVERAGE ANNUAL WIND SPEED                =  10.80 MPH
           AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  66.00 %
           AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  68.00 %
           AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  63.00 %
           AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  66.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS             TEXAS

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
      1.90        2.37        3.06        3.20        5.15        3.23
      2.12        2.03        2.42        4.11        2.57        2.57


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS             TEXAS

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

    JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
    -------     -------     -------     -------     -------     -------
     44.10       49.40       57.40       65.00       73.10       80.90
     85.00       84.40       77.50       67.20       55.10       46.70


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS             TEXAS
                  AND STATION LATITUDE  =  32.85 DEGREES



*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS                 1.93     2.15     2.72     3.17     4.26     3.50
                           4.03     1.92     3.59     3.31     2.63     3.58
```

```
  STD. DEVIATIONS          1.28      1.01      1.14      1.17      2.39      2.30
                           3.13      1.41      1.53      3.11      1.73      1.82

RUNOFF
------
  TOTALS                   0.027     0.084     0.052     0.070     0.284     0.270
                           0.336     0.087     0.132     0.429     0.049     0.161

  STD. DEVIATIONS          0.033     0.149     0.063     0.089     0.287     0.310
                           0.492     0.139     0.147     0.947     0.094     0.208

EVAPOTRANSPIRATION
------------------
  TOTALS                   1.827     1.790     2.171     2.964     3.175     2.459
                           3.072     1.741     2.615     2.131     1.372     1.676

  STD. DEVIATIONS          0.394     0.781     0.574     1.251     1.204     1.611
                           1.466     1.212     1.236     1.277     0.657     0.490

LATERAL DRAINAGE COLLECTED FROM LAYER  4
----------------------------------------
  TOTALS                   0.1082    0.0988    0.1153    0.1048    0.1197    0.1242
                           0.1191    0.1284    0.1087    0.1133    0.1059    0.1204

  STD. DEVIATIONS          0.1251    0.1128    0.1339    0.1164    0.1396    0.1466
                           0.1398    0.1546    0.1265    0.1361    0.1404    0.1310

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  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


-------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


DAILY AVERAGE HEAD ON TOP OF LAYER  5
-------------------------------------
  AVERAGES                 0.0017    0.0017    0.0018    0.0017    0.0018    0.0020
                           0.0018    0.0020    0.0017    0.0017    0.0017    0.0018

  STD. DEVIATIONS          0.0019    0.0019    0.0020    0.0018    0.0021    0.0023
                           0.0021    0.0024    0.0020    0.0021    0.0022    0.0020

*******************************************************************************


*******************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------
```

```
                                     INCHES            CU. FEET      PERCENT
                               -------------------  -------------  ---------
PRECIPITATION                  36.80    (   4.383)    133573.1     100.00

RUNOFF                          1.980   (  0.8400)      7187.62      5.381

EVAPOTRANSPIRATION             26.993   (  2.9317)     97985.83     73.357

LATERAL DRAINAGE COLLECTED      1.36679 (  1.58974)     4961.460    3.71442
  FROM LAYER  4

PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.009     0.00001
  LAYER  6

AVERAGE HEAD ON TOP             0.002 (    0.002)
  OF LAYER  5

CHANGE IN WATER STORAGE         6.457   (  2.9870)     23438.20     17.547

*******************************************************************************
```

```
******************************************************************************

            PEAK DAILY VALUES FOR YEARS   21 THROUGH   30
    ------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------    -------------
      PRECIPITATION                             4.59        16661.701

      RUNOFF                                    1.735        6297.2939

      DRAINAGE COLLECTED FROM LAYER  4          0.02007        72.84621

      PERCOLATION/LEAKAGE THROUGH LAYER  6      0.000000        0.00005

      AVERAGE HEAD ON TOP OF LAYER  5           0.009

      MAXIMUM HEAD ON TOP OF LAYER  5           0.018

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)              31.0 FEET

      SNOW WATER                                1.29         4675.1299


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.4617

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1870

       ***  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   30
      ----------------------------------------------------------------------
               LAYER         (INCHES)        (VOL/VOL)
               -----         --------        ---------
                 1            2.7444          0.2287

                 2          215.1977          0.3587

                 3            6.1988          0.2583

                 4            0.0060          0.0206

                 5            0.0000          0.0000

                 6            0.1875          0.7500

             SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     d:\DATA4.D4
TEMPERATURE DATA FILE:       d:\DATA7.D7
SOLAR RADIATION DATA FILE:   d:\DATA13.D13
EVAPOTRANSPIRATION DATA:     d:\DATA11.D11
SOIL AND DESIGN DATA FILE:   d:\DATA10.D10
OUTPUT DATA FILE:            d:\I100.OUT


TIME:  15:37      DATE:  11/ 2/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER INTERIM 100'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  11
           THICKNESS                  =     12.00    INCHES
           POROSITY                   =      0.4640 VOL/VOL
           FIELD CAPACITY             =      0.3100 VOL/VOL
           WILTING POINT              =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                    FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =   1200.00   INCHES
POROSITY                   =      0.6247 VOL/VOL
FIELD CAPACITY             =      0.5144 VOL/VOL
WILTING POINT              =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.3980 VOL/VOL
FIELD CAPACITY             =      0.2440 VOL/VOL
WILTING POINT              =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC


                    LAYER  4
                    --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =      0.28   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.  =   18.7000008000      CM/SEC
SLOPE                      =      1.00   PERCENT
DRAINAGE LENGTH            =    700.0    FEET


                    LAYER  5
                    --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                  =      0.04   INCHES
POROSITY                   =      0.0000 VOL/VOL
```

```
     FIELD CAPACITY              =      0.0000 VOL/VOL
     WILTING POINT               =      0.0000 VOL/VOL
     INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
     EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
     FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
     FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
     FML PLACEMENT QUALITY       =  3 - GOOD


                            LAYER  6
                            --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
     THICKNESS                   =      0.25   INCHES
     POROSITY                    =      0.7500 VOL/VOL
     FIELD CAPACITY              =      0.7470 VOL/VOL
     WILTING POINT               =      0.4000 VOL/VOL
     INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
     EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC


               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

    NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
             SOIL DATA BASE USING SOIL TEXTURE #11 WITH A
             FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
             AND A SLOPE LENGTH OF  200. FEET.

   SCS RUNOFF CURVE NUMBER              =     87.10
   FRACTION OF AREA ALLOWING RUNOFF     =     80.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
   EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
   INITIAL WATER IN EVAPORATIVE ZONE    =      3.100  INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.640  INCHES
   LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.870  INCHES
   INITIAL SNOW WATER                   =      0.000  INCHES
   INITIAL WATER IN LAYER MATERIALS     =    465.766  INCHES
   TOTAL INITIAL WATER                  =    465.766  INCHES
   TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             DALLAS                   TEXAS

       STATION LATITUDE                            =  32.85 DEGREES
```

```
         MAXIMUM LEAF AREA INDEX                     =   2.00
         START OF GROWING SEASON (JULIAN DATE)       =     63
         END OF GROWING SEASON (JULIAN DATE)         =    329
         EVAPORATIVE ZONE DEPTH                      =  10.0  INCHES
         AVERAGE ANNUAL WIND SPEED                   =  10.80 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY       =  66.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY       =  68.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY       =  63.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY       =  66.00 %


     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

 JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
 -------     -------     -------     -------     -------     -------
   1.90        2.37        3.06        3.20        5.15        3.23
   2.12        2.03        2.42        4.11        2.57        2.57


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

 JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
 -------     -------     -------     -------     -------     -------
  44.10       49.40       57.40       65.00       73.10       80.90
  85.00       84.40       77.50       67.20       55.10       46.70


     NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS
                AND STATION LATITUDE  =  32.85 DEGREES



*******************************************************************************

     AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   16 THROUGH   30
-------------------------------------------------------------------------------

                      JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                      -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------

    TOTALS              1.71     2.22     2.45     3.35     4.37     3.64
                        3.65     1.61     3.28     3.60     2.37     3.34
```

```
   STD. DEVIATIONS          1.20     1.32     1.18     1.53     2.20     2.56
                            2.72     1.24     1.50     3.28     1.73     1.75

 RUNOFF
 ------
   TOTALS                   0.023    0.093    0.041    0.208    0.460    0.327
                            0.314    0.067    0.137    0.555    0.099    0.173

   STD. DEVIATIONS          0.037    0.162    0.064    0.329    0.780    0.464
                            0.477    0.137    0.160    1.096    0.196    0.251

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   1.660    1.591    2.083    2.584    3.349    2.590
                            2.982    1.436    2.586    1.794    1.248    1.610

   STD. DEVIATIONS          0.550    0.690    0.994    1.456    1.123    1.741
                            1.535    1.098    1.201    1.093    0.661    0.486

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                   0.5684   0.5295   0.5812   0.5813   0.5780   0.6056
                            0.5849   0.5754   0.5563   0.5890   0.5636   0.6053

   STD. DEVIATIONS          0.0956   0.0771   0.0642   0.0668   0.0731   0.0593
                            0.0649   0.0573   0.0689   0.0594   0.0753   0.0546

 PERCOLATION/LEAKAGE THROUGH LAYER  6
 ------------------------------------
   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


-------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  5
 -------------------------------------
   AVERAGES                 0.0121   0.0124   0.0124   0.0128   0.0123   0.0133
                            0.0125   0.0123   0.0122   0.0125   0.0124   0.0129

   STD. DEVIATIONS          0.0020   0.0018   0.0014   0.0015   0.0016   0.0013
                            0.0014   0.0012   0.0015   0.0013   0.0017   0.0012

*******************************************************************************


*******************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   16 THROUGH   30
-------------------------------------------------------------------------------
```

```
                                 INCHES              CU. FEET     PERCENT
                            -------------------    -------------  ---------
PRECIPITATION                35.60     (    4.934)   129225.6      100.00

RUNOFF                        2.499    (   1.2777)     9071.59       7.020

EVAPOTRANSPIRATION           25.512    (   3.2612)    92609.22      71.665

LATERAL DRAINAGE COLLECTED    6.91824 (   0.37560)    25113.219    19.43363
  FROM LAYER  4

PERCOLATION/LEAKAGE THROUGH   0.00000 (   0.00000)        0.018     0.00001
  LAYER  6

AVERAGE HEAD ON TOP           0.013 (     0.001)
  OF LAYER  5

CHANGE IN WATER STORAGE       0.670    (   2.4439)     2431.53       1.882

*******************************************************************************
```

```
******************************************************************************

           PEAK DAILY VALUES FOR YEARS   16 THROUGH   30
------------------------------------------------------------------------
                                               (INCHES)     (CU. FT.)
                                              ----------   -------------
   PRECIPITATION                                6.00        21780.000

   RUNOFF                                       2.948       10699.7725

   DRAINAGE COLLECTED FROM LAYER  4             0.04181       151.76074

   PERCOLATION/LEAKAGE THROUGH LAYER  6         0.000000        0.00005

   AVERAGE HEAD ON TOP OF LAYER  5              0.028

   MAXIMUM HEAD ON TOP OF LAYER  5              0.055

   LOCATION OF MAXIMUM HEAD IN LAYER  4
         (DISTANCE FROM DRAIN)                  0.0 FEET

   SNOW WATER                                   2.56         9295.1191


   MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4577

   MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1870

    ***  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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```

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******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR    30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            2.7479         0.2290

                      2          466.2429         0.3885

                      3            6.6275         0.2761

                      4            0.0080         0.0286

                      5            0.0000         0.0000

                      6            0.1875         0.7500

                  SNOW WATER       0.000

******************************************************************************
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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    d:\DATA4.D4
TEMPERATURE DATA FILE:      d:\DATA7.D7
SOLAR RADIATION DATA FILE:  d:\DATA13.D13
EVAPOTRANSPIRATION DATA:    d:\DATA11.D11
SOIL AND DESIGN DATA FILE:  d:\DATA10.D10
OUTPUT DATA FILE:           d:\I150.OUT


TIME:  15:31     DATE:  11/ 2/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER INTERIM 150'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                       =      12.00    INCHES
           POROSITY                        =       0.4640 VOL/VOL
           FIELD CAPACITY                  =       0.3100 VOL/VOL
           WILTING POINT                   =       0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT      =       0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.       =   0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                            LAYER  2
                            --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =   1500.00   INCHES
POROSITY                     =      0.6148 VOL/VOL
FIELD CAPACITY               =      0.5114 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC



                            LAYER  3
                            --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    300.00   INCHES
POROSITY                     =      0.5539 VOL/VOL
FIELD CAPACITY               =      0.4945 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC



                            LAYER  4
                            --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC



                            LAYER  5
                            --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.26   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.   =   13.6499996000      CM/SEC
          SLOPE                       =      1.00    PERCENT
          DRAINAGE LENGTH             =    700.0     FEET


                                  LAYER  6
                                  --------

                       TYPE 4 - FLEXIBLE MEMBRANE LINER
                         MATERIAL TEXTURE NUMBER  36
          THICKNESS                   =      0.04    INCHES
          POROSITY                    =      0.0000 VOL/VOL
          FIELD CAPACITY              =      0.0000 VOL/VOL
          WILTING POINT               =      0.0000 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY         =      0.00    HOLES/ACRE
          FML INSTALLATION DEFECTS    =      0.00    HOLES/ACRE
          FML PLACEMENT QUALITY       =  3 - GOOD


                                  LAYER  7
                                  --------

                         TYPE 3 - BARRIER SOIL LINER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                   =      0.25    INCHES
          POROSITY                    =      0.7500 VOL/VOL
          FIELD CAPACITY              =      0.7470 VOL/VOL
          WILTING POINT               =      0.4000 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC


                   GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                   ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                 SOIL DATA BASE USING SOIL TEXTURE #11 WITH A
                 FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
                 AND A SLOPE LENGTH OF  200. FEET.

       SCS RUNOFF CURVE NUMBER            =     87.10
       FRACTION OF AREA ALLOWING RUNOFF   =     80.0     PERCENT
       AREA PROJECTED ON HORIZONTAL PLANE =      1.000   ACRES
       EVAPORATIVE ZONE DEPTH             =     10.0     INCHES
       INITIAL WATER IN EVAPORATIVE ZONE  =      3.100   INCHES
       UPPER LIMIT OF EVAPORATIVE STORAGE =      4.640   INCHES
       LOWER LIMIT OF EVAPORATIVE STORAGE =      1.870   INCHES
```

```
      INITIAL SNOW WATER                   =       0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS     =     693.766  INCHES
      TOTAL INITIAL WATER                  =     693.766  INCHES
      TOTAL SUBSURFACE INFLOW              =       0.00   INCHES/YEAR


                  EVAPOTRANSPIRATION AND WEATHER DATA
                  -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DALLAS                TEXAS

            STATION LATITUDE                         = 32.85 DEGREES
            MAXIMUM LEAF AREA INDEX                  =  2.00
            START OF GROWING SEASON (JULIAN DATE)    =    63
            END OF GROWING SEASON (JULIAN DATE)      =   329
            EVAPORATIVE ZONE DEPTH                   = 10.0  INCHES
            AVERAGE ANNUAL WIND SPEED                = 10.80 MPH
            AVERAGE 1ST QUARTER RELATIVE HUMIDITY    = 66.00 %
            AVERAGE 2ND QUARTER RELATIVE HUMIDITY    = 68.00 %
            AVERAGE 3RD QUARTER RELATIVE HUMIDITY    = 63.00 %
            AVERAGE 4TH QUARTER RELATIVE HUMIDITY    = 66.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS              TEXAS

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
   -------      -------      -------      -------      -------      -------
     1.90         2.37         3.06         3.20         5.15         3.23
     2.12         2.03         2.42         4.11         2.57         2.57


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS              TEXAS

            NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
   -------      -------      -------      -------      -------      -------
    44.10        49.40        57.40        65.00        73.10        80.90
    85.00        84.40        77.50        67.20        55.10        46.70


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS              TEXAS
                  AND STATION LATITUDE  =  32.85 DEGREES
```

```
*******************************************************************************

      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS                 1.93     2.15     2.72     3.17     4.26     3.50
                          4.03     1.92     3.59     3.31     2.63     3.58

   STD. DEVIATIONS        1.28     1.01     1.14     1.17     2.39     2.30
                          3.13     1.41     1.53     3.11     1.73     1.82

 RUNOFF
 ------
   TOTALS                 0.030    0.096    0.059    0.080    0.323    0.308
                          0.381    0.100    0.151    0.479    0.056    0.184

   STD. DEVIATIONS        0.038    0.171    0.071    0.102    0.326    0.355
                          0.559    0.158    0.168    1.052    0.107    0.237

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                 1.830    1.785    2.184    2.965    3.161    2.484
                          3.071    1.737    2.609    2.138    1.397    1.664

   STD. DEVIATIONS        0.393    0.777    0.581    1.251    1.207    1.637
                          1.473    1.218    1.226    1.275    0.647    0.491

 LATERAL DRAINAGE COLLECTED FROM LAYER  5
 ----------------------------------------
   TOTALS                 0.4245   0.4282   0.4602   0.4384   0.4591   0.4430
                          0.4573   0.4517   0.4374   0.4545   0.4363   0.4557

   STD. DEVIATIONS        0.0727   0.0439   0.0442   0.0408   0.0397   0.0336
                          0.0286   0.0313   0.0242   0.0203   0.0246   0.0262

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ------------------------------------
   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


-------------------------------------------------------------------------------
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  6
```

```
-------------------------------------
  AVERAGES                 0.0124   0.0137   0.0134   0.0132   0.0134   0.0134
                           0.0133   0.0132   0.0132   0.0133   0.0132   0.0133

  STD. DEVIATIONS          0.0021   0.0015   0.0013   0.0012   0.0012   0.0010
                           0.0008   0.0009   0.0007   0.0006   0.0007   0.0008

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES           CU. FEET     PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                 36.80    (   4.383)    133573.1     100.00

 RUNOFF                         2.248   (  0.9387)      8161.14      6.110

 EVAPOTRANSPIRATION            27.025   (  2.9312)     98101.46     73.444

 LATERAL DRAINAGE COLLECTED     5.34611 (  0.29479)    19406.367   14.52865
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)        0.018     0.00001
   LAYER  7

 AVERAGE HEAD ON TOP            0.013 (    0.001)
   OF LAYER  6

 CHANGE IN WATER STORAGE        2.177   (  2.5037)      7904.16      5.917
*******************************************************************************
```

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS   21 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              4.59         16661.701

      RUNOFF                                     1.884         6839.5244

      DRAINAGE COLLECTED FROM LAYER  5           0.02476         89.88327

      PERCOLATION/LEAKAGE THROUGH LAYER  7       0.000000         0.00005

      AVERAGE HEAD ON TOP OF LAYER  6            0.022

      MAXIMUM HEAD ON TOP OF LAYER  6            0.045

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)                0.0 FEET

      SNOW WATER                                 1.29          4675.1299


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4565

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1870


       ***  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   30
    ----------------------------------------------------------------------
              LAYER          (INCHES)        (VOL/VOL)
              -----          --------        ---------
                1              2.8603          0.2384

                2            597.2713          0.3982

                3            108.7606          0.3625

                4              6.4477          0.2687

                5              0.0131          0.0500

                6              0.0000          0.0000

                7              0.1875          0.7500

            SNOW WATER         0.000

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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     d:\DATA4.D4
TEMPERATURE DATA FILE:       d:\DATA7.D7
SOLAR RADIATION DATA FILE:   d:\DATA13.D13
EVAPOTRANSPIRATION DATA:     d:\DATA11.D11
SOIL AND DESIGN DATA FILE:   d:\DATA10.D10
OUTPUT DATA FILE:            d:\I188.OUT


TIME:  16: 0     DATE:  11/ 2/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER INTERIN 188'

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                     =     12.00    INCHES
           POROSITY                      =      0.4640 VOL/VOL
           FIELD CAPACITY                =      0.3100 VOL/VOL
           WILTING POINT                 =      0.1870 VOL/VOL
           INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                     LAYER  2
                     --------

         TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =   1500.00    INCHES
POROSITY                    =      0.6148 VOL/VOL
FIELD CAPACITY              =      0.5114 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                     LAYER  3
                     --------

         TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    756.00    INCHES
POROSITY                    =      0.5387 VOL/VOL
FIELD CAPACITY              =      0.4900 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                     LAYER  4
                     --------

         TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  10
THICKNESS                   =     24.00    INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                     LAYER  5
                     --------

           TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.25    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.   =    9.22000027000      CM/SEC
   SLOPE                       =       1.00   PERCENT
   DRAINAGE LENGTH             =     700.0    FEET


                          LAYER  6
                          --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
   THICKNESS                   =       0.04   INCHES
   POROSITY                    =       0.0000 VOL/VOL
   FIELD CAPACITY              =       0.0000 VOL/VOL
   WILTING POINT               =       0.0000 VOL/VOL
   INITIAL SOIL WATER CONTENT  =       0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
   FML PINHOLE DENSITY         =       0.00   HOLES/ACRE
   FML INSTALLATION DEFECTS    =       0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                          LAYER  7
                          --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER   0
   THICKNESS                   =       0.25   INCHES
   POROSITY                    =       0.7500 VOL/VOL
   FIELD CAPACITY              =       0.7470 VOL/VOL
   WILTING POINT               =       0.4000 VOL/VOL
   INITIAL SOIL WATER CONTENT  =       0.7500 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #11 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  500. FEET.

SCS RUNOFF CURVE NUMBER            =      86.70
FRACTION OF AREA ALLOWING RUNOFF   =      90.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =       1.000  ACRES
EVAPORATIVE ZONE DEPTH             =      10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =       3.100  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =       4.640  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =       1.870  INCHES
```

```
      INITIAL SNOW WATER                     =       0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS       =     867.046  INCHES
      TOTAL INITIAL WATER                    =     867.046  INCHES
      TOTAL SUBSURFACE INFLOW                =       0.00   INCHES/YEAR


                  EVAPOTRANSPIRATION AND WEATHER DATA
                  -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DALLAS                 TEXAS

            STATION LATITUDE                        =  32.85 DEGREES
            MAXIMUM LEAF AREA INDEX                 =   2.00
            START OF GROWING SEASON (JULIAN DATE)   =     63
            END OF GROWING SEASON (JULIAN DATE)     =    329
            EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
            AVERAGE ANNUAL WIND SPEED               =  10.80 MPH
            AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
            AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
            AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  63.00 %
            AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  66.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS                 TEXAS

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
   -------      -------      -------      -------      -------      -------
     1.90         2.37         3.06         3.20         5.15         3.23
     2.12         2.03         2.42         4.11         2.57         2.57


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS                 TEXAS

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
   -------      -------      -------      -------      -------      -------
    44.10        49.40        57.40        65.00        73.10        80.90
    85.00        84.40        77.50        67.20        55.10        46.70


       NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    DALLAS                 TEXAS
                  AND STATION LATITUDE  =  32.85 DEGREES
```

```
******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    6 THROUGH   10
------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 1.19     2.92     2.56     3.32     5.03     3.09
                           3.21     2.21     2.74     5.78     3.54     3.38

    STD. DEVIATIONS        0.70     1.06     1.38     2.23     3.28     2.03
                           2.38     1.68     1.48     3.85     2.95     2.55

  RUNOFF
  ------
    TOTALS                 0.000    0.087    0.118    0.252    0.682    0.213
                           0.667    0.127    0.112    0.977    0.474    0.134

    STD. DEVIATIONS        0.000    0.047    0.181    0.294    1.106    0.200
                           0.925    0.132    0.155    1.267    0.697    0.160

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 1.473    2.016    2.397    2.581    2.527    2.908
                           1.612    1.724    2.207    2.428    1.656    1.662

    STD. DEVIATIONS        0.351    0.710    0.968    1.152    1.287    1.081
                           0.751    1.364    1.288    1.022    0.691    0.646

  LATERAL DRAINAGE COLLECTED FROM LAYER  5
  ----------------------------------------
    TOTALS                 0.4810   0.5063   0.5618   0.5380   0.5553   0.5253
                           0.5449   0.5442   0.5258   0.5351   0.5095   0.5374

    STD. DEVIATIONS        0.1289   0.0819   0.0961   0.0861   0.0740   0.0742
                           0.0742   0.0598   0.0733   0.0780   0.0574   0.0686

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    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


------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  6
```

```
    -------------------------------------
    AVERAGES                  0.0208   0.0241   0.0243   0.0240   0.0240   0.0235
                              0.0235   0.0235   0.0235   0.0231   0.0227   0.0232

    STD. DEVIATIONS           0.0056   0.0039   0.0042   0.0038   0.0032   0.0033
                              0.0032   0.0026   0.0033   0.0034   0.0026   0.0030

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    6 THROUGH   10
-------------------------------------------------------------------------------
                                    INCHES             CU. FEET       PERCENT
                              -------------------    ------------    ---------
 PRECIPITATION                 38.98     (   7.188)     141490.1       100.00

 RUNOFF                         3.843    (  1.2223)      13950.84        9.860

 EVAPOTRANSPIRATION            25.190    (  3.1191)      91438.16       64.625

 LATERAL DRAINAGE COLLECTED     6.36462 (  0.73657)      23103.566     16.32875
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)          0.018      0.00001
   LAYER  7

 AVERAGE HEAD ON TOP            0.023 (     0.003)
   OF LAYER  6

 CHANGE IN WATER STORAGE        3.581    (  3.3703)      12997.59        9.186
*******************************************************************************
```

```
******************************************************************************

            PEAK DAILY VALUES FOR YEARS     6 THROUGH    10
   ------------------------------------------------------------------------
                                              (INCHES)       (CU. FT.)
                                             ----------    -------------
      PRECIPITATION                             4.72          17133.600

      RUNOFF                                    1.917          6957.3447

      DRAINAGE COLLECTED FROM LAYER  5          0.02870         104.18482

      PERCOLATION/LEAKAGE THROUGH LAYER  7      0.000000          0.00005

      AVERAGE HEAD ON TOP OF LAYER  6           0.038

      MAXIMUM HEAD ON TOP OF LAYER  6           0.077

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)               0.0 FEET

      SNOW WATER                                0.86           3135.2500


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.4613

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1870


       ***  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   10
     ----------------------------------------------------------------------

                LAYER          (INCHES)       (VOL/VOL)
                -----          --------       ---------
                  1              3.7169         0.3097

                  2            604.3853         0.4029

                  3            270.1839         0.3574

                  4              6.4535         0.2689

                  5              0.0217         0.0880

                  6              0.0000         0.0000

                  7              0.1875         0.7500

              SNOW WATER         0.000

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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     d:\DATA4.D4
TEMPERATURE DATA FILE:       d:\DATA7.D7
SOLAR RADIATION DATA FILE:   d:\DATA13.D13
EVAPOTRANSPIRATION DATA:     d:\DATA11.D11
SOIL AND DESIGN DATA FILE:   d:\DATA10.D10
OUTPUT DATA FILE:            d:\CLOSED.OUT


TIME:  15: 4     DATE:  11/ 2/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-OVERLINER CLOSED

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
           THICKNESS                    =     12.00    INCHES
           POROSITY                     =      0.3980 VOL/VOL
           FIELD CAPACITY               =      0.2440 VOL/VOL
           WILTING POINT                =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                                  LAYER  2
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
        THICKNESS                    =     12.00    INCHES
        POROSITY                     =      0.3980 VOL/VOL
        FIELD CAPACITY               =      0.2440 VOL/VOL
        WILTING POINT                =      0.1360 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                                  LAYER  3
                                  --------

                      TYPE 4 - FLEXIBLE MEMBRANE LINER
                        MATERIAL TEXTURE NUMBER  36
        THICKNESS                    =      0.04    INCHES
        POROSITY                     =      0.0000 VOL/VOL
        FIELD CAPACITY               =      0.0000 VOL/VOL
        WILTING POINT                =      0.0000 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
        FML PINHOLE DENSITY          =      1.00    HOLES/ACRE
        FML INSTALLATION DEFECTS     =      4.00    HOLES/ACRE
        FML PLACEMENT QUALITY        =  3 - GOOD


                                  LAYER  4
                                  --------

                        TYPE 3 - BARRIER SOIL LINER
                        MATERIAL TEXTURE NUMBER   0
        THICKNESS                    =     18.00    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.    =  0.999999975000E-05 CM/SEC


                                  LAYER  5
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  11
        THICKNESS                    =     12.00    INCHES
```

```
POROSITY                    =      0.4640 VOL/VOL
FIELD CAPACITY              =      0.3100 VOL/VOL
WILTING POINT               =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.639999998000E-04 CM/SEC


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =   1500.00   INCHES
POROSITY                    =      0.6148 VOL/VOL
FIELD CAPACITY              =      0.5114 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    756.00   INCHES
POROSITY                    =      0.5387 VOL/VOL
FIELD CAPACITY              =      0.4900 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                        LAYER  8
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  9
                        --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.25    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.    =   7.76999998000       CM/SEC
SLOPE                        =      1.00    PERCENT
DRAINAGE LENGTH              =    700.0     FEET


                          LAYER 10
                          --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
THICKNESS                    =      0.04    INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      0.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =      0.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER 11
                          --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.25    INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
           GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
           AND A SLOPE LENGTH OF  500. FEET.

 SCS RUNOFF CURVE NUMBER              =      80.10
```

```
    FRACTION OF AREA ALLOWING RUNOFF     =     100.0     PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE   =       1.000   ACRES
    EVAPORATIVE ZONE DEPTH               =      18.0     INCHES
    INITIAL WATER IN EVAPORATIVE ZONE    =       4.392   INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE   =       7.164   INCHES
    LOWER LIMIT OF EVAPORATIVE STORAGE   =       2.448   INCHES
    INITIAL SNOW WATER                   =       0.000   INCHES
    INITIAL WATER IN LAYER MATERIALS     =     880.588   INCHES
    TOTAL INITIAL WATER                  =     880.588   INCHES
    TOTAL SUBSURFACE INFLOW              =       0.00    INCHES/YEAR


                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              DALLAS                 TEXAS

          STATION LATITUDE                           = 32.85 DEGREES
          MAXIMUM LEAF AREA INDEX                    =  4.50
          START OF GROWING SEASON (JULIAN DATE)      =    63
          END OF GROWING SEASON (JULIAN DATE)        =   329
          EVAPORATIVE ZONE DEPTH                     = 18.0  INCHES
          AVERAGE ANNUAL WIND SPEED                  = 10.80 MPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY      = 66.00 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY      = 68.00 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY      = 63.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY      = 66.00 %


     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    1.90        2.37        3.06        3.20        5.15        3.23
    2.12        2.03        2.42        4.11        2.57        2.57


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   44.10       49.40       57.40       65.00       73.10       80.90
   85.00       84.40       77.50       67.20       55.10       46.70
```

```
        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DALLAS             TEXAS
                   AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 1.49     2.20     2.80     3.08     4.59     3.29
                           2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS        1.02     1.27     1.67     1.89     2.17     2.13
                           2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                 0.231    0.154    0.318    0.189    0.352    0.106
                           0.124    0.016    0.022    0.847    0.537    0.879

    STD. DEVIATIONS        0.410    0.410    0.709    0.443    0.820    0.204
                           0.289    0.039    0.049    1.590    1.034    1.518

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 1.673    1.770    2.669    4.424    4.729    3.465
                           2.959    1.935    2.408    1.751    1.035    1.400

    STD. DEVIATIONS        0.408    0.585    0.943    1.005    1.869    1.948
                           1.993    1.548    1.397    0.866    0.367    0.421

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                 0.0314   0.0274   0.0306   0.0241   0.0158   0.0134
                           0.0135   0.0123   0.0119   0.0195   0.0255   0.0309

    STD. DEVIATIONS        0.0126   0.0096   0.0093   0.0081   0.0061   0.0034
                           0.0036   0.0024   0.0025   0.0103   0.0141   0.0142

  LATERAL DRAINAGE COLLECTED FROM LAYER  9
  ----------------------------------------
    TOTALS                 0.3260   0.3088   0.3368   0.3263   0.3353   0.3219
                           0.3332   0.3299   0.3195   0.3311   0.3188   0.3263

    STD. DEVIATIONS        0.0896   0.0998   0.1110   0.1038   0.1047   0.0988
                           0.1006   0.0990   0.0975   0.1013   0.0904   0.0958

  PERCOLATION/LEAKAGE THROUGH LAYER 11
```

```
  ------------------------------------
    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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
    AVERAGES               15.3998  14.7275  15.0076  12.1243   7.5029   6.5148
                            6.3332   5.7299   5.7205   9.3725  12.8499  15.1297

    STD. DEVIATIONS         6.3262   5.3059   4.6271   4.1758   3.0544   1.7389
                            1.7835   1.1462   1.2067   5.1851   7.3282   7.1434

  DAILY AVERAGE HEAD ON TOP OF LAYER 10
  -------------------------------------
    AVERAGES                0.0167   0.0174   0.0173   0.0173   0.0172   0.0171
                            0.0171   0.0169   0.0169   0.0170   0.0169   0.0167

    STD. DEVIATIONS         0.0046   0.0057   0.0057   0.0055   0.0054   0.0052
                            0.0052   0.0051   0.0052   0.0052   0.0048   0.0049

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET     PERCENT
                               -------------------   ------------  ---------
 PRECIPITATION                 34.26    (   6.276)    124371.1     100.00

 RUNOFF                         3.774   (  2.9347)     13698.63     11.014

 EVAPOTRANSPIRATION            30.216   (  4.2443)    109684.16     88.191

 PERCOLATION/LEAKAGE THROUGH    0.25638 (  0.06252)       930.642    0.74828
   LAYER  4

 AVERAGE HEAD ON TOP           10.534 (     2.625)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED     3.91392 (  1.16512)     14207.516  11.42349
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)         0.018    0.00001
   LAYER 11
```

```
AVERAGE HEAD ON TOP              0.017 (     0.005)
  OF LAYER 10

CHANGE IN WATER STORAGE         -3.642    (  2.3787)      -13219.24    -10.629

*******************************************************************************
```

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              6.00          21780.000

      RUNOFF                                     3.413         12389.1777

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.001567          5.68974

      AVERAGE HEAD ON TOP OF LAYER  3           24.000

      DRAINAGE COLLECTED FROM LAYER  9           0.02820         102.37570

      PERCOLATION/LEAKAGE THROUGH LAYER 11       0.000000          0.00006

      AVERAGE HEAD ON TOP OF LAYER 10            0.045

      MAXIMUM HEAD ON TOP OF LAYER 10            0.089

      LOCATION OF MAXIMUM HEAD IN LAYER  9
            (DISTANCE FROM DRAIN)                5.0 FEET

      SNOW WATER                                 2.40           8713.1436


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3980

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1360


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
******************************************************************************

               FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                LAYER         (INCHES)       (VOL/VOL)
                -----         --------       ---------
                  1            2.4409         0.2034

                  2            3.8913         0.3243

                  3            0.0000         0.0000

                  4            7.6860         0.4270

                  5            3.7200         0.3100

                  6          515.5693         0.3437

                  7          231.6745         0.3064

                  8            6.1575         0.2566

                  9            0.0107         0.0437

                 10            0.0000         0.0000

                 11            0.1875         0.7500

               SNOW WATER      0.000

******************************************************************************
******************************************************************************
```

APPENDIX IIIC-B

LEACHATE COLLECTION SYSTEM DESIGN CALCULATIONS

MARILYN D. MORRISON
102273

3-20-12

Includes pages IIIC-B-1 through IIIC-B-103

CONTENTS

STATE OF TEXAS
MARILYN D. MORRISON
102273
LICENSED PROFESSIONAL ENGINEER

3.20.12

LEACHATE COLLECTION PIPE CAPACITY CALCULATIONS

CAMELOT LANDFILL
1339-351-11-02
SUBTITLE D COLLECTION PIPE
CAPACITY CALCULATIONS

REQUIRED: Size leachate collection system pipe in the undeveloped area and analyze the leachate collection pipe in the developed area:

METHOD:

A. Use leachate production rates determined from the HELP model analysis (see Appendix IIIC-A) to size the leachate collection pipes. The largest cell in the developed and the undeveloped phases is analyzed to provide for a conservative analysis.

B. Determine required hole size (perforations) based on characteristics of the surrounding drainage media.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.
2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.
3. Driscopipe, *Leachate Pipe Systems*, Phillips Drisco Inc., 1992.

SOLUTION:

Determine the peak daily flow rate estimate:

The following tables summarize the fill conditions that are likely to be present and have the greatest contribution of leachate into the LCS. The peak flow rate (lateral drainage in the LCS layer) is shown for each condition.

Developed Cells :
From the HELP model (Appendix IIIC-A; Developed Subtitle D area (Cells 1 and 2 and Cells 4B and 5)

CONDITION	PEAK cfd/ac	PEAK gpd/ac
Interim, 50' Waste	32.7	245
Interim, 100' Waste	26.7	200
Interim, 150' Waste	15.0	112
Interim, 200' Waste	11.5	86
Interim, 282'/298' Waste	9.9	74

For the developed cells the largest area draining to a leachate collection pipe is 29.5 acres (pipe in Cells 1-4B). For each fill condition, the highest leachate generation rate from the HELP runs for Developed Subtitle D cells (Cells 1 and 2) and (Cells 4B and 5) was used to be conservative. Also, even though there are four leachate pipes located in this area, the calculations were conservatively performed assuming that the entire drainage area will contribute flow to one pipe.

Therefore, the maximum leachate production expected in the leachate collection pipe is predicted to occur assuming the following scenario:

1. Interim condition, 50' waste over	5.50	ac
2. Interim condition, 100' waste over	6.40	ac
3. Interim condition, 150' waste over	8.50	ac
4. Interim condition, 200' waste over	5.50	ac
5. Interim condition, 282'/298' waste over	3.60	ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Interim, 50' Waste	5.50	245	1,345	0.0021
Interim, 100' Waste	6.40	200	1,278	0.0020
Interim, 150' Waste	8.50	112	954	0.0015
Interim, 200' Waste	5.50	86	473	0.0007
Interim, 282'/298' Waste	3.60	74	267	0.0004
Total=	29.50		4,317	0.0067

Undeveloped Cells :

From the HELP model (Appendix IIIC-A; Undeveloped area (Cells 6, 6A, 7, 7A, 10-13), Developed Subtitle D area (Cell 5), and Overliner area (a portion of Cell O1))

CONDITION	PEAK[1] cfd/ac	PEAK gpd/ac
Active, 10' Waste	50.0	374
Interim, 50' Waste	73.8	552
Interim, 100' Waste	164.3	1,229
Interim, 200' Waste	115.6	865
Interim, 287' Waste	171.2	1,281

[1] This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

For the undeveloped cells, the largest area draining to a leachate collection pipe is 43.9 acres (pipe in Cells 10 and 11). The leachate from Cell 5 and portion of Cell O1 will also drain to the pipe in Cells 10 and 11 and hence these areas were also considered. For each fill condition, the highest leachate generation rate from the HELP runs for Developed Subtitle D area for Cells 4B and 5, the Overliner area and the Undeveloped area was used to be conservative. Also, even though there are two leachate pipes located in this area, the calculations were conservatively performed assuming that the entire drainage will contribute flow to one pipe.

Therefore, the maximum leachate production expected in the leachate collection pipe is predicted to occur assuming the following scenario:

1. Active condition, 10' waste over	8.10	ac
2. Interim condition, 50' waste over	11.50	ac
3. Interim condition, 100' waste over	13.90	ac
4. Interim condition, 200' waste over	6.90	ac
5. Interim condition, 287' waste over	3.50	ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Active, 10' Waste	8.10	374	3,029	0.0047
Interim, 50' Waste	11.50	552	6,348	0.0098
Interim, 100' Waste	13.90	1,229	17,083	0.0264
Interim, 200' Waste	6.90	865	5,966	0.0092
Interim, 287' Waste	3.50	1,281	4,482	0.0069
Total=	43.90		36,909	0.0571

CAMELOT LANDFILL
1339-351-11-02
SUBTITLE D COLLECTION PIPE
CAPACITY CALCULATIONS

SUMMARY OF LEACHATE PRODUCTION:

Developed Cells Peak Leachate Production (cfs)	=	0.0067
Undeveloped Cells Peak Leachate Production (cfs)	=	0.0571

Developed Cells peak leachate production was used for the pipe capacity calculation for a 6" SDR 11 pipe.
Undeveloped Cells peak leachate production rate was used for the pipe capacity calculation for a 6" SDR 17 pipe.

Prep By: JLG
Date: 2/28/2012

Chkd By: MDM
Date: 2/28/2012

CAMELOT LANDFILL
1339-351-11-02
SUBTITLE D COLLECTION PIPE
CAPACITY CALCULATIONS

Determination of flow capacity (Q_{full}) for 6-inch SDR 11 perforated pipe:

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where: A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions

Standard Dimension Ratio (SDR) = 11.0

ID = 5.421 in
= 0.452 ft

$$A = \frac{\Pi \times d^2}{4}$$

A = 0.160 sq ft

$$R = \frac{d}{4}$$

R = 0.113 ft

S = Design slope of pipe S = 0.0030 ft / ft

n = Manning's number n = 0.015

Q_{full} = 0.203 cfs

CAMELOT LANDFILL
1339-351-11-02
SUBTITLE D COLLECTION PIPE
CAPACITY CALCULATIONS

Determination of flow capacity (Q_{full}) for proposed 6-inch SDR 17 perforated pipe:

Standard Dimension Ratio (SDR) = 17.0

ID =	5.845	in
=	0.487	ft
A =	0.186	sq ft
R =	0.122	ft
S = Design slope of pipe S =	0.0030	ft / ft
n = Manning's number n =	0.015	

Q_{full} = 0.248 cfs

Compare Peak Q_{max} and Q_{full} for the 6" SDR 11 pipe:

Q_{full} = 0.203 cfs >> Q_{max} = 0.0067 cfs

Compare Peak Q_{max} and Q_{full} for the 6" SDR 17 pipe:

Q_{full} = 0.248 cfs >> Q_{max} = 0.0571 cfs

Conclusion:

The existing 6-inch SDR 11 pipes will continue to exceed flow capacity requirements. An SDR 17 pipe with a nominal diameter of 6 inches exceeds flow capacity requirements for the undeveloped cells.

B. Perforation configuration for a 6-inch SDR 17 perforated pipes:

Pipe perforations must allow free passage of leachate and also prevent migration of drainage media into collection pipes. Therefore, size of perforations depends on media particle size. Two perforations alternatives are evaluated below:

For leachate collection pipes with slotted perforations:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} > 2.0$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is an ASTM D number 467 aggregate

D_{85} = 25 mm
= 0.984 in

Standard slot width: d = 0.125 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} = 7.9 > 2.0 \quad \text{(acceptable)}$$

For leachate collection pipes with circular holes:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} > 1.7$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is an ASTM D number 467 aggregate

D_{85} = 25 mm
= 0.984 in

Standard hole diameter d = 0.5 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 2.0 > 1.7 \quad \text{(acceptable)}$$

In Addition:

A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, the number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

LEACHATE COLLECTION PIPE
STRUCTURAL STABILITY

CAMELOT LANDFILL
1339-351-11-02
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE

REQUIRED: Analyze structural stability of the 6 inch diameter leachate collection system pipe.

METHOD:

A. Determine the critical load and calculate stress under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

NOTE:

1. The leachate trench details shown on pages IIIC-B-32 and IIIC-B-33 are for illustration purposes only to show parameters used in the following calcualtions. Leachate collection system details can be found in Appendix IIIA-A.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage,* Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

6. Quian, Xuede, R.M. Koerner, D. H. Gray, "Geotechnical Aspects of Landfill Design and Construction." Prentice-Hall, Inc., New Jersey, 2002.

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading:

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight = 190,500 lb
Tire pressure = 80 psi
Number of tires = 4

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

$$\boxed{F = 47{,}625 \quad \text{lb}}$$

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

$$\boxed{r = 13.8 \quad \text{in}}$$

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

$$y = p\,(1 - ((r/z)^2+1)^{-3/2})$$

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Protective cover thickness (in)

z = 24 in

$$\boxed{y = 27.8 \quad \text{psi}}$$

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L =	41.7	psi

P_D = (zw)/1728

Where:
P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z =	24	in
w =	115	pcf

P_D =	1.60	psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T =	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.00	ft protective cover @	115	pcf =	230	psf	
4.50	ft final & intrm cover @	115	pcf =	517.5	psf	
298.00	ft solid waste/soil @	65	pcf =	19,370	psf	Highest waste column thickness
			Σ =	20,118	psf	over an 6" LCS pipe.

P_T =	139.7	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	139.7	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

CAMELOT LANDFILL
1339-351-11-02
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE

Determine design stress:

1. Adjust critical stress to account for loss of strength in the pipe due to perforations:

$P_{DES1} = 12P_T / (12 - l_p)$

Where: l_p = Cumulative length of perforations per foot of pipe
P_T = Critical pipe stress (psi)
P_{DES1} = Pipe stress adjusted for loss of strength (psi)

6	holes / foot
0.5	in / hole

l_p =	3.0	in/ft

From determination of critical loading:

P_T =	139.7	psi

P_{DES1} =	186.3	psi

Adjust pipe stress determined above to account for effects of soil arching:

2. The design pipe stress is estimated by accounting for the soil structure interaction between the buried leachate collection pipe and its backfill to obtain a realistic loading condition on the pipe.

2a. For the burial conditions shown on Figure 1 (page IIIC-B-32), the pipe may be classified as a positive projecting conduit.

2b. Because the pipe is flexible and will deflect in the vertical plane as shown on Figure 2 (page IIIC-B-33), the pipe will experience a reduction in loading due to soil arching. Soil arching is present when the soil column over the pipe settles and creates shear stresses in the surrounding soil. Those shear stresses will support the soil column, thereby reducing the load experienced by the pipe (see Figure 3, page IIIC-B-33).

2c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\ 2} \qquad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right)e^{\pm 2k\mu(H_e/B_c)} \qquad (2)$$

Where:
W_c = Load per unit length of conduit (lb/ft)
γ = Unit weight of soil above conduit (pcf)
B_c = Outer diameter of conduit (ft)
H = Height of fill above conduit (ft)
H_e = Height of plane of equal settlement above critical plane (ft)
k = Lateral pressure ratio (earth pressure coefficient)
μ = tan ϕ
ϕ = Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p\left(\frac{H}{B_c}\right) \qquad (3)$$

Where:
r_{sd} = Settlement ratio
p = Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{\left(S_m + S_g\right) - \left(S_f + dc\right)}{S_m} \qquad (4)$$

Where:
S_m = Compression deformation of soil column adjacent to conduit
S_g = Settlement of natural ground adjacent to conduit
S_f = Settlement of conduit into foundation material
dc = Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \qquad (5)$$

Since the trench aggregate (PZB) is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and a the lower sign to a negative rsd.

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6" DIA PIPE

2d. Load analysis solution by trial and error

Step 1: Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.66

Step 2: Calculate S_m based on the estimated vertical stress at the level of the pipe and the deformation modulus E of the PZB.

$$S_m = P_{DES1} D / E_s$$

Where:
P_{DES1} = Pipe stress adjusted for loss of strength (psi)
D = Pipe diameter (in)
E_s = PZB soil modulus (psi)

P_{DES1} =	186.3	psi
D =	6.625	in
E_s =	3,000	psi

S_m =	0.411	in

Step 3: Calculate dc using Equation (5):

$$dc = S_m (1 - r_{sd})$$

dc =	0.681	in

Step 4: Use the Iowa Formula (provided below) to calculate load per unit length (W_c).

$$W_c = \frac{dc}{(DL)k}\left(\frac{EI}{r^3} + 0.061E'\right)$$

Where:
DL = Deflection lag factor
k = Bedding factor
E = Young's modulus for pipe material (psi)
I = Moment of inertia for pipe wall = $t^3/12$ (in^4/in)
r = Pipe radius (in)
E' = Modulus of soil reaction (psi)

DL = 2.5 (Ref 6)
k = 0.1 (Ref 6)
E = 28,500 psi (refer to chart 25 on page IIIC-B-34, based on P_{DES1} above)
t = 0.390 in (SDR 17.0 pipe)
I = 0.005 in^4/in
r = 3.3 in
E' = 3,000 psi

$\boxed{W_c = 509 \text{ lb/in}}$

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\,2}}$$

Composite unit weight for waste and soil:

6.50	ft soil @	115	pcf =	748	psf
298	ft waste @	65	pcf =	19,370	psf
			Total =	20,118	psf

γ = 66.07 pcf (weighted average based on above table)
B_c = 6.625 in

$\boxed{C_c = 303.4 \text{ (unitless)}}$

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H = 298 ft
H/B_c = 539.8

Assume: H_e/B_c = 2.23

$k\mu$ = 0.13 (Ref 4)
$e^{-2k\mu(He/Bc)}-1$ = -0.44
$-2k\mu$ = -0.26
$(H/B_c - H_e/B_c)$ 537.5
$e^{-2k\mu(He/Bc)}$ = 0.56

Left-hand-side of equation (LHS) = 303
Right-hand-side of equation (RHS) = 303

<u>Step 7:</u> Substitute H_e/B_c into equation given below to determine if proper value for rsd was used.

$$\left[\frac{1}{2k\mu} \pm \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) \pm \frac{r_{sd}\,p}{3}\right] \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} \pm \frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$
$$\pm \frac{r_{sd}\,p}{3}\left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} - \frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right) \mp \left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right) = \pm r_{sd}\,p\left(\frac{H}{B_c}\right)$$

Because r_{sd} is negative for the incomplete ditch condition, the lower signs in the above equation are used.

$p =$ 1
$k\mu =$ 0.13
$H/B_c =$ 539.8
$H_e/B_c =$ 2.23
$r_{sd} =$ -0.66

LHS = 355
RHS = 354

If LHS is not approximately equal to RHS, adjust value for r_{sd} in Step 1 and repeat solution procedure.

2e. Once the solutions to the above equations are determined, the design pipe stress may be calculated and the deflection of the pipe determined.

$P_{DES2} = W_c / D$

Where: P_{DES2} = Load on pipe adjusted to account for effects of soil arching (psi)

$W_c =$ 509 lb/in
$D =$ 6.6 in

$P_{DES2} =$ 77 psi

A summary table for the structural stability analysis is provided on page IIIC-B-20 for the 6-inch-diameter leachate collection pipe. A pipe will be selected from this table for use in the collection system based on the calculated factors of safety for each possible failure condition. An example calculation is provided below that outlines the procedures used to determine the factors of safety for all pipe SDR sizes shown in the summary table.

B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR = Standard dimension ratio = 17
S_Y = compressive yield strength = 1,500 psi
RD_{all} = allowable ring deflection = 4.2 %

1. Wall crushing (Ref 3)

$S_A = P_{DES2}\,(SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
S_A = Actual compressive stress (psi)
SDR = Standard dimension ratio
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
S_Y = Compressive yield strength (psi)
FS = Factor of safety against wall crushing

P_{DES2} = 77 psi

S_A = 614.9 psi
FS = 2.4

Compare calculated and suggested factor of safety: 2.4 > 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES2}$

Where:
P_{cb} = Critical buckling pressure at top of pipe (psi)
E' = Soil modulus (psi)
E = Stress/time dependent tensile modulus for design loading conditions (psi)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
FS = Factor of safety against wall buckling

E' = 3,000 psi
E = 16,500 psi for 50 years based on S_A above (see chart page IIIC-B-34)
P_{DES2} = 77 psi

P_{cb} = 122.3 psi
FS = 1.6

Compare calculated and suggested factor of safety: 1.6 > 1.0

3. Ring deflection (Ref 3)

$E_S = P_{DES2} / E'$

Where:
E_S = Soil strain (%)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
E' = Soil modulus (psi)

P_{DES2} = 77 psi
E' = 3,000 psi

$\boxed{E_S = 2.6 \ \%}$

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RDact) is equal to soil strain.

RD_{act} = 2.6 %

Allowable ring deflection, RD_{all} = 4.20 %

$\boxed{RD_{act} < RD_{all}\text{, design is acceptable}}$

Note: An additional factor of safety is inherent to the design of the leachate collection system due to the presence of a gravel envelope surrounding the leachate collection pipe. The gravel layer will transmit leachate in the event that the leachate collection pipe becomes plugged or crushed.

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6" DIA PIPE

Adjusted load to account for soil arching = 77 psi

SDR	Wall Crushing			Wall Buckling				Ring Deflection			
	S_Y	S_A	FS_{WC}	E[2]	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
32.5	1,500	1,210.6	1.2	13,000	3,000	41.1	0.5	8.1	3,000	2.6	3.2
26.0	1,500	960.8	1.6	13,000	3,000	57.4	0.7	6.5	3,000	2.6	2.5
21.0	1,500	768.6	2.0	14,000	3,000	82.1	1.1	5.2	3,000	2.6	2.0
19.0	1,500	691.7	2.2	15,000	3,000	98.7	1.3	4.7	3,000	2.6	1.8
17.0 [1]	1,500	614.9	2.4	16,500	3,000	122.3	1.6	4.2	3,000	2.6	1.6
15.5	1,500	557.2	2.7	17,500	3,000	144.7	1.9	3.9	3,000	2.6	1.5
13.5	1,500	480.8	3.1	19,500	3,000	187.7	2.4	3.4	3,000	2.6	1.3
11.0	1,500	384.3	3.9	22,000	3,000	271.3	3.5	2.7	3,000	2.6	1.1

▨ denotes standard size

[1] Select 6-inch-diameter HDPE SDR 17.0 pipe for use in the leachate collection system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the attached chart (page IIIC-B-34), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50 year duration (maximum loading is the overburden load on the pipe).

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SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
18"-DIA PIPE

REQUIRED: Analyze structural stability of the 18 inch diameter leachate collection system pipe.

METHOD: A. Determine the critical load and calculate stress under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

NOTE: The leachate trench details shown on pages IIIC-B-32 and IIIC-B-33 are for illustration purposes only to show parameters used in the following calcualtions. Leachate collection system details can be found in Appendix IIIA-A.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage,* Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

6. Quian, Xuede, R.M. Koerner, D. H. Gray, "Geotechnical Aspects of Landfill Design and Construction." Prentice-Hall, Inc., New Jersey, 2002.

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18"-DIA PIPE

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight = 190,500 lb
Tire pressure = 80 psi
Number of tires = 4

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F = 47,625 lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where: r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

r = 13.8 in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

$$y = p\,(1 - ((r/z)^2+1)^{-3/2})$$

Where: y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Protective cover thickness (in)

z = 24 in

y = 27.8 psi

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L =	41.7	psi

P_D = (zw)/1728

Where: P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z = 24 in
w = 115 pcf

P_D =	1.60	psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T =	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.00	ft gravel & cover @	115	pcf =	230	psf
4.50	ft final & intrm cover @	115	pcf =	517.5	psf
130.00	ft solid waste/soil @	65	pcf =	8,450	psf
			Σ =	9,198	psf

P_T =	63.9	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	63.9	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

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18"-DIA PIPE

Determine Desing Stress:

1. Adjust critical stress to account for loss of strength in the pipe due to perforations:

$$P_{DES1} = 12P_T / (12 - l_p)$$

Where:

l_p = Cumulative length of perforations per foot of pipe
P_T = Critical pipe stress (psi)
P_{DES1} = Pipe stress adjusted for loss of strength (psi)

6	holes / foot
0.5	in / hole

l_p =	3.0	in/ft

From determination of critical loading:

P_T =	63.9	psi

P_{DES1} =	85.2	psi

Adjust pipe stress determined above to account for effects of soil arching:

2. The design pipe stress is estimated by accounting for the soil structure interaction between the buried leachate collection pipe and its backfill to obtain a realistic loading condition on the pipe.

2a. For the burial conditions shown on Figure 1 (page IIIC-B-32), the pipe may be classified as a positive projecting conduit.

2b. Because the pipe is flexible and will deflect in the vertical plane as shown on Figure 2 (page IIIC-B-33), the pipe will experience a reduction in loading due to soil arching. Soil arching is present when the soil column over the pipe settles and creates shear stresses in the surrounding soil. Those shear stresses will support the soil column, thereby reducing the load experienced by the pipe (see Figure 3, page IIIC-B-33).

2c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\ 2} \qquad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)}-1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} \qquad (2)$$

Where: W_c = Load per unit length of conduit (lb/ft)
γ = Unit weight of soil above conduit (pcf)
B_c = Outer diameter of conduit (ft)
H = Height of fill above conduit (ft)
H_e = Height of plane of equal settlement above critical plane (ft)
k = Lateral pressure ratio (earth pressure coefficient)
μ = tan ϕ
ϕ = Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p \left(\frac{H}{B_c}\right) \qquad (3)$$

Where: r_{sd} = Settlement ratio
p = Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{\left(S_m + S_g\right) - \left(S_f + dc\right)}{S_m} \qquad (4)$$

Where: S_m = Compression deformation of soil column adjacent to conduit
S_g = Settlement of natural ground adjacent to conduit
S_f = Settlement of conduit into foundation material
dc = Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \qquad (5)$$

Since the trench aggregate (PZB) is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and a the lower sign to a negative r_{sd}.

2d. Load analysis solution by trial and error

Step 1: Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.69

Step 2: Calculate S_m based on the estimated vertical stress at the level of the pipe and the deformation modulus E of the PZB.

$S_m = P_{DES1} D / E_s$

Where:
P_{DES1} = Pipe stress adjusted for loss of strength (psi)
D = Pipe diameter (in)
E_s = PZB soil modulus (psi)

P_{DES1} =	85.2	psi
D =	18	in
E_s =	3,000	psi

S_m =	0.511	in

Step 3: Calculate dc using Equation (5):

$dc = S_m (1 - r_{sd})$

dc =	0.861	in

Step 4: Use the Iowa Formula (provided below) to calculate load per unit length (W_c).

$$W_c = \frac{dc}{(DL)k}\left(\frac{EI}{r^3} + 0.061E'\right)$$

Where:
DL = Deflection lag factor
k = Bedding factor
E = Young's modulus for pipe material (psi)
I = Moment of inertia for pipe wall = $t^3/12$ (in^4/in)
r = Pipe radius (in)
E' = Modulus of soil reaction (psi)

DL =	2.5	(Ref 6)
k =	0.1	(Ref 6)
E =	33,000	psi (refer to chart 25 on page IIIC-B-34, based on P_{DES1} above)
t =	1.059	in (SDR 17.0 pipe)
I =	0.099	in^4/in
r =	9.0	in
E' =	3,000	psi

$$\boxed{W_c = 646 \text{ lb/in}}$$

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\ 2}}$$

Composite unit weight for waste and soil:

6.50	ft waste @	115	pcf =	748	psf
130.00	ft soil @	65	pcf =	8,450	psf
			Total =	9,198	psf

γ = 67.4 pcf (weighted average based on above table)
B_c = 18 in

$$\boxed{C_c = 51.1 \text{ (unitless)}}$$

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H = 137 ft
H/B_c = 91.0

Assume: H_e/B_c = 2.30

$k\mu$ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.45	
$-2k\mu$ =	-0.26	
$(H/B_c - H_e/B_c)$	88.7	
$e^{-2k\mu(He/Bc)}$ =	0.55	

Left-hand-side of equation (LHS) = 51
Right-hand-side of equation (RHS) = 51

Step 7: Substitute H_e/B_c into equation given below to determine if proper value for r_{sd} was used.

$$\left[\frac{1}{2k\mu}\pm\left(\frac{H}{B_c}-\frac{H_e}{B_c}\right)\pm\frac{r_{sd}p}{3}\right]\frac{e^{\pm2k\mu(H_e/B_c)}-1}{\pm2k\mu}\pm\frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$
$$\pm\frac{r_{sd}p}{3}\left(\frac{H}{B_c}-\frac{H_e}{B_c}\right)e^{\pm2k\mu(H_e/B_c)}-\frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right)\mp\left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right)=\pm r_{sd}p\left(\frac{H}{B_c}\right)$$

Because r_{sd} is negative for the incomplete ditch condition, the lower signs in the above equation are used.

$p =$ 1
$k\mu =$ 0.13
$H/B_c =$ 91.0
$H_e/B_c =$ 2.3
$r_{sd} =$ -0.69

LHS = 62
RHS = 62

If LHS is not approximately equal to RHS, adjust value for r_{sd} in Step 1 and repeat solution procedure.

2e. Once the solutions to the above equations are determined, the design pipe stress may be calculated and the deflection of the pipe determined.

$P_{DES2} = W_c / D$

Where: P_{DES2} = Load on pipe adjusted to account for effects of soil arching (psi)

$W_c =$ 646 lb/in
$D =$ 18.0 in

$\boxed{P_{DES2} = 36 \text{ psi}}$

A summary table for the structural stability analysis is provided on page IIIC-B-31 for the 18-inch-diameter leachate collection pipe. A pipe will be selected from this table for use in the collection system based on the calculated factors of safety for each possible failure condition. An example calculation is provided below that outlines the procedures used to determine the factors of safety for all pipe SDR sizes shown in the summary table.

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B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR	= Standard dimension ratio	=	17	
S_Y	= compressive yield strength	=	1,500	psi
RD_{all}	= allowable ring deflection	=	4.2	%

1. Wall crushing (Ref 3)

$S_A = P_{DES2}\,(SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
S_A = Actual compressive stress (psi)
SDR = Standard dimension ratio
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
S_Y = Compressive yield strength (psi)
FS = Factor of safety against wall crushing

P_{DES2} = 36 psi

S_A = 287.0 psi
FS = 5.2

Compare calculated and suggested factor of safety: 5.2 > 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES2}$

Where:
P_{cb} = Critical buckling pressure at top of pipe (psi)
E' = Soil modulus (psi)
E = Stress/time dependent tensile modulus for design loading conditions (psi)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
FS = Factor of safety against wall buckling

E' = 3,000 psi
E = 25,500 psi for 50 years based on S_A above (see chart page IIIC-B-34)
P_{DES2} = 36 psi

P_{cb} = 152.1 psi
FS = 4.2

Compare calculated and suggested factor of safety: 4.2 > 1.0

3. Ring deflection (Ref 3)

$E_S = P_{DES2} / E'$

Where:
E_S = Soil strain (%)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
E' = Soil modulus (psi)

P_{DES2} = 36 psi
E' = 3,000 psi

$\boxed{E_S = 1.2 \%}$

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RDact) is equal to soil strain.

RD_{act} = 1.2 %

Allowable ring deflection, RD_{all} = 4.20 %

$\boxed{RD_{act} < RD_{all}\text{, design is acceptable}}$

Note: An additional factor of safety is inherent to the design of the leachate collection system due to the presence of a gravel envelope surrounding the leachate collection pipe. The gravel layer will transmit leachate in the event that the leachate collection pipe becomes plugged or crushed.

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18"-DIA PIPE

Adjusted load to account for soil arching = 36 psi

SDR	Wall Crushing			Wall Buckling				Ring Deflection			
	S_Y	S_A	FS_{WC}	E[2]	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
32.5	1,500	565.0	2.7	17,500	3,000	47.7	1.3	8.1	3,000	1.2	6.8
26.0	1,500	448.4	3.3	20,500	3,000	72.1	2.0	6.5	3,000	1.2	5.4
21.0	1,500	358.7	4.2	22,500	3,000	104.0	2.9	5.2	3,000	1.2	4.3
19.0	1,500	322.8	4.6	23,500	3,000	123.5	3.4	4.7	3,000	1.2	3.9
17.0 [1]	1,500	287.0	5.2	25,500	3,000	152.1	4.2	4.2	3,000	1.2	3.5
15.5	1,500	260.1	5.8	26,000	3,000	176.4	4.9	3.9	3,000	1.2	3.3
13.5	1,500	224.4	6.7	27,000	3,000	220.8	6.2	3.4	3,000	1.2	2.8
11.0	1,500	179.4	8.4	29,000	3,000	311.5	8.7	2.7	3,000	1.2	2.3

▨ denotes standard size

[1] Select 18-inch-diameter HDPE SDR 17.0 pipe for use in the leachate collection system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the attached chart (page IIIC-B-34), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50 year duration (maximum loading is the overburden load on the pipe).

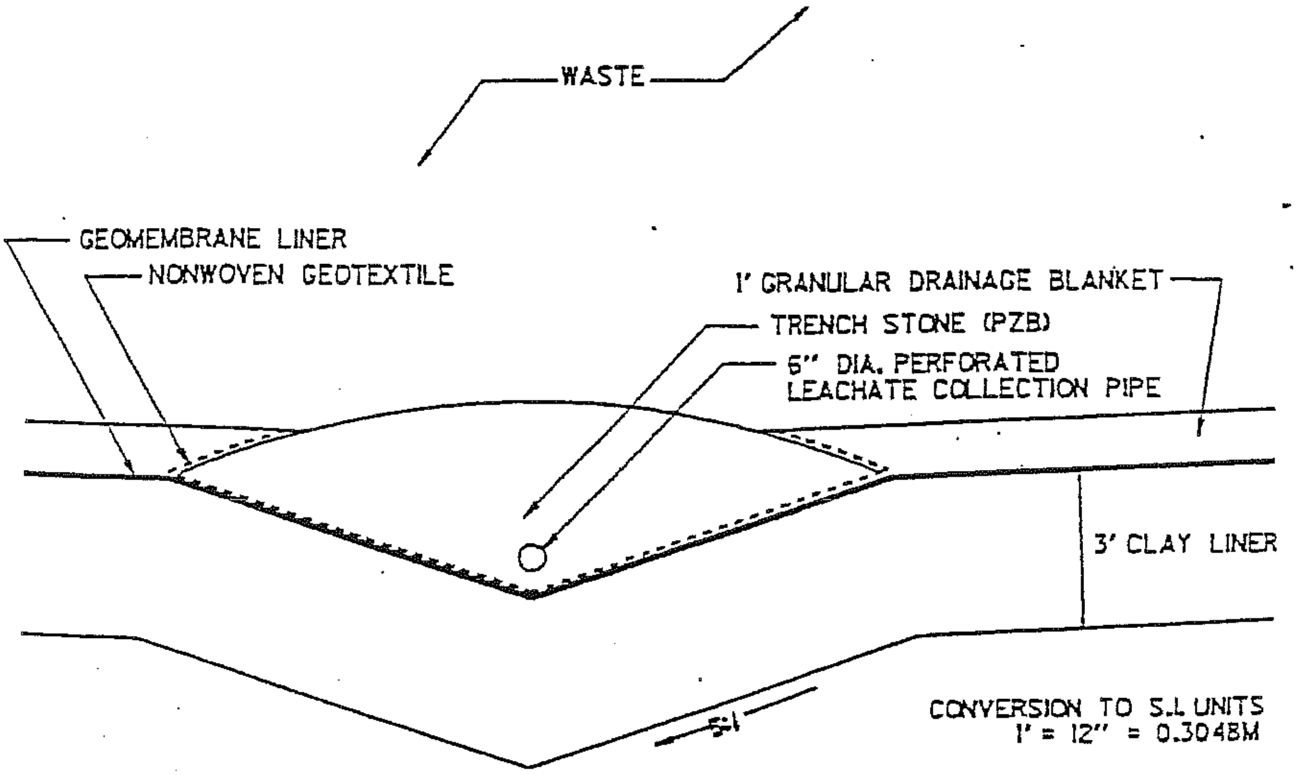

FIGURE 1: TYPICAL V-SHAPED TRENCH FOR LANDFILLS WITH COMPOSITE LINERS

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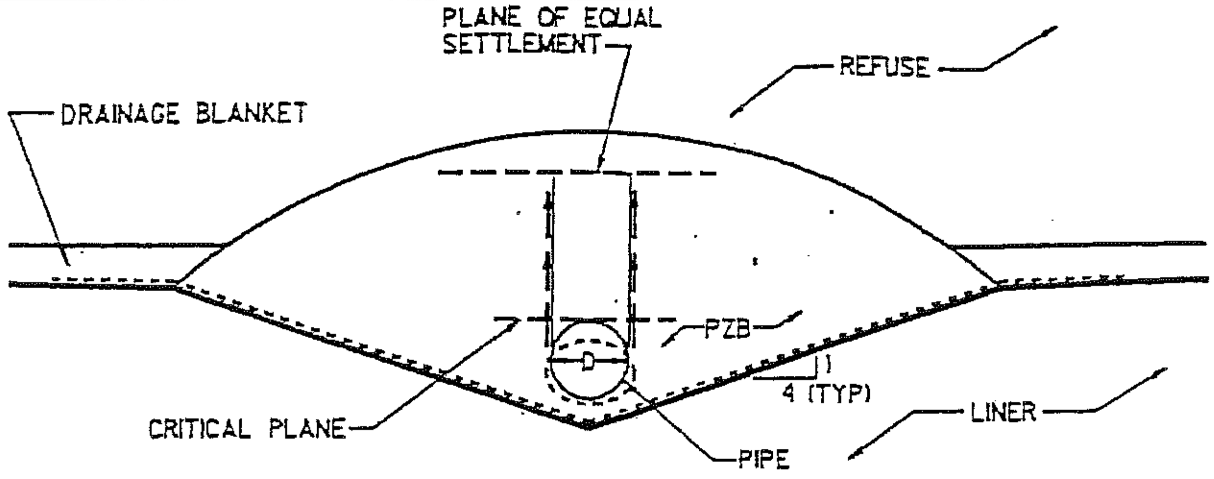

FIGURE 2: SETTLEMENT OF LEACHATE PIPE INDUCING SHEAR STRESSES IN PZB

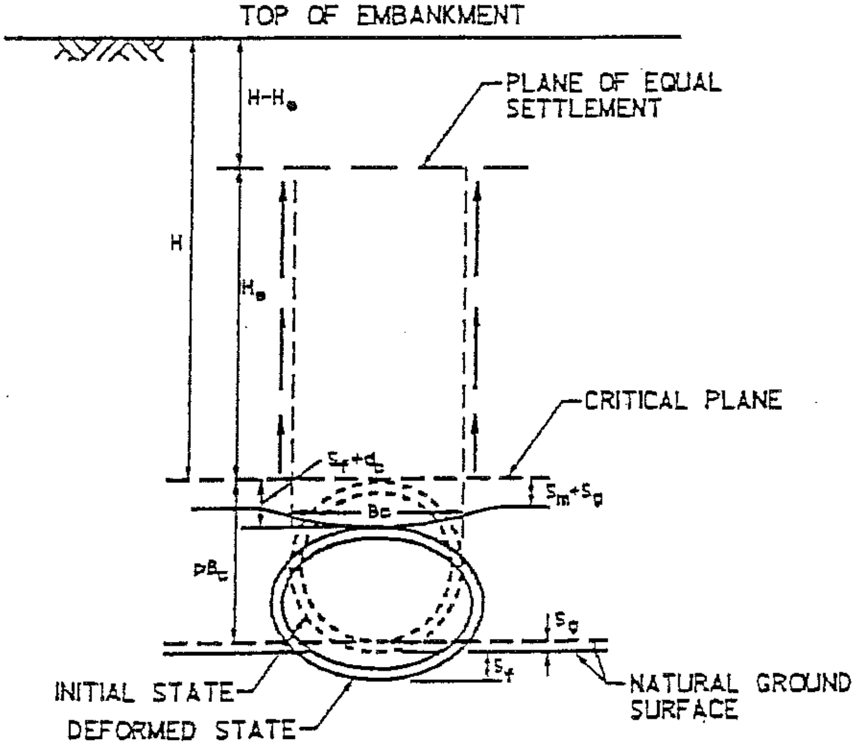

FIGURE 3: CASE OF AN INCOMPLETE DITCH CONDITION FOR A POSITIVE PROJECTING CONDUIT

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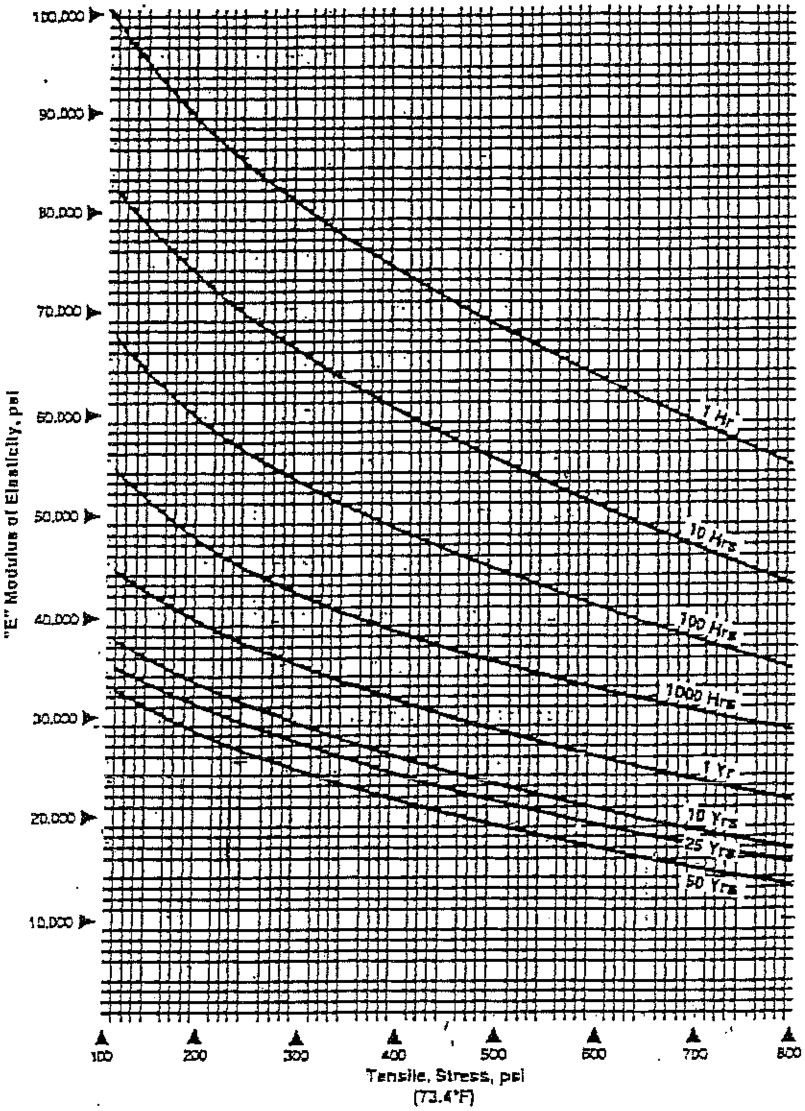
Chart 25

Time Dependent Modulus of Elasticity for Polyethylene Pipe vs. Stress Intensity (73.4°F)



NOTE: The short term modulus of elasticity of Driscopipe per ASTM D 638 is approximately 100,000 psi. Due to the cold flow (creep) characteristic of the pipe material, this modulus is dependent upon the stress intensity and the time duration of the applied stress.

---

3. Phillips 66 Driscopipe, "System Design", 1991.

LEACHATE SUMP DESIGN

REQUIRED: Size leachate collection sumps.

METHOD:

A. Use leachate production rates from HELP model and the sump drainage area from Sheet IIIC-B-41. The largest drainage area in the developed and the undeveloped area are analyzed to provide for a conservative analysis. Sump details are provided in Appendix IIIA-A Liner and Final Cover System Details.
B. Determine geometry of sump and its corresponding storage capacity.
C. Assume pump size and determine the average pump cycle time.

REFERENCES:

1. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

2. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Heisler, Sanford I., P.E., Wiley Engineer's Desk Reference, John Wiley & Sons, Inc., New York, 1998.

SOLUTION:

A. Average flow rate into sump

A.1 Determine the per acre flow rate for specific leachate collection sumps.

The following tables summarize the fill conditions that are likely to be present within each cell and have the greatest contribution of leachate into the LCS and sump system. The average flow rates (lateral drainage in the LCS layer) are shown for each condition.

Leachate sump drainage areas are shown on Sheet IIIC-B-41 Sump Drainage Areas.

Developed Cells:
From the HELP model (Appendix IIIC-A; Developed Subtitle D area (Cells 1, 2, 3, 4A, 4B, 5, 8, & 9A))

For the Developed Cells, the largest area draining to the sump is 48.5 acres (sump located in Cell 1). For each fill condition, the highest leachate generation rate from the HELP runs for Developed Subtitle D cells (Cells 1 and 2 and Cells 4B and 5) was used to be conservative.

CONDITION	Average cfy/ac	Average gpd/ac
Interim, 50' Waste	1,601.6	32.8
Interim, 100' Waste	3,862.2	79.1
Interim, 150' Waste	2,651.2	54.3
Interim, 200' Waste	2,484.3	50.9
Interim, 282'/298' Waste	1,935.7	39.7
Closed, 282'/298' Waste	2,035.8	41.7

Undeveloped Cells:
From the HELP model (Appendix IIIC-A; Undeveloped area (Cells 6, 6A, 7, 7A, 10-13), Developed Subtitle D area (Cell 5), and Overliner area (a portion of Cell O1))

For the undeveloped cells, the largest area draining to a sump is 43.9 acres (sump located in Cell 10). The leachate from Cell 5 and portion of O1 will also drain to the sump in Cell 10 and hence these areas were also considered. For each fill condition, the highest leachate generation rate from the HELP runs for the Developed Subtitle D area (Cells 4B and 5), the Overliner area, and the Undeveloped area was used to be conservative.

CONDITION	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	3,503.0	71.8
Interim, 50' Waste	5,066.3	103.8
Interim, 100' Waste	26,380.9	540.6
Interim, 200' Waste	23,199.6	475.4
Interim, 287' Waste	37,815.0	774.9
Closed, 287' Waste	21,609.7	442.9

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

CAMELOT LANDFILL
1339-351-11-02
SUBTITLE D LEACHATE SUMP DESIGN

1. Sump for Developed Cells

48.5 acres

Condition	Rate (gpd/ac)	Active		Inactive		Closed	
		area (ac)	rate (gpd)	area (ac)	rate (gpd)	area (ac)	rate (gpd)
Interim, 50' Waste	32.8	4.9	159.2	0.0	0.0	0.0	0.0
Interim, 100' Waste	79.1	6.1	479.8	0.0	0.0	0.0	0.0
Interim, 150' Waste	54.3	8.5	461.1	0.0	0.0	0.0	0.0
Interim, 200' Waste	50.9	9.7	493.8	0.0	0.0	0.0	0.0
Interim, 282'/298' Waste	39.7	14.6	577.2	48.5	1,923.9	0.0	0.0
Closed, 282'/298' Waste	41.7	4.9	202.3	0.0	0.0	48.5	2,023.4
Total		48.5	2,373.5	48.5	1,923.9	48.5	2,023.4

2. Sump for Undeveloped Cells

43.9 acres

Condition	Rate (gpd/ac)	Active		Inactive		Closed	
		area (ac)	rate (gpd)	area (ac)	rate (gpd)	area (ac)	rate (gpd)
Active, 10' Waste	71.8	4.4	315.1	0.0	0.0	0.0	0.0
Interim, 50' Waste	103.8	5.5	569.7	0.0	0.0	0.0	0.0
Interim, 100' Waste	540.6	7.7	4,153.4	0.0	0.0	0.0	0.0
Interim, 200' Waste	475.4	8.8	4,174.3	0.0	0.0	0.0	0.0
Interim, 287' Waste	774.9	13.2	10,206.1	43.9	34,020.2	0.0	0.0
Closed, 287' Waste	442.9	4.4	1,944.1	0.0	0.0	43.9	19,441.2
Total		43.9	21,362.7	43.9	34,020.2	43.9	19,441.2

B. Required storage capacity of sump

Assumed porosity of drainage stone: $P = 0.35$

$V_{\text{Daily Inflow}} = V_C / P$

1. Active

	V_C (gpd)	V_C (cu ft/day)	$V_{\text{Daily Inflow}}$ (cu ft/day)
Developed Cells	2,373.5	317.3	906.6
Undeveloped Cells	21,362.7	2,856.0	8,159.9

2. Inactive with Intermediate Cover

	V_C (gpd)	V_C (cu ft/day)	$V_{\text{Daily Inflow}}$ (cu ft/day)
Developed Cells	1,923.9	257.2	734.9
Undeveloped Cells	34,020.2	4,548.2	12,994.7

3. Closed

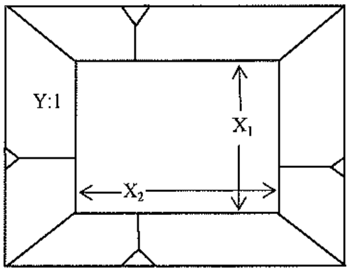
	V_C (gpd)	V_C (cu ft/day)	$V_{\text{Daily Inflow}}$ (cu ft/day)
Developed Cells	2,023.4	270.5	772.9
Undeveloped Cells	19,441.2	2,599.1	7,426.0

Total sump volume:

$$V_{TOT} = 1/3\left(A_1 + A_2 + \sqrt{(A_1 \cdot A_2)}\right)h$$

(Ref. 4, page 17)

Where:
A_1 = Area of bottom of sump
A_2 = Area of top of sump
h = Depth of sump



Y = Slope of sump side walls

$A_1 = X_1 * X_2$
$A_2 = (X_1 + 2(h*Y))*(X_2 + 2(h*Y))$

	X_1 (ft)	X_2 (ft)	Y (ft)	h (ft)	A_1 (ft^2)	A_2 (ft^2)	V_{TOT} (ft^3)
Developed Cells(1)	50	50	3	3.0	2,500	4,624	10,524
Undeveloped Cells	15	15	3	3.0	225	1,089	1,809

(1)Sump size for the sump in Cell 1 is assumed.

CAMELOT LANDFILL
1339-351-11-02
SUBTITLE D LEACHATE SUMP DESIGN

Compute the number of days storage provided for the following:

$$\text{STORAGE (Detention Time)} = \frac{V_{TOT}}{V_{\text{Daily Inflow}}}$$

1. Active

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Developed Cells	907	10,524	11.61
Undeveloped Cells	8,160	1,809	0.22

2. Inactive with Intermediate Cover

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Developed Cells	735	10,524	14.32
Undeveloped Cells	12,995	1,809	0.14

3. Closed

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Developed Cells	773	10,524	13.62
Undeveloped Cells	7,426	1,809	0.24

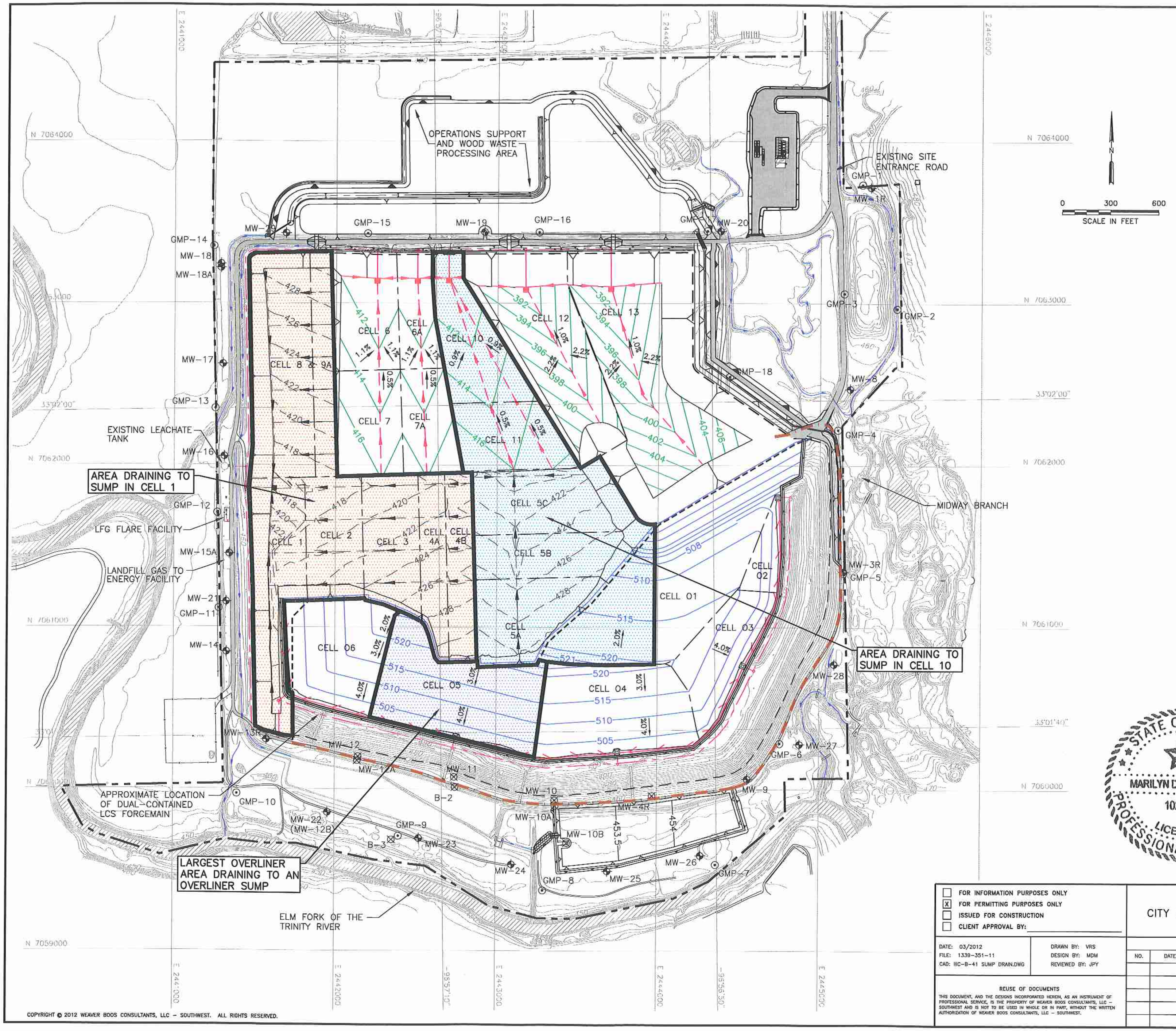
C. Estimated rate of leachate removal.

Using condition with highest inflow rate above.

Submersible pump capacity = 25 gpm

	Production	Average Pump Time	
	(gpd)	(min/day)	(hr/day)
Developed Cells	2,373.5	94.9	1.6
Undeveloped Cells	34,020.2	1360.8	22.7

Average pump time is less than 24 hours per day, therefore the design is acceptable. A pump with less capacity may also be used if it can be determined that the actual leachate generation is less than the design flow. Prior authorization from TCEQ will be obtained with a permit modification.



LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- LIMITS OF PRE-SUBTITLE D WASTE
- N 7064000 — STATE PLANE COORDINATE SYSTEM
- 33°02'00" — GEODETIC COORDINATE SYSTEM
- 500 — EXISTING CONTOUR
- EASEMENT
- CELL BOUNDARY
- 398 — PROPOSED EXCAVATION CONTOUR
- PROPOSED LEACHATE LINE
- ■ PROPOSED LEACHATE COLLECTION SUMP
- PROPOSED LEACHATE RISER
- 422 — AS-BUILT TOP OF SUBTITLE D CLAY LINER
- EXISTING LEACHATE LINE
- ■ EXISTING LEACHATE COLLECTION SUMP
- EXISTING LEACHATE RISER
- 515 — PROPOSED TOP OF OVERLINER CONTOUR
- PROPOSED OVERLINER LEACHATE LINE
- ⊠ PROPOSED OVERLINER LEACHATE COLLECTION SUMP
- LEACHATE FORCEMAIN
- 3H:1V SLOPE (TYPICAL)
- MW-8 GROUNDWATER MONITORING WELL
- GMP-1 GAS MONITORING PROBE
- MW-12 OBSERVATION WELL
- DRAINAGE AREA BOUNDARY
- APPROXIMATE LOCATION OF PROPOSED SLURRY WALL

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.

SUMP DRAINAGE AREAS

CELLS	AREA (ACRES)
CELL 1	48.5
CELL 10	43.9
CELL 05	12.6

STATE OF TEXAS
MARILYN D. MORRISON
102273
LICENSED PROFESSIONAL ENGINEER
3.2012

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☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION
☐ CLIENT APPROVAL BY: ____________

DATE: 03/2012
FILE: 1339-351-11
CAD: IIIC-B-41 SUMP DRAIN.DWG

DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

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PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
SUMP DRAINAGE AREAS

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
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(817) 735-9770

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SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

SHEET IIIC-B-41

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIC\IIIC-B-41 SUMP DRAINAGE AREAS.dwg, 3/20/2012 2:57:47 PM, rsellers

OVERLINER LEACHATE COLLECTION PIPE CAPACITY CALCULATIONS

CAMELOT LANDFILL
1339-351-11-02
OVERLINER PIPE CAPACITY CALCULATIONS

REQUIRED: Size overliner leachate collection system pipe:

METHOD:

A. Use leachate production rates determined from the HELP model analysis (see Appendix IIIC-A) to size the overliner leachate collection pipes.

B. Determine required hole size (perforations) based on characteristics of the surrounding drainage media.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Driscopipe, *Leachate Pipe Systems*, Phillips Drisco Inc., 1992.

SOLUTION:

Determine the peak daily flow rate estimate:

The following table summarizes the fill conditions that are likely to be present and have the greatest contribution of leachate into the overliner leachate drainage collection system.

From the HELP model (Appendix IIIC-A; Overliner) :

CONDITION	PEAK cfd/ac	PEAK gpd/ac
Active, 10' Waste	50.0	374.0
Interim, 50' Waste	72.8	544.5
Interim, 100' Waste	151.8	1,135.5
Interim, 150' Waste	89.9	672.5
Interim, 188' Waste	104.2	779.4

The largest pre-Subtitle D overliner drainage area is 12.60 acres located in Cell O5. Even though there are two leachate pipes located in this cell, to be conservative the calculations were performed assuming that the entire drainage will contribute flow to one pipe.

Therefore, the maximum leachate production expected in the leachate collection pipe for the pre-Subtitle D overliner area is predicted to occur assuming the following scenario:

1. Active, 10' Waste	1.50	ac
2. Interim, 50' Waste	2.18	ac
3. Interim, 100' Waste	3.40	ac
4. Interim, 150' Waste	2.62	ac
5. Interim, 188' Waste	1.50	ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Active, 10' Waste	1.5	374.0	561.0	0.0009
Interim, 50' Waste	3.2	544.5	1,742.5	0.0027
Interim, 100' Waste	4.2	1,135.5	4,768.9	0.0074
Interim, 150' Waste	2.4	672.5	1,613.9	0.0025
Interim, 188' Waste	1.3	779.4	1,013.2	0.0016
Total=	12.6		9,699.6	0.0150

The total pre-Subtitle D overliner peak leachate production (cfs)= 0.0150

CAMELOT LANDFILL
1339-351-11-02
OVERLINER PIPE CAPACITY CALCULATIONS

Determination of flow capacity (Q_{full}) for a 6-inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} AR^{2/3}S^{1/2}$$

Where:
A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions

From Pipe Structural Stability Calculations:

Standard Dimension Ratio (SDR) = 17

	ID =	5.845	in
	=	0.487	ft
$A = \frac{\Pi \times d^2}{4}$	A =	0.186	sq ft
$R = \frac{d}{4}$	R =	0.122	ft
S = Design slope of pipe	S^1 =	0.005	ft / ft

[1] The 0.5 percent slope was chosen as the minimum slope for the overliner leachate collection pipes. The leachate collection pipes will be placed at a slope that ensures a minimum 0.5 percent slope after settlement. Refer to Appendix IIIE-B.

n = Manning's number	n =	0.015

Q_{full} =	0.321	cfs

Compare Peak Q_{max} and Q_{full}:

Q_{full} =	0.321	cfs	>>	Q_{max} =	0.0150	cfs

Conclusion:

An SDR 17 pipe with an outer diameter of 6 inches exceeds flow capacity requirements. A perforated SDR 17 HDPE pipe will be used in the leachate collection trenches.

B. Perforation configuration for a 6-inch SDR 17 perforated pipe:

Pipe perforations must allow free passage of leachate and also prevent migration of drainage media into collection pipes. Therefore, size of perforations depends on media particle size. Two perforations alternatives are evaluated below:

For leachate collection pipes with slotted perforations:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} > 2.0$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is an ASTM D 448 number 467 aggregate
Refer to Section 3.5 of Appendix IIIC for size gradation requirements.

D_{85} = 25 mm
= 0.984 in

Standard slot width: d = 0.125 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} = 7.9 \quad > 2.0 \quad \text{(acceptable)}$$

For leachate collection pipes with circular holes:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} > 1.7$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is an ASTM D 448 number 467 aggregate
Refer to Section 3.5 of Appendix IIIC for size gradation requirements.

D_{85} = 25 mm
= 0.984 in

Standard hole diameter d = 0.5 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 2.0 \quad > 1.7 \quad \text{(acceptable)}$$

In Addition:

A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

OVERLINER LEACHATE COLLECTION PIPE STRUCTURAL STABILITY

CAMELOT LANDFILL
1339-351-11-02
OVERLINER PIPE STRUCTURAL STABILITY
6" DIA PIPE

REQUIRED: Analyze structural stability of the 6 inch diameter overliner leachate collection system pipe.

METHOD: A. Determine the critical load and calculate stress under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage,* Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

6. Quian, Xuede, R.M. Koerner, D. H. Gray, "Geotechnical Aspects of Landfill Design and Construction." Prentice-Hall, Inc., New Jersey, 2002.

CAMELOT LANDFILL
1339-351-11-02
OVERLINER PIPE STRUCTURAL STABILITY
6" DIA PIPE

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading:

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight = 190,500 lb
Tire pressure = 80 psi
Number of tires = 4

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F =	47,625	lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

r =	13.8	in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

$$y = p\,(1 - ((r/z)^2+1)^{-3/2})$$

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Protective cover thickness (in)

z = 24 in

y =	27.8	psi

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L =	41.7	psi

P_D = (zw)/1728

Where:
P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z =	24	in
w =	115	pcf

P_D =	1.60	psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T =	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.0	ft protective cover @	115	pcf =	230	psf
4.5	ft final & intrm cover @	115	pcf =	517.5	psf
30.0	ft solid waste/soil @	65	pcf =	1,950	psf
			Σ =	2,698	psf

P_T =	18.7	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	18.7	psi

Construction loading is most critical to the structural stability of the pipe and will be used to analyze pipe stability.

A summary table for the structural stability analysis is provided on page IIIC-B-53 for the 6-inch-diameter overliner leachate collection pipe. A pipe will be selected from this table for use in the overliner leachate collection system based on the calculated factors of safety for each possible failure condition. An example calculation is provided below that outlines the procedures used to determine the factors of safety for all pipe SDR sizes shown in the summary table.

B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR	= Standard dimension ratio	=	17	
S_Y	= compressive yield strength	=	1,500	psi
RD_{all}	= allowable ring deflection	=	4.2	%

1. Wall crushing (Ref 3)

$S_A = P_{DES}\,(SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
S_A = Actual compressive stress (psi)
SDR = Standard dimension ratio
P_{DES} = Critical pipe load (psi)
S_Y = Compressive yield strength (psi)
FS = Factor of safety against wall crushing

P_{DES} = 43.3 psi

S_A =	346.2	psi
FS =	4.3	

Compare calculated and suggested factor of safety:	4.3	> 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES}$

Where:
P_{cb} = Critical buckling pressure at top of pipe (psi)
E' = Soil modulus (psi)
E = Stress/time dependent tensile modulus for design loading conditions (psi)
P_{DES} = Critical pipe load (psi)
FS = Factor of safety against wall buckling

E' =	3,000	psi
E =	14,500	psi for 50 years based on S_A above (see chart page IIIC-B-34)
P_{DES} =	43.3	psi

P_{cb} =	114.7	psi
FS =	2.6	

Compare calculated and suggested factor of safety:	2.6	> 1.0

CAMELOT LANDFILL
1339-351-11-02
OVERLINER PIPE STRUCTURAL STABILITY
6" DIA PIPE

3. Ring deflection (Ref 3)

$E_S = P_{DES} / E'$

Where: E_S = Soil strain (%)
P_{DES} = Critical pipe load (psi)
E' = Soil modulus (psi)

$P_{DES} =$ 43.3 psi
$E' =$ 3,000 psi

$E_S =$ 1.4 %

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RDact) is equal to soil strain.

$RD_{act} =$ 1.4 %

Allowable ring deflection, $RD_{all} =$ 4.20 %

$RD_{act} < RD_{all}$, design is acceptable

Note: An additional factor of safety is inherent to the design of the overliner leachate collection system due to the presence of a gravel envelope surrounding the overliner leachate collection pipe. The gravel layer will transmit leachate in the event that the overliner leachate collection pipe becomes plugged or crushed.

CAMELOT LANDFILL
1339-351-11-02
OVERLINER PIPE STRUCTURAL STABILITY
6" DIA PIPE

Critical pipe load = 43.3 psi

	Wall Crushing			Wall Buckling				Ring Deflection			
SDR	S_Y	S_A	FS_{WC}	E[2]	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
32.5	1,500	681.5	2.2	15,000	3,000	44.1	1.0	8.1	3,000	1.4	5.6
26.0	1,500	540.9	2.8	18,000	3,000	67.5	1.6	6.5	3,000	1.4	4.5
21.0	1,500	432.7	3.5	21,000	3,000	100.5	2.3	5.2	3,000	1.4	3.6
19.0	1,500	389.4	3.9	22,000	3,000	119.5	2.8	4.7	3,000	1.4	3.3
17.0 [1]	1,500	346.2	4.3	23,000	3,000	144.4	3.3	4.2	3,000	1.4	2.9
15.5	1,500	313.7	4.8	24,000	3,000	169.4	3.9	3.9	3,000	1.4	2.7
13.5	1,500	270.7	5.5	26,000	3,000	216.7	5.0	3.4	3,000	1.4	2.4
11.0	1,500	216.4	6.9	27,500	3,000	303.4	7.0	2.7	3,000	1.4	1.9

▨ denotes standard size

[1] Select 6-inch-diameter HDPE SDR 17.0 pipe for use in the overliner leachate collection system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the attached chart (page IIIC-B-34), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50 year duration (maximum loading is the overburden load on the pipe).

CAMELOT LANDFILL
1339-351-11-02
OVERLINER PIPE STRUCTURAL STABILITY
18"-DIA PIPE

REQUIRED: Analyze structural stability of the overliner 18 inch diameter leachate collection system pipe.

METHOD: A. Determine the critical load and calculate stress under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage,* Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

6. Quian, Xuede, R.M. Koerner, D. H. Gray, "Geotechnical Aspects of Landfill Design and Construction." Prentice-Hall, Inc., New Jersey, 2002.

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight = 190,500 lb
Tire pressure = 80 psi
Number of tires = 4

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

$$\boxed{F = 47{,}625 \text{ lb}}$$

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

$$\boxed{r = 13.8 \text{ in}}$$

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

$$y = p\,(1 - ((r/z)^2+1)^{-3/2})$$

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Protective cover thickness (in)

$z =$ 24 in

$$\boxed{y = 27.8 \text{ psi}}$$

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L =	41.7	psi

P_D = (zw)/1728

Where: P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z = 24 in
w = 115 pcf

P_D =	1.60	psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T =	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.00	ft gravel & cover @	115	pcf =	230	psf
4.50	ft final & intrm cover @	115	pcf =	517.5	psf
30.00	ft solid waste/soil @	65	pcf =	1,950	psf
			Σ =	2,698	psf

P_T =	18.7	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	18.7	psi

Construction loading is most critical to the structural stability of the pipe and will be used to analyze the pipe stability.

A summary table for the structural stability analysis is provided on page IIIC-B-59 for the 18-inch-diameter overliner leachate collection pipe. A pipe will be selected from this table for use in the overliner collection system based on the calculated factors of safety for each possible failure condition. An example calculation is provided below that outlines the procedures used to determine the factors of safety for all pipe SDR sizes shown in the summary table.

B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR	= Standard dimension ratio	=	17	
S_Y	= compressive yield strength	=	1,500	psi
RD_{all}	= allowable ring deflection	=	4.2	%

1. Wall crushing (Ref 3)

$S_A = P_{DES}(SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
S_A = Actual compressive stress (psi)
SDR = Standard dimension ratio
P_{DES} = Critical pipe load (psi)
S_Y = Compressive yield strength (psi)
FS = Factor of safety against wall crushing

$P_{DES} =$ 43.3 psi

$S_A =$ 346.2 psi
FS = 4.3

Compare calculated and suggested factor of safety: 4.3 > 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES}$

Where:
P_{cb} = Critical buckling pressure at top of pipe (psi)
E' = Soil modulus (psi)
E = Stress/time dependent tensile modulus for design loading conditions (psi)
P_{DES} = Critical pipe load (psi)
FS = Factor of safety against wall buckling

E' = 3,000 psi
E = 23,000 psi for 50 years based on S_A above (see chart page IIIC-B-34)
$P_{DES} =$ 43.3 psi

$P_{cb} =$ 144.4 psi
FS = 3.3

Compare calculated and suggested factor of safety: 3.3 > 1.0

3. Ring deflection (Ref 3)

$E_S = P_{DES} / E'$

Where:
E_S = Soil strain (%)
P_{DES} = Critical pipe load (psi)
E' = Soil modulus (psi)

$P_{DES} =$ 43.3 psi
$E' =$ 3,000 psi

$\boxed{E_S = 1.4\ \%}$

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RD_{act}) is equal to soil strain.

$RD_{act} =$ 1.4 %

Allowable ring deflection, $RD_{all} =$ 4.20 %

$\boxed{RD_{act} < RD_{all}\text{, design is acceptable}}$

Note: An additional factor of safety is inherent to the design of the overliner leachate collection system due to the presence of a gravel envelope surrounding the overliner leachate collection pipe. The gravel layer will transmit leachate in the event that the overliner leachate collection pipe becomes plugged or crushed.

Prep By: JLG
Date: 2/28/2012

Chkd By: MDM
Date: 2/28/2012

CAMELOT LANDFILL
1339-351-11-02
OVERLINER PIPE STRUCTURAL STABILITY
18"-DIA PIPE

Critical pipe load = 43.3 psi

	Wall Crushing			Wall Buckling				Ring Deflection			
SDR	S_Y	S_A	FS_{WC}	E[2]	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
32.5	1,500	681.5	2.2	15,000	3,000	44.1	1.0	8.1	3,000	1.4	5.6
26.0	1,500	540.9	2.8	18,000	3,000	67.5	1.6	6.5	3,000	1.4	4.5
21.0	1,500	432.7	3.5	21,000	3,000	100.5	2.3	5.2	3,000	1.4	3.6
19.0	1,500	389.4	3.9	22,000	3,000	119.5	2.8	4.7	3,000	1.4	3.3
17.0[1]	1,500	346.2	4.3	23,000	3,000	144.4	3.3	4.2	3,000	1.4	2.9
15.5	1,500	313.7	4.8	24,000	3,000	169.4	3.9	3.9	3,000	1.4	2.7
13.5	1,500	270.7	5.5	25,500	3,000	214.6	5.0	3.4	3,000	1.4	2.4
11.0	1,500	216.4	6.9	27,500	3,000	303.4	7.0	2.7	3,000	1.4	1.9

▨ denotes standard size

[1] Select 18-inch-diameter HDPE SDR 17.0 pipe for use in the overliner leachate collection system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the attached chart (page IIIC-B-34), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50 year duration (maximum loading is the overburden load on the pipe).

OVERLINER LEACHATE SUMP DESIGN

CAMELOT LANDFILL
1339-351-11-02
OVERLINER LEACHATE SUMP DESIGN

REQUIRED: Size overliner leachate collection sumps.

METHOD:

A. Use leachate production rates from HELP model and the sump drainage area from Sheet IIIC-B-41. Overliner sump details are provided in Appendix IIIA-A - Liner, Overliner, and Final Cover System Details.

B. Determine geometry of sump and its corresponding storage capacity.

C. Assume pump size and determine the average pump cycle time.

REFERENCES:

1. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.
2. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.
3. Phillips 66 Driscopipe, *System Design*, 1991.
4. Heisler, Sanford I., P.E., Wiley Engineer's Desk Reference, John Wiley & Sons, Inc., New York, 1998.

SOLUTION:

A. Average flow rate into sump

A.1 Determine the per acre flow rate for specific leachate collection sumps.

The following tables summarize the fill conditions that are likely to be present within the pre-Subtitle D overliner area and have the greatest contribution of leachate into the LCS and sump system. The average flow rates (lateral drainage in the LCS layer) are shown:

From the HELP model (Appendix IIIC-A; pre-Subtitle D Overliner) for overliner:

CONDITION	AVERAGE cfy/ac	AVERAGE gpd/ac
Active, 10' Waste	3,503	72
Interim, 50' Waste	4,962	102
Interim, 100' Waste	25,113	515
Interim, 150' Waste	19,406	398
Interim, 188' Waste	23,104	473
Closed, 188' Waste	14,208	291

The area draining to the sump located in Cell O5 is 12.6 acres.

A.2 Determine the flow rate for the leachate collection sump.

1. Sump for pre-Subtitle D Overliner Area : 12.60 acres

Condition	Rate	Active		Inactive		Closed	
	(gpd/ac)	area (ac)	rate (gpd)	area (ac)	rate(gpd)	area (ac)	rate(gpd)
Active, 10' Waste	72	0.9	65	0.0	0.00	0.0	0.00
Interim, 50' Waste	102	1.3	132	0.0	0.00	0.0	0.00
Interim, 100' Waste	515	3.2	1,637	0.0	0.00	0.0	0.00
Interim, 150' Waste	398	3.6	1,448	0.0	0.00	0.0	0.00
Interim, 188' Waste	473	2.0	947	12.6	5,966	0.0	0.00
Closed, 188' Waste	291	1.6	460	0.0	0.00	12.6	3,669
Total Area Draining to Cell O5 Sump		12.6	4,688	12.6	5,966	12.6	3,669

The total active case flow rate from pre-Subtitle D overliner drainage area is	4,688	gpd.
The total inactive case flow rate from pre-Subtitle D overliner drainage area is	5,966	gpd.
The total closed case flow rate from pre-Subtitle D overliner drainage area is	3,669	gpd.

B. Required storage capacity of sump

Assumed porosity of drainage stone: P = 0.35

$V_{daily\ inflow} = V_C / P$

1. Active

Sump Location	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Cell O5	4,688	627	1,791

2. Inactive with Intermediate Cover

Sump Location	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Cell O5	5,966	798	2,279

3. Closed

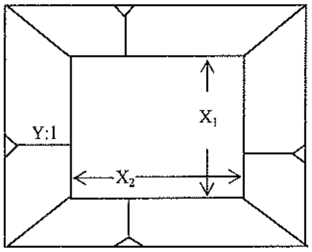
Sump Location	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Cell O5	3,669	490	1,401

Total sump volume:

$$V_{TOT} = 1/3\left(A_1 + A_2 + \sqrt{(A_1 \cdot A_2)}\right)h$$

(Ref. 4, page 17)

Where:
A_1 = Area of bottom of sump
A_2 = Area of top of sump
h = Depth of sump



Y = Slope of sump side walls

$A_1 = X_1 * X_2$
$A_2 = (X_1 + 2(h*Y))*(X_2 + 2(h*Y))$

Sump Location	X_1 (ft)	X_2 (ft)	Y (ft)	h (ft)	A_1 (ft^2)	A_2 (ft^2)	V_{TOT} (ft^3)
Cell O5	15	15	3	3.00	225	1,089	1,809

Compute the number of days storage provided for the following:

$$\text{STORAGE (Detention Time)} = \frac{V_{TOT}}{V_{\text{Daily Inflow}}}$$

1. Active

Sump Location	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Cell O5	1,791	1,809	1.01

2. Inactive with Intermediate Cover

Sump Location	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Cell O5	2,279	1,809	0.79

3. Closed

Sump Location	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Cell O5	1,401	1,809	1.29

C. Estimated rate of leachate removal (for active use)

Submersible pump capacity = 15 gpm

Sump Location	Production	Average Pump Time	
	(gpd)	(min/day)	(hr/day)
Cell O5	4,688	312.5	5.2

Example Calculation:

Leachate production rate = 4,688 gpd
Pump capacity = 15.0 gpm
Average Pump Time = Leachate production rate / Pump capacity
= 4,688 gpd / 15 gpm
= 312.5 min/day
= 5.2 hr/day

Average pump time is less than 24 hours per day, therefore the design is acceptable.

GEOTEXTILE DESIGN

REQUIRED: Determine geotextile properties for the following:

A. Geotextile "A" around the chimney drain granular drainage material. This is applicable to the liner and overliner systems.

B. Geotextile "B" used as top component of drainage geocomposite. This is applicable to the liner and overliner systems.

METHOD: Design geotextiles and determine material property requirements.

REFERENCES:

1. MIRAFI, *Geotextile Filter Design, Application, and Product Selection Guide* , 1991, http://www.tcmirafi.com/pdf/brochures/ef_guidelines.pdf.
2. Koerner, R.M., *Designing With Geosynthetics* , Fifth Edition, 2005.
3. AASHTO Designation: M288-06.
4. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.

SOLUTION:

A. Geotextile "A" Around the Chimney Drain Granular Drainage Material.

The design calculations assume the waste located above the chimney drain will have a hydraulic conductivity of $1.0\text{x}10^{-3}$ cm/s and the protective cover soil will consist of soils with a hydraulic conductivity less than $1.2\text{x}10^{-4}$ cm/s and percent fines (passing #200 sieve) greater than 20 percent.

If the protective cover material contains less than 20 percent fines, these geotextile calculations will be revised and included in the GLER for a specific cell to demonstrate the adequacy of the material used.

Retention:

Based on Chart 1 - "Soil Retention Criteria," given on page IIIC-B-71, the apparent opening size (O_{95}) may be determined.

$$O_{95} < 0.21 \text{ mm}$$

Permeability:

The required permeability is determined by comparing the permeability of the overlying waste material ($1.0\text{x}10^{-3}$ cm/s) and the protective cover ($1.2\text{x}10^{-4}$ cm/s) with the permeability of the geotextile after the appropriate reduction factors are applied to the laboratory permeability of the geotextile.

Minimum Laboratory Permeability Specified (k_{ult}) = 0.2 cm/s

To determine the allowable permeability (k_{allow}) of the geotextile, the following reduction factors are used:

Table 1 - Reduction Factors[1]

RF_{SCB} = Reduction factor for soil clogging and blinding	2.0
RF_{CR} = Reduction factor for creep reduction of void space	2.0
RF_{IN} = Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} = Reduction factor for chemical clogging	1.5
RF_{BC} = Reduction factor for biological clogging	2.0
Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 4.

$$k_{allow} = k_{ult} / ORF = (0.2 \text{ cm/s}) / 14.4$$

$$\boxed{k_{allow} = 1.4\text{E-}02 \text{ cm/s}}$$

$k_{allow} >> k_{waste}$ ($1.0\text{x}10^{-3}$ cm/s) or $k_{protective\ cover}$ ($1.2\text{x}10^{-4}$ cm/s).

Specification: Chimney drain geotextile permeability shall be equal to or greater than 0.2 cm/s as determined by ASTM D 4491.

Survivability:

Based on Table 2, "Survivability Strength Requirements," provided on page IIIC-B-72, geotextile properties should be selected considering high contact stresses (i.e., heavy confining stresses).

Durability:

Chemical compatibility with leachate will be considered during the selection process for the specific geotextile.

Summary of required properties for geotextile "A" (around the chimney drain granular drainage material):

Apparent opening size	<	0.21	mm
Grab tensile strength	>	157	lbs
Elongation	>=	50	%
Puncture strength	>	56	lbs
Trapezoid tear	>	56	lbs
Permeability	>=	0.2	cm/s

B. Geotextile "B" Used as Top Component of Drainage Geocomposite.

The design calculations assume the protective cover soil will consist of soils with a hydraulic conductivity less than $1.2\text{x}10^{-4}$ cm/s and percent fines (passing #200 sieve) greater than 20 percent.

If the protective cover material contains less than 20 percent fines, these geotextile calculations will be revised and included in the GLER for a specific cell to demonstrate adequacy of material used.

Retention:

Based on Chart 1 - "Soil Retention Criteria," given on page IIIC-B-71, the apparent opening size (O_{95}) may be determined.

$O_{95} <$ 0.21 mm

Permeability:

The required permeability is determined by comparing the permeability of the protective cover ($1.2\text{x}10^{-4}$ cm/s) with the permeability of the geotextile after the appropriate reduction factors are applied to the laboratory permeability of the geotextile.

Minimum Laboratory Permeability Specified (k_{ult}) = 0.2 cm/s

To determine the allowable permeability (k_{allow}) of the geotextile, the following reduction factors are used:

Table 2 - Reduction Factors[1]

RF_{SCB} = Reduction factor for soil clogging and blinding	2.0
RF_{CR} = Reduction factor for creep reduction of void space	2.0
RF_{IN} = Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} = Reduction factor for chemical clogging	1.5
RF_{BC} = Reduction factor for biological clogging	2.0
Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 4.

$k_{allow} = k_{ult}$ / ORF = (0.2 cm/s) / 14.4

$\boxed{k_{allow} = 1.4\text{E-}02 \text{ cm/s}}$

$k_{allow} >> k_{protective\ cover}$ ($1.2\text{x}10^{-4}$ cm/s).

Specification: Geotextile component of geocomposite permeability shall be equal to or greater than 0.2 cm/s as determined by ASTM D 4491.

Survivability:

Based on Table 2, "Survivability Strength Requirements," provided on page IIIC-B-72, geotextile properties should be selected considering high contact stresses (i.e., heavy confining stress).

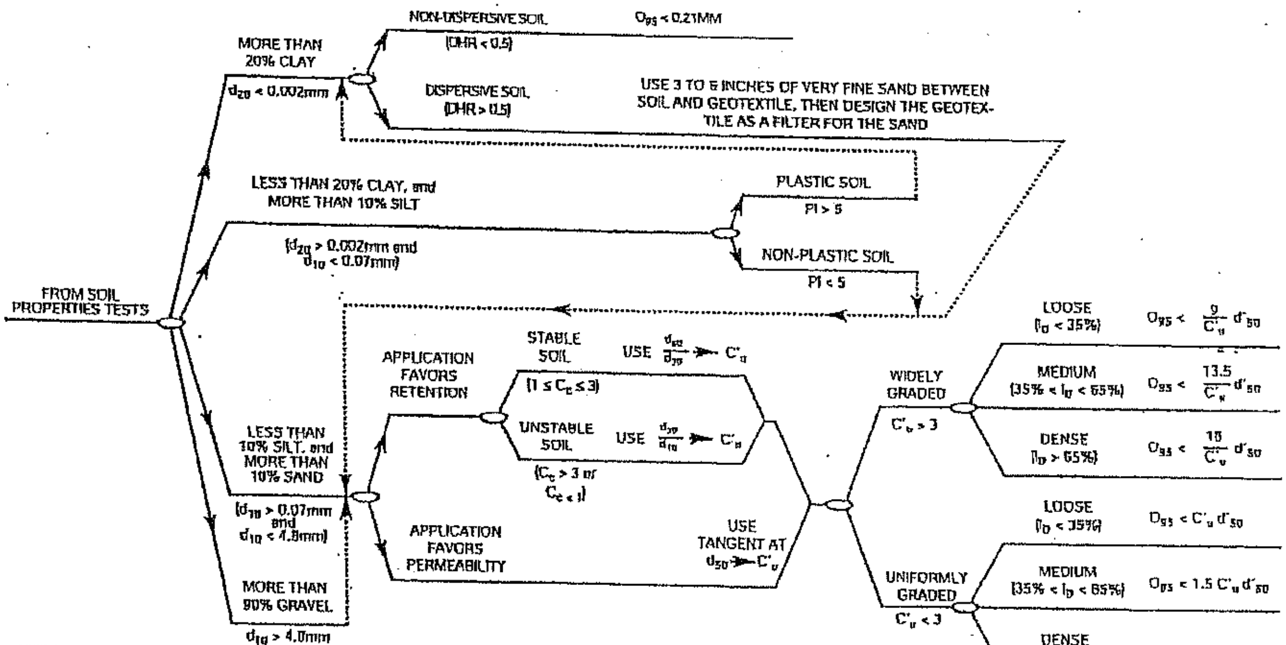
Durability:

Chemical compatibility with leachate will be considered during the selection process for the specific geotextile.

Summary of required properties for geotextile "B" (top component of drainage geocomposite):

Apparent opening size	<	0.21	mm
Grab tensile strength	>	157	lbs
Elongation	>=	50	%
Puncture strength	>	56	lbs
Trapezoid tear	>	56	lbs
Permeability	>=	0.2	cm/s

Chart 1. Soil Retention Criteria of Steady-State Flow Conditions



NOTES:

d_x = particle diameter of which size x percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremeties of a straight line drawn through the particle-size distribution, as directed above and d'_{50} is the midpoint of this line

$$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$$

I_D = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil
O_{95} = geotextile opening size

Table 2. Survivability Strength Requirements (after AASHTO, 1996)

		GRAB STRENGTH (LBS)	ELONGATION (%)	SEWN SEAM STRENGTH (LBS)	PUNCTURE STRENTH (LBS)	BURST STRENTH (LBS)	TRAPEZOID TEAR (LBS)
SUBSURFACE DRAINAGE	HIGH CONTACT STRESSES	247	< 50% *	222	90	392	56
	(ANGULAR DRAINAGE MEDIA) (HEAVY COMPACTION) or (HEAVY CONFINING STRESSES)	*157	≥ 50%	142	* 56	189	* 56
	LOW CONTACT STRESSES	180	< 50% *	162	67	305	56
	(ROUNDED DRAINAGE MEDIA) (LIGHT COMPACTION) or (LIGHT CONFINING STRESSES)	112	≥ 50%	101	40	138	40
ARMORED EROSION CONTROL	HIGH CONTACT STRESSES	247	< 50% *	222	90	392	56
	(DIRECT STONE PLACEMENT) (DROP HEIGHT > 3 FT)	202	≥ 50%	182	79	247	79
	LOW CONTACT STRESSES	247	< 50% *	222	90	292	56
	(SAND OR GEOTEXTILE CUSHION) and (DROP HEIGHT < 3 FT)	157	≥ 50%	142	56	189	56

* Only woven monofilament geotextiles are acceptable as < 50% elongation filtration geotextiles. No woven slit film geotextiles are permitted.

GROUNDWATER INFLOW CALCULATIONS

CAMELOT LANDFILL
1339-351-11-02

LEACHATE COLLECTION SYSTEM GROUNDWATER INFLOW RATE CALCULATION

REQUIRED: Determine the maximum groundwater inflow rate into the leachate collection system, consistent with §330.337(d).

METHOD:

1. Determine the permeability of the materials surrounding the liner system, the potentiometric conditions of the groundwater, and the geomembrane hole size and spacing.
2. Calculate the maximum groundwater inflow rate into the leachate collection system.

REFERENCES:

1. Rowe, R. Kerry et al. *Barrier Systems for Waste Disposal Facilities,* 2nd Edition, Spon Press, 2004

SOLUTION:

1. **Determine the permeability of the materials surrounding the liner system, the potentiometric conditions of the groundwater, and the geomembrane hole size and spacing.**

The maximum groundwater unit flow rate can be defined with the following equation:

q_o=ki, where

q_o= Unit groundwater flow rate below the liner system
k = Hydraulic conductivity of the soil below the liner system
i = Hydraulic gradient along the soil below the liner system

As indicated in Part III, Appendix IIIG, the hydraulic properties of the Alluvial Stratum Lower Sand Zone include a arithmetic mean horizontal hydraulic conductivity (k) of $7.83\text{x}10^{-4}$ cm/s and a hydraulic gradient (i) of 0.002 ft/ft.

Therefore, the unit groundwater flow rate below the liner system is q_o=ki.

k=	7.83E-04	cm/s
i=	0.002	ft/ft
q_o=	1.57E-06	cm/s

2. **Calculate the maximum groundwater inflow rate into the leachate collection system.**

To calculate the groundwater inflow to the liner system, the following equation is used:

$$h_w = \left\{ \frac{r_0^2 q_0}{2k_{om}} + \frac{Q}{2\pi k_{om}} \left[\ln\left(\frac{Q}{\pi r_0^2 q_0}\right) - 1 \right] + \frac{1}{4g^2} \left(\frac{Q}{1.88 r_0^2}\right)^4 \right\}^{0.5}$$

where

h_w= Groundwater head on the liner
r_o= Radius of the geomembrane defect
q_o= Unit groundwater flow rate below the liner system
Q= Inflow rate through the geomembrane into the leachate collection system
k_{om}= Hydraulic conductivity of the layer upgradient of the geomembrane liner system
g= Acceleration due to gravity

CAMELOT LANDFILL
1339-351-11-02

LEACHATE COLLECTION SYSTEM GROUNDWATER INFLOW RATE CALCULATION

The groundwater head on the liner (h_w) is taken from the location where the potentiometric levels are the most critical. Drawing IIID-A-1 in Appendix IIID-A shows a highest measured groundwater map. Based on this map, the most critical area of the leachate collection system occurs along the sidewall of Cell 13. The potentiometric level of the groundwater is at approximately 450 ft-msl, while the elevation of the unweathered shale (bottom of uppermost aquifer) is 435 ft-msl. Therefore, the groundwater head along the sidewall of Cell 13 is estimated to be 15 ft.

To be conservative, the pinhole density is assumed to be 1 pinhole per acre and the geomembrane installation defects is assumed to be 4 holes per acre.

The area of 1 hole of geomembrane installation defect equals 1 cm^2 and 1 pinhole has a diameter of 1 mm.

The radius of the geomembrane defect (r_o) based on the pinhole density and geomembrane installation defect equals 0.03717 ft.

In order to calculate the inflow rate through the geomembrane into the leachate collection system (Q), the following calculated values are used.

$h_w =$ 15 ft
$r_o =$ 0.03717 ft
$q_o =$ 1.57E-06 cm/s or
5.1E-08 ft/s
$g =$ 32.2 ft/s^2
$k_{om} =$ 1.0E-07 cm/s or
3.3E-09 ft/s
$Q =$ 6.6E-07 cf/s or
0.006 in/yr per acre

Conclusion: The HELP run with the highest peak head on liner (i.e., the Undeveloped Subtitle D - Closed 287' waste) was rerun and 0.006 in/yr of groundwater inflow was added based on the above calculations. The updated HELP run is presented on Sheets IIIC-B-77 through IIIC-B-86. As shown, there is an insignificant increase in the average annual flow rate (21,610 cf/year vs 21,632 cf/year) and no increase in the average annual head on the liner. Also, the peak flow rate increased only slightly (170.5 cf/day vs 170.6 cf/day) and the peak daily head on the liner remained the same. Therefore, it can be concluded that the design and capacity of leachate collection system is not significantly affected by groundwater inflow.

```
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**                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             **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP 307\CAMELOT\closd\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP 307\CAMELOT\closd\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAMELOT\closd\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP 307\CAMELOT\closd\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAMELOT\closd\DATA10.D10
OUTPUT DATA FILE:           C:\HELP 307\CAMELOT\closd\CLOSED.OUT


TIME:  11:20     DATE:  11/ 3/2011


*******************************************************************************

     TITLE:  CAMELOT LANDFILL-UNDEV AREA CLOSED

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                     =     12.00    INCHES
           POROSITY                      =      0.3980 VOL/VOL
           FIELD CAPACITY                =      0.2440 VOL/VOL
           WILTING POINT                 =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                              LAYER  2
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  10
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.3980 VOL/VOL
FIELD CAPACITY               =       0.2440 VOL/VOL
WILTING POINT                =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.119999997000E-03 CM/SEC


                              LAYER  3
                              --------

                   TYPE 4 - FLEXIBLE MEMBRANE LINER
                     MATERIAL TEXTURE NUMBER  36
THICKNESS                    =       0.04    INCHES
POROSITY                     =       0.0000 VOL/VOL
FIELD CAPACITY               =       0.0000 VOL/VOL
WILTING POINT                =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY        =   3 - GOOD


                              LAYER  4
                              --------

                     TYPE 3 - BARRIER SOIL LINER
                     MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      18.00    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.    =   0.999999975000E-05 CM/SEC


                              LAYER  5
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  11
THICKNESS                    =      12.00    INCHES
```

```
          POROSITY                     =      0.4640 VOL/VOL
          FIELD CAPACITY               =      0.3100 VOL/VOL
          WILTING POINT                =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC


                                  LAYER  6
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =   1500.00    INCHES
          POROSITY                     =      0.6148 VOL/VOL
          FIELD CAPACITY               =      0.5114 VOL/VOL
          WILTING POINT                =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                  LAYER  7
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =   1944.00    INCHES
          POROSITY                     =      0.4985 VOL/VOL
          FIELD CAPACITY               =      0.4790 VOL/VOL
          WILTING POINT                =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                                  LAYER  8
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =     24.00    INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                                  LAYER  9
                                  --------
```

```
              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.15    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.    =    4.59000015000      CM/SEC
SLOPE                        =       0.90    PERCENT
DRAINAGE LENGTH              =     350.0     FEET
SUBSURFACE INFLOW            =       0.01    INCHES/YR


                         LAYER 10
                         --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.06    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     =       0.00    HOLES/ACRE
FML PLACEMENT QUALITY        =   3 - GOOD


                         LAYER 11
                         --------

                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 #10 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
         AND A SLOPE LENGTH OF  500. FEET.
```

```
        SCS RUNOFF CURVE NUMBER              =    80.10
        FRACTION OF AREA ALLOWING RUNOFF     =   100.0    PERCENT
        AREA PROJECTED ON HORIZONTAL PLANE   =     1.000  ACRES
        EVAPORATIVE ZONE DEPTH               =    18.0    INCHES
        INITIAL WATER IN EVAPORATIVE ZONE    =     4.392  INCHES
        UPPER LIMIT OF EVAPORATIVE STORAGE   =     7.164  INCHES
        LOWER LIMIT OF EVAPORATIVE STORAGE   =     2.448  INCHES
        INITIAL SNOW WATER                   =     0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS     =  1342.087  INCHES
        TOTAL INITIAL WATER                  =  1342.087  INCHES
        TOTAL SUBSURFACE INFLOW              =     0.01   INCHES/YEAR


                     EVAPOTRANSPIRATION AND WEATHER DATA
                     -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  DALLAS                TEXAS

              STATION LATITUDE                        = 32.85 DEGREES
              MAXIMUM LEAF AREA INDEX                 =  4.50
              START OF GROWING SEASON (JULIAN DATE)   =    63
              END OF GROWING SEASON (JULIAN DATE)     =   329
              EVAPORATIVE ZONE DEPTH                  = 18.0  INCHES
              AVERAGE ANNUAL WIND SPEED               = 10.80 MPH
              AVERAGE 1ST QUARTER RELATIVE HUMIDITY   = 66.00 %
              AVERAGE 2ND QUARTER RELATIVE HUMIDITY   = 68.00 %
              AVERAGE 3RD QUARTER RELATIVE HUMIDITY   = 63.00 %
              AVERAGE 4TH QUARTER RELATIVE HUMIDITY   = 66.00 %


         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS              TEXAS

                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

     JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
     -------      -------      -------      -------      -------      -------
       1.90         2.37         3.06         3.20         5.15         3.23
       2.12         2.03         2.42         4.11         2.57         2.57


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS              TEXAS

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

     JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
     -------      -------      -------      -------      -------      -------
      44.10        49.40        57.40        65.00        73.10        80.90
      85.00        84.40        77.50        67.20        55.10        46.70
```

```
          NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                    COEFFICIENTS FOR    DALLAS             TEXAS
                      AND STATION LATITUDE  =  32.85 DEGREES




*******************************************************************************

          AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                             JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                             -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                     1.49     2.20     2.80     3.08     4.59     3.29
                               2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS            1.02     1.27     1.67     1.89     2.17     2.13
                               2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                     0.231    0.154    0.318    0.189    0.352    0.106
                               0.124    0.016    0.022    0.847    0.537    0.879

    STD. DEVIATIONS            0.410    0.410    0.709    0.443    0.820    0.204
                               0.289    0.039    0.049    1.590    1.034    1.518

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                     1.673    1.770    2.669    4.424    4.729    3.465
                               2.959    1.935    2.408    1.751    1.035    1.400

    STD. DEVIATIONS            0.408    0.585    0.943    1.005    1.869    1.948
                               1.993    1.548    1.397    0.866    0.367    0.421

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                     0.0314   0.0274   0.0306   0.0241   0.0158   0.0134
                               0.0135   0.0123   0.0119   0.0195   0.0255   0.0309

    STD. DEVIATIONS            0.0126   0.0096   0.0093   0.0081   0.0061   0.0034
                               0.0036   0.0024   0.0025   0.0103   0.0141   0.0142

  SUBSURFACE INFLOW INTO LAYER  9
  -------------------------------
    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

  LATERAL DRAINAGE COLLECTED FROM LAYER  9
  ----------------------------------------
    TOTALS                     0.4997   0.4747   0.5199   0.4959   0.5074   0.4878
```

```
                         0.5068   0.5013   0.4886   0.5003   0.4808   0.4958

   STD. DEVIATIONS       0.1882   0.2126   0.2181   0.2083   0.2064   0.1993
                         0.2091   0.2006   0.1951   0.1973   0.1951   0.1937

 PERCOLATION/LEAKAGE THROUGH LAYER 11
 ------------------------------------
   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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
   AVERAGES             15.3998  14.7275  15.0076  12.1243   7.5029   6.5148
                         6.3332   5.7299   5.7205   9.3725  12.8499  15.1297

   STD. DEVIATIONS       6.3262   5.3059   4.6271   4.1758   3.0544   1.7389
                         1.7835   1.1462   1.2067   5.1851   7.3282   7.1434

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   AVERAGES              0.0241   0.0251   0.0251   0.0247   0.0245   0.0243
                         0.0244   0.0242   0.0243   0.0241   0.0240   0.0239

   STD. DEVIATIONS       0.0091   0.0113   0.0105   0.0104   0.0100   0.0099
                         0.0101   0.0097   0.0097   0.0095   0.0097   0.0093

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET       PERCENT
                                -------------------  --------------   ---------
 PRECIPITATION                   34.26     (   6.276)     124371.1      100.00

 RUNOFF                           3.774    (  2.9347)      13698.63      11.014

 EVAPOTRANSPIRATION              30.216    (  4.2443)     109684.16      88.191

 PERCOLATION/LEAKAGE THROUGH      0.25638 (  0.06252)        930.642      0.74828
   LAYER  4

 AVERAGE HEAD ON TOP             10.534 (     2.625)
   OF LAYER  3
```

```
SUBSURFACE INFLOW INTO          0.00000                          0.000     0.00000
  LAYER  9

LATERAL DRAINAGE COLLECTED      5.95910 (   2.39717)       21631.529    17.39273
  FROM LAYER  9

PERCOLATION/LEAKAGE THROUGH     0.00000 (   0.00000)           0.009     0.00001
  LAYER 11

AVERAGE HEAD ON TOP             0.024 (     0.010)
  OF LAYER 10

CHANGE IN WATER STORAGE        -5.681    (  3.0871)      -20621.45    -16.581

*******************************************************************************


*******************************************************************************

             PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
   ------------------------------------------------------------------------
                                                  (INCHES)      (CU. FT.)
                                                 ----------    -------------
        PRECIPITATION                               6.00         21780.000

        RUNOFF                                      3.413        12389.1777

        PERCOLATION/LEAKAGE THROUGH LAYER  4        0.001567         5.68974

        AVERAGE HEAD ON TOP OF LAYER  3            24.000

        DRAINAGE COLLECTED FROM LAYER  9            0.04700        170.59813

        PERCOLATION/LEAKAGE THROUGH LAYER 11        0.000000         0.00003

        AVERAGE HEAD ON TOP OF LAYER 10             0.070

        MAXIMUM HEAD ON TOP OF LAYER 10             0.138

        LOCATION OF MAXIMUM HEAD IN LAYER  9
              (DISTANCE FROM DRAIN)                 6.1 FEET

        SNOW WATER                                  2.40          8713.1436


        MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3980

        MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1360

         ***  Maximum heads are computed using McEnroe's equations.  ***

              Reference:  Maximum Saturated Depth over Landfill Liner
                          by Bruce M. McEnroe, University of Kansas
```

```
                         ASCE Journal of Environmental Engineering
                         Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************




******************************************************************************

                     FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                      LAYER        (INCHES)       (VOL/VOL)
                      -----        --------       ---------
                        1           2.4409         0.2034

                        2           3.8913         0.3243

                        3           0.0000         0.0000

                        4           7.6860         0.4270

                        5           3.7200         0.3100

                        6         547.8275         0.3652

                        7         589.5682         0.3033

                        8           6.2666         0.2611

                        9           0.0135         0.0907

                       10           0.0000         0.0000

                       11          10.2480         0.4270

                     SNOW WATER     0.000

******************************************************************************
******************************************************************************
```

CHIMNEY DRAIN CALCULATIONS

CAMELOT LANDFILL
1339-351-11-02
UNDEVELOPED SUBTITLE D LEACHATE COLLECTION SYSTEM
CHIMNEY DRAIN CALCULATIONS

Required: Evaluate the adequacy of the chimney drain design along the leachate collection pipe for the maximum leachate impingement rate.

Method:

1. Determine the maximum leachate inflow rate into the chimney drain.
2. Determine the minimum drainage capacity of the chimney drain.
3. Compare the allowable flow rate to the required flow rate.

References:

1. GSE Nonwoven Geotextile (6 oz/sy)
2. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.

Solution:

1. Determine the maximum leachate inflow rate into the chimney drain.

A comparison of the developed Subtitle D area, undeveloped area, and overliner area was developed to determine the worst case scenario (i.e., which scenario generates the maximum leachate inflow rate).

Cells	**Peak Daily Generation Rate, q**		**Maximum Drainage Length, L[1]**	**Inflow Rate, Q_{req}**
	(cf/ac/day)	**(cfs/sf)**	**(ft)**	**(cfs)**
Developed Subtitle D Area (Cells 1 and 2)[2]	32.7	8.69E-09	440	3.82E-06
Developed Subtitle D Area (Cells 4B and 5)	25.8	6.86E-09	1710	1.17E-05
Undeveloped Area (Cells 6, 6A, 7, 7A, and 10-13)	170.5	4.53E-08	700	3.17E-05

[1] The maximum drainage length as shown takes in to account both sides draining to the chimney drain.

[2] Tire chip area (Cells 3, 4A, 8, and 9A) is included in the analysis for the Developed Subtitle D Area (Cells 1 and 2).

Note: The peak daily generation rate is from HELP model analyses in Appendix IIIC, Appendix IIIC-A.

Maximum leachate inflow rate to the chimney drain per unit length (1 ft) is calculated using the following equation:

$$Q_{req} = L * 1 * q$$

where:

Q_{req} = Maximum leachate inflow rate into chimney drain, cfs
L = Maximum length draining to chimney drain from both sides
q = Peak daily leachate generation rate from HELP model listed above, cfs/sf

Maximum Leachate Generation Rate from above table:

Q_{req} = 3.17E-05 cfs

2. Determine the minimum drainage capacity of the chimney drain.

Minimum drainage capacity of the chimney drain per unit length (1 ft):

$$Q_{ult} = k * i * w * 1$$

where:

Q_{ult} = Ultimate flow rate
k = Minimum permeability of the geotextile wrap
i = Hydraulic gradient = 1 under free drainage
w = Width of the chimney drain keyed into the waste layer, measured at the top of protective layer, min. 4 ft, as shown in Appendix IIIA-A, Drawing A.4.

k = 0.2 cm/s = 6.56E-03 fps (Ref. 1)
i = 1
w = 4 ft

Q_{ult} = 2.62E-02 cfs

To determine the allowable drainage capacity of the geotextile, the following reduction factors are used:

Table 1 - Reduction Factors[1]

RF_{SCB} = Reduction factor for soil clogging and blinding	2.0
RF_{CR} = Reduction factor for creep reduction of void space	2.0
RF_{IN} = Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} = Reduction factor for chemical clogging	1.5
RF_{BC} = Reduction factor for biological clogging	2.0
Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 2.

$$Q_{allow} = Q_{ult} / ORF$$

where:

Q_{allow} = Allowable flow rate
Q_{ult} = Ultimate flow rate
ORF = Overall reduction factor from Table 1

Q_{allow} = 1.82E-03 cfs

3. Compare the allowable flow rate to the required flow rate.

Q_{allow} = 1.82E-03 cfs >> Q_{req} = 3.17E-05 cfs

The predicted flow does not exceed the capacity of the chimney drain geotextile. The proposed chimney drain design is adequate to convey the generated leachate to the leachate collection pipe.

Prep By: MDM
Date: 3/20/2012

Chkd By: NT
Date: 3/20/2012

CAMELOT LANDFILL
1339-351-11-02
LEACHATE COLLECTION SYSTEM CHIMNEY DRAIN CAPACITY CALCULATIONS

Purpose: The purpose of this calculation is to demonstrate that the capacity of the chimney drain is sufficient to carry the expected leachate flow rate to the sump to provide redundancy.

Method:

1. Determine the expected leachate inflow rate into the chimney drain.
2. Determine the capacity of the chimney drain.
3. Compare the chimney drain capacity to the expected inflow rate.

References:

1. Expected leachate generation information in Appendix IIIC-E.

CAMELOT LANDFILL
1339-351-11-02
LEACHATE COLLECTION SYSTEM CHIMNEY DRAIN CAPACITY CALCULATIONS

Solution:

1. Determine the expected leachate inflow rate into the chimney drain.

$Q_{exp} = q * A$

where: Q_{exp} = Expected leachate inflow rate into chimney drain during active life (flow will decrease after final cover is installed)
q = Expected leachate generation rate (refer to Appendix IIIC-E)
A = Largest area draining to a chimney drain (Cells 5, 10, and 11)

q = 9,991 gal/ac/yr = 9.72E-10 cfs/sf
A = 43.9 ac = 1,912,284 sf

$\boxed{Q_{exp} = 0.0019 \text{ cfs}}$

2. Determine the capacity of the chimney drain.

$Q_{cd} = k/\eta * i * A$

where: Q_{cd} = Maximum capacity of chimney drain, cfs/ft
k = Permeability of drainage stone, ft/s
η = Porosity of drainage stone
i = Slope of chimney drain, ft/ft
A = Cross-sectional area of chimney drain assuming 12 inches of head on liner, sf

k = 1.0 cm/s = 0.033 ft/s
η = 0.35
i = 0.003 ft/ft (minimum post-settlement slope of LCS pipe listed in Appendix IIIJ)
A = 14.0 sf (refer to Detail L1 on Drawing A.4)

$\boxed{Q_{cd} = 0.0039 \text{ cfs}}$

3. Compare the chimney drain capacity to the expected inflow rate.

$\boxed{Q_{cd} = 0.0039 \text{ cfs} \quad >> \quad Q_{exp} = 0.0019 \text{ cfs}}$

Conclusion:

The chimney drain design is adequate to convey the expected generated leachate to the sump to provide redundancy.

3H:1V SIDESLOPE DOUBLE-SIDED GEOCOMPOSITE CALCULATIONS

CAMELOT LANDFILL
1339-351-11-02
LEACHATE COLLECTION LAYER DESIGN
DOUBLE-SIDED DRAINAGE GEOCOMPOSITE EVALUATION FOR UNDEVELOPED AREA SIDESLOPES

Required: Determine the minimum requirements of the 250-mil-thick double-sided geocomposite used for the 3H:1V sideslopes of leachate collection system for the undeveloped areas.

Method:

1.a. Use the maximum peak flow from the HELP Model analysis in Appendix IIIC-A as the flow into the double-sided drainage geocomposite located on the 3H:1V sideslopes

1.b. Determine the minimum required transmissivity of the 250-mil-thick, double-sided geocomposite leachate collection layer.

2. Determine the transmissivity of the double-sided drainage geocomposite.

2.a. Determine the overburden pressure acting on the double-sided drainage geocomposite.

2.b. Determine the transmissivity reduction factors of safety for strength and environmental conditions based on the critical loading condition.

2.c. Determine the reduced transmissivity of double-sided geocomposite.

3. Compare reduced laboratory transmissivity of double-sided drainage geocomposite with the required transmissivity for double-sided geocomposite.

4. Determine the head on liner.

5. Conclusion.

References:

1. Koerner, R.M., *Designing With Geosynthetics*, Third Edition, 1994.

2. *HELP* Model results in Appendix IIIC-A of the Site Development Plan.

3. Gray, Donald H.,Koerner, Robert M., Qian, Xuede, *Geotechnical Aspects of Landfill Design and Construction,* 2002

4. Geosynthetic Institute, GRI Standard GC8, 2001.

5. Giroud, J.P. et al., *Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers*, Geosynthetics International, Vol 7, 2000.

6. GSE Drainage Design Manual, May 2004.

7. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1.a. Determine the flow into the double-sided drainage geocomposite:

Note: The maximum flow into the double-sided geocomposite used on the 3H:1V area has been obtained from the peak leachate generation rate from the HELP Model analysis for the Undeveloped area since the flow rate is higher compared to that of the HELP Model analysis for the Overliner area in Appendix IIIC-A. The actual waste column thickness above the 3H:1V sideslope is 240ft. The flow rate was obtained from Closed 287ft run for the Undeveloped area.

Undeveloped area (Cells 6, 6A, 7, 7A, 10-13)

Flow into double-sided geocomposite, $q =$ 170.5 cf/ac/day, generated by HELP Model

Flow into unit area of geocomposite, $q_s = q\ /\ (43560 * 24 * 60 * 60)$

$q_s =$ 4.53E-08 cfs/sf

Longest 3H:1V sideslope, $L_S =$ 830 ft (this drainage length includes Cell O1 that will drain into the 3H:1V sideslope of Cell 13)

Unit flow, $q_L = q_s * L_S$

$q_L =$ 3.76E-05 cf/ft-s (or sf/s)

Notes:

1. The value q_L is used to develop the minimum required transmissivity of the double-sided geocomposite.

1.b. Determine the required transmissivity (T_r) of the double-sided geocomposite:

Undeveloped area (Cells 6, 6A, 7, 7A, 10-13)

$T_r = q_L\ /\ (\mathrm{Sin}\ \beta)$

$\beta =$ 18.4 ° (3H:1V placement slope for double-sided geocomposite)

$\mathrm{Sin}\ \beta =$ 0.32

$T_r =$ 1.19E-04 sf/s

$T_r =$ 1.11E-05 m^2/s

2. Determine the transmissivity of the double-sided drainage geocomposite:

The transmissivity of geocomposite is first determined by laboratory testing. This transmissivity is reduced as detailed in step 2.b to determine the design transmissivity (T_D) value. T_D value is then compared to T_r value.

2.a. Overburden pressure acting on the double-sided drainage geocomposite:

Assume the geocomposite leachate collection layer will undergo linear compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (250 mil)=	0.25	in
Unit Weight of Soil =	115	pcf
Unit Weight of Waste and Soil[5] =	75	pcf

Table 1.1 - Undeveloped area (Cells 6, 6A, 7, 7A, 10-13)

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	P[3] (psf)	t[4] (in)
Closed-240'	240	6.5	18,748	0.143

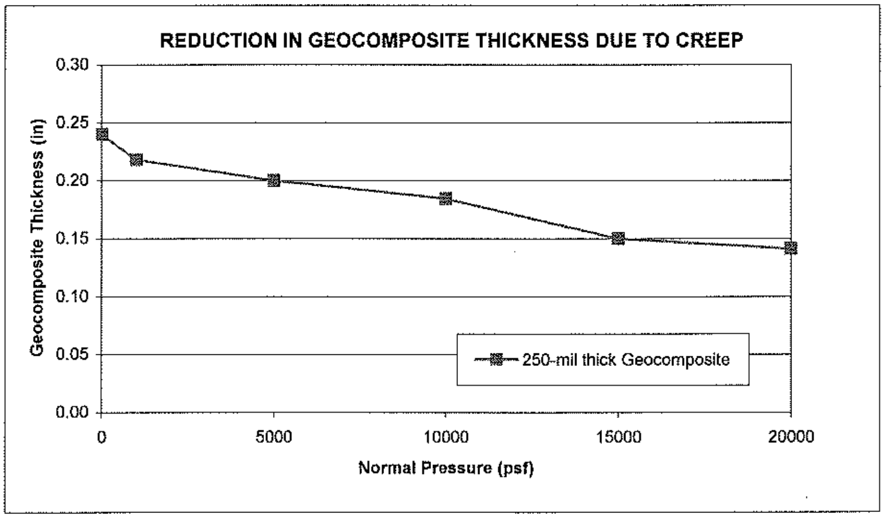
[1] d_W is the depth of waste and daily cover soil above the 3H:1V slope of the geocomposite leachate collection layer.

[2] d_S is the depth of soil above the geocomposite leachate collection layer.

[3] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[4] t is the thickness of the geocomposite leachate collection layer after being subjected to linear compression based on the chart below adapted from Ref. 6.

[5] The unit weight of waste/soil is selected at the midpoint of the 240-ft-thick waste column using the Unit Weight Profile for MSW graph provided in Ref. 7.



2.b. Reduction factors and factor of safety for strength and environmental conditions:

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition
		Interim (240' Waste)
RF_{IN}	Delayed Intrusion	1.1
RF_{CC}	Chemical Clogging	1.7
RF_{BC}	Biological Clogging	1.1
	Total Reduction Factor[2]	2.06
Overall Factor of Safety to Account for Uncertainties		2.0
Overall Reduction Factor (ORF)[3]		4.11

[1] Values are interpreted from References 1, 3, and 4.

[2] The Total Reduction Factor is a product of all the reduction factors for the fill condition.

[3] The Overall Reduction Factor is a product of the Total Reduction Factor and Overall Factor of Safety to Account for Uncertainties for the fill condition.

2.c. Determine the reduced transmissivity of double-sided geocomposite:

Undeveloped area (Cells 6, 6A, 7, 7A, 10-13)

Laboratory transmissivity value for 250-mil-thick double-sided geocomposite with 6 oz/sy geotextile, T_{Lb} based on the graph on page IIIC-B-99.

T_{Lb}= 6.24E-05 m^2/s

T_{LbR}= T_{Lb}/ORF Reduced manufacturer transmissivity (ORF is the overall reduction factor defined in Table 2.)

T_{LbR}= 1.52E-05 m^2/s

3. Required (T_r) versus reduced laboratory (T_{LbR}) transmissivity comparison:

Undeveloped area (Cells 6, 6A, 7, 7A, 10-13)

$T_r =$	1.11E-05 m^2/s	This value was determined in Step 1.b.
$T_{LbR} =$	1.52E-05 m^2/s	This value was determined in Step 2.c.

Ratio of T_{LbR} to T_r should be higher than 1 in order for the specified geocomposite to be acceptable.

$T_{LbR} / T_r =$ 1.37

4. Determine the head on the liner:

The head on liner is determined using the following formula:

$$T_{\max} = \frac{\sqrt{(\tan^2\beta + \frac{4q_h}{k_1})} - \tan\beta}{2\cos\beta} * L$$

(Ref. 5)

where,
T_{max}= maximum head on liner, ft
β= slope, deg
q_h= inflow rate, in/s
k_1= hydraulic conductivity of geocomposite, in/s
L= slope length, ft

$\beta=$	18.4 °
$\tan\beta=$	0.33
$\tan^2\beta=$	0.11
$\cos\beta=$	0.95

k_1 is hydraulic conductivity and is calculated using the following equation:
$k_1 = T_{LbR} / t$

Undeveloped area (Cells 6, 6A, 7, 7A, 10-13)

$k_1 =$	0.004	m/s
=	0.16	in/s
$q_h =$	4.53E-08	fps
=	5.44E-07	in/s
L=	830	ft
$T_{max} =$	0.0087	ft
=	0.104	in

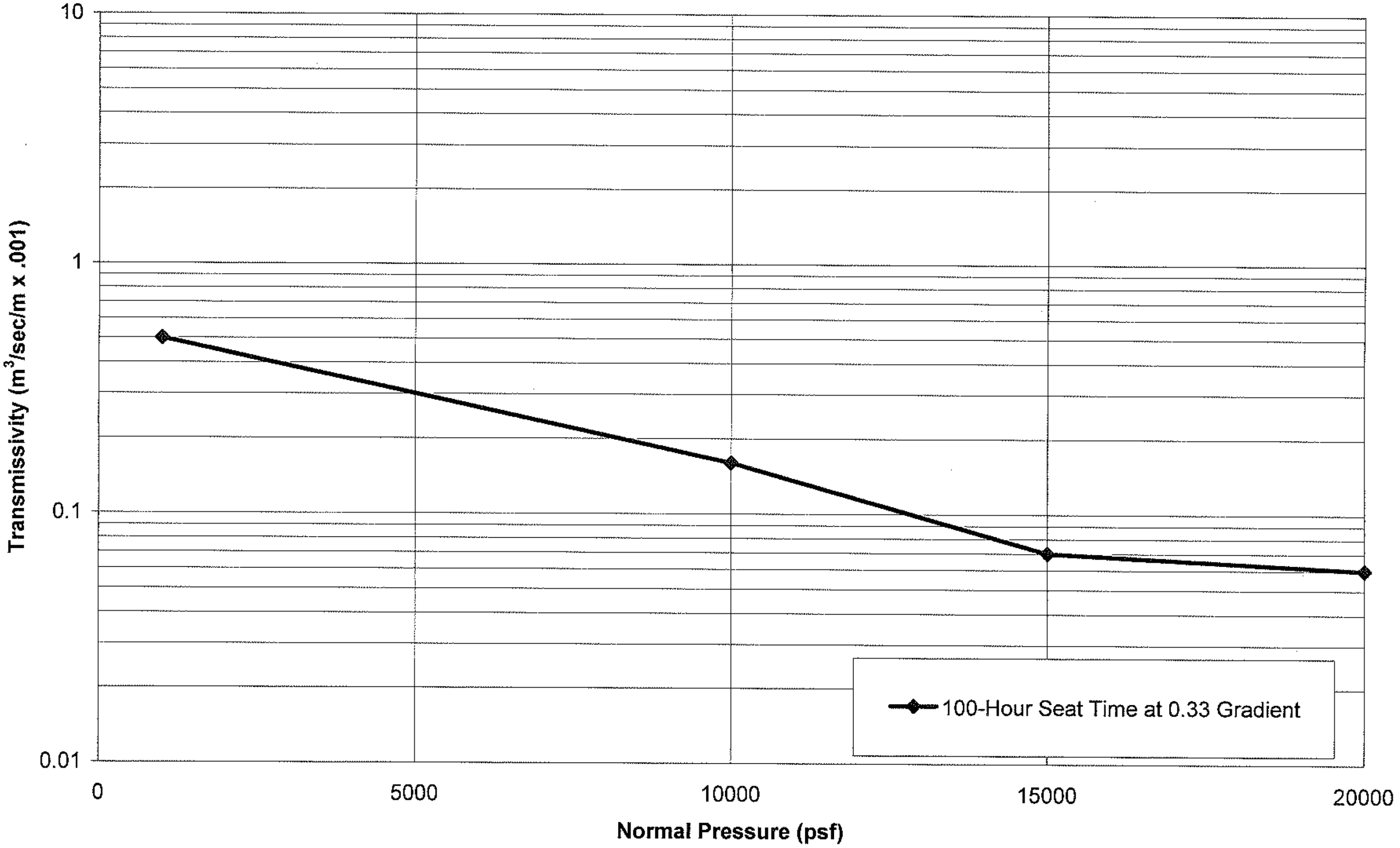
T_{max} is less than the compressed thickness of the geocomposite listed in Table 1.1.

5. Conclusion:

The transmissivity of the specified doubled-sided drainage geocomposite is higher than the transmissivity that is required based on the lines and grades established for the leachate collection system. Therefore, the specified double-sided drainage geocomposite is acceptable for the design.

For the undeveloped Subtitle D liner areas using a 250-mil thick geocomposite, the transmissivity of the double-sided geocomposite shall be measured at a minimum gradient of 0.33 under a minimum normal pressure of 1,000, 10,000, and 18,748 psf (or higher), boundary conditions consisting of soil/ geocomposite/geomembrane with a minimum seating time of 100 hours. The minimum transmissivity shall be $6.24 \times 10^{-5} m^2/s$.

TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE
6 oz/sy Polypropylene Geotextiles with 250 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



MAXIMUM HEAD CALCULATION FOR CELLS 3/4A/8/9A

Required: Determine the head on the tire chips in Cells 8, 9A, 3 and 4A and show that the flow is within the tire chips.

Background: Cells 8, 9A,3, and 4A were constructed with the following Alternate Liner System (from top to bottom).

- 12-inch-thick Tire Chip Leachate Collection System
- 12-inch-thick General Fill Layer
- 60-mil HDPE Geomembrane
- 2-foot-thick Compacted Clay Liner (CCL)

This alternate liner system was approved by the TCEQ in November 1999. The material requirements for the tire chip layer are listed below:

- Tire Chip Layer - The 12-inch-thick tire chip layer consists of pieces of scrap tires that have a basic geometrical shape and a nominal size of 2 to 4 inches.

The alternate liner design was completed assuming a leachate based on the liner system of 24 inches (e.g., the design assumed the 12-inch-thick general fill layer and the 12-inch-thick tire chip layer were saturated).

Method:

1. Use the maximum peak flow from the HELP Model analysis in Appendix IIIC-A as the flow into the tire chips.
2. Determine the head on liner.
3. Conclusion.

References:

1. Dana N.Humphrey, *Civil Engineering Application of Tire Shreds*, Presented at the Tire Industry Conference, Hilton Head, South Carolina, March 3, 1999.
2. Giroud, J.P. et al., *Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers*, Geosynthetics International, Vol 7, 2000.
3. D.B. Narejo and M. Shettima, *Use of Recycled Automobile Tires to Design Landfill Components*, Geosynthetics International, Vol 2, No 3, 1995.

Solution:

1. Determine the flow into the tire chips:

The maximum peak leachate generation rate from the HELP model analysis for the Developed Subtitle D area (Cells 4B and 5 and Cells 1 and 2) was used as the flow into the tire chips.

Flow into tire chips, q_h = 32.7 cf/ac/day, generated by HELP Model (Appendix IIIC-A)

2. Determine the head on the tire chips:

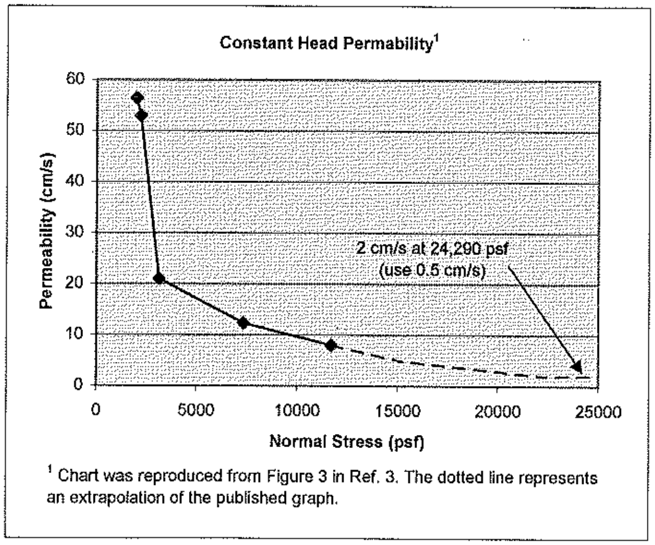
The head on tire chips is determined using the following formula:

$$T_{\max} = \frac{\sqrt{(\tan^2 \beta + \frac{4q_h}{k_1})} - \tan \beta}{2 \cos \beta} * L$$

where,
T_{max}= maximum head on tire chips, ft
β= slope, deg
q_h= inflow rate, in/s
k_1= hydraulic conductivity of tire chips, in/s
L= slope length, ft

β=	0.630 °
tanβ=	0.011
$\tan^2\beta$=	1.21E-04
cosβ=	1.00

k_1 is hydraulic conductivity and is obtained from Ref 3. The permeability was established from the following graph:



[1] Chart was reproduced from Figure 3 in Ref. 3. The dotted line represents an extrapolation of the published graph.

k_1 =	0.5	cm/s
=	0.19685	in/s
q_h=	28.90	cf/ac/day
=	7.96E-03	in/day
=	9.21E-08	in/s
L=	220	ft
T_{max}=	0.009	ft
=	0.112	in

5. Conclusion:

T_{max} (0.112 inches) is less than the thickness of the tire chips (12 inches). Therefore, the flow will be within the tire chips, which is consistent with the original approval to use tire chips (approved by the TCEQ in November 1999).

APPENDIX IIIC-C

CONTAINMENT BERM AND DIVERSION BERM CALCULATIONS

STATE OF TEXAS
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102273
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3.20.12

Includes pages IIIC-C-1 through IIIC-C-8

CAMELOT LANDFILL
1339-351-11-02
CONTAINMENT / DIVERSION BERM

REQUIRED:

1. Determine the height of the contaminated water berm required at the working face.
2. Determine the height of the diversion berm required for run-on control of the working face.

PROCEDURE:

Containment Berm Calculations

1. Determine the 25-year, 24-hour rainfall.
2. Calculate the volume of water captured behind the containment berm for 25-year, 24-hour rainfall event.
3. Calculate the height of the containment berm required to hold the volume of water calculated in step 2.

Diversion Berm Calculations

1. Determine the 25-year frequency runoff flow rates for the diversion berm run-on drainage areas by the Rational Method.
2. Calculate the capacity of the diversion berm swales at various slopes.
3. Calculate the height of the diversion berm required for the flow rate of run-on surface water.

REFERENCES:

1. Dodson & Associates, Inc., "ProHEC-1 Program Documentation", 1992.

2. Texas Department of Highways and Public Transportation, Bridge Division Hydraulic Manual, 3rd Edition, December 1985.

SOLUTION:

Containment Berm Calculations

1. Based on Reference 1, the 25-year, 24-hour rainfall volume for Denton County is:

   $R \approx$ 7.30 in

2. Determine the volume of storage required.

   $V_R = CAR$

   Where:

   C = Runoff coefficient = 0.5
   A = Drainage area = varies ac
   R = 25-year, 24-hour rainfall depth = 7.3 in

   The storage volume required for varying drainage areas are shown on the attached table.

3. Determine the height of the containment berm for a non-sloping water storage area.

   $$H = \frac{V_R}{A_{stor}}$$

   Where: A_{stor} = Storage area (sf)

   Values for height of the containment berm (H) are listed on Sheet IIIC-C-8 for several storage areas.

4. Determine the height of the berm for a sloping water storage area.

   The volume contained by the berm is equal to the cross-sectional storage area multiplied by the width of the berm. The computed volume must be greater than the volume found in step 2.

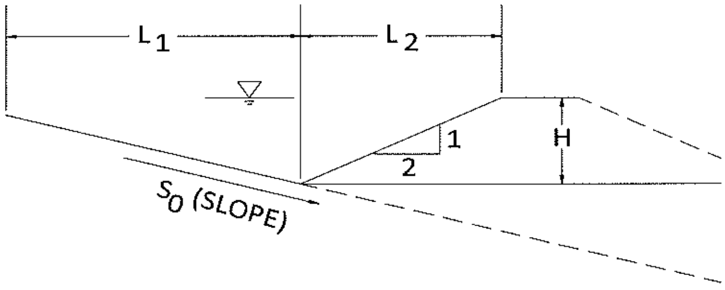
   $V_C = A_sW$

   Where:

   A_s = Cross-sectional storage area (sf)
   W = Width (ft)

   The minimum width of the downstream berm is 100 feet.

Figure 1. Cross Section of Berm and Storage Area



$$A_s = \frac{(L_1 + L_2)H}{2}$$

Where:

$L_1 = \frac{H}{So}$ (feet)

$L_2 =$ 2H (feet)

$S_o =$ Slope of active cell (ft/ft)

Example calculations:

1. Non-sloping water storage area:

Variables:	$S_o =$	0.00	%	$R =$	7.3	in
	$A_{stor} =$	0.25	ac	$C =$	0.5	
	$A =$	0.50	ac	$W =$	100	ft
Volume:	$V_R =$	6,625	cf			
Height:	$H =$	0.608	ft			

2. Sloping water storage area:

Variables:	$S_o =$	1.00	%	$R =$	7.3	in
	$A_{stor} =$	0.25	ac	$C =$	0.5	
	$A =$	0.50	ac	$W =$	100	ft

Height: An iterative process is used to determine the height of the berm required to meet the storage volume requirement for a non-sloping storage area.

$H =$ 1.2 ft

Check to ensure that the above berm height is adequate:

$L_1 =$ 120.00 ft
$L_2 =$ 2.40 ft
$A_s =$ 73.44 sf
$V_C =$ 7,344 cf

V_C is larger than V_R, berm has adequate height. See page IIIC-C-5 and Sheet IIIC-C-8 for summary.

3. Sloping water storage area:

Variables:

S_o =	2.00	%	R =	7.3	in
A_{stor} =	0.25	ac	C =	0.5	
A =	0.50	ac	W =	100	ft

Height: An iterative process is used to determine the height of the berm required to meet the storage volume requirement for a non-sloping storage area.

H = 1.6 ft

Check to ensure that the above berm height is adequate:

L_1 = 80.00 ft
L_2 = 3.20 ft
A_s = 66.56 sf
V_C = 6,656 cf

V_C is larger than V_R, berm has adequate height. See page IIIC-C-5 and Sheet IIIC-C-8 for summary.

Prep By: JLG
Date: 2/28/2012

Chkd By: MDM
Date: 2/28/2012

CAMELOT LANDFILL
1339-351-11-02
CONTAINMENT BERM

Drainage Area	Storage Area	Volume Required		Slope	Berm Height	Cross Sectional Area	Width	Water Surface Area	Volume Provided	L_1[1]	L_2[1]
(ac)	(ac)	(cf)		(%)	(ft)	(sf)	(ft)	(ac)	(cf)	(ft)	(ft)
0.5	0.25	6,625		0	0.608						
				1	1.2	73.44	100	0.281	7,344	120.0	2.4
				2	1.6	66.56	100	0.191	6,656	80.0	3.2
1.0	0.50	13,250		0	0.608						
				1	1.7	147.39	100	0.398	14,739	170.0	3.4
				2	2.3	137.54	100	0.275	13,754	115.0	4.6
2.0	1.00	26,499		0	0.608						
				1	2.3	269.79	100	0.539	26,979	230.0	4.6
				2	3.2	266.24	100	0.382	26,624	160.0	6.4
4.0	2.00	52,998		0	0.608						
				1	3.25	538.69	100	0.761	53,869	325.0	6.5
				2	4.55	538.27	100	0.543	53,827	227.5	9.1

[1] L_1 and L_2 are shown on the Figure 1 on page IIIC-C-2.

Diversion Berm Calculations

- As shown on Sheet IIIC-C-8, several swales were analyzed to determine the adequacy of the swale configuration.
- Hydraulic calculations are summarized on Sheet IIIC-C-8.

The swales were analyzed by the Rational Method.

From Reference 2 for Denton County:

$Q = C\,I\,A$

C = 0.5 (intermediate cover)
I = intensity, in/hr
A = drainage area, ac

$$I = \frac{b}{(t_c + d)^e}$$

b = 90
d = 8.5
e = 0.781
t_c is assumed to be 10 min. for all cases

I = 9.22 in/hr

Diversion Berm

Area(ac)	Flow Rate (cfs)
0.5	2.3
1	4.6
1.5	6.9
2	9.2
2.5	11.5
3	13.8

Prep By: JLG
Date: 2/28/2012

CAMELOT LANDFILL
1339-351-11-02
DIVERSION BERM

Chkd By: MDM
Date: 2/28/2012

For 33H:1V Diversion Berm Area Slope

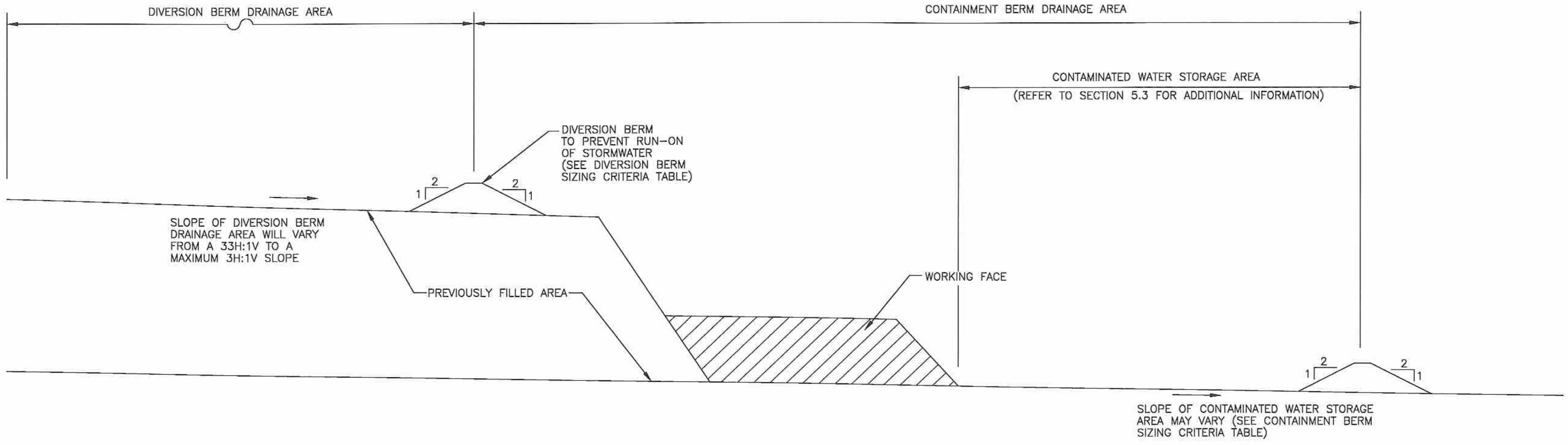
Drainage Area	Flow Rate (cfs)	Bottom Slope(ft/ft)	Manning's n	Side Slope (left)	Side Slope (right)	Bottom Width(ft)	Normal Depth(ft)	Flow Vel. (fps)	Froude Number	Velocity Head(ft)	Energy Head(ft)	Flow Area (sf)	Flow Top Width(ft)
0.5	2.3	0.01	0.03	2	33.0	0	0.30	1.42	0.640	0.03	0.34	1.62	10.66
1	4.6	0.01	0.03	2	33.0	0	0.40	1.68	0.667	0.04	0.44	2.73	13.84
1.5	6.9	0.01	0.03	2	33.0	0	0.46	1.86	0.684	0.05	0.51	3.71	16.11
2	9.2	0.01	0.03	2	33.0	0	0.51	2.00	0.696	0.06	0.57	4.60	17.95
2.5	11.5	0.01	0.03	2	33.0	0	0.56	2.11	0.705	0.07	0.63	5.45	19.52
3	13.8	0.01	0.03	2	33.0	0	0.60	2.21	0.713	0.08	0.67	6.25	20.91

Note: Calculations were performed using the HYDROCALC Hydraulics for Windows developed by Dodson and Associates(Version 1.2a, 1996).

For 3H:1V Diversion Berm Area Slope

Drainage Area	Flow Rate (cfs)	Bottom Slope(ft/ft)	Manning's n	Side Slope (left)	Side Slope (right)	Bottom Width(ft)	Normal Depth(ft)	Flow Vel. (fps)	Froude Number	Velocity Head(ft)	Energy Head(ft)	Flow Area (sf)	Flow Top Width(ft)
0.5	2.3	0.01	0.03	2	3	0	0.64	2.22	0.689	0.08	0.72	1.04	3.22
1	4.6	0.01	0.03	2	3	0	0.84	2.63	0.715	0.11	0.94	1.75	4.19
1.5	6.9	0.01	0.03	2	3	0	0.97	2.92	0.737	0.13	1.11	2.37	4.86
2	9.2	0.01	0.03	2	3	0	1.08	3.13	0.750	0.15	1.24	2.94	5.42
2.5	11.5	0.01	0.03	2	3	0	1.18	3.31	0.759	0.17	1.35	3.48	5.90
3	13.8	0.01	0.03	2	3	0	1.26	3.46	0.767	0.19	1.45	3.99	6.32

Note: Calculations were performed using the HYDROCALC Hydraulics for Windows developed by Dodson and Associates(Version 1.2a, 1996).



CONTAINMENT BERM SIZING CRITERIA *

CONTAINMENT BERM DRAINAGE AREA (ACRES)	CONTAMINATED WATER STORAGE AREA (ACRES)	FLOOR SLOPE OF CONTAMINATED WATER STORAGE AREA	REQUIRED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)
0.5	0.25	0 %	0.608
		1 %	1.2
		2 %	1.6
1.0	0.50	0 %	0.608
		1 %	1.7
		2 %	2.3
2.0	1.00	0 %	0.608
		1 %	2.3
		2 %	3.2
4.0	2.00	0 %	0.608
		1 %	3.25
		2 %	4.55

* CONTAINMENT BERM WILL BE SIZED USING THE ABOVE TABLE AS A GUIDLINE TO CONTAIN STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT. SUPPORTING CALCULATIONS ARE INCLUDED ON PAGES IIIC–C–2 THROUGH IIIC–C–5. NOTE THAT THE CRITERIA SET FORTH IN THE ABOVE TABLE IS BASED ON A MINIMUM DOWNSLOPE CONTAINMENT BERM LENGTH OF 100 FEET.

DIVERSION BERM SIZING CRITERIA *

DIVERSION BERM DRAINAGE AREA (ACRES)	MINIMUM 3%			MAXIMUM 33%		
	FLOW RATE (CFS)	FLOW DEPTH (FT)	REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)	FLOW RATE (CFS)	FLOW DEPTH (FT)	REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)
0.5	2.3	0.30	1.30	2.3	0.64	1.64
1	4.6	0.40	1.40	4.6	0.84	1.84
1.5	6.9	0.46	1.46	6.9	0.97	1.97
2	9.2	0.51	1.51	9.2	1.08	2.08
2.5	11.5	0.56	1.56	11.5	1.18	2.18
3	13.8	0.60	1.60	13.8	1.26	2.26

* DIVERSION BERM WILL BE SIZED USING THE ABOVE TABLE AS A GUIDELINE TO CONTAIN STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT. SUPPORTING CALCULATIONS ARE INCLUDED ON PAGES IIIC–C–6 THROUGH IIIC–C–7.

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102273
3-20-12

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☐ CLIENT APPROVAL BY: ____________________

DATE: 03/2012
FILE: 1339–351–11
CAD: IIIC–C–8 CONTAM WTR PLAN.DWG

DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

REUSE OF DOCUMENTS

PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE AND
CONTAMINATED WATER PLAN

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F–3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

FORT WORTH, TX
(817) 735–9770

GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

SHEET IIIC–C–8

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APPENDIX IIIC-D

STORAGE TANK CALCULATIONS AND FORCEMAIN CAPACITY

STATE OF TEXAS
MARILYN D. MORRISON
102273
LICENSED
PROFESSIONAL ENGINEER

3-20-12

Includes pages IIIC-D-1 through IIIC-D-12

Prep By: JLG
Date: 2/29/2012

CAMELOT LANDFILL
1339-351-11-02-6B.3
ON-SITE LEACHATE STORAGE TANK CAPACITY

Chkd By: MDM
Date: 2/29/2012

Required:

1. Determine if the existing 100,000-gallon leachate storage tank will provide adequate storage for the life of the site and the postclosure period.

Method:

1. Determine the leachate generation at the site based on actual leachate generation information.
2. Design the secondary containment area for the leachate storage tanks.

Existing Condition:

The existing 100,000-gallon leachate storage tank is located to the west of the existing Subtitle D area (see Figures 4-1 and 4-3 in Appendix IIIC). The 100,000-gallon leachate storage tank provides enough storage capacity for the leachate currently generated at the site. The storage tank will be emptied, as required, to maintain capacity for the leachate currently generated at the site. However, the leachate level in the tank will be managed to provide a minimum of 30,000 gallons of emergency backup storage capacity.

The actual leachate generation data has been used to estimate the amount of leachate to be stored in the storage tanks. The actual leachate generation information is included in Section 6 of Appendix IIIC and in Appendix IIIC-E.

Solution:

1. Determine the leachate generation at the site based on actual leachate generation information.

The actual annual average leachate generated = 9,991 gal/acre/year (Refer to Section 6 of App IIIC)

= 27 gal/acre/day

Phases of Development	**Total Area, acres**	**Leachate Generation, gallons per day**
Cells 1 through 3, 4A, 4B, 5, 7, 8, and 9A	73	1,986
Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, and 10 through 12	116	3,180
Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O2	159	4,361
Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O4	187	5,110
Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209	5,725
All Cells	209	5,023 [1]

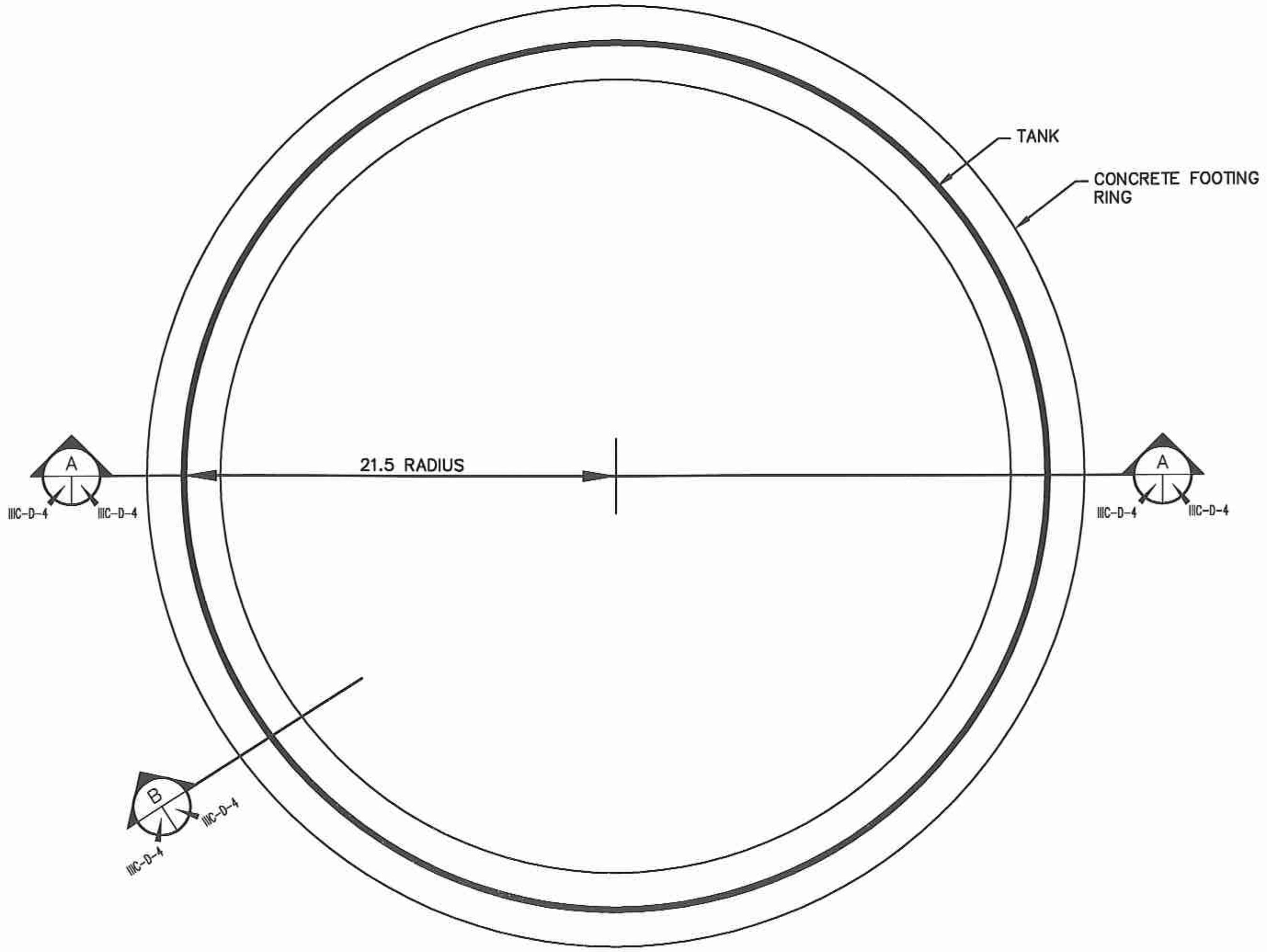
[1] Cells 1, 2, 8, and 9A will be closed during the previous development; therefore, only 10 percent of the leachate generation rate was used for these closed areas.

Summary

The existing 100,000-gallon storage tank will be managed so that 30,000 gallons of back-up storage capacity is maintained in the tank for emergency situations. The back-up storage capacity will provide several days of storage. Typically, leachate will be conveyed from the tank to the POTW.

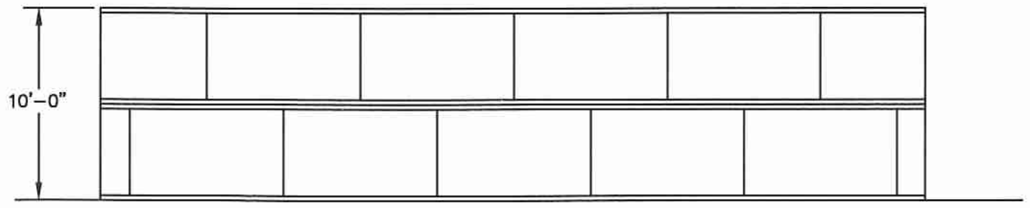
2. Design the secondary containment area for the leachate storage tank.

The existing 100,000-gallon storage tank is a double-walled steel tank that contains an inner tank ("storage vessel") consisting of a geomembrane liner. The secondary geomembrane liner, attached to the inner surface of the steel tank, collects any leachate that may infiltrate through the primary geomembrane liner. Therefore, the 100,000-gallon storage tank design provides secondary containment. Details of the 100,000-gallon storage tank are shown on Sheet IIID-C-4.



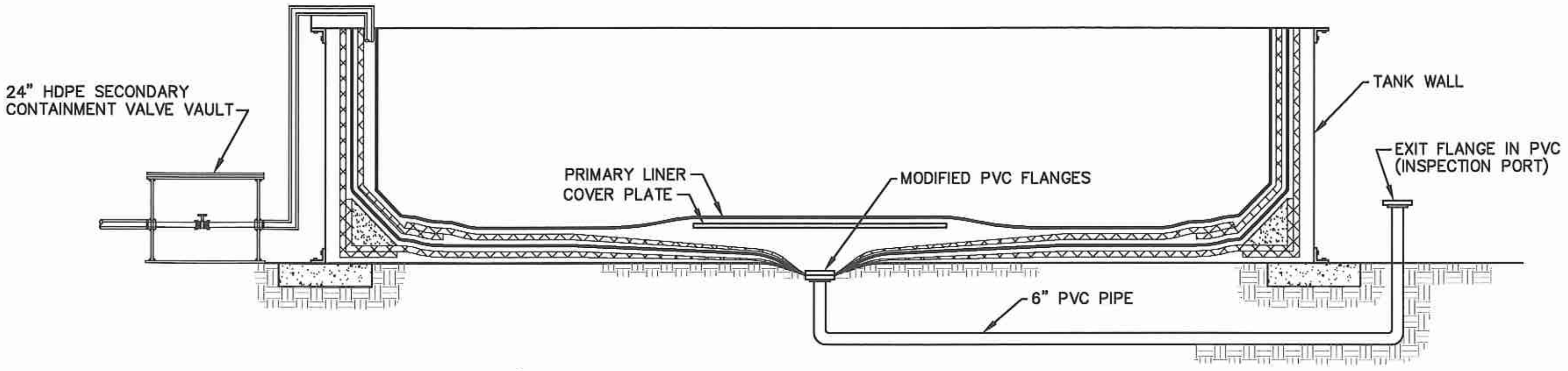
MODULAR TANK
PLAN
NTS

0 5 10
SCALE IN FEET

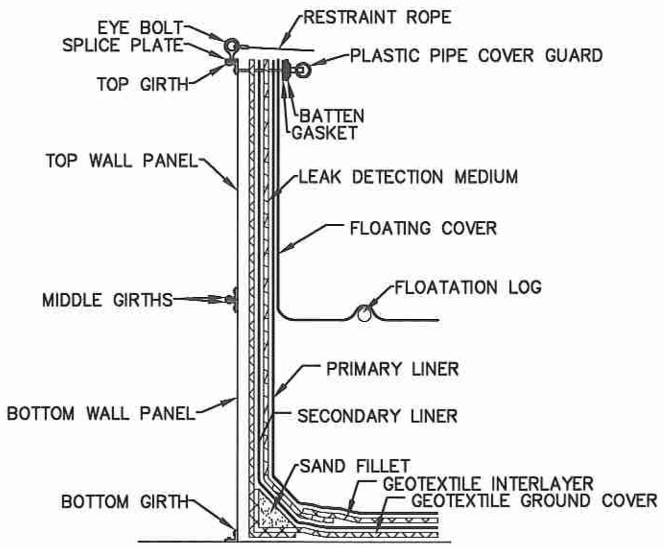


MODULAR TANK
ELEVATION
NTS

0 5 10
SCALE IN FEET



A TYPICAL SECTION AT LEAK DETECTION SUMP
NTS
IIIC-D-4 IIIC-D-4



B TYPICAL SECTION
NTS
IIIC-D-4 IIIC-D-4

MARILYN D. MORRISON
102273
3.20.12

TANK VOLUME GALLONS	TANK DIMENSIONS
100,000	43' DIA X 10'

NOTE:

1. 100,000 GALLON MODULAR TANK HAS A DOUBLE LINER, LEAK DETECTION SUMP, AND A FLOATING COVER.
2. BACK FLOW PREVENTION VALVES WILL BE INSTALLED, AS NEEDED.

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PREPARED FOR
CITY OF FARMERS BRANCH

MAJOR PERMIT AMENDMENT LEACHATE STORAGE TANK DETAILS

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

DATE: 03/2012
FILE: 1339-351-11
CAD: IIIC-D-4 TANK DETAILS.DWG

DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

REVISIONS

NO.	DATE	DESCRIPTION

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SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

SHEET IIIC-D-4

O:\1339\351\EXPANSION 2009\PART III-SDP\IIIC\IIIC-D-4 TANK DETAILS.DWG, 3/1/2012 12:38:14 PM, jwilson, 1:2

REQUIRED:

1. Size the leachate forcemain collection pipes.
2. Evaluate the capacity of the pipe connecting the tank to the metering vault.

METHOD:

1. A. Use leachate production rates provided in Appendix IIIC-A (based on the HELP model analysis) to determine the required capacity of the leachate collection forcemain pipes.

   B. Determine the capacity of the leachate collection system forcemain pipes.

   C. Calculate the maximum pressure experienced by the forcemain pipes.

   D. Evaluate the flow velocity in the forcemain pipes.

   E. Conclusion.

2. A. Determine the maximum flow to the pipe connecting the tank to the metering vault.

   B. Calculate the capacity of the pipe connecting the tank to the metering vault.

   C. Conclusion.

Note: Forcemain and storage tank details are provided on Figures 4-1 through 4-3 in Appendix IIIC.

REFERENCES:

1. Driscopipe Systems Design, Phillips 66. 1992 Phillips Driscopipe, Inc. 1235-91 A 01

SOLUTION:

1. **Size the leachate forcemain collection pipes.**
   A. **Use leachate production rates provided in Appendix IIIC-A to determine the required capacity of the leachate collection forcemain pipe.**

CONDITION	AREA[1]	AVERAGE ANNUAL		TOTAL FLOW	FLOW[3]
	ac	cfy[2]	gpd/ac	gpd	cfs
Active, 10' Waste	7.00	3503.0	72	503	0.0008
Interim, 50' Waste	25.00	5066.3	104	2,596	0.0040
Interim, 100' Waste	35.00	26380.9	541	18,922	0.0293
Interim, 150' Waste	50.00	19406.4	398	19,885	0.0308
Interim, 188' Waste	35.00	23103.6	473	16,571	0.0256
Interim 200' Waste	25.00	23199.6	475	11,886	0.0184
Interim 282' Waste	15.00	1935.7	40	595	0.0009
Interim 287' Waste	11.00	37815.0	775	8,524	0.0132
Interim, 298' Waste	6.14	1661.7	34	209	0.0003
Total =	209.14				0.1233

[1] Total limits of waste area of 209.14 acres is represented with different waste column thicknesses for demonstration purposes.

[2] The average annual flows in cubic feet per year (cfy) have been obtained from the HELP Model summary tables included on pages IIIC-A-27 through IIIC-A-30. The highest values for a given waste thickness have been used for demonstration purposes.

[3] There are two leachate forcemain pipes, one serving the overliner area and the other in the Subtitle D area. For each forcemain pipe the entire limits of waste area was taken into consideration to be conservative.

Total maximum leachate production = Q = 0.1233 cubic feet per second (cfs)
Q = 55 gallons per minute (gpm)
Q = 79,691 gallons per day (gpd)[1]

[1] Note that this leachate estimate provides for a very conservative design given that the leachate flow rate based on actual site leachate data shows an average flow rate of less than 6,000 gpd (refer to Sheet IIIC-D-2).

Required capacity of leachate forcemain pipe = 79,691 gpd

B. Determine the capacity of the leachate collection system forcemain pipe.

Capacity of the forcemain is calculated by using the following formula from Ref. 1.

$$\Delta P_{100} = \frac{452 * Q^{1.85}}{C^{1.85} * D^{4.86}} \qquad \text{Eq. 1}$$

where:

ΔP_{100} = Friction pressure loss, pounds per square inch per 100 feet of pipe
Q = Rate of flow, gallons per minute
C = Pipe coefficient, See Chart 4 on Page IIIC-D-12
D = Pipe internal diameter, inches

Rearrange Equation 1 to solve for Q.

$$Q = \left(\frac{\Delta P_{100} * C^{1.85} * D^{4.86}}{452}\right)^{(1/1.85)} \qquad \text{Eq. 2}$$

Calculate ΔP_{100}:

$$\Delta P_{100} = (P - \Delta h) / (L/100)$$

where:

P = Pipe strength, psi
Δh = Geometric head difference, psi
L = Pipe length, ft

P = 100 psi (refer to page IIIC-D-11 for SDR17 pipe)

Calculate Δh:

Overliner Forcemain:

Elevation at the low point of forcemain = 462 ft-msl
Elevation at the high point of forcemain = 500 ft-msl
Δh = 38 ft

Convert units from feet to psi:

Note: 1 psi is equal to 2.31 feet of water column.

$$\Delta h \text{ (psi)} = \Delta h \text{ (ft)} / (2.31 \text{ ft/psi})$$

Δh = 16.47 psi

Pipe Strength Available for Friction Loss = $P - \Delta h$

Pipe Strength for Friction Loss = 83.53 psi

L= 6,550 ft

(Note: Forcemain length is assumed to be the total length from the existing leachate tank (refer to Figure 3-1 in Appendix IIIC for location) extending to the Pre-subtitle D area).

$$\Delta P_{100} = (100-16.47)/(6{,}550/100)$$

ΔP_{100} = 1.28 psi

Calculate maximum capacity of the 3-inch pipe by using Equation 2 above:

C = 155 (refer to page IIIC-D-12)
D = 3.088 inches, internal diameter of forcemain (refer to page IIIC-D-11)

$$Q = [(\Delta P_{100} C^{1.85} D^{4.86})/452]^{(1/1.85)}$$

$$Q = [(1.28 * 155^{1.85} * 3.088^{4.86})/452]^{(1/1.85)}$$

Q = 125.49 gpm
$\boxed{Q = 180{,}705 \text{ gpd}}$

The above calculated value reflects the maximum capacity of the overliner pipe, which is greater than the required capacity (i.e., 180,705 gpd > 79,691 gpd).

Subtitle D Forcemain:

Elevation at the low point of forcemain = 458 ft-msl
Elevation at the high point of forcemain = 462 ft-msl
$\Delta h =$ 4 ft

Convert units from feet to psi:

Note: 1 psi is equal to 2.31 feet of water column.

Δh (psi) = Δh (ft) / (2.31 ft/psi)

$\Delta h =$ 1.73 psi

Pipe Strength Available for Friction Loss = P - Δh

Pipe Strength for Friction Loss = 98.27 psi

L= 3,700 ft

(Note: Forcemain length is assumed to be the total length from the existing leachate tank (refer to Figure 3-1 in Appendix IIIC for location) extending to the Subtitle D area).

$\Delta P_{100} =$ (100-1.73)/(3,700/100)

$\Delta P_{100} =$ 2.66 psi

Calculate maximum capacity of the 3-inch pipe by using Equation 2 above:

C = 155 (refer to page IIIC-D-12)
D = 3.088 inches, internal diameter of forcemain (refer to page IIIC-D-11)

$$Q = [(\Delta P_{100} C^{1.85} D^{4.86})/452]^{(1/1.85)}$$

$$Q = [(2.66*155^{1.85}*3.088^{4.86})/452]^{(1/1.85)}$$

Q = 186.56 gpm
Q = 268,645 gpd

The above calculated value reflects the maximum capacity of the Subtitle D pipe, which is greater than the required capacity (i.e., 268,645 gpd > 79,691 gpd).

C. Calculate the maximum pressure experienced by the forcemain pipe.

Calculate head loss in the 3-inch diameter forcemain using the following equation from Ref. 1:

$$\Delta P_{100} = \frac{452*Q^{1.85}}{C^{1.85}*D^{4.86}}$$

Q = 55 gpm (from Step A)
C = 155 From Chart 4 on Page IIIC-D-12.
D = 3.088 inches, diameter of discharge pipe contained in a 6-inch diameter containment pipe

$\Delta P_{100} =$ 0.28 psi

Overliner Forcemain:

Total head loss ($\Sigma\Delta P$) = ΔP_{100} * (L/100) = 0.28 psi x (6550/100)

$\Sigma\Delta P$= 18.37 psi

To account for local head losses (elbows, etc.) multiply the calculated total head loss with a factor of safety of 1.2.

F.S.= 1.2
$\Sigma\Delta P$ * F.S.= 22.04 psi

Calculate total head at the pump:

$P_{tot} = \Delta h + \Sigma\Delta P$

where:

P_{tot} = Total head at pump, psi
Δh = Geometric head (from Step B)
$\Sigma\Delta P$ = Total head loss, psi

P_{tot} = 16.47 psi + 22.04 psi

P= 38.51 psi

Subtitle D Forcemain:

Total head loss ($\Sigma\Delta P$) = ΔP_{100} * (L/100) = 0.28 psi x (3700/100)

$\Sigma\Delta P$= 10.38 psi

To account for local head losses (elbows, etc.) multiply the calculated total head loss with a factor of safety of 1.2.

F.S.= 1.2
$\Sigma\Delta P$ * F.S.= 12.45 psi

Calculate total head at the pump:

$P_{tot} = \Delta h + \Sigma\Delta P$

where:

P_{tot} = Total head at pump, psi
Δh = Geometric head (from Step B)
$\Sigma\Delta P$ = Total head loss, psi

P_{tot} = 1.73 psi + 12.45 psi

P= 14.18 psi

D. Evaluate the flow velocity in the forcemain pipe.

$V = 0.408 * (Q/D^2)$ (Ref. 1)

where:

Q = Rate of flow, gpm
D = Pipe internal diameter, inches

Q = 55 gpm (from Step A)
D = 3.088 inches

V=	2.37	fps

E. Conclusion.

The pipe capacity (125 gpm for the overliner forcemain and 186 gpm for the Subtitle D forcemain) is not exceeded by the expected flow of 55 gpm.

The forcemain can withstand 100 psi, and the maximum pressure calculated as 38.51 psi. Therefore, the pipe strength is acceptable.

The calculated velocity of the 3-inch forcemain for 55 gpm of flow is well within acceptable flow velocity range.

2. Evaluate the capacity of the pipe connecting the tank to the metering vault.
A. Determine the maximum flow to the pipe connecting the tank to the metering vault.

According to the leachate storage tank calculations, the maximum daily leachate flow rate, Q_{max}, to the tank when the entire site is developed will be: 5,725 gpd (Refer to page IIIC-D-2).

B. Calculate the capacity of the pipe connecting the tank to the metering vault.

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2} \qquad A = \frac{\Pi \times d^2}{4} \qquad R = \frac{d}{4}$$

Where:

A = Cross-sectional area of pipe, with d representing the inside diameter
R = Hydraulic radius of pipe under full flow conditions
S = Design slope of pipe
n = Manning's number

Standard Dimension Ratio (SDR) = 11.0
d = 1.943 in = 0.162 ft
A = 0.021 sq ft
R = 0.040 ft
S = 0.003 ft / ft
n = 0.015

Q_{full} =	0.013	cfs	=	8512.6	gpd

C. Conclusion.

Q_{full} =	8512.6	gpd	>>	Q_{max} =	5725	gpd

The 2-inch diameter leachate line connecting the tank to the metering vault has enough capacity to handle the maximum daily leachate flow rate determined in the storage tank calculations.

3/4" (1.050 OD)

SDR 11	160 psi	0.12 lbs./ft.	0.860 ID	.095 wall

1" (1.315 OD)

SDR 11	160 psi	0.19 lbs./ft.	1.075 ID	.120 wall

1-1/4" (1.660 OD)

SDR 11	160 psi	0.31 lbs./ft.	1.358 ID	.151 wall

1-1/2" (1.900 OD)

SDR 11	160 psi	0.41 lbs./ft.	1.554 ID	.173 wall

2" (2.375 OD)

SDR 7	267 psi	0.94 lbs/ft	1.697 ID	.339 wall
SDR 9	200 psi	0.76	1.847	.264
SDR 11 ●	**160 psi**	**0.64**	**1.943**	**.216**
SDR 13.5	128 psi	0.53	2.023	.176
SDR 15.5	110 psi	0.47	2.069	.153
SDR 17	100 psi	0.43	2.095	.140

3" (3.500 OD)

SDR 7	267 psi	2.05 lbs/ft.	2.500 ID	.500 wall
SDR 9	200 psi	1.66	2.722	.389
SDR 11 ●	**160 psi**	**1.39**	**2.864**	**.318**
SDR 13.5	128 psi	1.15	2.982	.259
SDR 15.5	110 psi	1.02	3.048	.226
SDR 17 ●	**100 psi**	**0.93**	**3.088**	**.206**
SDR 19	89 psi	0.84	3.132	.184
SDR 21	80 psi	0.77	3.166	.167
SDR 26	64 psi	0.62	3.230	.135
SDR 32.5	51 psi	0.50	3.284	.108

4" (4.500 OD)

SDR 7	267 psi	3.39 lbs/ft.	3.214 ID	.643 wall
SDR 9	200 psi	2.74	3.500	.500
SDR 11 ●	**160 psi**	**2.29**	**3.682**	**.409**
SDR 13.3	128 psi	1.90	3.834	.333
SDR 15.5 ●	**110 psi**	**1.68**	**3.020**	**.290**
SDR 17 ●	**100 psi**	**1.54**	**3.970**	**.265**
SDR 19	89 psi	1.39	4.026	.237
SDR 21	80 psi	1.26	4.072	.214
SDR 26 ●	**64 psi**	**1.03**	**4.154**	**.173**
SDR 32.5	51 psi	0.83	4.224	.138

5-3/8" (5.375 OD)

SDR 17	100 psi	2.20 lbs./ft.	4.743 ID	.316 wall
SDR 21	80 psi	1.80	4.863	.256
SDR 26	64 psi	1.47	4.961	.207
SDR 32.5	51 psi	1.18	5.045	.165

5" (5.563 OD)

SDR 7	267 psi	5.17 lbs/ft.	3.973 ID	.795 wall
SDR 9	200 psi	4.18	4.327	.618
SDR 11	160 psi	3.51	4.551	.506
SDR 13.5	128 psi	2.91	4.739	.412
SDR 15.5	110 psi	2.57	4.845	.359
SDR 17	100 psi	2.35	4.909	.327
SDR 19	89 psi	2.12	4.977	.293
SDR 21	80 psi	1.93	5.033	.265
SDR 26	64 psi	1.57	5.135	.214
SDR 32.5	51 psi	1.27	5.221	.171

6" (6.625 OD)

SDR 7	267 psi	7.33 lbs./ft.	4.733 ID	.946 wall
SDR 9	200 psi	5.93	5.153	.736
SDR 11 ●	**160 psi**	**4.97**	**5.421**	**.602**
SDR 13.5	128 psi	4.13	5.643	.491
SDR 15.5	110 psi	3.63	5.771	.427
SDR 17 ●	**100 psi**	**3.34**	**5.845**	**.390**
SDR 19	89 psi	3.01	5.927	.349
SDR 21 ●	**80 psi**	**2.73**	**5.995**	**.315**
SDR 26 ●	**64 psi**	**2.23**	**6.115**	**.255**
SDR 32.5 ●	**51 psi**	**1.80**	**6.217**	**.204**

7" (7.125 OD)

SDR 7	267 psi	8.49 lbs./ft.	5.089 ID	1.018 wall
SDR 9	200 psi	6.86	5.541	.792
SDR 11	160 psi	5.75	5.829	.648
SDR 13.5	128 psi	4.78	6.069	.528
SDR 15.5	110 psi	4.21	6.205	.460
SDR 17	100 psi	3.86	6.287	.419
SDR 19	89 psi	3.48	6.375	.375
SDR 21	80 psi	3.16	6.445	.340
SDR 26 ●	**64 psi**	**2.58**	**6.577**	**.274**
SDR 32.5	51 psi	2.08	6.685	.220

8" (8.625 OD)

SDR 7	267 psi	12.43 lbs.ft.	6.161 ID	1.232 wall
SDR 9	200 psi	10.05	6.709	.958
SDR 11 ●	**160 psi**	**8.42**	**7.057**	**.784**
SDR 13.5	128 psi	7.00	7.347	.639
SDR 15.5	110 psi	6.16	7.513	.556
SDR 17 ●	**100 psi**	**5.65**	**7.611**	**.507**
SDR 19	89 psi	5.10	7.717	.454
SDR 21 ●	**80 psi**	**4.64**	**7.803**	**.411**
SDR 26 ●	**64 psi**	**3.79**	**7.961**	**.332**
SDR 32.5 ●	**51 psi**	**3.05**	**8.095**	**.265**

● denotes standard sizes

Chart 4

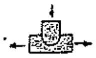
Table of "C" Values for "Hazen and Williams Formula"

Constant	Type of Pipe
155	Driscopipe
140	New steel pipe or tubing Glass tubing Asbestos cement
130	Copper tubing Ordinary brass pipe Cast iron – new Cast iron – tar coated but new Cast iron – fully cement lined
125	Steel pipe – old
120	Wood stave pipe Concrete pipe New wrought iron pipe Four to six years old cast iron pipe
110	Ten to twelve years old cast iron pipe Vitrified pipe Spiral riveted steel, flow with lap Galvanized steel
100	Spiral riveted steel, flow against lap Thirteen to twenty years old cast iron pipe Galvanized steel – over 5 years old Cast iron – tar coated over 10 years old
90	Twenty-six to thirty-year old cast iron pipe
60	Corrugated steel pipe

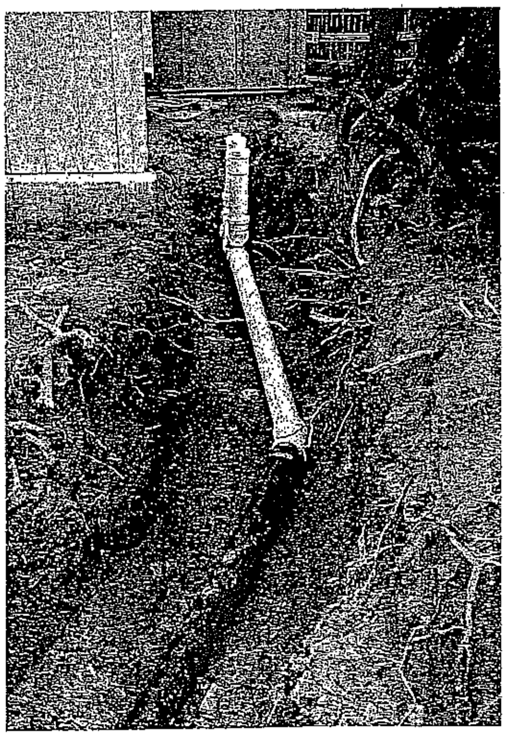
Fitting Pressure Drop: Listed below in Chart 5 are various common piping system components and the associated pressure loss through the fitting expressed as an equivalent length of straight pipe in terms of diameters. The inside diameter (in feet) multiplied by the equivalent length diameters gives the equivalent length (in feet) of pipe. This equivalent length of pipe is added to the total footage of the piping system when calculating the total system pressure drop.

These equivalent lengths should be considered an approximation suitable for most installations.

Chart 5

Fabricated Fitting	Equiv. Length
Running Tee 	20 D
Branch Tee 	50 D
90° Fab, Ell 	30 D
60° Fab, Ell 	25 D
45° Fab, Ell 	18 D
45° Fab, Wye 	60 D
Conventional Globe Valve (Full Open)	350 D
Conventional Angle Valve (Full Open)	180 D
Conventional Wedge Gate Valve (Full Open)	15 D
Butterfly Valve (Full Open)	40 D
Conventional Swing Check Valve	100D

(See Appendix for further data on resistance of valves and fittings to flow).



APPENDIX IIIC-E

SITE LEACHATE GENERATION INFORMATION

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3.20.12

Includes pages IIIC-E-1 through IIIC-E-13

CONTENTS

This appendix includes the following leachate generation information.

- Sheet IIIC-E-2. Summary table listing the leachate generation information for 2008, 2009, and 2010 for Camelot Landfill.
- Sheets IIIC-E-3 through IIIC-E-4. Summary of leachate generation volume over the life of the site using actual leachate generation rate information.
- Sheets IIIC-E-5 through IIIC-E-7. Summary of leachate generation over the life of the site using the HELP analysis included in Appendices IIIC-A and IIIC-E.
- Sheets IIIC-E-8 through IIIC-E-9. Leachate depth on liner calculations for the actual leachate generation rates.
- Sheets IIIC-E-10 through IIIC-E-13. HELP summary sheets for the postclosure cases.

This information is summarized in Section 6 of the Leachate and Contaminated Water Management Plan.

CAMELOT LANDFILL
13395-351-11-02
LEACHATE GENERATION SUMMARY TABLE

Purpose: Summarize the leachate information for the Camelot Landfill. The leachate generation information was provided by site personnel. The site location is shown on Sheet IIIC-E-3.

Table IIIC-E-1
Camelot Landfill - Summary

Year	Annual Rainfall[1] (in)	Total Leachate generated per year (gallons)	Amount Recirculated Per Year (gallons)	Percent Leachate Recirculated (%)	Lined Area (acres)	Average Waste Column Thickness (feet)	Leachate Generated (gallons/ac/year)
2008	33.54	290,312	55,766	19.2%	58	60	5,005
2009	43.64	1,149,300	277,855	24.2%	66	70	17,414
2010	32.12	498,527	525,913	100%	66	76	7,553
Average	36.43	646,046	286,511	48%	63	69	9,991

[1] The rainfall data was obtained from site personnel.

LEACHATE GENERATION VOLUMES USING ACTUAL LEACHATE GENERATION INFORMATION

Required: Estimate the leachate volume generated over the life of the site and the postclosure period using leachate generation information from the Camelot Landfill and information obtained from an EPA study.

References:

1. Bonaparte, Rudolph, Daniel, David E., and Koerner, Robert M. "Assessment and Recommendations for Improving the Performance of Waste Containment Systems," U.S. EPA, EPA/600/R-02/099, Dec. 2002.
2. Leachate generation information for the Camelot Landfill obtained from Republic site personnel.

Procedure:

1. Determine the approximate cell development sequence.
2. Estimate the leachate generation volume of each stage of development.

Solution:

1. Determine the approximate sector development sequence.

The approximate cell development sequence is shown on Table IIIC-E-2. Leachate generation volumes will be compared for the following years.

- 2011
- 2017
- 2023
- 2029
- 2034
- 2039
- 2040 through 2049 - First 10 years of postclosure period
- 2050 through 2059 - Second 10 years of postclosure period
- 2060 through 2069 - Third 10 years of postclosure period

2. Estimate the leachate generation volume of each stage of development.

This information is provided on Sheet IIIC-E-5.

CAMELOT LANDFILL
1339-351-11-02
LEACHATE GENERATION VOLUMES USING ACTUAL LEACHATE GENERATION INFORMATION

TABLE IIIC-E-2
Leachate Generation Volume Over the Life of the Site

Year	Cells Developed	Lined Area (acres)	Leachate Generation Rate (gallons per acre)	Total Leachate Generated (gallons)	Source of Information
2011	Cells 1 through 3, 4A, 4B, 5, 7, 8, and 9A	72.6	9,991	725,347	Leachate generation information from Camelot Landfill (average of 2008 to 2010) was used on a per acre basis to estimate the leachate generation rate.
2017	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, and 10 through 12	116.2	9,991	1,160,954	
2023	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O2	159.4	9,991	1,592,565	
2029	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O4	186.8	9,991	1,866,319	
2034	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	9,991	2,089,118	
2039	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	9,991	1,889,798	Leachate generation information from Camelot Landfill (average of 2008 to 2010) was used on a per acre basis to estimate the leachate generation rate. 28.5 acres of the landfill area will be closed in 2034. As noted below for years 2040 through 2049, the leachate generation rate is assumed to be 10% of the value assumed for the year 2034. Therefore for year 2039 (after 6 years of closed condition for the 28.5-ac area), 30 percent of the leachate generation rate assumed in 2034 was used.
SITE CLOSURE IN 2039					
2040 through 2049	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	999	208,912	As noted in Ref. 1, it is projected that the leachate generation rates are decreased by a factor of four within one year after closure and by one order of magnitude within 2 to 4 years and almost negligible after 9 years. Based on this reference, the leachate generation was assumed to be 10% of the year 2039 for the first 10 years and for the second and third 10 years, the leachate generation was assumed to be 2% of the leachate generation in year 2039.
2050 through 2059	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	200	41,782	
2060 through 2069	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	200	41,782	

LEACHATE GENERATION VOLUME OVER THE LIFE OF THE SITE USING HELP

Required: Estimate the leachate volume generated over the life of the site and the post-closure period using information included in Appendices IIIC-A and IIIC-E (HELP modeling information).

Reference: HELP model analyses included in Appendix IIIC-A and Appendix IIIC-E.

Procedure:

1. The cell development sequence established on Sheet IIIC-E-5 will be used for this analysis.
2. Estimate the leachate generation value for each stage of development. This information is provided on Table IIIC-E-3. The HELP model summary information is provided on Table IIIC-E-4.

Table IIIC-E-3
Leachate Generation Value During the Life of the Site

Year	Cells Developed	Lined Area (acres)	Total Leachate Generated		Source of Information
			Average (gal/year)	Peak (gal/year)	
2011	Cells 1 through 3, 4A, 4B, 5, 7, 8, and 9A	72.6	1,517,445	5,460,264	Cell 7 assumed an active 10-foot waste column thickness HELP run, Cells 4A, 4B, and 5 assumed an interim 50-foot waste column thickness HELP run, and Cells 1-3, 8, and 9A assumed an interim 100-foot waste column thickness HELP run to determine the average and peak leachate generation rates.
2017	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, and 10 through 12	116.2	3,240,746	11,840,855	Cell 12 assumed an active 10-foot waste column thickness HELP run, Cells 6, 6A, 7, 7A, 10, and 11 assumed an interim 50-foot waste column thickness HELP run, Cells 4A, 4B, and 5 assumed an interim 100-foot waste column thickness HELP run, and Cells 1-3, 8, and 9A assumed an interim 150-foot waste column thickness HELP run to determine the average and peak leachate generation rates.
2023	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O2	159.4	9,722,647	25,457,743	Cells 13, O1, and O2 assumed an active 10-foot waste column thickness HELP run, Cell 12 assumed an interim 50-foot waste column thickness HELP run, Cells 6, 6A, 7, 7A, 10, and 11 assumed an interim 100-foot waste column thickness HELP run, Cells 4A, 4B, and 5 assumed an interim 150-foot waste column thickness HELP run, and Cells 1-3, 8, and 9A assumed an interim 200-foot waste column thickness HELP run to determine the average and peak leachate generation rates.
2029	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O4	186.8	12,411,442	31,587,782	Cells O3 and O4 assumed an active 10-foot waste column thickness HELP run, Cells 13, O1, and O2 assumed an interim 50-foot waste column thickness HELP run, Cell 12 assumed an interim 100-foot waste column thickness HELP run, Cells 6, 6A, 7, 7A, 10, and 11, 4A, 4B, and 5 assumed an interim 200-foot waste column thickness HELP run, and Cells 1-3, 8, and 9A assumed the maximum interim (282-foot) waste column thickness HELP run to determine the average and peak leachate generation rates.
2034	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	23,655,618	50,392,970	Cell O5 and O6 assumed an active 10-foot waste column thickness HELP run, Cells 13, O1-O4 assumed an interim 100-foot waste column thickness HELP run, Cells 6, 6A, 7, 7A, 10-12 assumed an interim 200-foot waste column thickness HELP run, Cells 3, 4A, 4B, and 5 assumed the maximum interim (282-foot for Cells 3 and 4A and 298-foot for Cells 4B and 5) waste column thickness HELP run, and Cells 1-3, 8, and 9A assumed a closed case HELP run to determine the average and peak leachate generation rates.
2039	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	20,409,462	55,727,793	All cells assumed a closed case HELP run to determine the average and peak leachate generation rates.
2040-2049	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	12,439,387	17,466,179	All cells assumed a closed case HELP run to determine the average and peak leachate generation rates. The final moisture content values of the waste layers calculated in the HELP run for the year 2039 were input as the initial moisture content values in the HELP run for years 2040 to 2049.
2050-2059	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	11,022,172	15,779,394	All cells assumed a closed case HELP run to determine the average and peak leachate generation rates. The final moisture content values of the waste layers calculated in the HELP run for the years 2040 to 2049 were input as the initial moisture content values in the HELP run for years 2050 to 2059.
2060-2069	Cells 1 through 3, 4A, 4B, 5, 6, 6A, 7, 7A, 8, 9A, 10 through 13, and O1 through O6	209.1	9,925,756	13,556,130	All cells assumed a closed case HELP run to determine the average and peak leachate generation rates. The final moisture content values of the waste layers calculated in the HELP run for the year 2050 to 2059 were input as the initial moisture content values in the HELP run for years 2060 to 2069.

Table IIIC-E-4[1]
Summary of Leachate Generation Rates

Developed Subtitle D Area (Cells 1 & 2)				
	Average (cf/year/acre)	Average (gal/year/acre)	Peak (cf/day/acre)	Peak (gal/day/acre)
Interim (50 ft)	1,601.6	11,981.6	32.7	244.6
Interim (100 ft)	3,862.2	28,893.1	26.7	199.7
Interim (150 ft)	2,651.2	19,833.6	15.0	112.2
Interim (200 ft)	2,484.3	18,585.0	11.5	86.0
Interim (282 ft)	1,935.7	14,481.0	9.9	74.1
Closed (282 ft)	2,035.8	15,229.8	8.9	66.6
Post Closure (First 10 Years)	1,798.6	13,455	8.4	62.8
Post Closure (Second 10 Years)	1,695.3	12,683	7.8	58.4
Post Closure (Third 10 Years)	1,660.3	12,421	7.7	57.6

Developed Subtitle D Area (Cells 4B & 5)				
	Average (cf/year/acre)	Average (gal/year/acre)	Peak (cf/day/acre)	Peak (gal/day/acre)
Interim (50 ft)	1,579.2	11,814.0	25.8	193.0
Interim (100 ft)	3,852.1	28,817.6	21.2	158.6
Interim (150 ft)	2,638.1	19,735.6	8.6	64.3
Interim (200 ft)	2,470.6	18,482.6	6.1	45.6
Interim (298 ft)	1,661.7	12,431.2	6.4	47.9
Closed (298 ft)	1,743.3	13,041.6	6.3	47.1
Post Closure (First 10 Years)	1,504.3	11,254	5.8	43.4
Post Closure (Second 10 Years)	1,491.1	11,155	5.6	41.9
Post Closure (Third 10 Years)	1,460.1	10,923	5.7	42.6

Undeveloped Area (Cells 6, 6A, 7, 7A, & 10-13)				
	Average (cf/year/acre)	Average (gal/year/acre)	Peak (cf/day/acre)	Peak (gal/day/acre)
Active (10 ft)	2,873.2	21,494.4	36.9	276.0
Interim (50 ft)	5,066.3	37,901.0	73.8	552.1
Interim (100 ft)	26,380.9	197,355.5	164.3	1229.1
Interim (200 ft)	23,199.6	173,556.2	115.6	864.8
Interim (287 ft)	37,815.0	282,894.0	171.2	1280.7
Closed (287 ft)	21,609.7	161,662.2	170.5	1275.5
Post Closure (First 10 Years)	12,328.0	92,226	47.9	358.3
Post Closure (Second 10 Years)	10,894.9	81,505	43.5	325.4
Post Closure (Third 10 Years)	9,719.6	72,712	35.7	267.1

Overliner Area (Cells O1-O6)				
	Average (cf/year/acre)	Average (gal/year/acre)	Peak (cf/day/acre)	Peak (gal/day/acre)
Active (10 ft)	3,503.0	26,205.9	50.0	374.1
Interim (50 ft)	4,961.5	37,117.0	72.8	544.6
Interim (100 ft)	25,113.2	187,871.8	151.8	1135.6
Interim (150 ft)	19,406.4	145,179.3	89.9	672.5
Interim (188 ft)	23,103.6	172,838.0	104.2	779.5
Closed (188 ft)	14,207.5	106,286.3	102.4	766.1
Post Closure (First 10 Years)	9,140.6	68,381	33.7	252.1
Post Closure (Second 10 Years)	8,006.1	59,894	29.9	223.7
Post Closure (Third 10 Years)	7,189.1	53,782	26.7	199.7

[1] Refer to Appendix IIIC-A for detailed HELP analyses results for the Active through Closed cases. Refer to pages IIIC-E-10 through IIIC-E-13 for the HELP summary sheets for the Postclosure cases.

CAMELOT LANDFILL
1339-351-11-02
LEACHATE COLLECTION HEAD ON LINER

Required: Determine the leachate depth on the liner system using the actual leachate generated information provided on Sheet IIIC-E-5.

References:

1. Giroud, J.P. et al., *Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers*, Geosynthetics International, Vol 7, 2000.
2. Dana N.Humphrey, *Civil Engineering Application of Tire Shreds*, Presented at the Tire Industry Conference, Hilton Head, South Carolina, March 3, 1999.

Procedure:

1. Use the following equation to determine the head on the liner:

$$T_{\max} = \frac{\sqrt{(\tan^2\beta + \frac{4q_h}{k_1})} - \tan\beta}{2\cos\beta} * L \qquad \text{(Ref. 1)}$$

where,
T_{max}= maximum head on liner, ft
β= slope, deg
q_h= inflow rate, in/s
k_1= hydraulic conductivity of geocomposite, in/s
L= slope length, ft

Developed Subtitle D Area (Cells 1 & 2)

β= 0.63 °
$\tan\beta$= 0.011
$\tan^2\beta$= 0.0001
$\cos\beta$= 1.00
L= 220.00 ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_1 (in/s)	T_{max} (in)
Interim (50 ft waste)	9,991	1.17E-08	4.66	0.0006
Interim (100 ft waste)	9,991	1.17E-08	2.22	0.0013
Interim (150 ft waste)	9,991	1.17E-08	1.82	0.0015
Interim (200 ft waste)	9,991	1.17E-08	1.55	0.0018
Interim (282 ft waste)	9,991	1.17E-08	1.16	0.0024
Closed (282 ft waste)	9,038	1.06E-08	1.01	0.0025
Post Closure (0-10)	999	1.17E-09	1.01	0.0003
Post Closure (10-20)	200	2.33E-10	1.01	0.0001
Post Closure (20-30)	200	2.33E-10	1.01	0.0001

CAMELOT LANDFILL
1339-351-11-02
LEACHATE COLLECTION HEAD ON LINER

Developed Subtitle D Area (Cells 4B and 5)

β= 0.63 °
$\tan\beta$= 0.011
$\tan^2\beta$= 0.0001
$\cos\beta$= 1.00
L= 855.00 ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_l (in/s)	T_{max} (in)
Interim (50 ft waste)	9,991	1.17E-08	0.93	0.0117
Interim (100 ft waste)	9,991	1.17E-08	0.39	0.0279
Interim (150 ft waste)	9,991	1.17E-08	0.24	0.0460
Interim (200 ft waste)	9,991	1.17E-08	0.22	0.0502
Interim (298 ft waste)	9,991	1.17E-08	0.20	0.0553
Closed (298 ft waste)	9,038	1.06E-08	0.17	0.0568
Post Closure (0-10)	999	1.17E-09	0.16	0.0067
Post Closure (10-20)	200	2.33E-10	0.16	0.0013
Post Closure (20-30)	200	2.33E-10	0.16	0.0013

Undeveloped Area (Cells 6, 6A, 7, 7A, & 10-13)

β= 0.52 °
$\tan\beta$= 0.009
$\tan^2\beta$= 0.0001
$\cos\beta$= 1.00
L= 350.00 ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_l (in/s)	T_{max} (in)
Active (10 ft waste)	9,991	1.17E-08	12.35	0.0004
Interim (50 ft waste)	9,991	1.17E-08	7.73	0.0007
Interim (100 ft waste)	9,991	1.17E-08	5.18	0.0011
Interim (200 ft waste)	9,991	1.17E-08	3.14	0.0017
Interim (287 ft waste)	9,991	1.17E-08	2.11	0.0026
Closed (287 ft waste)	9,038	1.06E-08	1.81	0.0027
Post Closure (0-10)	999	1.17E-09	1.81	0.0003
Post Closure (10-20)	200	2.33E-10	1.81	0.0001
Post Closure (20-30)	200	2.33E-10	1.81	0.0001

Overliner Area (Cells O1-O6)

β= 0.57 °
$\tan\beta$= 0.010
$\tan^2\beta$= 0.0001
$\cos\beta$= 1.00
L= 700.00 ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_l (in/s)	T_{max} (in)
Active (10 ft waste)	9,991	1.17E-08	16.00	0.0006
Interim (50 ft waste)	9,991	1.17E-08	10.28	0.0010
Interim (100 ft waste)	9,991	1.17E-08	7.36	0.0013
Interim (150 ft waste)	9,991	1.17E-08	5.37	0.0018
Interim (188 ft waste)	9,991	1.17E-08	3.63	0.0027
Closed (188 ft waste)	9,038	1.06E-08	3.06	0.0029
Post Closure (0-10)	999	1.17E-09	3.06	0.0003
Post Closure (10-20)	200	2.33E-10	3.06	0.0001
Post Closure (20-30)	200	2.33E-10	3.06	0.0001

Prep By: JLG
Date: 3/20/2012

Chkd By: MDM
Date:3/20/2012

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY SHEET
DEVELOPED SUBTITLE D AREA (CELLS 1 AND 2)

		CLOSED (282 FT WASTE) 2040-2049	CLOSED (282 FT WASTE) 2050-2059	CLOSED (282 FT WASTE) 2060-2069
GENERAL	Case No.	1	2	3
INFORMATION	No. of Years	30	30	30
	Ground Cover	GOOD	GOOD	GOOD
	SCS Runoff Curve No.	82.4	82.4	82.4
	Model Area (acre)	1	1	1
	Runoff Area (%)	100	100	100
	Maximum Leaf Area Index	4.5	4.5	4.5
	Evaporative Zone Depth (inch)	18	18	18
TOPSOIL	Thickness (in)	12	12	12
LAYER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
EROSION	Thickness (in)	12	12	12
LAYER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
FLEXIBLE	Thickness (in)	0.04	0.04	0.04
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	4	4	4
	Placement Quality	GOOD	GOOD	GOOD
INFILTRATION	Thickness (in)	18	18	18
LAYER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 0)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-05	1.0E-05	1.0E-05
INTERMEDIATE	Thickness (in)	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6148	0.6148	0.6148
	Field Capacity (vol/vol)	0.5114	0.5114	0.5114
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3850	0.3880	0.3910
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)	1884	1884	1884
(Texture = 0)	Porosity (vol/vol)	0.5007	0.5007	0.5007
	Field Capacity (vol/vol)	0.4793	0.4793	0.4793
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3710	0.3680	0.3650
	Hyd. Conductivity (cm/s)	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	5.5E-06	5.5E-06	5.5E-06
LEACHATE	Thickness (in)	0.119	0.119	0.119
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	2.56	2.56	2.56
	Slope[1] (%)	1.1	1.1	1.1
	Slope Length (ft)	220	220	220
FLEXIBLE	Thickness (in)	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0
	Placement Quality	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	36.80	36.80	36.80
RUNOFF	Average Annual (in)	5.59	5.59	5.59
EVAPOTRANSPIRATION	Average Annual (in)	30.63	30.63	30.63
LATERAL	Average Annual (cf/year)	1,798.6	1,695.3	1,660.3
DRAINAGE COLLECTED	Peak Daily (cf/day)	8.4	7.8	7.7
HEAD ON LINER	Average Annual (in)	0.002	0.002	0.002
	Peak Daily (in)	0.006	0.005	0.006

[1] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the developed area presented in Appendix IIIJ-B.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

Prep By: JLG
Date: 3/20/2012

Chkd By: MDM
Date: 3/20/2012

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY SHEET
DEVELOPED SUBTITLE D AREA (CELLS 4B, 5)

		CLOSED (298 FT WASTE) 2040-2049	CLOSED (298 FT WASTE) 2050-2059	CLOSED (298 FT WASTE) 2060-2069
GENERAL	Case No.	1	2	3
INFORMATION	No. of Years	30	30	30
	Ground Cover	GOOD	GOOD	GOOD
	SCS Runoff Curve No.	80.1	80.1	80.1
	Model Area (acre)	1	1	1
	Runoff Area (%)	100	100	100
	Maximum Leaf Area Index	4.5	4.5	4.5
	Evaporative Zone Depth (inch)	18	18	18
TOPSOIL	Thickness (in)	12	12	12
LAYER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
EROSION	Thickness (in)	12	12	12
LAYER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
FLEXIBLE	Thickness (in)	0.04	0.04	0.04
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	4	4	4
	Placement Quality	GOOD	GOOD	GOOD
INFILTRATION	Thickness (in)	18	18	18
LAYER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 0)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-05	1.0E-05	1.0E-05
INTERMEDIATE	Thickness (in)	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6148	0.6148	0.6148
	Field Capacity (vol/vol)	0.5114	0.5114	0.5114
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3850	0.3880	0.3910
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)	2076	2076	2076
(Texture = 0)	Porosity (vol/vol)	0.4941	0.4941	0.4941
	Field Capacity (vol/vol)	0.4775	0.4775	0.4775
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3710	0.3690	0.3670
	Hyd. Conductivity (cm/s)	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	4.6E-06	4.6E-06	4.6E-06
LEACHATE	Thickness (in)	0.118	0.118	0.118
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	0.44	0.44	0.44
	Slope[1] (%)	1.1	1.1	1.1
	Slope Length (ft)	855	855	855
FLEXIBLE	Thickness (in)	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0
	Placement Quality	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	36.80	36.80	36.80
RUNOFF	Average Annual (in)	5.50	5.50	5.50
EVAPOTRANSPIRATION	Average Annual (in)	30.73	30.73	30.73
LATERAL	Average Annual (cf/year)	1,504.3	1,491.1	1,460.1
DRAINAGE COLLECTED	Peak Daily (cf/day)	5.8	5.6	5.7
HEAD ON LINER	Average Annual (in)	0.035	0.035	0.034
	Peak Daily (in)	0.099	0.097	0.097

[1] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the developed area presented in Appendix IIIJ-B.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY
UNDEVELOPED AREA

		CLOSED (287 FT WASTE) 2040-2049	CLOSED (287 FT WASTE) 2050-2059	CLOSED (287 FT WASTE) 2060-2069
GENERAL	Case No.	1	2	3
INFORMATION	No. of Years	30	30	30
	Ground Cover	GOOD	GOOD	GOOD
	SCS Runoff Curve No.	80.1	80.1	80.1
	Model Area (acre)	1	1	1
	Runoff Area (%)	100	100	100
	Maximum Leaf Area Index	4.5	4.5	4.5
	Evaporative Zone Depth (inch)	18	18	18
TOPSOIL	Thickness (in)	12	12	12
LAYER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
EROSION	Thickness (in)	12	12	12
LAYER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
FLEXIBLE	Thickness (in)	0.04	0.04	0.04
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	4	4	4
	Placement Quality	GOOD	GOOD	GOOD
INFILTRATION	Thickness (in)	18	18	18
LAYER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 0)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-05	1.0E-05	1.0E-05
INTERMEDIATE	Thickness (in)	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05
WASTE TOP^2	Thickness (in)	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6148	0.6148	0.6148
	Field Capacity (vol/vol)	0.5114	0.5114	0.5114
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3650	0.3550	0.3460
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM^2	Thickness (in)	1944	1944	1944
(Texture = 0)	Porosity (vol/vol)	0.4985	0.4985	0.4985
	Field Capacity (vol/vol)	0.4790	0.4790	0.4790
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3030	0.2950	0.2880
	Hyd. Conductivity (cm/s)	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.149	0.149	0.149
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	4.59	4.59	4.59
	Slope^1 (%)	0.9	0.9	0.9
	Slope Length (ft)	350	350	350
FLEXIBLE	Thickness (in)	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0
	Placement Quality	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	36.80	36.80	36.80
RUNOFF	Average Annual (in)	5.50	5.50	5.50
EVAPOTRANSPIRATION	Average Annual (in)	30.73	30.73	30.73
LATERAL	Average Annual (cf/year)	12,328.0	10,894.9	9,719.6
DRAINAGE COLLECTED	Peak Daily (cf/day)	47.9	43.5	35.7
HEAD ON LINER	Average Annual (in)	0.014	0.012	0.011
	Peak Daily (in)	0.039	0.036	0.029

[1] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the developed area presented in Appendix IIIJ-B.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594

Prep By: JLG
Date: 3/20/2012

Chkd By: MDM
Date: 3/20/2012

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY SHEET
OVERLINER DESIGN

		CLOSED (188 FT WASTE) 2040-2049	CLOSED (188 FT WASTE) 2050-2059	CLOSED (188 FT WASTE) 2060-2069
GENERAL	Case No.	1	2	3
INFORMATION	No. of Years	30	30	30
	Ground Cover	GOOD	GOOD	GOOD
	SCS Runoff Curve No.	80.1	80.1	80.1
	Model Area (acre)	1	1	1
	Runoff Area (%)	100	100	100
	Maximum Leaf Area Index	4.5	4.5	4.5
	Evaporative Zone Depth (inch)	18	18	18
TOPSOIL	Thickness (in)	12	12	12
LAYER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
EROSION	Thickness (in)	12	12	12
LAYER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
FLEXIBLE	Thickness (in)	0.04	0.04	0.04
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	4	4	4
	Placement Quality	GOOD	GOOD	GOOD
INFILTRATION	Thickness (in)	18	18	18
LAYER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 0)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-05	1.0E-05	1.0E-05
INTERMEDIATE	Thickness (in)	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6148	0.6148	0.6148
	Field Capacity (vol/vol)	0.5114	0.5114	0.5114
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3440	0.3340	0.3260
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)	756	756	756
(Texture = 0)	Porosity (vol/vol)	0.5387	0.5387	0.5387
	Field Capacity (vol/vol)	0.4900	0.4900	0.4900
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3060	0.2980	0.2910
	Hyd. Conductivity (cm/s)	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.246	0.246	0.246
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	7.77	7.77	7.77
	Slope[1] (%)	1	1	1
	Slope Length (ft)	700	700	700
FLEXIBLE	Thickness (in)	0.04	0.04	0.04
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0
(Texture = 36)	Install. Defects (holes/acre)	0	0	0
	Placement Quality	GOOD	GOOD	GOOD
GEOSYNTHETIC	Thickness (in)	0.25	0.25	0.25
CLAY LINER	Porosity (vol/vol)	0.7500	0.7500	0.7500
(Texture = 0)	Field Capacity (vol/vol)	0.7470	0.7470	0.7470
	Wilting Point (vol/vol)	0.4000	0.4000	0.4000
	Init. Moisture Content (vol/vol)	0.7500	0.7500	0.7500
	Hyd. Conductivity (cm/s)	5.0E-09	5.0E-09	5.0E-09
PRECIPITATION	Average Annual (in)	36.80	36.80	36.80
RUNOFF	Average Annual (in)	5.50	5.50	5.50
EVAPOTRANSPIRATION	Average Annual (in)	30.73	30.73	30.73
LATERAL	Average Annual (cf/year)	9,140.6	8,006.1	7,189.1
DRAINAGE COLLECTED	Peak Daily (cf/day)	33.7	29.9	26.7
HEAD ON LINER	Average Annual (in)	0.011	0.010	0.009
	Peak Daily (in)	0.031	0.025	0.023

[1] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the developed area presented in Appendix IIIJ-B.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594

CAMELOT LANDFILL
CITY OF LEWISVILLE, DENTON COUNTY
TCEQ PERMIT NO. MSW-1312B

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIID
LINER QUALITY CONTROL PLAN

Prepared for

City of Farmers Branch

March 2012

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED PROFESSIONAL ENGINEER

3-21-12

Prepared by

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WBC Project No. 1339-351-11-02-6B.4

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3-21-12

1 INTRODUCTION

1.1 Purpose

This appendix addresses §330.63(d)(4)(G), §330.337, §330.339, and §330.341.

This Liner Quality Control Plan (LQCP) has been prepared to provide the Operator, Design Engineer, Construction Quality Assurance Professional of Record, and the Contractor the means to govern the construction quality and to satisfy the environmental protection requirements under current Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Rules (MSWR). More specifically, the LQCP addresses the soil and geosynthetic components of the liner system. The provisions of this LQCP were developed based on the latest technical guidelines of the TCEQ, including quality control of construction, testing frequencies and procedures, and quality assurance of sampling and testing procedures.

This LQCP is divided into the following parts:

- Section 1 – Introduction
- Section 2 – Construction Quality Assurance for Earthwork and Drainage Aggregates
- Section 3 – Construction Quality Assurance for Geosynthetics
- Section 4 – Construction Quality Assurance for Geosynthetic Clay Liner
- Section 5 – Construction Quality Assurance for Piping
- Section 6 – Liners Constructed Below the Highest Groundwater Level
- Section 7 – Geotechnical Strength Testing Requirements
- Section 8 – Documentation

1.2 Definitions

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

ASTM

The American Society for Testing and Materials

Construction Quality Assurance (CQA)

A planned system of activities that provides the Operator and permitting agency assurance that the facility was constructed as specified in the design. Construction quality assurance includes observations and evaluations of materials, and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for a project.

Construction Quality Assurance Professional of Record (POR)

The POR is an authorized representative of the Operator and has overall responsibility for construction quality assurance that confirms that the facility was constructed in accordance with plans and specifications approved by the permitting agency. The POR must be registered as a Professional Engineer in Texas and experienced in geotechnical testing and its interpretations. Experience and education must include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance and quality control testing, and hydrogeology. The POR must show competency and experience in certifying like installations, and be approved by the permitting agency, and be presently employed by or practicing as a geotechnical engineer in a recognized geotechnical/environmental engineering organization. POR or his designated representative will be on-site during all liner system construction.

The POR may also be known in applicable regulations and guidelines as the CQA Engineer, Resident Project Representative, or the Geotechnical Professional (GP).

Construction Quality Assurance (CQA) Monitors

These are representatives of the POR who work under direct supervision of the POR. The CQA monitor is responsible for quality assurance monitoring and performing onsite tests and observations. The CQA monitor is on site full-time during construction and reports directly to the POR. The CQA monitor performing daily QA/QC observation and testing will be NICET-certified in geotechnical engineering technology at level II or higher for soils testing; a CQA monitor with a minimum of four years of directly related experience; a CQA monitor with a minimum of six months of directly related experience and has completed the Geosynthetic Institutes (GSI) Construction Quality Assurance Inspectors Certification Program (CQA-ICP); or a graduate engineer or geologist with one year of directly related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA monitor(s) on behalf of the POR.

Additional CQA monitors may be used if they work under the direction of a qualified CQA monitor who is onsite full-time.

Contract Documents

These are the official set of documents issued by the Operator. The documents include bidding requirements, contract forms, contract conditions, specifications, contract drawings, addenda, and contract modifications.

Contract Specifications

These are the qualitative requirements for products, materials, and workmanship upon which the contract is based.

Contractor

This is the person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered into a contract with the Operator, and who is referred to throughout the contract documents by singular number and masculine gender.

Design Engineer

These individuals or firms are responsible for the design and preparation of the project construction drawings and specifications. Also referred to as "designer" or "engineer."

Earthwork

This is a construction activity involving the use of soil materials as defined in the construction specifications and Section 2 of this plan.

Film Tear Bond (FTB)

A failure in the geomembrane sheet material on either side of the seam and not within the seam itself.

Geomembrane Liner (GM)

This is a synthetic lining material, also referred to as geomembrane, membrane liner, or sheet. The term Flexible Membrane Liner (FML) is also used for GM. A 60-mil-thick high density polyethylene (HDPE) geomembrane is used for the bottom liner and a 40-mil-thick linear low density polyethylene (LLDPE) geomembrane is used for the overliner. Textured and smooth geomembrane used for the bottom liner and overliner are described in Sections 3.3 and 3.4, respectively.

Geomembrane Liner Evaluation Report (GLER)

Certification report for the geomembrane liner, prepared and sealed by the POR that is submitted to the TCEQ for approval. Also referred to as flexible membrane liner evaluation report (FMLER).

Geosynthetic Clay Liner (GCL)

This is a synthetic lining material, which in the most basic form consists of bentonite sandwiched between two geotextiles. Also referred as prefabricated bentonite blankets, mats or panels, or clay blankets, mats or panels.

Geosynthetic Clay Liner Evaluation Report (GCLER)

Certification report for the geosynthetic clay liner, prepared and sealed by POR, which is submitted to TCEQ for approval.

Geosynthetics Contractor

This individual is also referred to as the "contractor" or "installer," and is the person or firm responsible for geosynthetic construction. This definition applies to any person installing FML or geotextile, even if not his primary function.

Independent Testing Laboratory

A laboratory that is independent of ownership or control by the permittee or any party to the construction of the liner system or the manufacturer of the liner system products used.

Manufacturing Quality Assurance (MQA)

A planned system of activities that provides assurance that the raw materials were constructed (manufactured) as specified.

Manufacturing Quality Control (MQC)

A planned system of inspection that is used to directly monitor and control the manufacture of a material.

Nonconformance

This is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

Operator

The organization that will operate the disposal unit.

Organics

Organic matter is material that may be capable of decay (e.g., plant material), the product of decay, or both.

Permittee's Representative

This is the person that is an official representative of the permittee responsible for planning, organizing, and controlling the design and construction activities.

Panel

This is a unit area of the FML, which will be seamed in the field.

Quality Assurance

This is a planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents. Quality assurance includes quality control. Quality assurance will be performed by the POR and CQA monitor.

Quality Control

These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. Quality control will be performed by the contractor.

Soil Liner Evaluation Report (SLER)

Construction report for the soil liner prepared and sealed by the POR and submitted to the TCEQ.

2 CONSTRUCTION QUALITY ASSURANCE FOR EARTHWORK AND DRAINAGE AGGREGATES

2.1 Introduction

This section of the LQCP addresses the construction of the soil and drainage components of the liner system and the overliner system and outlines the LQCP program to be implemented with regard to materials selection and evaluation, laboratory test requirements, field test requirements, and treatment of problems.

The scope of earthwork and related construction quality assurance includes the following elements:

- Subgrade preparation
- Soil liner stockpile
- Soil liner placement
- General fill
- Drainage aggregates
- Anchor trench backfill
- Excavation dewatering

2.2 Composite Liner

The landfill is designed to include a Subtitle D composite liner for the undeveloped liner area. The liner system for the undeveloped area will consist of a 2-foot-thick compacted clay liner and a 60-mil-thick high density polyethylene (HDPE) Flexible Membrane Liner (FML). In addition, the landfill design also includes an overliner system for the pre-Subtitle D area. The overliner will be placed on a 12-inch soil subgrade and will consist of a GCL overlain by a 40-mil linear low-density polyethylene (LLDPE) FML that is textured on both sides.

The liner systems are detailed in Appendix IIIA – Landfill Unit Design Information. A structural stability analysis for the liner and overliner systems, including calculations for anchor trench runout lengths, stress on the liner components, and an interface slope stability analysis, is included in Appendix IIIJ – Geotechnical Report.

2.3 Earthwork Construction

The following paragraphs describe general construction procedures to be used for various earthwork components within the landfill. The earthwork construction specifications will be developed based on the material and construction procedures outlined in this section of the LQCP for each specific liner construction. The earthwork construction specifications will include details for compaction of soils, cross sections showing typical slopes, widths, and thicknesses for compacted lifts.

2.3.1 Subgrade

Subgrade refers to a surface which is exposed after stripping topsoil or excavating to establish the grade directly beneath the composite liner. The prepared subgrade must conform to the Excavation Plan included in Appendix IIIA – Landfill Unit Design Information.

Prior to beginning liner construction, the subgrade area will be stripped to a depth sufficient to remove all loose surface soils or soft zones within the exposed excavation. The liner subgrade area will be proof rolled with heavy, rubber tired construction equipment to detect unstable areas. Unstable areas will be undercut to firm material and refilled with suitable compacted general fill. Soil used for backfill will meet the same material requirements as the soil liner and will be installed in accordance with the soil liner installation procedures. The fill will be free of organics, foreign objects, and other deleterious matter, and compacted sufficiently to provide a firm base for composite liner placement. The subgrade will also be scarified prior to placement of the first lift of clay liner. The subgrade preparation specifications for each liner construction event will be developed in accordance with this section. Construction project specifications and construction plans will be developed for each cell construction event in accordance with this LQCP consistent with the Excavation Plan and the sector design as contained in the approved Site Development Plan.

Subgrade voids and cracks are expected to be minor. However, the subgrade will be re-worked as necessary to provide a foundation suitable for soil liner placement. Visual examination of the subgrade preparation by the CQA monitor will generally be sufficient to evaluate its suitability as a foundation for the subgrade. The CQA monitor may find that physical testing is necessary to evaluate the prepared subgrade or fill placed in large voids.

The POR will approve the prepared subgrade prior to the placement of soil liner or structural fill. Approval will be based on a review of test information, if applicable, and CQA monitoring of the subgrade preparation. Additionally, during the subgrade acceptance, the POR will verify that the underlying material is consistent with the geotechnical design assumptions included in Appendix IIIJ.

Surveying will be performed to verify that the finished subgrade is to the lines and grades specified in design with a vertical tolerance of -0.2 feet to +0.0 feet to ensure that the clay liner will achieve a 2-foot minimum thickness. The surface slope of the top layer of clay liner will conform to the slope requirements of the leachate collection layer.

2.3.2 Soil Liner

The soil liner will consist of a minimum 2-foot-thick compacted clay liner (measured perpendicular to the subgrade surface) that will extend along the floor and side slopes of the landfill. The soil liner will be constructed in continuous, single, compacted lifts (6 inches thick) parallel to the floor and sideslope subgrades. Details depicting the liner system are included in Appendix IIIA – Landfill Unit Design Information.

2.3.2.1 Soil Borrow Material

Adequate clayey soil liner material will be available from proposed landfill excavations and/or onsite borrow sources. The liner soil will be free of debris, rock greater than 1 inch in diameter, vegetative matter, frozen materials, foreign objects, and organics. Laboratory tests will verify that materials are adequate to meet the compacted clay liner requirements listed in §330.339(c)(5) prior to liner construction. As necessary, an off-site borrow source can be used for soil liner and protective cover construction.

Soils used in soil liners will have the following minimum values verified by testing in a soil laboratory prior to liner construction.

Table 2-1
Required Borrow Soil Properties

Test[1]	Specification
Coefficient of Permeability (Remolded Sample)[2]	1.0×10^{-7} cm/s or less
Plasticity Index	15 minimum
Liquid Limit, percent	30 minimum
Percent Passing No. 200 Mesh Sieve	30 minimum
Percent Passing 1-inch Sieve	100

[1] Testing will be performed in accordance with the test methods included in Section 2.4.
[2] The coefficient of permeability for remolded sample is run at a minimum of 95% of the maximum dry density at or above the optimum moisture content.

Representative preliminary sampling and testing will be performed on stockpiled soils to be used as liner material or on off-site borrow source material. Prior to construction of each new cell, conformance tests that include liquid limit, plastic limit, percent passing the No. 200 sieve, Standard Proctor (ASTM D 698) compaction test, and coefficient of permeability test will be performed for each material proposed for each individual liner construction. The coefficient of permeability test specimens will be prepared by laboratory compaction to a dry density of approximately 95 percent of the Standard Proctor maximum dry density at or above the optimum moisture content. One Proctor moisture-density relationship and remolded coefficient of permeability test will be required for each different material. The soil is considered as a separate soil borrow source if the liquid limit or plasticity index is determined to vary by more than 10 points. Additional conformance tests will be conducted if there are visual changes (color, texture, etc.) in borrow material or as determined necessary by the POR. The liquid limit and plastic limit testing will be performed on the separate borrow source as an initial determination. If the liquid limit or plasticity index varies by more than 10 points then all other testing listed in Table 2-1 will be performed on the separate borrow source.

The CQA monitor, Earthwork Contractor, and/or Operator will identify the clay material during excavation, and the clay material will be stockpiled separately, if stockpiling is required. The liquid limit and plastic limit testing will be performed on the separate borrow source as an initial determination. If the liquid limit or plasticity index varies by more than 10 points then all other testing listed in Table 2-1 will be performed on the separate borrow source.

The physical characteristics of the liner materials will be evaluated through visual observation before and during construction. To adjust moisture of the material properly, any clod sizes will first be crushed into manageable sizes of 4 inches in diameter or less. Rocks and clods within the compacted liner must be less than 1 inch in diameter. Soil clod size will be reduced to the smallest size necessary to achieve the coefficient of permeability reported by the testing laboratory. Additionally, the rock content of the soil liner will not be more than 10 percent by weight. Water used for the soil liner moisture adjustment must be clean and not contaminated by waste or any objectionable material. Stormwater collected onsite may be used if it has not come into contact with solid waste.

2.3.2.2 Liner Construction

The soil liner material will be placed in maximum 8-inch-thick loose lifts to produce compacted lift thickness of approximately 6 inches. The soil liner will have elevations, slopes, thickness, and widths as depicted on Drawing A.1 – Excavation Plan, and Drawings A.4 and A.5 – Liner System Details in Appendix IIIA – Landfill Unit Design Information. A temporary hydrostatic pressure relief system will be installed as discussed in Appendix IIID-C.

The liner material will be compacted to a minimum of 95 percent of the maximum dry density at or above the optimum moisture content as determined by Standard Proctor (ASTM D 698). The compaction of the clay liner will be verified by a third party independent laboratory to result in a coefficient of permeability of $1x10^{-7}$ cm/s or less. The POR will perform strength testing for clay (internal/interface) at the highest established moisture content and reduce the allowable highest moisture content if necessary.

The soil liner must be compacted with a pad/tamping-foot (preferable) or prong-foot (sheepsfoot) roller. The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of the previously compacted lift; therefore, the lift thickness must not be greater than the pad or prong length. Use of pad/tamping-foot or prong-foot rollers will provide sufficient roughening of liner lifts surface for bonding between lifts. These procedures are necessary to achieve adequate bonding between lifts and reduce seepage pathways. Adequate cleaning devices must be in place and maintained on the compaction roller so that the prongs or pad feet do not become clogged with clay soils to the point that they cannot achieve full penetration during initial compaction. The footed roller is necessary to achieve this bonding and to reduce the individual clods and achieve a blending of the soil matrix through its kneading action. In addition to the kneading action, weight of the compaction equipment is important. The minimum weight of the compactor should be 40,000 pounds (in no case ground pressure should be less than 1,500 lbs per linear foot for each drum or wheel length), and a minimum of four passes are recommended for the compaction process. A pass is defined as one pass (1 direction) of the compactor, not just an axle, over a given area. The recommended minimum of four passes is for a vehicle with front and rear drums. The Caterpillar 815B and 825C are examples of equipment typically used to achieve satisfactory results.

The soil liner will not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed drum which is at a minimum 1,500 lbs per linear foot of drum length.

During the construction of continuous liners, the new liner segment will not be constructed by "butting" the entire thickness of the new liner directly against the edge of the old liner. The tie-in will be constructed by a sloped transition (typical 5 horizontal to 1 vertical) as shown in Appendix IIIA – Landfill Unit Design Information. The length of the tie-in must be at least 5 feet per foot of liner thickness. The tie-in will be scarified prior to placement of the next lift.

CQA testing of the soil liner will be performed as the liner is being constructed. Testing of the soil liner is addressed in Section 2.4. Sections of compacted soil liner which do not pass both the density and moisture requirements will be reworked with additional passes of the compactor until the section in question passes. All field density and moisture test results will be incorporated into the SLER.

Hydraulic conductivity samples will be obtained by pushing a sampler through the constructed clay liner. The sample from each test location will be sealed and transported to the laboratory. Two samples may be collected at each sample location and labeled the "A" and "B" sample. The sampling holes (e.g., samples for hydraulic conductivity) will be backfilled with bentonite or a bentonite/clay liner soil material mixture consisting of at least 20 percent bentonite.

If the integrity of the "A" sample appears to have been compromised during the transportation of the sample prior to testing, the "B" sample may be tested. In addition, if an "A" sample hydraulic conductivity test does not comply with the minimum allowable value, the "B" sample collected at the same location may be tested to determine compliance with the hydraulic conductivity requirements if during testing of the "A" sample the ASTM D 5084 or EM 1110-2-1906 procedure was not followed or the permeameter malfunctioned.

The POR will provide a detailed justification of the use of the "B" sample, if applicable, in the SLER.

If the "B" sample passes, the area will be considered in compliance. If the "B" sample fails (or Sample "A" fails in such a way that there is not an option to use the "B" sample), the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location). Additional tests may be taken to further define the unsatisfactory area. The area defined unsatisfactory will be reworked and retested in accordance with this section.

Furthermore, if it is determined that the "B" sample may not be used to replace the "A" sample result, then the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location).

Once the exact area is determined, the constructed liner lifts will be removed to the bottom of the lift that did not pass the hydraulic conductivity test, and reconstructed until all the samples obtained from the failed area meet the hydraulic conductivity requirements. At a minimum, one hydraulic conductivity test will be performed for each lift, given that the reconstructed liner area is not larger than 100,000 square feet (i.e., 4 hydraulic conductivity tests per 100,000 square feet of reconstructed liner area). The reconstructed liner area will be tied into the currently constructed liner with a 5H:1V transition slope according to the tie-in detail included in Appendix IIIA – Landfill Unit Design Information. Reconstructed liner area is also subject to field density and moisture content testing per Table 2-2 (at least one field density and one moisture content test is required for each lift regardless of the size of the area that is reconstructed).

Each lift of the reconstructed liner area will be tested for hydraulic conductivity. Reconstruction activities, including additional testing and surveying, will be incorporated into the SLER.

Soil liner construction and testing will be conducted in a systematic and timely fashion on each lift. Delays will be avoided in liner construction. Construction and testing of the soil liner will generally not exceed 60 working days from beginning of liner installation to completion. The TCEQ will be notified during construction if delays in excess of 60 days are anticipated. Reasons for liner construction taking more than 60 days to complete will be fully explained in the SLER submittal.

The finished surface of the final lift of soil liner must be rolled with a smooth, steel-wheeled roller to obtain a hard, uniform, and smooth surface. The surface of the final lift of soil liner will then be inspected by the CQA monitor. All undesired materials will be removed from the liner surface, and any voids created by removing undesired materials will be backfilled with liner material to the density specifications outlined for liner construction and tested at the discretion of the CQA monitor.

Surveying will be performed to verify that the finished top of liner grade is to the lines and grades specified in construction plans for a particular cell. Top of soil liner surveying will be performed within a tolerance of 0.0 feet to +0.2 feet. The surface slope of the top layer will conform to the slope requirements of the leachate collection layer. Survey frequency is included in Table 2-2.

The POR will submit to the TCEQ a SLER for approval of each soil liner area.

This LQCP has been developed in accordance with the TCEQ MSWR. The requirements for testing and evaluation of the soil liner during construction are included in this LQCP. The construction methods and test procedures documented in the SLER will be consistent with this LQCP and TCEQ regulations.

The soil liner will be prevented from losing moisture during the SLER approval process. Preserving the moisture content of the installed soil liner will be dependent on the earthwork contractors means and methods, and is subject to POR approval.

Upon completion of liner construction SLER markers will be installed to clearly indicate the limits of constructed and approved liner areas in accordance with Section 4.7 – Landfill Markers and Benchmark of the approved Site Operating Plan. SLER markers will be located so that they are not destroyed during operations. The POR will document in the GLER that SLER markers are installed prior to approval of GLER. Any damaged SLER marker will be replaced and/or re-installed immediately.

2.3.3 Overliner Construction

The GCL subgrade prepared using the existing cover soil will have to be verified to have a minimum of 12 inches finished thickness. The existing soil final cover, where it exists, will be stripped to leave at least 12 inches of soil for GCL subgrade. As an alternative to verifying the thickness of existing cover soils, a 12-inch-thick soil may be placed as a single layer to establish GCL subgrade. The GCL subgrade will have elevations, slopes, thickness, and widths as depicted on Drawing A.1 – Excavation Plan and Drawing A.9 – Overliner System Details in Appendix IIIA – Landfill Unit Design Information. Refer to Section 4.3.1 for GCL subgrade preparation.

The GCL subgrade construction and testing will be conducted in a systematic and timely fashion. Delays will be avoided in overliner construction. Construction and testing of the overliner will generally not exceed 60 working days from beginning of GCL installation to completion of placement of protective cover. The TCEQ will be notified during construction if delays in excess of 60 days are anticipated. Reasons for overliner construction taking more than 60 days to complete will be fully explained in the GCLER submittal.

The GCL subgrade surface must be rolled with a smooth, steel-wheeled roller to obtain a firm, uniform, and smooth surface (refer to Section 4.3.1 for additional requirements for GCL subgrade). The surface of the GCL subgrade will then be inspected by the CQA monitor. All materials determined to be GCL will be removed from the subgrade surface, and any voids created by removing undesired materials will be backfilled with subgrade material and compacted to establish a firm, uniform, and smooth surface. If the existing cover soil layer is used as subgrade, then a Texas Registered Surveyor will measure the minimum thickness of 12 inches on a 100-foot grid. Soil coring or test pits can be used to verify the thickness of the in-place soils. Once the survey is complete, any disturbed areas for surveying will be backfilled with subgrade material and compacted to establish a firm, uniform, and smooth surface. The POR will observe that the finished subgrade is uniform between thickness verification locations.

Surveying will be performed to verify that the finished GCL subgrade layer has been constructed to a minimum thickness of 12 inches if 12-inch-thick subgrade soil is placed over one existing surface. The thickness verification locations will be established by a Texas registered surveyor on a 100-foot grid. The POR and CQA monitor will verify that the GCL subgrade is placed uniformly between each settlement plate.

A GCL subgrade thickness drawing at each of the survey measurement grid points will be provided. Coordinates defining the perimeter of the overliner geomembrane subgrade will be called out on one of the final drawings. The GCL subgrade thickness drawing will be sealed by a Texas registered surveyor. After the construction of the GCL subgrade is complete, the Texas registered surveyor will survey the final elevation of the subgrade. The certification drawings will be included in the GCLER. The surveying will verify that the GCL subgrade slopes are consistent with the approved top of overliner plan (Drawing IIIA.1 in Appendix IIIA). A statement that confirms that the as-built slopes are consistent with the approved top of overliner plan will be included in the GCLER.

The POR will incorporate the subgrade-related information into the GCLER.

2.3.4 General Fill/Structural Fill

General fill material placed below the composite bottom liner (e.g., over-excavated areas within the liner construction area) will be placed in uniform lifts which do not exceed 8 inches in loose thickness similar to compacted clay liners that will be placed over the back-filled area. General structural fill (e.g., perimeter berm construction) will be placed in uniform lifts which do not exceed 12 inches in loose thickness. The fill placed below the liner will be compacted to at least 95 percent of Standard Proctor maximum dry density (ASTM D 698).

2.3.5 Drainage Aggregate Around Pipes

The coarse aggregate selected for placement around the leachate collection pipes used in the leachate collection system (LCS) for the composite liner and overliner and for the temporary hydrostatic pressure relief system discussed in Section 6 will consist of normal (e.g., unit weight of 90 to 110 pcf) or lightweight (e.g., unit weight less than 70 pcf) materials that comply with the following criteria. The LCS aggregate will have a calcium carbonate content less than 15 percent. Either the J&L Testing method or the

ASTM D 3042 method, modified to use a solution of hydrochloric acid having a pH of 5, can be used to determine calcium carbonate content. The drainage aggregate will meet the following gradation for ASTM D 448, size number 467.

Sieve Size Square Opening	Percent Passing
2 inches	100
1½ inches	95 - 100
¾ inch	35 - 70
3/8 inch	10 - 30
No. 4 (3/16 inch)	0 - 5

However, if approved by the POR, coarse aggregates not complying with the size number 467 gradation may also be used if demonstrated to have a hydraulic conductivity of at least 1.0 cm/s and meet the filter gradation requirements given below (in no case will the maximum rock size be more than 2 inches) for the specific leachate collection pipe perforation design:

For circular holes in the leachate collection pipe:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Hole Diameter}} > 1.7$$

For slots in the leachate collection pipe:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Slot Width}} > 2.0$$

The coarse aggregate will be tested for gradation (ASTM D 448) at the supply source or from the on-site stockpile prior to acceptance. Gradation testing will be conducted at a minimum frequency of 1 test per 3,000 cubic yards of coarse aggregate or per liner construction event if less than 3,000 cubic yards of coarse aggregate is required for the specific construction. The aggregate will be free of organics, angular rocks, foreign objects, or other deleterious materials. The physical characteristics of the aggregate will be evaluated through visual observation and laboratory classification testing before construction and visual observation during construction. The coarse aggregate may be tested during construction at the discretion of the CQA monitor. The test results for the coarse aggregate will be included in the GLER.

2.3.6 Protective Cover

Protective cover will be placed over the drainage layer in accordance with this section and approved Excavation Plan (Appendix IIIA, Appendix IIIA-A, Drawing IIIA.1). The geosynthetics of the composite liner system will be covered with a minimum of 2 feet of protective cover for the Subtitle D composite liner. The protective cover will consist of soil materials that have not previously come in contact with solid waste or other deleterious materials, and do not contain materials detrimental to the underlying geosynthetics. The protective cover will be free of organics, foreign objects, or other deleterious materials. The physical characteristics of the protective cover will be evaluated through visual observation (and laboratory testing if the POR deems it necessary) before construction and visual observation during construction. Additional testing during construction will be at the discretion of the CQA monitor. The protective cover will have passageways (i.e., chimney drains) to allow moisture to drain to the leachate collection system.

The protective cover layer will be placed using any low ground pressure equipment as outlined in Section 3.7. The protective cover will be placed by spreading in front of the spreading equipment with a minimum of 12 inches of soil between the spreading equipment and the installed geosynthetics. Under no circumstances will the construction equipment come in direct contact with the installed geosynthetics.

The thickness of the protective cover layer placed over the composite liner and overliner will be verified with surveying procedures at a minimum of 1 survey point per 5,000 square feet of constructed area by a licensed Texas land surveyor with a minimum 2 reference points. The survey results and method of surveying for the protective cover will be included in the GLER.

During construction the CQA monitor will:

- Verify that grade control is performed prior to work.
- Verify that underlying geosynthetic installations are not damaged during placement operations or by survey grade controls. Mark damaged geosynthetics and verify that damage is repaired.
- Verify that the cover soil for sideslopes is pushed from the toe up the slope.
- Monitor haul road thickness over geosynthetic installations and verify that equipment hauling and materials placement meet equipment specifications. (See Section 3.7)
- The POR will coordinate with the project surveyor to perform a thickness verification survey of the protective cover materials upon completion of placement operations. Verify corrective action measures as determined by the verification survey.

2.3.7 Anchor Trench Backfill

The anchor trench backfill material for geosynthetic anchoring will be placed in uniform lifts which do not exceed 12 inches in loose thickness and will be compacted. In-place moisture/density tests may be performed at the discretion of the CQA monitor to evaluate the quality of the backfill. If testing is performed, the compaction will be at least 90 percent of standard Proctor maximum dry density (ASTM D698). The test results will not be required as part of the GLER or GCLER.

2.3.8 Surface Water Removal

The excavation may encounter water from storm events. Soil liner will not be placed in standing water. The excavation area will therefore have a temporary sump area to collect water entering the excavation and be graded to allow drainage at planned areas. Portable pumps will be on site to dewater the sumps. Temporary earthen berms will be constructed to divert surface flow away from the excavation. Surface water that accumulates on the constructed liner or geosynthetics surface will be removed promptly after the end of a rainfall event. POR will inspect and approve the constructed area that received rainfall prior to placement of overlying liner system component. The criteria for approval of the finished surface of the soil liner for geomembrane placement will follow the requirements of Section 3.3.3 and 3.4.5 and for geocomposite placement on top of geomembrane will follow the requirements of Section 3.6.3. Surface water from the site will be discharged per the site's TPDES permit requirement.

2.3.9 Excavations Below Groundwater

Construction of liners below groundwater is discussed in Section 6 of this document.

2.3.10 Liner Tie-In Construction

Newly constructed liners will be tied-in with any adjoining existing liners. Additionally, terminations will be constructed for future tie-ins along edges where the liner will be extended in the future. The tie-ins with existing clay liners will be constructed utilizing a sloped transition a minimum of 10 feet wide for the 2-foot-thick clay liner. Terminations for future tie-ins will be constructed by extending the clay liner approximately 10 feet past the limits for the cell under construction. The liner tie-in details are shown in Appendix IIIA – Landfill Unit Design Information. Waste and intermediate cover will not be deposited closer than 10 feet to the edge of any cell or 20 feet from the leading edge of a constructed clay liner (whichever is greater) where a future tie-in will be constructed. Red-colored markers (i.e., SLER markers) will be placed along the limits of the cells with constructed clay liners and tied to the site grid system in accordance with Title 30 TAC §330.143(b)(1).

2.4 Construction Testing

2.4.1 Standard Operating Procedures

CQA monitors with qualified professional experience in geotechnical engineering and/or engineering geology will perform field and laboratory tests in accordance with applicable standards specified in this LQCP. All quality control testing and evaluation of soil liners will be performed during construction of the liner and must be complete before placement of the leachate collection system, except for the testing required for the final constructed lift, verification of liner thickness, or cover material thickness. Standard operating and test procedures will be utilized per the POR's direction. Sampling from the constructed soil liner lifts will be performed in accordance with ASTM D 1587. The sampling holes (e.g., samples for coefficient of permeability test) will be backfilled with bentonite or bentonite/liner soil material mixture. Prior written approval from the TCEQ via a permit modification will be obtained if any changes will be made to material requirements or procedures set forth on this LQCP.

The following test standards apply as called out in this LQCP and in the technical specifications provided in this LQCP.

Standard Test Method	Test Description
ASTM D 698	Moisture-density relations of soils and soil-aggregate mixtures, using 5½-lb hammer and 12-inch drop
ASTM D 422	Particle size analysis of soils
ASTM D 6938	Standard test method for in-place density and water content of soil and soil aggregate by nuclear methods (shallow depth)
ASTM D 1587	Thin-walled tube sampling of soils for geotechnical purposes
ASTM D 2167	Density and unit weight of a soil in place by the rubber balloon method
ASTM D 2216	Laboratory determination of water (moisture) content of soil, rock, and soil-aggregate mixtures
ASTM D 2434	Method of test for permeability of porous granular material
ASTM D 5084	Method of test for permeability of fine-grained soils
ASTM D 4318	Atterberg limits
ASTM D 1140	Amount of material in soils finer than the No. 200 sieve
ASTM D 2487	Classification of soils for engineering purposes
ASTM D 2488	Description and identification of soils (visual-manual procedure)
EM 1110-2-1906, Appendix VII	U.S. Army Corps of Engineers permeability test
ASTM D 448	Standard classification for sizes of aggregate for road and bridge construction
ASTM D 3042	Test method for insoluble residue in carbonate aggregates

2.4.2 Test Frequencies

This LQCP establishes the minimum test frequencies for the soil liner construction quality assurance. The test frequencies for soil liner are listed in Table 2-2. Additional testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Additional testing may also be performed to provide additional data for engineering evaluation. The minimum number of tests is interpreted to mean minimum number of passing tests, and any tests that do not meet the requirements will not contribute to the total number of tests performed to satisfy the minimum test frequency.

Table 2-2
Required Tests and Observations on Compacted Clay Liner

Parameter	Frequency	Test Method	Passing Criteria
Field Density and Moisture	1 each 8,000 SF per 6-inch parallel lift	ASTM D 6938 and ASTM D 2216[1]	95% Maximum Standard Proctor Dry Density. Standard Proctor optimum moisture content or greater determined during preconstruction testing
Sieve Analysis (passing no. 200)	1 test per 100,000 square feet per 6-inch parallel lift, with a minimum of 1 test per 6-inch lift	ASTM D 1140	30 percent minimum
Atterberg Limits (liquid and plastic limit)	1 test per 100,000 square feet per 6-inch parallel lift, with a minimum of 1 test per 6-inch lift	ASTM D 4318	PI = 15 percent minimum LL = 30 percent minimum
Coefficient Permeability (Hydraulic Conductivity)[2]	1 test per 100,000 square feet per 6-inch parallel lift, with a minimum of 1 test per 6-inch lift	ASTM D 5084 (Falling head, flex wall) Corps of Engineers EM 1110-2-1906, Appendix VII (Falling head permeameter)	1.0x10^{-7} cm/s or less
Thickness Verification[3]	1 each 5,000 square feet with a minimum of 2 reference points by a licensed Texas land surveyor	Survey subgrade and top of clay liner and protective cover layer	2 feet minimum compacted clay liner thickness and 2 feet minimum protective cover thickness

[1] This method is not applicable if the field nuclear gauge reads both density and moisture.

[2] Field permeability testing performed in accordance with Title 30 TAC §330.339(c)(7), may be performed to augment this testing program if a permit modification is submitted and approved by the TCEQ.

[3] Thickness verification for the overliner will be 2 feet minimum protective cover thickness and 1 foot subgrade thickness.

Geomembrane composite liner system may require general fill (e.g., establish excavation grades by means of backfilling as necessary as discussed in Section 2.3.1 – Subgrade) and structural fill (e.g., berms around the excavation perimeter). Testing will be limited to one moisture density relationship (ASTM D 698) per borrow source (as defined in Section 2.3.2.1) per project.

2.5 Reporting

The POR will submit to the TCEQ a SLER for approval of each Subtitle D soil liner area. Section 8 describes the documentation requirements.

3 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

3.1 Introduction

Section 3 describes CQA procedures for the installation of geosynthetic components, except GCL for which procedures are provided in Section 4.

The scope of geosynthetic related construction quality assurance includes the following elements:

- Bottom Liner Geomembrane
  - 60-mil HDPE – smooth on slopes less than 7H:1V and textured on both sides for slopes greater than or equal to 7H:1V
- Overliner Geomembrane
  - 40-mil LLDPE – textured on both sides regardless of slope
- Geotextile
- Drainage Layer
  - Single-sided drainage geocomposite (on bottom liner floor grades)
  - Double-sided drainage geocomposite (bottom liner side slopes and overliner slopes)

The overall goal of the geosynthetics quality assurance program is to assure that proper construction techniques and procedures are used, the geosynthetic contractor implements his quality control plan in accordance with this LQCP, and that the project is built in accordance with the project construction drawings and technical specifications that will be developed in accordance with this LQCP for each liner construction. The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are avoided and/or corrected before construction is complete. A GLER, prepared after project completion, will document that the constructed facility meets design intent and specifications outlined in this LQCP.

3.2 Geosynthetics Quality Assurance

3.2.1 General

The composite liner system provides the primary means for preventing leachate infiltration into groundwater. A geomembrane is a component of both the bottom liner and the overliner. Proper geomembrane installation is a crucial work element, which greatly affects the performance of the liner systems. Construction quality control for the geomembrane installation will be performed by the geomembrane installation contractor. Construction quality assurance for the geomembrane installation will be performed by the POR to assure the geomembrane is constructed as specified in the design. Construction must be conducted in accordance with the procedures outlined in this LQCP. To monitor compliance, a quality assurance program will include the following:

- A review of the manufacturer's quality control testing
- Material conformance testing by an independent third party laboratory
- Field and construction testing
- Construction monitoring

The manufacturer's quality control testing will include resin and geomembrane testing. The required tests for material properties are included in Section 3.3 (bottom liner) and 3.4 (overliner).

Conformance testing refers to material testing performed by an independent third party laboratory that takes place prior to material installation. Field and construction testing includes testing that occurs during geosynthetics installation.

Quality assurance testing will be conducted in accordance with this LQCP. Field testing will be observed by the CQA monitor. Documentation must meet the requirements of this LQCP.

3.3 Bottom Liner Geomembrane

The bottom liner geomembrane will consist of a 60-mil HDPE geomembrane. The geomembrane will be smooth on both sides on slopes less than 7H:1V and textured on both sides on slopes greater than or equal to 7H:1V. Required manufacturer's quality control tests for the bottom liner geomembrane are included in Table 3-1 and required material properties for the bottom liner geomembrane are included in Table 3-2. Interface strength parameters for the composite liner that includes HDPE geomembrane are presented in Section 7. During each construction event, the strength parameters used in the geotechnical analysis will be tested for as part of the pre-construction testing program. The POR will update the geotechnical analysis as part of the SLER for each construction event if the strength values do not meet the minimum required values listed in Appendix

IIIJ. The updated geotechnical analysis will meet the minimum factor of safety requirements set forth in Appendix IIIJ.

3.3.1 Delivery

Upon delivery of FML, the CQA monitor will observe that:

- The geomembrane is delivered in rolls and is not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the geomembrane will be damaged if it is folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location in accordance with the manufacturer's specifications and stacked not more than 5 rolls high. The geomembrane is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.
- All manufacturing documentation required by the specifications outlined in this LQCP has been received and reviewed for compliance. This documentation will be included in the GLER.
- A geosynthetics receipt log form has been completed for all materials received.

Damaged geomembrane will be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until all documentation has been received, reviewed, and accepted.

3.3.2 Conformance Testing

Tests. One geomembrane sample will be obtained for every resin lot of material supplied and for each 100,000 square feet of geomembrane installed. The material will be sampled at the site by the CQA monitor. The samples will be forwarded to the independent third-party laboratory for the following conformance tests:

- Specific gravity/Density (ASTM D 1505 or alternate ASTM D 792, Method A if approved by the POR)
- Carbon black content (ASTM D 4218)
- Carbon black dispersion (ASTM D 5596)
- Thickness (ASTM D 5199 for smooth FML and for textured FML use ASTM D 5994
- Tensile properties (ASTM D 638/Type IV, ASTM D 6693 may be used upon approval by POR)

Table 3-1
Required Testing for 60-mil-thick Smooth and Textured (Both Sides) HDPE Geomembranes[1]

Test	Type of Test	Standard Test Method	Frequency of Testing (Minimum)
Resin	Specific Gravity/Density	ASTM D 792, Method A or ASTM D 1505	Per 100,000 SF and every resin lot
	Melt Flow Index	ASTM D 1238	Per 100,000 SF and every resin lot
Manufacturer's Quality Control	Thickness	ASTM D 5199 (smooth) or ASTM D 5994[2] (textured)	Per Roll of Geomembrane
	Specific Gravity/Density	ASTM D 1505/D 792	Per 200,000 pounds
	Carbon Black Content	ASTM D 4218	Per 20,000 pounds
	Carbon Black Dispersion	ASTM D 5596	Per 45,000 pounds
	Tensile Properties	ASTM D 638 / Type IV (ASTM D 6693 may be used as an alternative upon POR's approval)	Per 20,000 pounds
	Tear	ASTM D 1004	Per 45,000 pounds
	Puncture	ASTM D 4833	Per 45,000 pounds
	Stress Crack Resistance	ASTM D 5397	Per GRI-GM 10
	Oxidative Induction Time	ASTM D 3895 or ASTM D 5885	Per 200,000 pounds
	Oven Aging @ 85°C Standard OIT (min. avg.) or High pressure OIT - % retained after 90 days for both	ASTM D 5721 ASTM D 3895 ASTM D 5885	Per each formulation
	UV Resistance[3] High Pressure OIT (min. avg.) - % retained after 1,600 hours	GRI GM11 ASTM D 5885	Per each formulation
	Asperity Height	GRI GM12	Every 2nd roll[4]

[1] All tests will conform to the minimum requirements set forth by GRI testing standard GM13. Required values for the parameters are listed in Table 3-2.

[2] ASTM D 1593 may also be used for thickness of textured geomembrane.

[3] 20 hours of UV cycle at 75°C followed by 4 hours condensation at 60°C.

[4] Measurement side will be alternated for double-sided textured sheet. This testing is specified for textured geomembrane only.

Table 3-2
Minimum Required Properties of 60-mil-thick Smooth and Textured (Both Sides) HDPE Geomembranes

Property	Test Method	Minimum Required Property[8]	
		Smooth	Textured
Thickness, mils			
Minimum average	ASTM D 5199 (smooth)	60	57
Lowest individual reading	ASTM D 5994 (textured)	54	51
Lowest individual of 8 of 10 readings		NA	54
Density, g/cc	ASTM D 1505/D 792	0.940	0.940
Asperity Height, mils	GRI GM12	N/A	10
Tensile Properties[1]	ASTM D 638 (Type IV Specimen @ 2 in/min) (ASTM D 6693 may be used as an alternative upon approval by POR)		
1. Yield Strength, lb/in		126	126
2. Break Strength, lb/in		228	90
3. Yield Elongation, %		12	12
4. Break Elongation, %		700	100
Tear Resistance, lb	ASTM D 1004	42	42
Puncture Resistance, lb	ASTM D 4833	108	90
Stress Crack Resistance[2], hrs	ASTM D 5397	300	300
Carbon Black Content[3], %	ASTM D 1603	2.0 – 3.0	2.0 – 3.0
Carbon Black Dispersion[4], Category	ASTM D 5596	see note 4	see note 4
Oxidative Induction Time (OIT)[5] (Minimum Average)			
Standard OIT, minutes	ASTM D 3895	100	100
High Pressure OIT, minutes	ASTM D 5885	400	400
Oven Aging at 85°C	ASTM D 5721		
Standard OIT – % retained after 90 days	ASTM D 3895	55	55
High Pressure OIT – % retained after 90 days	ASTM D 5885	80	80
UV Resistance[6]	GRI GM 11		
High Pressure OIT[7] – % retained after 1600 hrs	ASTM D 5885	50	50
Seam Properties (4 out of 5 specimens, 5th specimen can be as low as 80% per GRI-GM19)	ASTM D 6392		
1. Shear Strength, lb/in		120	120
2. Peel Strength, lb/in		91 & FTB (78, Extrusion Weld)	91 & FTB (78, Extrusion Weld)

[1] Machine direction (MD) and cross machine direction (XMD) average values will be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 1.3 inches; break elongation is calculated using a gauge length of 2.0 inches.

[2] The yield stress used to calculate the applied load for the Single Point Notched Constant Tensile Load (SP-NCTL) test will be the mean value via MQC testing.

[3] Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.

[4] Carbon black dispersion for 10 different views: 9 in Categories 1 and 2 and 1 (max) in Category 3.

[5] The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

[6] The condition of the test will be 20 hr UV cycle at 75°C followed by 4 hr. condensation at 60°C.

[7] UV resistance is based on percent retained value regardless of the original HP-OIT value.

[8] Minimum required properties are based on GRI-GM13, except for the seam properties which are based on GRI-GM19.

The density of the geomembrane must be greater than 0.94 g/cc; the carbon black content must be between 2 percent and 3 percent; and recycled or reclaimed material must not be used in the manufacturing process.

The design engineer may require additional test procedures and will inform the third party laboratory in writing. The POR must review all test results and report any nonconformance to the design engineer prior to product installation. In addition to the conformance thickness tests shown above, field thickness measurements must be taken at maximum 5-foot intervals along the leading edge of each geomembrane panel. For smooth geomembranes, no single measurement will be less than 10 percent below the required nominal thickness for the panel to be accepted (i.e., for 60-mil geomembrane a minimum thickness of 54 mils is required) and the average must be at least 60 mils. Refer to Table 3-2 for a complete listing of the material requirements for both smooth and textured geomembranes that will be used for the composite Subtitle D bottom liner.

Sampling Procedure. Samples will be taken across the entire roll width. Unless otherwise specified, samples will be approximately 15 inches long by the roll width. The CQA monitor must mark the machine direction and the manufacturer's roll identification number on the sample. The CQA monitor must also assign a conformance test number to the sample and mark the sample with that number.

3.3.3 Geomembrane Installation

Surface Preparation. Prior to any geomembrane installation, the installed soil liner surface will be inspected by the CQA and geosynthetics contractor. The POR or CQA monitor must observe the following:

- All lines and grades for the soil liner have been verified by the surveyor and accepted by the contractor for geosynthetic installation. The POR or his representative, the owner, and geomembrane installer will certify and accept in writing the finished final lift of the soil liner.
- The soil liner has been prepared in accordance with the earthwork construction plans and specifications as outlined in Section 2.
- The soil liner surface is free of surface irregularities and protrusions. The soil liner will be rolled and compacted to ensure a clean surface.
- The soil liner surface does not contain stones or other objects that could damage the geomembrane and underlying soil liner. The surface of the soil liner will be smooth and free of foreign and organic material, sharp objects, exposed soil or aggregate particles greater than 3/4 inches (or less if recommended by the geosynthetic manufacturer), or other deleterious material.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.
- There are no excessively soft areas in the soil liner that could result in geomembrane damage.

- The geomembrane will not be placed over soil liner during inclement weather such as rain or high winds.
- The soil liner is not saturated, and no standing water is present above the soil liner.
- The soil liner has not desiccated (e.g., areas with desiccation cracks).
- All construction stakes and hubs have been removed and the resultant holes have been backfilled. There are no rocks, debris, or any other objects on the soil liner surface.
- The geosynthetics contractor has certified in writing that the soil liner surface on which the geomembrane will be installed is acceptable.

Panel Placement. Prior to the installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings.

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations.

During panel placement, the POR or CQA monitor must:

- Observe that geomembrane is placed in direct and uniform contact with the underlying compacted clay soil liner.
- Record roll numbers, panel numbers, and dimensions on the panel or seam logs. Measure and record thickness of leading edge of each panel at 5-foot maximum intervals. No single thickness measurement can be less than 10 percent (15 percent for textured) below the required nominal thickness.
- Observe the sheet surface as it is deployed and record all panel defects and repair of the defects (panel rejected, patch installed, extradite placed over the defect, etc.) on the repair sheet. All repairs must be made in accordance with the specifications as outlined in Section 3.3.5 and located on a repair drawing.
- Observe that support equipment is not allowed on the geomembrane during handling (see Section 3.7 also).
- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance.
- Observe that there are no stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.
- Observe that the geomembrane is not dragged across a surface that could damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, as necessary.

- Record weather conditions including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, or wind, etc.). In addition, geomembrane will not be placed when the air temperature is less than 41°F, or when standing water or frost is on the ground, unless this requirement is waived by the design engineer and TCEQ. Excessive wind is that which can lift and move the geomembrane panels.
- Observe that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown geomembrane). Excessive wrinkles will be walked-out or removed at the discretion of the CQA monitor.
- Observe that no more panels are deployed than can be seamed on the same day.
- Observe that there are no horizontal seams on side slopes, and the textured material extends a minimum of approximately 5 feet out past the toe of the slope where textured geomembrane is used.

The CQA monitor must inform both the contractor and the POR of the above conditions.

Field Seaming. The contractor must provide the POR with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels will be seamed until the panel layout drawing has been accepted by the POR. A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Prior to geomembrane welding, each welder and welding apparatus (both wedge and extrusion welders), must be tested, at a minimum, at daily start-up and at midday break, or any break that the seaming machine is stopped more than 30 minutes to determine if the equipment is functioning properly. The GLER will include the names for each seamer and the time and the temperatures for each seaming apparatus used each day. One trial weld will be taken prior to the start of work. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required). Trial weld samples must comply with "Passing Criteria for Welds" included in Section 3.3.4 – Construction Testing. The CQA monitor must observe all welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. The trial weld be completed under conditions similar to those under which the panels will be welded. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392 and GRI-GM19:

Hot Wedge: AD and AD-Brk>25%

Extrusion Fillet: AD1, AD2, AD-WLD (unless strength is achieved)

Additionally, there will be no apparent weld separation (i.e., greater than 1/8 inch). The third party strength tests must meet the manufacturer's specifications for the sample sheets, or the percentage of the manufacturer's parent sheet strength as determined by the manufacturer. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. If, at any time, the CQA monitor believes that an owner or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (±30° Fahrenheit), humidity, or wind speed, the test weld will be repeated. The test weld must be allowed to cool to ambient temperature before testing. If a weld test fails the shear or peel test, the length of the non-passing weld will be identified at a 10-foot interval and the failed area will be patched. Patching will performed by placing additional geomembrane over the failed area or removing the failed area geomembrane weld and patching it with additional geomembrane per POR's direction. Welding for patches must comply with the welding passing criteria requirements outlined in this section.

Construction quality assurance documentation of trial seam procedures will include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday.
- The welder, the welding apparatus number, time, date, ambient air temperature, and welding machine temperatures.

During geomembrane welding operations, the CQA monitor must observe the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.
- The extrusion welder is purged prior to beginning a weld until all the heat-degraded extradite is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).
- The ambient temperature, measured 6 inches above the geomembrane surface, is between 41° and 104° Fahrenheit unless more stringent limits are required by the manufacturer.

- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding.
- The weld is free of dust, rocks, and other debris.
- The seams are overlapped a minimum of 3 inches for extrusion and hot-wedge welding, or in accordance with manufacturer's recommendations, whichever is more stringent. Panels will be overlapped (shingled) in the downgrade direction.
- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- The panels are being welded in accordance with the plans and specifications that will be developed in accordance with this section for each liner construction. Seams will be oriented parallel to the line of maximum slope with no horizontal seams on side slopes. In corners and odd-shaped geometric locations, the number of field seams will be minimized.
- There is no free moisture in the weld area.
- Measure surface sheet temperature every two hours.
- Observe that at the end of each day or installation segment, all unseamed edges are anchored with sandbags or other approved device. Penetration anchors will not be used to secure the geomembrane.

3.3.4 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests for geomembrane include vacuum testing for extrusion welds and air pressure testing for dual track fusion welds. Nondestructive testing must be performed over the entire length of the seam.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to document the date, time and location of seaming and testing, and to observe and document that testing was performed in compliance with this section and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

- For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section, which has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is reduced to approximately 3 to 5 psi gauge. Any pinholes, porosity or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than ten seconds.

- Air pressure testing is used to test double seams with an enclosed air space (i.e., dual-track fusion welds). Both ends of the air channel will be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi or ½ psi per mil of geomembrane thickness, whichever is greater. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive testing, the CQA monitor must perform the following work:

- Review technical specifications regarding test procedures.
- Observe that equipment operators are fully trained and qualified to perform their work.
- Observe that test equipment meets project specifications that will be developed in accordance with this LQCP for each liner construction.
- Observe that the entire length of each seam is tested in accordance with the specifications outlined in this section.
- Observe all continuity testing and record results on the appropriate log.
- Observe that all testing is completed in accordance with the specifications outlined in this section.
- Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane and inform the contractor of any required repairs, then record the repair area on the repair log.
- Observe that all repairs are completed and tested in accordance with the project specifications outlined in this section and Section 3.3.5.
- Record all completed and tested repairs on the repair log and the repair drawing.

Destructive Seam Testing. Destructive seam tests for geomembrane seams will be performed at intervals of at least one test per 500 linear feet of seam length. At a minimum, a destructive test will be completed for each welding machine used for seaming. A destructive test will also be performed for individual repairs (or additional seaming for the failed seams) of more than 10 feet of seaming. The CQA monitor must perform additional tests if he suspects a seam does not meet specification requirements outlined in this section. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination
- Insufficient overlap
- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear) in accordance with ASTM D 6392. The purpose of peel and shear tests is to evaluate seam strength and to evaluate long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature prior to testing.

The CQA monitor selects locations where seam samples will be cut for laboratory testing. Select these locations as follows:

- A minimum of one random test within each 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals.
- Sample locations will not be disclosed to the contractor prior to completion of the seam.
- A maximum frequency must be agreed to by the contractor, POR, and the Operator at the preconstruction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the POR. Samples taken as the result of failed tests do not count toward the total number of required tests.

Sampling Procedures. The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number, which contains the seam number and destructive test number.

- Record sample location on the panel layout drawing and destructive seam log.
- Record the sample location, weather conditions, and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.).

For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. Cut two 1-inch-wide coupons from each end of the sample. The contractor must test two of these coupons in shear and two in peel (one shear and one peel from each end) using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of the air channel will be tested in peel. The CQA monitor must observe the tests and record the results on the destructive seam test log. A geomembrane seam sample passes the field testing when the break is Film Tear Bond (FTB) and the seam strength meets the required strength values for peel and shear given previously for trial seams under field seaming and below for third party laboratory testing. As previously discussed, both welds have to pass for dual-track welds. Also, it is recommended that additional samples be obtained as discussed in the following paragraph if there is apparent separation of the weld (i.e., greater than 1/8 inch) during peel testing.

If one or both of the 1-inch specimens fail in either peel or shear, the contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations, or (2) take two additional test samples 10 feet or more in either direction from the point of the failed test and repeat this procedure. For tracking purposes the additional samples will be identified by assigning an identifying letter to the initial destructive test sample number (e.g., DS-6A and B). Only satisfactory tests count toward the required minimum number, and additional tests (i.e., A and B) count as one test, if passing. If the second set of tests pass, the contractor can reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly, and appropriate corrective action must be taken immediately.

If the field test coupons are satisfactory, divide the remaining sample into three parts: one 12-inch by 12-inch section for the contractor, one 12-inch by 16-inch section for the third party laboratory for testing, and one 12-inch by 12-inch section for the operator to archive. The laboratory sample will be shipped to the third party laboratory for over-night delivery and next day testing.

If the laboratory test fails in either peel or shear, the contractor must either reconstruct the entire seam between passing test locations or recover additional samples at least 10 feet on either side of the failed sample for retesting. Sample size and disposition must be as described in the preceding paragraph. This process is repeated until passed tests bracket the failed seam section. All seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

Third Party Laboratory Testing. Destructive samples must be shipped to the third party laboratory for seam testing. Testing for each sample will include 5 bonded seam shear strength tests and 5 peel adhesion tests (10 for dual-track welds). For dual-track welds each peel test specimen (coupon) will be tested on both sides of the air channel (i.e., the inner and outer welds). At least four of the five specimens tested in peel and shear will meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the passing criteria listed below. Additionally, 4 out of 5 of the peel test coupons must have no greater than 25 percent seam separation. For dual-track welds if either weld exhibits greater than 25 percent separation or does not meet the required strength, that coupon is considered out of compliance and two out of compliance coupons cause the weld to fail. The third party laboratory must provide test results within 24 hours, in writing or via telephone, to the CQA monitor. Certified test results are to be provided within 5 days. The CQA monitor must immediately notify the POR in the event of a calibration discrepancy or failed test results.

Passing Criteria for Welds. Passing criteria are established by GRI GM19 for geomembranes. A passing extrusion or fusion welded seam will be achieved when the following values are tested. The following values listed for shear and peel strengths are for 4 out of 5 test specimens (the 5th specimen can be as low as 80 percent of the listed values). Elongation measurements will be omitted for field testing.

• Shear strength (lb/in)	120 (90 for Textured)
• Shear elongation at break (%)	50
• Peel strength (lb/in)	91 (78 Extrusion Weld) & FTB
• Peel separation (%)	25

A passing extrusion or fusion welded seam will be achieved in peel when:

- Yield strength for 4 of 5 specimens (10 tests for dual-track welds) is not less than the above minimum peel strength value and the average of all 5 specimens is not less than the minimum value.
- No greater than 25 percent of the seam width peels (separates) at any point for 4 of 5 specimens (both inner and outer welds for dual-track welds).

A passing extrusion or fusion weld will be achieved in shear when:

- Yield strength for 4 of 5 specimens is not less than the above minimum shear strength value and the average for all 5 specimens is not less than the minimum value.
- Break strain for 4 out of 5 specimens is at least 50 percent.

3.3.5 Repairs

Any portion of the geomembrane with a detected flaw, or which fails a nondestructive or destructive test, or where destructive tests were cut, or where nondestructive tests left cuts or holes, must be repaired in accordance with the specific liner construction specifications and consistent with all the applicable parts (e.g., material requirement, installation, testing, etc.) of this section. The CQA monitor must locate and record all repairs on the repair sheet and panel layout drawing. Repair techniques include the following:

- Patching – used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion – used to repair small defects in the panels and seams. In general, this procedure will be used for defects less than ⅜-inch in the largest dimension.
- Capping – used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.
- Removal – used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal will be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one hour prior to the repair.
- Clean and dry all surfaces at the time of repair.
- Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches prior to extrusion welding.
- Testing of repaired seams consistent with Section 3.3.4 – Construction Testing.

3.3.6 Wrinkles

During placement of cover materials over the geomembrane, temperature changes or creep can cause wrinkles to develop in the geomembrane. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane, which could result in the geomembrane folding. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being covered by soil. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

3.3.7 Folded Material

All folded geomembrane must be removed. Remnant folds evident after deployment of the roll, which are due to manufacturing process, are acceptable.

3.3.8 Geomembrane Anchor Trench

The geomembrane anchor trench will be left open until seaming is completed. Expansion and contraction of the geomembrane will be accounted for in the liner placement. Prior to backfilling, the depth of penetration of the geomembrane into the anchor trench must be verified by the CQA monitor at a minimum of 100-foot spacings along the anchor trench. The anchor trench will be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

3.3.9 Geomembrane Acceptance

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the Operator. In the event the contractor is responsible for placing cover over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete, and the cover material is placed. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be walked by the Operator's and contractor's representatives. Any damage or defect found during this inspection will be repaired properly by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the geomembrane will be accepted by the POR only when the following has been completed:

- The installation is finished.
- All seams have been inspected and verified to be acceptable.
- All required laboratory and field tests have been completed and reviewed.
- All required contractor-supplied documentation has been received and reviewed.
- All as-built record drawings have been completed and verified by the POR. The as-built drawings show the true panel dimensions, the location of all seams, trenches, pipes, appurtenances, and repairs.
- Acceptance of the GLER by TCEQ.

3.3.10 Bridging

Bridging must be removed.

3.4 Overliner Geomembrane

3.4.1 General

This section describes material types, handling, installation, and testing of overliner geomembrane. LLDPE geomembrane that is textured on both sides will be used for the overliner. The required tests for 40-mil LLDPE are summarized in Table 3-3. Required material properties for 40-mil LLDPE are included in Table 3-4. Interface strength parameters for the composite overliner that includes LLDPE geomembrane are included in Section 7. Prior to each construction event, the strength parameters used in the geotechnical analysis will be verified. The POR will update the geotechnical analysis and include the updated analysis for the GLER of each specific construction event if the testing results indicate lower interface strength values than the ones used in the geotechnical analysis. The updated geotechnical analysis will meet the minimum factor of safety requirements set forth in Appendix IIIJ.

Table 3-3
Required Testing for 40-mil-thick Textured (Both Sides) LLDPE Geomembrane

Test	Type of Test	Standard Test Method	Frequency of Testing
Resin	Density	ASTM D 1505	Per 200,000 pounds and every resin lot
	Melt Flow Index	ASTM D 1238 (90/2.16 and 190/21.6)	
Resin/Compound Evaluation	Per manufacturer's quality control specifications	Per manufacturer's quality control specifications	Per manufacturer's quality control specifications
Manufacturer's Quality Control	Testing per GRI Standard, GRI Test Method GM17 for 40 mil LLDPE		
Conformance Testing by 3rd Party Independent Laboratory	Thickness[1]	ASTM D 5994 (textured LLDPE)	Per 100,000 ft^2 and every resin lot
	Specific Gravity/Density	ASTM D 1505/D 792	
	Carbon Black Content	ASTM D 1603	
	Carbon Black Dispersion	ASTM D 5596	
	Tensile Properties	ASTM D 6693, Type IV	
Destructive Seam Field Testing[2]	Shear & Peel	ASTM D 6392	Various for field, lab, and archive
Non-Destructive Seam Field Testing	Air Pressure	GRI GM6	All dual-track fusion weld seams
	Vacuum	ASTM D 5641	All non-air pressure tested seams when possible
	Other		Concurrence of TCEQ

[1] Field thickness measurements for each panel must be conducted. Use ASTM D 374/D 5994 and perform 1 series of measurements among the leading edge of each panel, with individual measurements no greater than 5 feet apart. No single measurement will be less than 15% below the required nominal thickness in order for the panel to be acceptable. As an alternative to field thickness measurements, the conformance thickness testing will be performed in a third party laboratory and the test frequency will be doubled.

[2] Passing criteria for the geomembrane materials are listed in Table 3-4. Passing criteria for seams are listed in Section 3.4.6.

Table 3-4
Minimum Required Properties of 40-mil-thick Textured (Both Sides) LLDPE Geomembrane

Property	Test Method	Minimum Required Property
Thickness, mils Minimum average Lowest individual reading Lowest individual of 8 of 10 readings	ASTM D 5199	 38 34 36
Density, g/cc (maximum)	ASTM D 1505/D 792	0.939
Asperity Height, mils	GRI GM12	10
Tensile Properties[1] Break Strength, lb/in Break Elongation, %	ASTM D 6693, Type IV	 60 250
2% modulus – lb/in (max)	ASTM D 5323	2,400
Tear Resistance, lb	ASTM D 1004	22
Puncture Resistance, lb	ASTM D 4833	44
Break Resistance Strain, % (min)	ASTM D 5617	30
Carbon Black Content[2], %	ASTM D 1603	2.0 – 3.0
Carbon Black Dispersion[4], Category	ASTM D 5596	(see note 3)
Oxidative Induction Time (OIT),[6] minimum average Standard OIT, minutes or High Pressure OIT, minutes	 ASTM D 3895 ASTM D 5885	 100 400
Oven Aging at 85°C Standard OIT - % retained after 90 days or High Pressure OIT - % retained after 90 days	ASTM D 5721 ASTM D 3895 ASTM D 5885	 35 60
UV Resistance[4] High Pressure OIT[5] - % retained after 1600 hrs	GRI GM 11 ASTM D 5885	 35
Seam Properties (4 out of 5 specimens, 5th specimen can be as low as 80% per GRI-GM19) Shear Strength, lb/in Peel Strength, lb/in	ASTM D 6392	 60 50 (44, Extrusion Weld) & FTB

[1] Machine direction (MD) and cross machine direction (XMD) average values will be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.

[2] Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.

[3] Carbon black dispersion for 10 different views; 9 in Categories 1 or 2 and 1 in Category 3.

[4] The condition of the test will be 20 hr UV cycle at 75°C followed by 4 hr. condensation at 60°C.

[5] UV resistance is based on percent retained value regardless of the original HP-OIT value.

[6] The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

3.4.2 Delivery

Upon delivery of the geomembrane, the CQA monitor will observe that:

- The geomembrane is delivered in rolls and is not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the geomembrane will be damaged if it is folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location in accordance with the manufacturer's specifications and stacked not more than five rolls high. The geomembrane is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.
- Manufacturing documentation required by the specifications outlined in this LQCP has been received and reviewed for compliance. This documentation will be included in the GLER.
- The geosynthetics receipt log form has been completed for materials received.

Damaged geomembrane will be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until documentation has been received, reviewed, and accepted.

3.4.3 Conformance Testing

Tests. One geomembrane sample will be obtained for every resin lot of material supplied and for each 100,000 square feet of geomembrane. The material will be sampled at the site by the CQA monitor. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Specific gravity/Density (ASTM D 1505 or alternate ASTM D 792, Method A if approved by the POR)
- Carbon black content (ASTM D 1603)
- Carbon black dispersion (ASTM D 5596)
- Thickness (ASTM D 5994 for textured geomembrane)
- Tensile properties (ASTM D 638/Type IV Specimen, ASTM D 6693 may be used upon approval by POR)

3.4.4 Anchor Trench Backfill

General fill material placed in anchor trenches will be placed in uniform lifts, which do not exceed 12 inches in loose thickness and are compacted. In-place moisture/density tests may be taken at the discretion of the CQA monitor to evaluate the quality of the backfill. The test results will not be required as part of the GLER. Slightly rounded corners will be provided in anchor trenches where the geomembrane enters the trench so as to avoid sharp bends in the geomembrane. No loose soil (e.g., excessive water content) will be allowed to underlie the anchored components of the liner system.

3.4.5 Geomembrane Installation

Surface Preparation. Prior to any geomembrane installation, the GCL on which the geomembrane will be placed will be inspected by the CQA and geosynthetics contractor. The POR or CQA monitor must observe the following:

- When placing the geomembrane on the overliner GCL, construction placement equipment should not be permitted to ride directly on the GCL. Overliner geomembrane will be moved by hand or by using small pneumatic-tire lifting units. Other techniques, such as use of block and tackles, have also been used.
- All-terrain vehicles (ATVs) or equipment with smooth, oversized tires of maximum ground contact pressure of 28 to 41 kPa (4-6 psi) can be used; however, the following restrictions will be imposed:
    - The vehicle can be operated on the previously placed GCL only when deploying materials.
    - There should be no sudden stops or starts.
    - There should be no spinning of tires or sliding at any time.
    - Vehicle tires must be smooth and clean of mud, dirt, and debris that could potentially puncture or damage the underlying GCL.
    - All entering and exiting on the GCL should be done at 90-degree angles to the material.
    - There should be no excessive turning while driving on the GCL. Movement should be primarily forward and backward while deploying, and turning should be minimized to the greatest extent possible.
    - There should be no driving over wrinkles in geosynthetics.
    - There should be no more than one person riding on vehicle.
    - Vehicles should not be used on slopes.
- The underlying GCL should have all folds, wrinkles, and other undulations removed before placement of the overlying geomembrane.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.

- The geomembrane will not be placed during inclement weather such as rain or high winds.
- The geosynthetics contractor has certified in writing that the surface on which the geomembrane will be installed is acceptable.

Consistent with Section 4.3.1, the POR will verify that only panels that can be covered on the same day with geomembrane will be deployed.

Panel Placement. Prior to the installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings.

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations.

During panel placement, the POR or CQA monitor must:

- Observe that the geomembrane is placed in direct and uniform contact with underlying GCL.
- Record roll numbers, panel numbers, and dimensions on the panel or seam logs. Measure and record thickness of leading edge of each panel at 5-foot maximum intervals. No single thickness measurement can be less than 10 percent below the required nominal thickness.
- Observe the sheet surface as it is deployed and record panel defects and repair of the defects (panel rejected, patch installed, extradite placed over the defect, etc.) on the repair sheet. Repairs must be made in accordance with the specifications as outlined in Section 3.4.7 and located on a repair drawing.
- Observe that support equipment is not allowed on the geomembrane during handling (see Section 3.7 also).
- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance.
- Observe that there are no stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.
- Observe that the geomembrane is not dragged across a surface that could damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, as necessary.
- Record weather conditions including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, geomembrane seaming operation will not be performed when the air temperature is less than 41°F or greater than 104°F, or when standing

water or frost is on the ground, unless these requirements are waived by the design engineer. Excessive wind is that which can lift and move the geomembrane panels.

- Observe that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown geomembrane). Excessive wrinkles will be walked-out or removed at the discretion of the CQA monitor.
- Observe that no more panels are deployed than can be seamed on the same day.

The CQA monitor must inform both the contractor and the POR of the above conditions.

Field Seaming. The contractor must provide the POR with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels will be seamed until the panel layout drawing has been accepted by the POR. A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Prior to geomembrane welding, each welder and welding apparatus (both wedge and extrusion welder) must be tested, at a minimum, at daily start-up and at mid day break, or any break that the seaming machine is stopped more than 30 minutes to determine if the equipment is functioning properly. The GLER will include the names for each seamer and the time and the temperatures for each seaming apparatus used each day. In addition, a trial weld will also be obtained prior to seaming the tie-in. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required). Trial weld samples must comply with "Passing Criteria for Welds" included in Section 3.4.6 – Construction Testing. The CQA monitor must observe welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. The trial weld will be completed under conditions similar to those under which the panels will be welded. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392 and GRI GM19:

Hot Wedge:	AD and AD-Brk>25%
Extrusion Fillet:	AD1, AD2, AD-WLD (unless strength is achieved)

Additionally, there will be no apparent weld separation (i.e., greater than 1/8 inch). The third party strength tests must meet the manufacturer's specifications for the sample sheets, or percentage of the manufacturer's parent sheet strength as determined by the manufacturer. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. If, at any time, the CQA monitor believes that an operator or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (±30° Fahrenheit), humidity, or wind speed, the test weld will be repeated. The test weld must be allowed to cool to ambient temperature before testing. If a weld test fails the shear or peel test, the length of the non-passing weld will be identified at a 10-foot interval, and the failed area will be patched. Patching will be performed by placing additional geomembrane material over the failed area or removing the failed geomembrane weld and patching it with additional geomembrane per POR's direction. The welding for patches must comply with the welding passing criteria requirements outlined in this section.

Construction quality assurance documentation of trial seam procedures will include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday.
- The welder, the welding apparatus number, time, date, ambient air temperature, and welding machine temperatures.

During geomembrane welding operations, the CQA monitor must observe the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.
- The extrusion welder is purged prior to beginning a weld until the heat-degraded extradite is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).
- The ambient temperature, measured 6 inches above the geomembrane surface, is between 41°F and 104°F, or manufacturer's recommended temperature limits if they are more stringent.
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding.
- The weld is free of dust, rocks, and other debris.
- The seams are overlapped a minimum of 3 inches for extrusion and hot-wedge welding, or in accordance with manufacturer's recommendations, whichever is more stringent. Panels will be overlapped (shingled) in the downgrade direction.

- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- The panels are being welded in accordance with the plans and specifications that will be developed in accordance with this section for each liner construction. Seams will be oriented parallel to the line of maximum slope with no horizontal seams on side slopes. In corners and odd-shaped geometric locations, the number of field seams will be minimized.
- There is no free moisture in the weld area.
- Measure surface sheet temperature every two hours.
- Observe that at the end of each day or installation segment, unseamed edges are anchored with sandbags or other approved device. Penetration anchors will not be used to secure the geomembrane.

3.4.6 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests for geomembrane include vacuum testing for extrusion welds and air pressure testing for dual-track fusion welds. Nondestructive testing must be performed over the entire length of the seam.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to document the date, time, and location of seaming and testing, and to observe and document that testing was performed in compliance with this section and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

- For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section that has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is reduced to approximately 3 to 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than ten seconds.
- Air pressure testing is used to test double seams with an enclosed air space (i.e., dual-track fusion welds). Both ends of the air channel will be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted

into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive testing, the CQA monitor must perform the following work:

- Review technical specifications regarding test procedures.
- Observe that equipment operators are fully trained and qualified to perform their work.
- Observe that test equipment meets project specifications that will be developed in accordance with this LQCP for each overliner construction.
- Observe that the entire length of each seam is tested in accordance with the specifications outlined in this section.
- Observe all continuity testing and record results on the appropriate log.
- Observe that testing is completed in accordance with the project specifications outlined in this section.
- Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane and inform the contractor of any required repairs, then record the repair area on the repair log.
- Observe that repairs are completed and tested in accordance with the project specifications outlined in this section and Section 3.4.7.
- Record completed and tested repairs on the repair log and the repair drawing.

Destructive Seam Testing. Destructive seam tests for geomembrane seams will be performed at a frequency of at least one test for each 500 linear feet of seam length. At a minimum, a destructive test will be completed for each welding machine used for seaming. A destructive test will also be completed for individual repairs (or additional seaming for the failed welds) of more than 10 feet of seam length. The CQA monitor must perform additional tests if he suspects a seam does not meet specification requirements outlined in this section. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination

- Insufficient overlap
- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear) in accordance with ASTM D 6392. The purpose of peel and shear tests is to evaluate seam strength and to evaluate long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature prior to testing.

The CQA monitor selects locations where seam samples will be cut for laboratory testing. Select these locations as follows:

- A minimum of one random test within each 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals.
- Sample locations will not be disclosed to the contractor prior to completion of the seam.
- A maximum frequency must be agreed to by the contractor, POR, and the Operator at the preconstruction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the POR. Samples taken as the result of failed tests do not count toward the total number of required tests.

Sampling Procedures. The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number that contains the seam number and destructive test number.
- Record sample location on the panel layout drawing and destructive seam log.
- Record the sample location, weather conditions, and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.).

For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. Cut two 1-inch-wide coupons from each end of the sample (a total of 4 coupons). The contractor must test two of these coupons in shear and two in peel (one shear and one peel from each end) using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of the air channel will be tested in peel. The CQA monitor must observe the tests and record the results on the destructive seam test log. A geomembrane seam sample passes the field testing when the break is a film tear bond (FTB) and the seam strength meets the required strength values for peel and shear given previously for trial seams under field seaming and below for third party laboratory testing. As previously discussed, both welds have to pass for dual-track welds. Also, it is recommended that additional samples be obtained as discussed in the following paragraph if there is apparent separation of the weld (i.e., greater than 1/8 inch) during peel testing.

If one or both of the 1-inch specimens fail in either peel or shear, the contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations, or (2) take two additional test samples 10 feet or more in either direction from the point of the failed test and repeat this procedure. For tracking purposes the additional samples will be identified by assigning an identifying letter to the initial destructive test sample number (e.g., DS-6A and B). Only satisfactory tests count toward the required minimum number, and additional tests (i.e., A and B) count as one test, if passing. If the second set of tests pass, the contractor can reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly, and appropriate corrective action must be taken immediately.

If the field test coupons are satisfactory, divide the remaining sample into three parts: one 12-inch by 12-inch section for the contractor, one 12-inch by 16-inch section for the third party laboratory for testing, and one 12-inch by 12-inch section for the Operator to archive. The laboratory sample will be shipped to the third party laboratory for overnight delivery and subsequent testing.

If the laboratory test fails in either peel or shear, the contractor must either reconstruct the entire seam between passing test locations or recover additional samples at least 10 feet on either side of the failed sample for retesting. Sample size and disposition must be as described in the preceding paragraph. This process is repeated until passed tests bracket the failed seam section. Seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

Third Party Laboratory Testing. Destructive samples must be shipped to the third party laboratory for seam testing. Testing for each sample will include five bonded seam shear strength tests and five peel adhesion tests (ten for dual-track welds). For dual-track welds each peel test specimen (coupon) will be tested on both sides of the air channel (i.e., the inner and outer welds). At least four of the five specimens tested in peel and shear will meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the passing criteria listed below. Additionally, 4 of 5 of the peel test coupons must have no greater than 25 percent seam separation. For dual-track welds if either weld exhibits greater than 25 percent separation or does not meet the required strength, that coupon is considered out of compliance and two out of compliance coupons cause the weld to fail. The third party laboratory must provide test results in timely manner, in writing or via telephone, to the POR. Certified test results are to be provided within five days. The CQA monitor must immediately notify the POR in the event of a calibration discrepancy or failed test results.

Passing Criteria for Welds. Passing criteria are established by Geosynthetic Institute GRI Test Method GM-19 for geomembrane seams. A passing extrusion or fusion welded seam will be achieved when the following values are tested. The following values listed for shear and peel strengths are for 4 out of 5 test specimens (the 5th specimen can be as low as 80 percent of the listed values) for 40-mil textured LLDPE. Elongation measurements will be omitted for field testing.

• Shear strength (lb/in)	60
• Shear elongation at break (%)	50
• Peel strength (lb/in)	50 (44, Extrusion Weld) & FTB
• Peel separation (%)	25

A passing extrusion or fusion welded seam will be achieved in peel when:

- Yield strength for 4 of 5 specimens (10 tests for dual-track welds) is not less than the above minimum peel strength value and the average of all 5 specimens is not less than the minimum value.
- No greater than 25 percent of the seam width peels (separates) at any point for 4 of 5 specimens (both inner and outer welds for dual-track welds).

A passing extrusion or fusion weld will be achieved in shear when:

- Yield strength for 4 of 5 specimens is not less than the above minimum shear strength value and the average for all 5 specimens is not less than the minimum value.
- Break strain for 4 out of 5 specimens is at least 50 percent.

3.4.7 Repairs

Any portion of the geomembrane with a detected flaw, which fails a nondestructive or destructive test, where destructive tests were cut, or where nondestructive tests left cuts or holes must be repaired in accordance with the specifications developed for each phase of overliner construction and consistent with application parts (e.g., material requirements, installation, testing, etc.) of Section 3.4 of this LQCP. The CQA monitor must locate and record all repairs on the repair sheet and panel layout drawing. Repair techniques include the following:

- Patching – used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion – used to repair small defects in the panels and seams. In general, this procedure will be used for defects less than 3/8-inch in the largest dimension.

- Capping – used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.
- Removal – used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal will be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one hour prior to the repair.
- Clean and dry surfaces at the time of repair.
- Extend patches or caps at least 6 inches beyond the edge of the defect, and round corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches prior to extrusion welding.
- Perform testing on repair seams consistent with Section 3.4.6 – Construction Testing.

3.4.8 Wrinkles

During placement of cover materials over the geomembrane, temperature change or creep can cause wrinkles to develop in the geomembrane. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane which could result in the geomembrane folding. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being covered by soil. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

3.4.9 Folded Material

Folded geomembrane must be removed. Remnant folds evident after deployment of the roll that are due to manufacturing process are acceptable.

3.4.10 Geomembrane Anchor Trench

The geomembrane anchor trench will be left open until seaming is completed. Expansion and contraction of the geomembrane will be accounted for in the geomembrane placement. Prior to backfilling, the depth of penetration of the geomembrane into the anchor trench must be verified by the CQA monitor at a minimum of 100-foot spacing along the anchor trench. The anchor trench will be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

3.4.11 Geomembrane Acceptance

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the Operator. In the event the contractor is responsible for placing cover over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete, and the cover material is placed. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be walked by the Operator's and contractor's representatives. Any damage or defect found during this inspection will be repaired properly by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the geomembrane will be accepted by the POR only when the following has been completed:

- The installation is finished.
- Seams have been inspected and verified to be acceptable.
- Required laboratory and field tests have been completed and reviewed.
- Required contractor-supplied documentation has been received and reviewed.
- As-built record drawings have been completed and verified by the POR. The as-built drawings show the true panel dimensions, the location of seams, trenches, pipes, appurtenances, and repairs.
- Acceptance of the GLER by TCEQ.

3.4.12 Bridging

Bridging must be removed.

3.5 Geotextiles

Geotextiles will be used to prevent clogging of drainage materials. The main usage of geotextiles will be enveloping drainage stone used for chimney drains in the leachate collection system (LCS). Geotextiles for the LCS will meet the design requirements set forth in Appendix IIIC – Leachate and Contaminated Water Management Plan.

3.5.1 Delivery

During delivery the CQA monitor must observe the following:

- Equipment used to unload the rolls will not damage the geotextile.
- Rolls are wrapped in impermeable and opaque protection covers.
- Care is used when unloading the rolls.
- All documentation required by this LQCP and the specifications has been received and reviewed for compliance with this LQCP.

- Each roll is marked or tagged with the manufacturer's name, project identification, lot number, roll number, and roll dimensions.
- Materials are stored in a location that will protect the rolls from precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls must be rejected and removed from the site or stored at a location separate from accepted rolls, designated by the Operator. All rolls which do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

3.5.2 Testing

The geotextile manufacturer will conduct manufacturer quality control (MQC) testing and certify that the materials delivered to the site comply with project specifications outlined in this LQCP. The material certification will be reviewed by the POR and approved for the project prior to acceptance of any of the material. The MQC testing will include the following tests with at least one test for each 100,000 square feet of geotextile delivered.

- Grab tensile strength/elongation (ASTM D 4632)
- Mass per unit area (ASTM D 5261)
- Thickness (ASTM D 5199)
- Puncture resistance (ASTM D 4833)
- Trapezoidal tear strength (ASTM D 4533)
- Hydraulic tests (ASTM D 4491)
- Apparent opening size (ASTM D 4751)

Where optional procedures are noted in the test method, the specification requirements of this LQCP prevail. The POR will review all test results and report any nonconformance.

3.5.3 Geotextile Installation

Surface Preparation. Prior to geotextile installation, the CQA monitor must observe the following:

- All lines and grades have been verified by the surveyor.
- The supporting surface does not contain stones that could damage the geotextile or the underlying geomembrane.
- There are no excessively soft areas that could result in damage to the geotextile, or other components of the liner system.
- Construction stakes and hubs have been removed.

Geotextile Placement. During geotextile placement, the CQA monitor must:

- Observe the geotextile as it is deployed, and record all defects and disposition of the defects (panel rejected, patch installed, etc.). Repairs are to be made in accordance with the specifications outlined in Section 3.5.4.
- Observe that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Observe that people working on the geotextile do not smoke, wear shoes that could damage the geotextile, or engage in activities that could damage the geotextile.
- Observe that the geotextile is securely anchored in an anchor trench.
- Observe that the geotextiles are anchored to prevent movement by the wind.
- Observe that the panels are overlapped a minimum of six inches.
- Examine the geotextile after installation to ensure that no potentially harmful foreign objects are present.
- Observe that seams (where required) are continuously sewn or thermal bonded in accordance with the manufacturer's recommendations and the project specifications outlined in this LQCP.

The CQA monitor must inform both the contractor and POR if the above conditions are not met.

3.5.4 Repairs

Repair procedures include:

- Patching – used to repair large holes, tears, and large defects.
- Removal – used to replace areas with large defects where the preceding method is not appropriate.

Holes, tears, and defects must be repaired in the following manner. Soil or other material which may have penetrated the defect must be removed completely prior to repair. If located on a slope, the defect must be patched using the same type of geotextile and continuously seamed into place. Should any tear, hole, or defect exceed 30 percent of the width of the roll, the roll will be cut off and the defect removed or the roll removed and replaced. If the defect is not located on a slope, the patch must be made using the same type of material seamed into place with a minimum of 24 inches overlap in all directions. Seams will be either thermal bonded or sewn in accordance with the manufacturer's recommendations.

3.6 Drainage Geocomposite – Geonet and Geotextile

A drainage geocomposite will be used for the liner and overliner LCS and temporary groundwater dewatering system (see Section 6). The drainage geocomposite will meet the requirements set forth in Appendix IIIJ – Geotechnical Report and Appendix IIIC – Leachate and Contaminated Water Management Plan of the Site Development Plan along with this LQCP. Manufacturer's testing for geotextile and drainage geocomposite for the composite liner are listed in Table 3-5. The drainage geocomposite for the composite liner will meet the required properties listed in Table 3-5. The drainage geocomposite for the groundwater dewatering system will meet the required properties listed in Table 3-6.

3.6.1 Delivery

Upon delivery the CQA monitor must observe the following:

- The drainage geocomposite is wrapped in rolls with protective covering.
- The rolls are not damaged during unloading.
- Protect the drainage geocomposite from mud, soil, dirt, dust, debris, cutting, or impact forces.
- Each roll must be marked or tagged with proper identification.

Any damaged rolls will be rejected and removed from the site or stored at a location, separate from accepted rolls, designated by the Operator. All rolls which do not have proper manufacturer's documentation will also be stored at a separate location until all documentation has been received and approved.

3.6.2 Testing

The drainage geocomposite manufacturer (or supplier) will conduct quality control testing and certify that all materials delivered to the site comply with the specifications listed in Table 3-5 and Table 3-6. The minimum testing frequency will be one test sample per 100,000 square feet of geocomposite (or geonet/geotextile). See footnote 2 of Table 3-5 and Table 3-6 for testing frequency for transmissivity. The material certifications will be reviewed by the POR to verify that the geocomposite meets the values given in Table 3-5 and Table 3-6.

Geonet will be tested by the manufacturer for thickness, tensile strength, and carbon black content. Geotextile will be tested for mass per unit area, grab tensile strength, and AOS. The finished geocomposite will be tested for peel adhesion and transmissivity (note that the geocomposite transmissivity tests need to be conducted by a third party laboratory only under the specific conditions listed in Table 3-5 and Table 3-6, footnote 2). The manufacturer's testing for drainage material is also summarized in Table 3-5 and Table 3-6. Additionally, material strength parameters (e.g., cohesion, friction angle) used for geotechnical analysis in Appendix IIIJ – Geotechnical Report will be verified prior to construction using actual construction materials, and slope stability analysis will be updated as necessary based on site-specific material data, as discussed in Section 7.

Where optional procedures are noted in the test method, the specification requirements of this LQCP prevail. The CQA monitor will review all test results and will report any nonconformance to the POR and to the contractor.

3.6.3 Installation

Surface Preparation. Prior to drainage geocomposite installation, the CQA monitor will observe the following:

- All lines and grades have been verified by the surveyor (where required).
- The subgrade has been prepared in accordance with the earthwork specifications outlined in Section 2.
- When placed over a geomembrane, the geomembrane installation, including all required documentation, has been completed.
- The supporting surface does not contain stones that could damage the geocomposite or the geomembrane.

Drainage Geocomposite Placement. During placement, the CQA monitor must:

- Verify that single-sided geocomposite is placed on floor grades and double-sided geocomposite is placed on sideslopes with minimum required runouts.
- Observe the drainage geocomposite as it is deployed and record defects and disposition of the defects (panel rejected, patch installed, etc.). Repairs are to be made in accordance with the specifications outlined in Section 3.6.4.
- Verify that equipment used does not damage the drainage geocomposite or underlying geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.
- Verify that people working on the drainage geocomposite do not smoke, wear shoes that could damage the drainage geocomposite, or engage in activities that could damage the drainage geocomposite or underlying geomembrane.
- Verify that the drainage geocomposite is anchored to prevent movement by the wind (the contractor is responsible for any damage resulting to or from wind blown drainage geocomposite).
- Verify that the drainage geocomposite remains free of contaminants such as soil, grease, fuel, etc.
- Observe that the drainage geocomposite is laid smooth and free of tension, stress, folds, wrinkles, or creases.
- Observe that equipment or geocomposite complies with Section 3.7.

- Observe that on slopes the drainage geocomposite is secured in the liner anchor trench and then rolled down the slope.
- Observe that adjacent rolls of drainage geocomposite are overlapped a minimum of six inches, tied, and seamed in accordance with the manufacturer's recommendations.
- Observe that tying is with plastic fasteners in accordance with the manufacturer's recommendations. In the absence of other specifications the drainage geocomposite panels will be tied approximately every 5 feet along the roll length (edges) and every 1 foot along the roll width (ends).
- Observe that the geotextile component is overlapped and either heat bonded or sewn together.

Table 3-5
Geotextile and Drainage Geocomposite Required Testing and Properties

Responsible Party	Material	Test	Standard	Required Property[4]
Manufacturer	Geotextile	Unit Weight	ASTM D 5261	6 oz/sy
		Apparent Opening Size	ASTM D 4751	80 sieve
		Grab Strength	ASTM D 4632	157 lbs
		Tear Strength	ASTM D 4533	56 lbs
		Puncture Strength	ASTM D 4833	56 lbs
		Permeability	ASTM D 4491	0.2 cm/s
Manufacturer	HDPE Geonet	Specific Gravity	ASTM D 1505	0.939 g/cm^3
		Thickness	ASTM D 5199	0.25 inch (bottom liner); 0.30 inch (overliner)
		Carbon Black	ASTM D 1603	2%
		Tensile Strength	ASTM D 5035	45 lb/in (peak)
Third Party Laboratory	Drainage Geocomposite	Transmissivity	ASTM D 4716	See Notes 2 and 3
		Strength	ASTM D 5321	See Table 3-6
Manufacturer		Peel Adhesion	ASTM D 7005	1.0 lb/in

[1] The minimum testing frequency will be one test sample per 100,000 square feet. The drainage geocomposite is single sided for the floor grades of the bottom liner. The drainage geocomposite will be double sided for the sideslopes of the bottom liner and overliner areas.

[2] Liner: As noted in Appendix IIIC, Appendices IIIC-A and IIIC-B, the transmissivity of the single-sided geocomposite will be measured at a gradient of 0.009 under normal pressures of 1,000, 15,000 and 23,421 (or higher) psf, boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours and will be performed for the first 100,000 square feet of liner construction. For each additional 100,000 square feet of single-sided geocomposite placement area, one additional transmissivity test will be performed under the maximum normal stress (i.e., 23,421 psf) or higher with all the same assumptions as the first three tests. The minimum transmissivity will be 9.94x10^{-4} m^2/s. The transmissivity of the double-sided geocomposite will be measured at a gradient of 0.33 under a minimum normal pressure of 1,000, 10,000, and 18,748 (or higher) psf, boundary conditions consisting of soil/geocomposite/geomembrane with a minimum seating time of 100 hours and will be performed for the first 100,000 square feet of liner construction. For each additional 100,000 square feet of double-sided geocomposite placement area, one additional transmissivity test will be performed under the maximum normal stress (i.e., 18,748 psf) or higher with all the same assumptions as the first three tests. The minimum transmissivity will be 6.24x10^{-5} m^2/s.

[3] Overliner: As noted in Appendix IIIC, Appendix IIIC-A and IIIC-B, the transmissivity of the overliner double-sided geocomposite will be measured at a minimum gradient of 0.01 under a minimum normal pressure of 1,000, 10,000, and 13,720 (or higher) psf, boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours and will be performed for the first 100,000 square feet of liner construction. The minimum transmissivity will be 2.77x10^{-3} m^2/s. For each additional 100,000 square feet single-sided geocomposite placement area, one additional transmissivity test will be performed under the minimum normal stress of 13,720 psf with all the same assumptions as the first three tests.

[4] Minimum required property values are based on engineering judgment and experience with similar materials. However, each material will be tested prior to construction to verify that it meets the minimum required properties.

Table 3-6
Required Testing and Properties of Drainage Geocomposite for Dewatering System[1, 5]

Responsible Party	Material	Test	Standard	Required Property[4]
Manufacturer	Geotextile	Unit Weight	ASTM D 5261	6 oz/sy
		Apparent Opening Size	ASTM D 4751	80 sieve
		Grab Strength	ASTM D 4632	157 lbs
		Tear Strength	ASTM D 4533	56 lbs
		Puncture Strength	ASTM D 4833	56 lbs
		Permeability	ASTM D 4491	0.20 cm/s
Manufacturer	HDPE Geonet	Specific Gravity	ASTM D 1505	0.939 g/cm^3
		Thickness	ASTM D 5199	0.20 inch
		Carbon Black	ASTM D 1603	2%
		Tensile Strength	ASTM D 5035	45 lb/in (peak)
Third Party Laboratory	Drainage Geocomposite	Transmissivity[2]	ASTM D 4716	1.18x10^{-4} m^2/s (see Note 2)
Manufacturer		Peel Adhesion	ASTM D 7005	1.0 lb/in

[1] The minimum testing frequency will be one test sample per 100,000 square feet of dewatering system construction.

[2] As noted in Appendix IIID-C, the transmissivity of the dewatering system geocomposite will be measured at a minimum gradient of 0.33 under a minimum normal pressure of 4,455 psf for a minimum seating time of 100 hours.

[3] Refer to Section 7 for interface strength requirements associated with the dewatering system drainage geocomposite.

[4] Minimum required property values are based on engineering judgment and experience with similar materials. However, each material will be tested prior to construction to verify that it meets the minimum required properties.

[5] The dewatering system design information is provided in Appendix IIID-C.

3.6.4 Repairs

Repair procedures include:

- Holes or tears in the drainage geocomposite will be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
- Secure patch to the originally installed drainage geocomposite by tying every 6 inches.
- Where the hole or tear width across the roll is more than 50 percent of the roll width the damaged area will be cut out across the entire roll and the two portions of the drainage geocomposite will be jointed.

3.7 Equipment on Geosynthetic Materials

Construction equipment on the bottom liner and overliner systems will be minimized to reduce the potential for liner puncture. The CQA monitor will verify that small equipment such as generators are placed on scrap liner material (rub sheets) above geosynthetic materials in the liner system. Aggregate drainage layers and/or protective cover will be placed using low ground pressure equipment. The CQA monitor will verify that the geosynthetics are not displaced while the soil layers are being placed.

Unless otherwise specified by the POR, all lifts of protective soil material placed over geosynthetics will conform with the following guidelines.

Equipment Ground Pressure (psi)	Minimum Lift Thickness (in)
<5.0	12
5.1 – 8.0	18
8.1 – 16.0	24
>16.0	36

No equipment will be left running and unattended over the lined area.

3.8 Reporting

The POR will submit to the TCEQ a GLER for approval of the flexible membrane liner, leachate collection system and protective cover. Section 8 describes the documentation requirements.

4 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETIC CLAY LINER

4.1 Introduction

GCL will be placed in the overliner area (reinforced GCL only) above a 12-inch-thick soil subgrade. The GCL will be covered with a minimum 24-inch-thick protective cover. A geotechnical analysis of the overliner system with a GCL is included in Appendix IIIJ – Geotechnical Report. Material properties based on Geosynthetic Research Institute recommendations as described in GRI-GCL3 have been included in Table 4-1 – Required Testing for GCL Materials. The GCL used for the overliner will meet or exceed the required properties.

4.2 Material Requirements

1. A reinforced GCL which consists of bentonite encapsulated between two geotextiles, one nonwoven and one woven, which are needle punched together will be used for the entire overliner area. The GCL materials and its components will be tested in accordance with Table 4-1 by the supplier/GCL manufacturer and a third party independent laboratory and will have the required values listed in Table 4-2. A certificate of analysis for each GCL panel will be submitted as part of the quality control documentation. The GCL permeability will be certified by the manufacturer and will be tested by an independent laboratory at frequencies included in Table 4-1. The manufacturer will provide recommended seaming procedures and supporting test (flow box or other suitable device). The manufacturer will provide documentation showing the GCL seams are no more permeable than the GCL itself at a confining pressure anticipated in the field. The minimum shear strength of hydrated GCL (reinforced) will meet the requirements set forth in Section 7. The nonwoven side of the GCL will be in contact with the geomembrane. Table 4-2 includes further details for the GCL material.
2. The GCL will be shipped in rolls, which are wrapped individually in relatively impermeable and opaque protective covers. The roll may be stacked only as allowed by manufacturer's recommendations. The GCL rolls must be stored above ground (i.e., wooden pallets) and covered with a waterproof tarpaulin.
3. GCL testing will be performed by the manufacturer and a third-party independent laboratory. The POR will review the manufacturer's certification (quality control certificate) and verify that the GCL meets the values given in the plan or specifications for those tests listed in Table 4-1. Required quality control

documentation will be submitted to the POR a minimum of 7 days prior to deployment of any GCL. Requirements for GCL materials are listed in Table 4-2.

4. The POR will perform verification testing as required by additional detailed construction specifications or as required by the POR.

4.3 GCL Installation

Installation of GCL will have continuous on-site monitoring during construction by the POR or his designated representative. The installer will provide a panel layout plan, which will be reviewed by the POR prior to any material deployment. The POR must review field conditions and approve revised panel layout plan if the field conditions vary from the original plan layout.

4.3.1 Subgrade Preparation

The surface of subgrade for the GCL installation will be stable. It will be smooth and free of foreign and organic material, sharp objects, exposed soil or aggregate particles greater than 3/4 inch (or less if recommended by the manufacturer), or other deleterious materials. Standing water or excessive water on the subgrade will not be allowed. If standing water is encountered it will be removed and soils with excessive moisture will be excavated and replaced with suitable borrowed soils to provide a firm, smooth-surfaced base for GCL placement. The POR will verify that the subgrade does not contain excessive moisture, and that soft soil is removed from the area. A firm, smooth-surfaced base grade will be established before GCL placement. The POR may require additional compaction and grading that will result in a smooth surface (e.g., proof rolling), as necessary. The thickness of the subgrade will be verified (i.e., 1-foot minimum thickness) with surveying procedures in accordance with Section 2.3.3.

Prior to GCL installation, the POR will verify the following:

- The grades below the GCL have been verified and accepted by the GCL contractor.
- Required documentation for constructed layers and subgrade preparation below the GCL have been completed and are acceptable.
- The supporting surface has been rolled to provide a smooth surface and does not contain materials, which could damage the GCL or adjacent layer. The subgrade will be rolled with a smooth-drum compactor. Protrusions extending more than 3/4 inches (or less if recommended by the manufacturer) from the base grade surface will be either removed or pushed into the surface with a smooth-drum compactor.

4.3.2 Deployment

Equipment used to deploy GCL over soil must not cause excessive rutting of the GCL subgrade. Deployed GCL panels should contain no folds or excessive slack. Generators, gasoline or solvent cans, tools, or supplies must not be stored directly on GCL. Installation personnel must not smoke or wear damaging shoes when working on GCL.

GCL seams will be constructed overlapping their adjacent edges a minimum of 12 inches. GCL seams will be constructed per manufacturer's directions. The CQA monitor will verify that steps are taken to minimize the presence of loose soil or other debris within the overlap zone.

GCL on sideslopes must not be unrolled in a direction perpendicular to the direction of the slope. GCL should be anchored temporarily (e.g., sandbags) at the top of the slope and then unrolled working from the top of the slope so as to keep the material free of wrinkles and folds, and GCL should be anchored at the bottom of the slope.

Horizontal seams will only be allowed on the slopes under one of the following conditions:

- 2 feet of overlap with horizontal seams being staggered.
- 1 foot of overlap with the underlying panel having a 1-foot runout anchored with 6 inches of subgrade.

Manufacturer hydraulic conductivity testing of GCL seams must be performed by using a flow box or other suitable device per adjoining material and type. Hydraulic conductivity value must be equal to or less than the specified hydraulic conductivity value for the GCL ($5x10^{-9}$ cm/s).

The POR or his designated representative will observe the GCL as it is deployed for even bentonite distribution, thin spots, or other panel defects. Defects and the disposition of the defects (panel rejected, patch installed, etc.) will be recorded. Repairs are to be made in accordance with the specifications at the discretion of the POR. The POR will verify that only panels that can be covered on the same day with an FML are deployed and that the GCL panels are not placed during wet, rainy weather. In accordance with the construction specifications, the POR will also verify the following:

- Proper GCL deployment techniques.
- Proper overlap during deployment.
- Seams between GCL panels are constructed per manufacturer's recommendations.
- The bentonite does not exceed the specified amount of hydration prior to covering.
- Defects are patched and overlapped properly.
- On sideslopes, the GCL is anchored at the top and then unrolled.

- Observe that no debris is trapped beneath or within the GCL.
- Observe that broken needle pieces do not exist within needle-punched GCL.
- Observe that wind speed is less than 40 miles per hour unless a lower wind speed is recommended by the manufacturer. At a minimum, a hand-held anemometer will be used, and readings will be taken at least once a day during GCL deployment to verify that the wind speed is less than 40 miles per hour.

The POR will observe the GCL for premature hydration visually and by walking over the GCL to locate soft spots. GCL that has prematurely hydrated according to the specifications will be removed and replaced with new GCL. These observations will be documented in the GCLER.

4.3.3 GCL Anchor Trench

The GCL anchor trench will be left open to allow installation of FML. Temporary anchoring will be provided until the placement of FML by using sand bags as discussed in Section 4.3.2. Slightly rounded corners will be provided in anchor trenches where the GCL enters the trench so as to avoid sharp bends in the GCL. No loose soil (e.g., excessive water content) will be allowed to underlie the anchored components of the liner system. Backfilling of soil will be in accordance with Section 2.3.4.

4.3.4 Patching

Torn or otherwise damaged GCL (with no loss of bentonite from the GCL) must be patched with the same type of GCL. The GCL patch must extend at least 12 inches beyond the damaged area and must be bonded to the main GCL to avoid shifting during backfilling. If the GCL damage includes loss of bentonite, the patch must consist of full GCL extending at least 12 inches beyond the damaged area. Lapping procedures must be the same as specified for original laps of GCL panels.

4.4 GCL Protection

Protection of GCL will be verified from production to deployment using the procedures discussed in this section. The manufacturer will provide inspection reports demonstrating that needle-punched nonwoven geotextile were inspected using metal detectors for the presence of broken needles and were found to be needle free. GCL must be rolled by the manufacturer in a fashion to prevent collapse during transit. Rolls will be labeled and bagged in a packaging that is resistant to water.

Visual inspection of each GCL roll will be made during unloading to identify any packaging that has been damaged. Rolls with damaged packaging will be marked and set aside for further inspection. The packaging will be repaired, for acceptable GCL rolls, prior to being placed in storage. If necessary, the party responsible for unloading the

GCL will contact the manufacturer prior to shipment to ascertain the suitability of the proposed unloading methods and equipment.

The GCL-installing contractor will be responsible for the storage of GCL material. A dedicated storage area will be selected at the job site or at an alternate offsite area per owner's direction. The selected area will be level, dry, and well drained. Rolls will be stored in a manner that prevents sliding or rolling from the stacks. Rolls should be stacked no higher than three rolls to protect the integrity of roll cores and ensure safe material handling. Stored GCL materials will be covered with a plastic sheet or tarpaulin until it is installed. The integrity and legibility of the labels will be preserved during storage.

Construction equipment (other than low contact pressure rubber-tired vehicles such as ATVs or golf carts) on the GCL will not be allowed. The CQA monitor will verify that small equipment such as generators is placed on scrap FML material (rub sheets). The protective cover will be placed (using low ground pressure equipment as discussed under Section 2.3.6) as soon as possible after installation of FML and drainage layer. Refer to Section 3.6 for equipment operating requirements over geosynthetic materials.

The CQA monitor will verify that GCL (or overlying geosynthetics) are not displaced or damaged while overlying materials are being placed.

4.5 Reporting

The POR will submit to the TCEQ a GCLER for approval of the GCL. Section 8 describes the documentation requirements.

Table 4-1
Required Testing for GCL Materials

Responsible Party	Test	Type of Test	Standard Test Method	Frequency of Testing
Supplier or GCL Manufacturer	Bentonite[1]	Free Swell	ASTM D 5890	per 50 tons (minimum of 1 test for each construction event)
		Fluid Loss	ASTM D 5891	
	Geotextile	Mass/Unit Area	ASTM D 5261	per 25,000 sy
		Grab Tensile Strength	ASTM D 4632	
GCL Manufacturer	GCL Product	Clay Mass/Unit Area	ASTM D 5993	per 5,000 sy
		Bentonite Moisture Content	ASTM D 5993	
		Tensile Strength	ASTM D 6768	per 25,000 sy
		Peel Strength	ASTM D 6496	per 5,000 sy
		Permeability[2]	ASTM D 5887	per 30,000 sy
		Lap Joint Permeability	Flow box or other suitable device	per GCL adjoining material and lap type[3]
Independent Laboratory (Conformance Testing)	GCL Product	Clay Mass/Unit Area	ASTM D 5993	per 100,000 sf
		Permeability	ASTM D 5887	
		Direct Shear[4]	ASTM D 6243	1 per construction event

[1] Tests to be performed on bentonite before incorporation into GCL.

[2] Report last 20 permeability values, ending on production date of supplied GCL.

[3] May also be done as conformance testing.

[4] Not applicable for slopes of 4 percent or flatter. Testing must be on material in hydrated states and must use strain rates, confining pressures, and other parameters, which simulate field conditions. Only reinforced GCL (bentonite encapsulated between two geotextiles, one nonwoven and one woven, which are needle punched together) will be used for the entire overliner area. The nonwoven side of the GCL will be in contact with the geomembrane. Refer to Appendix IIIJ – Geotechnical Report for the stability analysis.

Table 4-2
Required Properties for Reinforced GCL Materials

Property	Required Values[1]
Free Swell (milliliters)	24 (minimum)
Fluid Loss (milliliters)	18 (maximum)
Bentonite Mass per Unit Area[2] (lb/sf)	0.75 (minimum)
Tensile Strength[3] (lb/in)	23 (minimum)
Peel Strength (lb/in)	2.1 (minimum)
GCL Permeability[4] (cm/s)	5×10^{-9} (maximum)
Lab Joint Permeability[5, 6] (cm/s)	5×10^{-9} (maximum)

[1] Manufacturer will demonstrate that the above listed values will be met prior to shipment in accordance with Table 4-1.

[2] Bentonite mass per unit area of GCL must be reported at zero percent moisture content for the finished product.

[3] Value is required for GCL and geotextile.

[4] Permeability is listed for the finished product at a gradient of 1.0.

[5] Minimum overlap is 6 inches. The values listed are minimum dry bentonite amount for 6 inches of overlap. Manufacturer specified value will be used if it is higher.

[6] Manufacturer will provide certification that seams are no more permeable than the GCL material under similar normal stress conditions.

5 QUALITY ASSURANCE FOR PIPING

5.1 Introduction

This section describes CQA procedures for the installation of HDPE pipe for the leachate collection system used for the composite liner and overliner. This plan stresses careful documentation during the quality assurance process, from the selection of materials through installation.

The goal of the pipe quality assurance program is to assure that proper construction techniques and procedures are used, and that the project is built in accordance with the project construction drawings and specifications that will be developed in accordance with this LQCP for each liner construction. The following specifications apply to the leachate collection system piping:

- Minimum internal diameter = 5.845 inches for leachate collection pipe and nominal diameter of 18 inches for riser pipe
- Standard dimension ratio = 17
- Perforation hole diameter = 0.5 inches (if slotted pipe is used, standard slot width = 0.125 inches)
- Young's modulus for pipe material = 33,000 psi
- For LCS design/requirements regarding chemical resistance, refer to Appendix IIIC.

The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are corrected before construction is complete. A construction report, prepared after project completion, will document that the constructed facility meets design standards and specifications.

5.2 Pipe and Fittings

5.2.1 General

Construction must be conducted in accordance with the project construction drawings and specifications for each liner constructed. Piping design and specifications are provided in Appendix IIIC – Leachate and Contaminated Water Management Plan. To monitor compliance, a quality assurance program will be implemented that includes: (1) a review of the manufacturer's quality control testing, (2) material conformance testing, and (3) construction monitoring. Conformance testing refers to testing by an independent third party laboratory that will take place prior to material installation on materials delivered to the site.

5.2.2 Delivery

The CQA monitor will observe:

- That upon delivery, the pipe and pipe fittings are in compliance with the requirements of the construction specifications that will be developed in accordance with this LQCP for each liner construction.
- That a storage location is selected in which the pipe and pipe fittings are protected from excessive heat, cold, construction traffic, hazardous chemicals, and solvents. If the pipe and pipe fittings are stored at a location where other construction materials are present, the CQA monitor will assure that stacking or insertion of the other construction materials onto or into the pipe and pipe fitting is prohibited. The CQA monitor will periodically examine the storage area to observe that the pipe fittings are undamaged, and have been protected.
- That upon transporting pipe and fittings from the storage location to the construction site, the contractor will use pliable straps, slings, or rope to lift the pipe. Steel cables or chains will not be allowed to transport or lift the pipe.
- That the contractor will provide that a pipe greater than 20 feet in length will be lifted with at least two support points. The contractor will not drop, impact, or bump into the pipe, particularly at the pipe ends. Pipe and fitting ends must be cleaned of all dirt, debris, oil, or any other contaminant which may prohibit making a sound joint.

The CQA monitor will document all activities associated with the handling and storage of this material in order to maintain compliance with this portion of the CQA plan.

5.2.3 Conformance Testing

Prior to the installation of pipe, the pipe manufacturer will provide to the Operator and the POR a quality control certificate for each lot or batch of pipe provided. The quality control certificate will be signed by a responsible party employed by the pipe manufacturer, such as the quality control manager. The quality control certificate and documentation will include:

- A description of the pipe delivered to the project, including but not limited to the strength classification, diameter, perforations, and production lot.
- Properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the specifications that will be developed in accordance with this LQCP for each liner construction, or equivalent.

- A certification that property values given in the properties sheet are minimum values and are guaranteed by the pipe manufacturer.
- A list of quantities and descriptions of materials other than the base resin which comprise the pipe.
- The sampling procedure and results of testing for actual samples manufactured in the same lot as the pipe delivered to the project.

The CQA monitor will observe that:

- The property values certified by the pipe manufacturer meet all of the specifications that will be developed in accordance with this LQCP for each liner construction.
- The measurements of properties by the pipe manufacturer are properly documented and that the test methods used are acceptable.
- Verification that the quality control certificates have been provided at the specified frequency for all lots or batches of pipe, and that each certificate identifies the pipe lot/batch related to it.
- The certified properties meet the specifications that will be developed in accordance with this LQCP for each liner construction.

5.2.4 Pipe and Fitting Installation

Surface Preparation. Prior to pipe installation, the CQA monitor must observe the following:

- All lines and grades have been verified by the contractor and project surveyor.
- The pipe trenches are swept clean of any deleterious material which may damage the pipe or geomembrane or may clog the pipe.
- Pipe perforations for leachate collection system are drilled in the pipe outside of the drainage trench where the pipe is to be laid. The drill cuttings must be completely removed from the pipe prior to being placed in the drainage trench.
- Pipe perforations are to the correct size and spacing according to the project specifications that will be developed in accordance with this LQCP for each liner construction. Perforations can be either factory installed slots or factory predrilled holes or field drilled holes.

Pipe and Fitting Placement. During pipe and fitting installation, the CQA monitor will:

- Observe all pipe, pipe fittings, and joints as the pipe is being laid. The CQA monitor will observe that pipes and fittings are not broken, cracked, or otherwise damaged or unsatisfactory. Prior to fusing (if fusion welding is utilized), the pipe installer will provide for a fusion surface area which is clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

- If fusion welding is utilized, verify welder credentials and that the procedure is consistent with the pipe manufacturer's recommendations.
- Observe that the pipe and fittings are being constructed in accordance with specifications that will be developed in accordance with this LQCP for each liner construction and accepted practices.
- Observe that the people and equipment utilized to install the pipe do not damage the pipe or any other component of the liner system.

6 LINERS CONSTRUCTED BELOW THE HIGHEST GROUNDWATER LEVEL

6.1 Introduction

Liners constructed below the groundwater surface could potentially experience uplift due to hydrostatic pressure acting on the geomembrane liner. This section of the LQCP describes procedures for short term and long-term protection of the liner system due to hydrostatic pressure uplift that may result from liner construction below the highest measured groundwater table.

The geology of the site generally consists of alluvial sands and clays overlying weathered and unweathered Shale Strata. The base of the proposed excavation will be primarily founded in the Shale Strata. The shallow groundwater is contained within the sandy and gravelly alluvial soils which overlie the Shale Strata. The unweathered Shale Strata is considered an aquiclude. Only where the alluvium is exposed is there a potential for seepage. A temporary dewatering system will be constructed for the perimeter sidewalls above the contact of the alluvium with the shale. As discussed in Section 6.6, the stability of the Shale Strata will be evaluated prior to and during liner construction for Cells 12 and 13.

Long-term liner stability will be provided in the form of ballast that will be created by the weight of protective cover, solid waste, and final cover as applicable. Ballast calculations are included in Appendix IIID-B – Example Ballast Thickness Calculations. Ballast is provided for the entire undeveloped area. The highest measured groundwater surface is included in Appendix IIID-A and used in the ballast calculations.

6.2 Highest Measured Groundwater Levels

Based on the current hydrogeologic investigation and previous investigations, the site geology consists of three strata: The Alluvial Stratum, the Weathered Shale Stratum, and the Unweathered Shale Stratum. Water levels from the current monitoring wells and piezometers screened in the Alluvial Stratum indicate that the groundwater levels are higher than the excavation floor. As discussed in Section 6.3, a temporary dewatering system is designed for the undeveloped portion to control hydrostatic pressure that may act on the liner system. Long-term stability of the liner system will be ensured by the use of waste-as-ballast to counteract potential uplift pressures created by hydrostatic forces acting on the bottom of the liner system.

A highest groundwater potentiometric surface map is included in Appendix IIID-A. Detailed groundwater information is presented in Appendix IIIG – Geology Report. Drawing IIID-A-1 shows the current highest measured groundwater potentiometric surface at the site.

As each new cell is designed, the highest measured water levels will be adjusted upward for possible higher well level data and the highest measured groundwater potentiometric contours for that cell will be used for design of ballast. Any temporary hydrostatic relief system design different than the one presented in Appendix IIID-C will be submitted to the TCEQ for approval as a modification to the LQCP.

6.3 Temporary Dewatering System

A temporary dewatering system is installed in the currently developed Subtitle D areas, and a temporary dewatering system will be installed in the undeveloped areas. Sheet IIID-C-3 shows the locations of the existing and future temporary dewatering systems.

6.3.1 Dewatering System for Developed Area

The existing dewatering system design includes a trench installed at the perimeter sidewalls or at the toe of excavation above the contact of the alluvium with the shale. The dewatering system consists of a trench with a minimum depth of 3 feet and minimum width of 6 inches. The temporary trench consists of a perforated pipe enveloped with gravel and a geotextile wrap. A geocomposite drainage layer extends up the slope to match the seasonal high water table to maintain the drawdown condition produced by the open excavation. The trenches are constructed at the face of the slope with 1 foot above the unweathered shale and a minimum of 2 feet of penetration into the shale. The location of the existing dewatering trench is shown on Sheet IIID-C-3 (refer to Appendix IIID-C for additional information).

6.3.2 Dewatering System for Undeveloped Area

This temporary dewatering system design has been developed to prevent the build-up of hydrostatic groundwater uplift in the undeveloped areas. The temporary dewatering system design is based on the highest measured groundwater contours shown in Drawing IIID-A-1, as discussed in Section 6.2.

Appendix IIID-C includes the design of a temporary dewatering system that will be installed beneath the liner. As shown in Appendix IIID-C, a drainage geocomposite will convey water from seep to a collection trench that drains to a collection sump or open excavation, similar to the design discussed in Section 6.3.1. The dewatering system is designed to lower the groundwater surface to below the sideslope excavation grades. Any water collected in the sump (if used) will be removed by a submersible pump and pumped to the perimeter stormwater system where it will be discharged from the site consistent with the TPDES Stormwater Permit. The pumps will be activated upon installation of the dewatering system and will remain operational until the BER is approved. The pumps will be operated automatically by pressure transducers. Control levels for the automatic pump will be set to maintain sump liquid levels below the top of the sump.

The temporary dewatering system will remain operational until enough ballast is placed in the form of protective cover and solid waste over the impacted area. Once sufficient ballast is in place and with the written approval of TCEQ, the dewatering system will be decommissioned.

A different hydrostatic pressure relief system may be used at the site if it is designed using the same methodology as the design included in Appendix IIID-C (e.g., relieve potential hydrostatic uplift pressure that may develop on the geomembrane liner) and approved by TCEQ through a permit modification. If during future cell design, the conditions are such that a different system (e.g., collector trenches, diversion channels adjacent to the sector, or a combination of options) is considered more efficient, the system design will be submitted to TCEQ for approval as a permit modification to the LQCP.

6.4 Control of Seepage During Construction

Seepage of free water from the exposed soils is not expected during liner construction due to the temporary dewatering system that will be in place before liner construction is initiated. The temporary dewatering system is discussed in Section 6.3 and Appendix IIID-C. During construction, the subgrade must be maintained in a firm and unyielding condition to provide a satisfactory foundation for construction of the soil liner. If an unexpected seepage is encountered, the wet soils will be over-excavated and replaced with compacted general fill to seal off the seepage. Soft areas will be undercut to firm material and refilled with suitable compacted general fill. The fill will be free from organics, foreign objects, and other deleterious matter. The fill will also be compacted sufficiently to provide a firm base for soil liner placement, as detailed in Section 2.

6.5 Temporary Dewatering System Materials

6.5.1 Dewatering System Drainage Aggregate

The drainage aggregate for the dewatering trench will have a hydraulic conductivity of at least 1 cm/s and a gradation that is compatible with the underdrain pipe perforation specification. Refer to Appendix IIID-C for aggregate gradation for perforated pipe.

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Hole Diameter of Pipe Perforation}} > 1.70$$

The coarse aggregate will be tested for gradation (ASTM D 448) prior to delivery of granular material to the site. Gradation testing will be performed at a minimum frequency of 1 test per 3,000 cubic yards or per specific liner project if granular material used is less than this amount. The aggregate will be free of organics and foreign objects. Calcium carbonate content testing will not be required due to: (1) the dewatering system will be operational for a relatively short period of time (i.e., until enough waste-as-ballast is in place), and (2) water pH is expected to be neutral. The physical characteristics of the aggregate will be evaluated through visual observation and laboratory classification testing before construction and visual observation during construction. During installation, a CQA monitor will observe that granular material is free of organics and foreign objects. The test results for the coarse aggregate will be included in the SLER.

6.5.2 Dewatering System Piping

The dewatering trench pipe will consist of a 4-inch-diameter HDPE SDR-17 pipe, or an engineer approved equivalent.

Typical total perforation will be 1 square inch per 1 foot of pipe length. Perforation sizes (hole diameter or slot width) will be in accordance with the gradation versus perforation requirements outlined in Section 6.5.1. Refer to Appendix IIID-C for slot and perforation sizing. Prior to installation of dewatering trench pipe, the CQA monitor must observe the following:

- Installation lines and grades have been verified by the contractor and project surveyor.
- The pipe trench is clean of any deleterious material which may damage the pipe or geofabric or may clog the pipe.
- Pipe perforations are drilled outside of the underdrain trench. The drill cuttings will be completely removed from the pipe prior to being placed in the drainage trench.
- Pipe perforations are to the correct size and spacing according to the project specifications that will be developed in accordance with this LQCP for each liner construction. Perforations can be either factory predrilled holes or field drilled holes.
- Observe all pipe, pipe fittings, and joints as the pipe is being laid. The CQA monitor will observe that pipes and fittings are not broken, cracked, or otherwise damaged or unsatisfactory. Prior to fusing, (if fusion welding is utilized) the pipe installer will provide for a fusion surface area which is clean and free of moisture, dust, dirt, debris of any kind, and foreign material.
- If fusion welding is utilized, verify welder credentials and that the procedure is consistent with the pipe manufacturer's recommendations.
- Observe that the pipe and fittings are being constructed in accordance with specifications that will be developed in accordance with this LQCP for each liner construction and accepted practices.

- Observe that geotextile wrapping around the pipes and trench complies with project specifications outlined in Section 3.5.
- Observe that the people and equipment utilized to install the pipe do not damage the pipe or any other component of the dewatering system.
- Pipe grades will be established prior to pipe placement by grading the bottom of the trench.

6.5.3 Geotextile

The non-woven geotextile will be wrapped around the drainage stone and the collection pipe in the temporary dewatering trench. It will have a weight of at least 6 oz/sy nonwoven and meet the minimum requirements specified in Appendix IIID-C. There will not be any direct contact between the geotextile and any compaction equipment.

6.5.4 Drainage Geocomposite

A drainage geocomposite will be used for the dewatering layer. The drainage geocomposite will meet the requirements set forth in Appendix IIID-C and will also meet the requirements of the construction drawings and specifications for each specific liner construction. Design flow capacity for the drainage geocomposite is estimated in Appendix IIID-C. The POR will ensure that the flow capacity of drainage geocomposite is equivalent to the required capacity estimated in Appendix IIID-C under similar loading conditions.

Upon delivery of the drainage geocomposite the CQA monitor will observe the following:

- The drainage geocomposite is wrapped in rolls with protective covering.
- The rolls are not damaged during unloading.
- Protect the drainage geocomposite from mud, soil, dirt, dust, debris, cutting, or impact forces.
- Each roll must be marked or tagged with proper identification.

Any damaged rolls will be rejected and removed from the site or stored at a location, separate from accepted rolls, designated by the Operator. All rolls which do not have proper manufacturer's documentation will also be stored at a separate location until all documentation has been received and approved. During the installation the CQA monitor will observe the following.

- The subgrade has been prepared in accordance with the earthwork specifications outlined in Section 2. All lines and grades have been verified by the surveyor.
- The supporting surface does not contain stones that could damage the drainage geocomposite.

- All repairs are to be made in accordance with the specifications outlined in Section 3.6.4.
- Equipment used does not damage the drainage geocomposite by handling, trafficking, leakage of hydrocarbons, or by other means.
- People working on the drainage geocomposite will not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite.
- The drainage geocomposite is anchored to prevent movement by the wind.
- The drainage geocomposite remains free of contaminants such as soil, grease, fuel, etc.
- The drainage geocomposite is laid smooth and free of tension, stress, folds, wrinkles, or creases.
- On slopes the geocomposite is secured in the anchor trench and then rolled down the slope.
- Adjacent rolls of drainage geocomposite are overlapped a minimum of six inches, tied, and seamed in accordance with the manufacturer's recommendations.
- Observe that drainage geocomposite is overlapped and either heat bonded or sewn together.
- Holes or tears in the drainage geocomposite will be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
- Secure patch to the originally installed geocomposite by tying every 6 inches.
- Where the hole or tear width across the roll is more than 50 percent of the roll width, the damaged area will be cut out across the entire roll and the two portions of the drainage geocomposite will be joined.

6.5.5 Documentation

Dewatering system installation will be incorporated into the SLER for each cell in accordance with Section 8. The installed dewatering system will be operated until a BER prepared in accordance with Section 8.3 is approved by the TCEQ.

6.5.6 Dewatering System Operation

When pumps are used for the dewatering system, regardless of its location, they will be inspected on a weekly basis to monitor groundwater discharge at the pump outlet pipe. The amount of groundwater pumped will be recorded on a monthly basis. The pumps will be equipped with pressure transducers and the transducer readings will be recorded on a weekly basis to ensure that groundwater pressure in the sump is below the geomembrane elevations. As an alternative to measuring groundwater levels with automatic pressure transducers, the groundwater levels in the dewatering sump may be checked manually by using a calibrated rod that will be lowered into the extraction riser or an equivalent method. The POR will identify the allowable head in the groundwater dewatering sump for each installation. All information/data generated associated with each groundwater dewatering operation will be kept in the site operating record. The dewatering pipes will be cleaned out if it is determined that they are clogged. The determination may be based upon an unexpected decrease in flow of groundwater to the dewatering sump. Each groundwater dewatering system installed will be operational until a ballast evaluation report is approved by the TCEQ.

6.6 Stability of Shale Strata

The temporary dewatering system discussed in Section 6.3 is developed for the uppermost groundwater bearing zone which is located at elevations above the excavation grades (refer to Sheet IIID-C-5 in Appendix IIID-C for the groundwater seepage areas). Below the uppermost groundwater zone, the Shale Strata provides a barrier layer (or aquiclude) to the groundwater in the Woodbine Strata. The top of Woodbine Strata contours are shown on Figure IIIG-C-12 in Appendix IIIG – Geology Report. As shown on Sheet IIID-C-5, the bottom of future excavation areas extends below the top of the Shale Strata. Cells 12 and 13 are significantly deeper than the other undeveloped cells, and the EDE for these cells is 387 ft-msl. The top of Woodbine elevation in the Cell 12 and 13 area ranges from about 340 ft-msl to 350 ft-msl. Therefore, there is approximately 40 feet of Shale Strata separating the bottom of excavation from the top of Woodbine. This 40-foot-thick shale layer provides a barrier layer between the bottom of the landfill and the Woodbine Strata.

As part of the site exploration, a borehole (WB-4) was drilled to the Woodbine Formation (refer to Figure IIIG-C-2 in Appendix IIIG). The water level in the Woodbine Formation was observed to be about 2.5 feet below the bottom of the Shale Strata. Based on this information, the Woodbine is unconfined below the Cell 12 and 13 area.

As noted in Section 1.4.1 in Appendix IIIG, regional hydrogeological information indicates that the Woodbine Aquifer is confined by the Eagle Ford Shale Strata in the area. Thus, the potential exists that hydrostatic uplift forces could develop on the bottom of the Shale Strata in the future. Therefore, the potentiometric level in the Woodbine Aquifer will be verified prior to construction to confirm that any hydrostatic pressure on the Shale Strata is at acceptable levels before proceeding with excavation and liner construction.

As discussed in Appendix IIID-C, at least two months prior to construction of Cells 12 and 13, piezometers will be installed to monitor the water levels of the Woodbine Strata. The POR will develop a demonstration, which is outlined in Appendix IIID-C, to show that the water levels in the Woodbine Strata will not adversely affect the shale layer (i.e., verify that any hydrostatic pressure on the Shale Strata will be at acceptable levels). The POR will include the groundwater level data obtained from the Woodbine and the demonstration in the SLER for the constructed liner. Upon approval of the SLER, the

POR will decommission the observation piezometers in accordance with the applicable state regulations.

6.7 Liner System Ballast

Ballasting is required to protect the liner system from hydrostatic uplift in areas of the landfill excavation which have been identified to exist below the highest measured groundwater potentiometric surface as defined in Section 6.2. The protective cover soil above the liner system, as well as additional waste placed above the liner system will provide the necessary ballast (weight) for protection of the liner system from hydrostatic uplift.

The factor of safety against hydrostatic uplift must be calculated for those portions of the liner where the liner is below the highest groundwater potentiometric surface. The calculated factor of safety against uplift at the liner (using the weight of the protective cover and waste) must be 1.5. The thickness of ballast required to ballast the uplift force must be calculated and submitted with the GLER. Procedures for calculating the anticipated hydrostatic uplift forces, factor of safety against uplift, and required thickness of ballast are included in Appendix IIID-B. Additionally, example ballast calculations are included in Appendix IIID-B. The most recent highest measured groundwater data as defined in Section 6.2 will be used for ballast calculation. The ballast demonstration included in Appendix IIID-B must be updated each time a dewatering system is installed to account for possible higher hydrostatic head measurements.

6.7.1 Waste-As-Ballast Placement Record

When waste is used for ballast, landfill personnel working under the supervision of the site manager will be on site full-time during the placement of the first 5 feet of waste over the liner system. The site operator will verify and document on a daily basis that this lower 5 feet of waste does not contain large bulky items, which cannot be compacted to the required density. The site operator will also document on a daily basis that the waste used for ballast has been properly compacted with compaction equipment, which weighs in excess of 40,000 pounds. When waste is used as ballast, the factor of safety against hydrostatic pressure uplift at the geomembrane liner will be 1.5. This documentation will be placed in the site operating record.

Additionally, the Site Manager will complete and sign a waste-as-ballast placement record that will be attached to the BER (see Section 8 for BER required documentation). The form to be used by the Site Manager is included in Appendix IIID-D. One form will be required for each area (or combination of areas) described by approved liner evaluation reports.

6.8 Liner Performance Verification

When ballast is required for a liner, the POR or his representative will verify that the ballast meets the established criteria and uplift of the liner system did not occur during construction. The verification, including but not limited to inspections, compaction, weight, density of material, thickness, and top elevations, will be documented in the BER, which will be submitted to the TCEQ for approval (see Section 8). In the event that uplift occurs, the POR will develop a corrective action to remediate the uplift. The POR will immediately contact the TCEQ and implement initial procedures as soon as the uplift is detected.

6.8.1 Observations for Indications of Seepage

The POR or his representative will observe the liner subgrade for the presence of seepage during construction. To aid in the documentation that short-term uplift has not occurred during ballast placement, the POR will provide a summary of where seepage, if any, was observed, the methods and procedures used to control the seepage, and observations that all seepage has been controlled.

6.8.2 Surveying During Construction

To document that short-term uplift has not occurred during construction of the liner, the POR will verify that the elevations of the geomembrane liner are consistent with the geomembrane liner elevations shown on the construction drawings. The POR will also verify that the protective cover elevations have not increased from those submitted with the GLER. The protective cover elevations will be taken once between the GLER approval and waste placement to document no short-term uplift has occurred. Survey measurements to check against uplift will be taken at a minimum frequency of one measurement per 10,000 square feet by a third party surveyor.

6.9 Documentation

Documentation for issues related to construction below the high water table will be included in the SLER, GLER, and BER. These documents are discussed in detail in Section 8. Documentation specifically related to liners constructed below the highest measured groundwater potentiometric surface will include:

- A current highest measured potentiometric surface map and recent water-level information (Section 6.2).
- A discussion addressing the areas (if any) where the bottom of compacted clay liner extends below the highest measured potentiometric level.
- A discussion identifying the groundwater condition.
- Uplift and ballast calculations for liners with an installed dewatering system.

- A discussion addressing any seepage that may have been encountered.
- Description of the dewatering system installed.
- The BER will contain the documentation substantiating that the appropriate depth of ballast has been placed over the liner system and that the liner did not experience hydrostatic uplift.

7 GEOTECHNICAL STRENGTH TESTING REQUIREMENTS

This section of the LQCP addresses the geotechnical strength requirements for the Subtitle D bottom liner and overliner system. Each component of the Subtitle D bottom liner and overliner system is subject to the material testing requirements outlined in Sections 2 through 6 of this LQCP, as applicable. Prior to each Subtitle D bottom liner and overliner construction event, the geotechnical testing outlined in Table 7-1 will be performed using actual materials to verify that the Subtitle D bottom liner and overliner meet the material strength requirements. A geotechnical analysis using the strength parameters listed in Table 7-1 is presented in Appendix IIIJ.

The testing outlined in Table 7-1 will be performed under the supervision of the POR by a third party independent geotechnical laboratory. The POR will ensure that (1) the strength values are met, or (2) provide an updated geotechnical analysis in the GLER that will be submitted to TCEQ after each liner and overliner construction event. If the geotechnical analysis is updated, the resulting factor of safety values must meet the recommended minimum factor of safety values established in Appendix IIIJ.

Table 7-1
Minimum Required Strength for Various Parameters for Subtitle D Liner, Geotechnical Bottom Liner, and Overliner Components[1]

Interface Description	Peak Strength		Residual Strength	
	Adhesion (psf)	Friction Angle (degree)	Adhesion (psf)	Friction Angle (degree)
Liner System Component Interface				
Protective Cover/Double-sided Geocomposite Interface	100	18	80	14
Geocomposite/Textured HDPE Geomembrane Interface	100	21	80	10
Textured HDPE Geomembrane/Clay Liner Interface	200	15	80	10
Clay Liner (Internal)	100	18	80	13
Clay Liner/Underdrain Geocomposite Interface	200	18	80	10
Underdrain Geocomposite/Subgrade Interface	200	15	80	10
Protective Cover/Single-sided Geocomposite-Geotextile Interface	100	18	80	14
Single-sided Geocomposite-Geonet/Smooth HDPE Geomembrane Interface	100	13	80	8
Smooth HDPE Geomembrane/Clay Liner Interface	100	13	80	8
Overliner Component Interface				
Overliner Protective Cover (Internal)	100	18	80	10
Overliner Protective Cover/Double-sided Geocomposite-Geotextile	100	18	80	14
Double-sided Geocomposite/Textured LLDPE Geomembrane	100	21	80	10
Textured LLDPE Geomembrane/Reinforced GCL Interface	100	18	80	10
Reinforced GCL (Internal)	100	24	80	11
Reinforced GCL/Soil Subgrade Interface	100	25	80	12

[1] The adhesion and interface friction angle of liner and overliner components will be determined using ASTM D5321 by a third party verified geotechnical laboratory to verify they meet the values used in the slope stability analysis included in Appendix IIIJ-A. This test may be performed using stack testing (i.e., performing a single test combining all components of the bottom liner or overliner system). Refer to Appendix IIIJ-A-4 for detailed strength information and procedures for calculating factors of safety.

8 DOCUMENTATION

The quality assurance plan depends on thorough monitoring and documentation of all construction activities. Therefore, the POR and CQA monitor will document that all quality assurance requirements have been addressed and satisfied. Documentation will consist of daily recordkeeping, testing and installation reports, nonconformance reports (if necessary), progress reports, photographic records, and design and specification revisions. The appropriate documentation will be included in the SLER, GCLER, GLER, and BER (if required). Standard report forms will be provided by the POR prior to construction.

8.1 Preparation of SLER, GCLER, and GLER

The POR will submit to the TCEQ a SLER for review and acceptance for each soil liner portion of the composite liner. After construction of the geosynthetics portion of the liner, the POR will submit a GCLER and a GLER to the TCEQ for review and acceptance. For the overliner construction, only submittal of a GCLER and a GLER will be required. The GCLER and the GLER may be submitted as a single document. All of these reports will be approved by TCEQ prior to placement of solid waste over the specified constructed area.

Testing, evaluation, and submission of the SLERs, GCLERs, and GLERs for the composite liner system and overliner system will be in accordance with this LQCP. The construction methods and test procedures documented in the SLERs, GCLERs, and GLERs will be consistent with this LQCP, the TCEQ MSWR, and specifications outlined in this LQCP.

At a minimum, the SLER, GCLER, and GLER will contain:

- A summary of all construction activities.
- A summary of all laboratory and field test results.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- As-built record drawings signed and sealed by a licensed Texas land surveyor.
- A statement of compliance with the permit LQCP and construction plans.

- The reports will be signed and stamped by a professional engineer(s) licensed to practice in the state of Texas.

The as-built record drawings will accurately identify the constructed location of all work items, including the piping and anchor trenches. The POR will review and verify that as-built drawings are correct. As-built drawings will be included in the SLER and GLER as appropriate.

8.2 Reporting Requirements

The SLER, GCLER, and GLER will be signed and sealed by the POR and signed by the Site Manager and submitted in triplicate (including all attachments) to the MSW Permits Section of the Waste Permits Division of the TCEQ for review and acceptance. If the Executive Director provides no response, either written or verbal, within 14 days of receipt, the owner or operator may continue facility construction or operation. Any notice of deficiency received from the TCEQ will be promptly addressed and incorporated into the SLER/GCLER/GLER report. No solid waste will be placed over the constructed liner areas until the final acceptance is obtained from the TCEQ. Additionally, upon approval of this application if a new liner area is developed, prior to accepting any solid waste to the newly developed liner area, a pre-opening inspection will be requested. The TCEQ staff will conduct a pre-opening inspection within 14 days of the request. If the TCEQ does not provide a written or verbal response 14 days after conducting the pre-opening inspection, the newly developed liner area will be considered acceptable for solid waste placement, given that the SLER, GCLER, and GLER for the area are also submitted to the TCEQ in accordance with this section.

If a layer of waste is not placed over the top of the protective cover in the dewatering system installation area within 6 months, then the POR will visually observe that the liner is not damaged (e.g., excessive erosion) due to prolonged exposure of the surface of the protective cover. Repairs will be done promptly and the POR will report findings and measures taken to repair damage in a letter report to the executive director for review and acceptance.

8.3 Ballast Evaluation Report

Existing and future dewatering system BERs will be submitted in accordance with this section. A BER will be completed and filed with the TCEQ documenting that enough ballast has been placed in a lined area to offset the potential hydrostatic uplift forces which may exist below the liner system. At a minimum, the information listed below will be included as applicable with the BER.

- The top of protective cover elevations immediately after construction compared to the elevations obtained between SLER approval and waste placement, to document the liner did not undergo uplift prior to placement of waste (whether waste ballast is required or not).

- If waste is used for ballast, verification from the Site Manager that the weight of the compaction equipment being used to compact the waste ballast is no less than 40,000 pounds, and that this compaction equipment was utilized during the entire period of placing waste ballast.
- If waste is used for ballast, documentation of the observations that the initial 5 feet of waste used for ballast on the liner system is free of brush and large bulky items, which may not be compacted to the required density.
- A waste-as-ballast placement record (Appendix IIID-D) completed and signed by the Site Manager.
- Survey of the top of waste to document that the required waste ballast thickness has been placed.
- Water-level measurements taken in the site monitor well/piezometer system adjacent to the liner construction area to verify that the groundwater level has not exceeded the design high water level.
- Final ballast thickness calculation using procedures included in Appendix IIID-B and the as-built minimum densities and thicknesses for each component as well as updated groundwater levels.

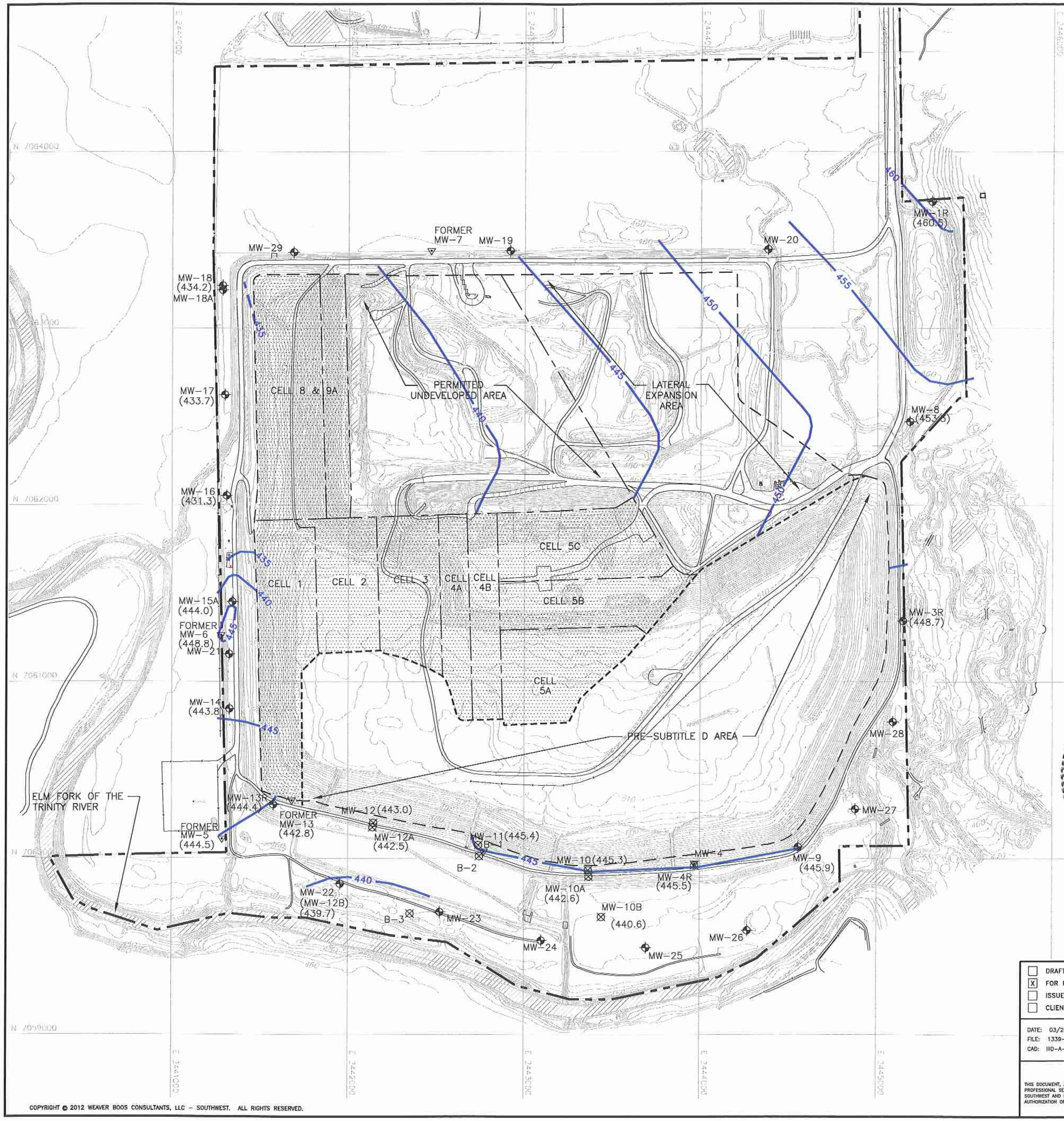
APPENDIX IIID-A

HIGHEST MEASURED GROUNDWATER INFORMATION

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

3-21-12

Includes page IIID-A-1



NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.
3. GROUNDWATER CONTOURS WERE PRODUCED USING EACH WELL'S HIGHEST RECORDED GROUNDWATER ELEVATION AND DO NOT REPRESENT A SINGLE GROUNDWATER MONITORING EVENT OR ACTUAL GROUNDWATER SURFACE.
4. VALUES SHOWN ARE THE HIGHEST MEASURED GROUNDWATER ELEVATIONS IN FT-MSL.

NEVZAT TURAN
84059

3-21-12

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION
☐ CLIENT APPROVAL BY: ____________

DATE: 03/2012
FILE: 1339-351-11
CAD: IIID-A-1 HIGH GW MAP.dwg

DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

REUSE OF DOCUMENTS

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PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
HIGHEST MEASURED GROUNDWATER MAP

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

FORT WORTH, TX
(817) 735-9770

GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

DRAWING IIID-A-1

O:\1339\351\EXPANSION 2009\PART III-SDP\IIID\IIID-A-1 HIGHEST GW MAP.dwg, jwilson, 1:2

APPENDIX IIID-B

EXAMPLE BALLAST THICKNESS CALCULATIONS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

3-21-12

Includes pages IIID-B-1 through IIID-B-9

BALLAST THICKNESS CALCULATION

The ballast requirements evaluated in this appendix are based on the current highest measured groundwater surface shown on Drawing IIID-A-1. As discussed in Section 6.7, the ballast calculations are performed assuming that the maximum hydrostatic uplift pressure acts at the geomembrane liner. The evaluation points on the sideslopes were calculated in the vertical and the normal directions.

The actual thickness of ballast required must be calculated and submitted with the Soil Liner Evaluation Report (SLER). A summary of the procedure, which will be used to calculate ballast thickness, is discussed below. Example calculations are also presented on pages IIID-B-4 through IIID-B-6. The lined area may be divided into smaller subareas to determine the ballast requirements. The thickness of ballast required will be calculated using the following methodology:

A. The highest groundwater potentiometric surface elevations will be determined from the updated water level data as discussed in Section 6.2 and illustrated in Appendix IIID-A.

At each evaluation point, determine the maximum hydrostatic uplift pressures acting at the geomembrane liner.

At each evaluation point, determine the uplift pressure acting on the geomembrane liner using the unit weight of water times the vertical distance from the geomembrane liner to the highest measured water table.

$$P_{H2O=}\gamma_{H2O}{*}\mathrm{H}$$

where:

γ_{H2O} = unit weight of water (pcf)

H = vertical distance from the bottom of the liner (ft)

P_{H20} = uplift pressure on the base of the liner (psf)

B. At each evaluation point, determine the resisting pressure for both vertical and normal directions on sideslopes against uplift.

Determine the vertical and normal resisting pressure at the evaluation points using the unit weight of the protective cover layer times the thickness of the protective cover layer.

$$\Sigma\, R_{i,v} = \Sigma(\gamma_i{*}\mathrm{T}_{i,})$$

where:
$T_{i,v}$ = thickness of ballast component (protective cover) in vertical direction
γ_i = unit weight (pcf) of ballast component (protective cover)
$R_{i,v}$ = resisting pressure (psf) provided by each ballast component (protective cover) in vertical direction

$$\sum R_{i,n} = \Sigma(\gamma_i * T_{i,n})$$

where:
$T_{i,n}$ = thickness of ballast component (protective cover) in normal direction
γ_i = unit weight (pcf) of ballast component (protective cover)
$R_{i,n}$ = resisting pressure (psf) provided by each ballast component (protective cover) in normal direction

C. Evaluate the factor of safety in the vertical and normal direction at each evaluation point as a ratio of the total resisting pressure to uplift pressure.

The factor of safety (FS) against uplift due to the hydrostatic pressure acting at the geomembrane liner in the vertical and normal direction is calculated as the resisting pressure determined in B divided by the uplift pressure determined in A.

$$FS_v = \sum R_{i,v} / P_{H2O}$$

$$FS_n = \sum R_{i,n} / P_{H2O}$$

If the factor of safety is less than 1.2, additional ballast will be necessary to offset the hydrostatic forces. See Section D for determining the thickness of additional ballast if necessary.

D. Determine the additional ballast necessary to offset hydrostatic pressures acting at the bottom of the liner in the vertical and normal direction.

If the factor of safety calculated in Section C is less than 1.2, determine the thickness of additional ballast in the form of waste (T_{waste}) in the vertical and normal direction to offset the hydrostatic uplift pressure at the evaluation point.

Use a factor of safety of 1.5 against uplift pressure when utilizing solid waste and protective cover.

Use a unit weight of 1200 lb/cy for in-place solid waste per Title 30 TAC §330.337(h)(2).

Calculate the minimum required waste column thickness that provides additional ballast to offset the hydrostatic uplift pressure with a factor of safety of 1.5 in the vertical direction.

$$R_{waste,v} = \gamma_{waste} * T_{waste,v}$$

where:
$T_{waste,v}$ = waste thickness (ft) in vertical direction
γ_{waste} = unit weight of waste (pcf)
$R_{waste,v}$ = resisting pressure of waste (psf) in vertical direction

$$P_{H2O} = \frac{\sum R_{i,v}}{1.5} + \frac{R_{waste,v}}{1.5}$$

Substituting appropriate values and solving for height of waste in the vertical direction:

$$T_{waste,v} = \frac{1.5}{\gamma_{waste}} * \left(P_{H2O} - \frac{\sum R_{i,v}}{1.5} \right)$$

Calculate the minimum required waste column thickness that provides additional ballast to offset the hydrostatic uplift pressure with a factor of safety of 1.5 in the normal direction.

$$R_{waste,n} = \gamma_{waste} * T_{waste,n}$$

where:
$T_{waste,n}$ = waste thickness (ft) in normal direction
γ_{waste} = unit weight of waste (pcf)
$R_{waste,n}$ = resisting pressure of waste (psf) in normal direction

$$P_{H2O} = \frac{\sum R_{i,n}}{1.5} + \frac{R_{waste,n}}{1.5}$$

Substituting the appropriate values and solving for height of waste in the normal direction:

$$T_{waste,n} = \frac{1.5}{\gamma_{waste}} * \left(P_{H2O} - \frac{\sum R_{i,n}}{1.5} \right)$$

If waste and protective cover do not provide enough ballast against uplift, final cover will be used for ballast with a factor of safety of 1.5.

Prep By: JLG
Date: 3/20/2012

Chkd By: MDM
Date: 3.20.12

CAMELOT LANDFILL
1339-351-11
EXAMPLE BALLAST THICKNESS CALCULATIONS
EVALUATION OF SIDEWALL OF LINER

Required: Provide example calculations to be used to estimate the amount of ballast required for the sidewall of the liner prior to decommissioning the dewatering system.

Solution: Estimate the amount of ballast needed for the sidewall of the liner.

An example calculation using Evaluation Point No. 2 is shown below. A summary of the calculation results for each evaluation point located on the liner side slopes is shown on Sheet IIID-B-7. Sheet IIID-B-8 shows the location of the evaluation points and the top of waste elevation required for ballast at each evaluation point. Sheet IIID-B-9 provides a typical cross section showing the top of waste grades required for ballast.

Definition of terms/variables:

H = Maximum groundwater head above top of clay liner, ft
P_{H20} = Maximum uplift pressure created by groundwater head, psf
$R_{pc,\,v}$ = Counteracting ballast pressure from protective cover - vertical, psf
$R_{pc,\,n}$ = Counteracting ballast pressure from protective cover - normal, psf
E_{H20} = Highest potentiometric surface elevation, ft-msl
E_{liner} = Elevation of top of clay liner (geomembrane), ft-msl
$E_{waste,\,v}$ = Required top of waste elevation needed for ballast - vertical, ft-msl
$E_{waste,\,n}$ = Required top of waste elevation needed for ballast - normal, ft-msl
γ_{H20} = Unit weight of water, pcf
γ_{pc} = Unit weight of protective cover, pcf
γ_{waste} = Unit weight of waste, lb/cy (Assumed to be 1200 lb/cy per 30 TAC Section 330.337(h)(2).)
$T_{pc,\,v}$ = Thickness of protective cover as ballast - vertical, ft
$T_{pc,\,n}$ = Thickness of protective cover as ballast - normal, ft
$T_{waste,\,v}$ = Required waste thickness needed for ballast - vertical, ft
$T_{waste,\,n}$ = Required waste thickness needed for ballast - normal, ft
$E_{pc,v}$ = Elevation of top of protective cover - vertical, ft-msl
$E_{pc,n}$ = Elevation of top of protective cover - normal, ft-msl
$FS_{pc,\,v}$ = Calculated factor of safety with protective cover installed - vertical
$FS_{pc,\,n}$ = Calculated factor of safety with protective cover installed - normal
$E_{top\ waste,\,v}$ = Design top of waste elevation - vertical, ft-msl
$E_{top\ waste,\,n}$ = Design top of waste elevation - normal, ft-msl

Prep By: JLG
Date: 3/20/2012

Chkd By: MDM
Date: 3-20-12

CAMELOT LANDFILL
1339-351-11
EXAMPLE BALLAST THICKNESS CALCULATIONS
EVALUATION OF SIDEWALL OF LINER

Example calculation using Evaluation Point No. 2

Parameters:

$E_{H20} =$ 434.2 ft-msl
$E_{liner} =$ 421.1 ft-msl
$\gamma_{H20} =$ 62.4 pcf
$\beta =$ side slope angle = 18.43
$\cos\beta =$ 0.9487
$T_{pc,\,v} =$ 2.1 ft ($T_{pc,v}/\cos\beta$)
$T_{pc,\,n} =$ 2.0 ft

$\gamma_{pc} =$ 115 pcf
$\gamma_{waste} =$ 1200 lb/cy
$E_{top\ waste,\,v} =$ 501.5 ft-msl
$E_{top\ waste,\,n} =$ 509.1 ft-msl

Calculate the maximum groundwater head above the top of clay liner.

$H = E_{H20} - E_{liner}$
$H =$ 13.1 ft

Calculate the maximum hydrostatic uplift pressure created by the groundwater head.

$P_{H2O} = (\gamma_{H2O} \times H)$
$P_{H2O} =$ 817 psf

Calculate the counteracting ballast pressure from the protective cover in the vertical and normal directions.

$R_{pc,\,v} = (\gamma_{pc} \times T_{pc,\,v})$
$R_{pc,\,v} =$ 242 psf

$R_{pc,\,n} = (\gamma_{pc} \times T_{pc,\,n})$
$R_{pc,\,n} =$ 230 psf

Compare the uplift pressure to the ballast pressure by calculating the factors of safety in the vertical and normal direction with protective cover as ballast at the evaluation point.

$FS_{pc,\,v} = R_{pc,\,v}/P_{H2O} =$ 0.3

$FS_{pc,\,n} = R_{pc,\,n}/P_{H2O} =$ 0.3

The minimum required factor of safety for protective cover as ballast is 1.2. Since the factor of safety against uplift is less than 1.2 additional ballast (in the form of waste) will be necessary to counteract the hydrostatic uplift pressure acting at the top of clay liner (geomembrane). If the factor of safety against uplift was 1.2 or greater, then no additional ballast would be necessary indicating that the protective cover provides enough ballast to counteract the hydrostatic uplift pressure acting at the top of clay liner. When solid waste is necessary as ballast, a factor of safety of 1.5 is used for protective cover and solid waste.

CAMELOT LANDFILL
1339-351-11
EXAMPLE BALLAST THICKNESS CALCULATIONS
EVALUATION OF SIDEWALL OF LINER

Determine amount of additional ballast in the form of waste necessary to offset the hydrostatic pressure acting at the top of clay liner in the vertical and normal direction. Use a factor of safety of 1.5 for protective cover and solid waste.

$T_{waste,\,v} = [(1.5 \times P_{H2O}) - R_{pc,\,v}]/\gamma_{waste}$
$T_{waste,\,v} = 22.1$ ft

$E_{waste,\,v} = E_{liner} + T_{pc,\,v} + T_{waste,\,v}$
$E_{waste,\,v} = 445.3$ ft-msl

$T_{waste,\,n} = [(1.5 \times P_{H2O}) - R_{pc,\,n}]/\gamma_{waste}$
$T_{waste,\,n} = 22.4$ ft

$E_{waste,\,n} = E_{liner} + T_{pc,\,n} + T_{waste,\,n}$
$E_{waste,\,n} = 445.5$ ft-msl

Check to verify that the required top of waste elevation is less than the design top of waste elevation in the vertical and normal direction.

$E_{top\ waste,\,v} = 501.5$ ft-msl

$E_{top\ waste,\,v} > E_{waste,\,v}$
501.5 ft-msl > 445.3 ft-msl

$E_{top\ waste,\,n} = 509.1$ ft-msl

$E_{top\ waste,\,n} > E_{waste,\,n}$
509.1 ft-msl > 445.5 ft-msl

The required top of waste elevation needed as ballast is less than the design top of waste elevation. Therefore, the design top of waste elevation allows for the required top of waste elevation needed for ballast.

Prep By: JLG
Date: 3/20/2012

Chkd By: MDM
Date: 3-20-12

CAMELOT LANDFILL
1339-351-11
EXAMPLE BALLAST THICKNESS CALCULATIONS
EVALUATION OF SIDEWALL OF LINER

Unit Weight of Water = 62.4 pcf
Unit Weight of Protective Cover = 115 pcf
Unit Weight of Waste = 1200 pcy

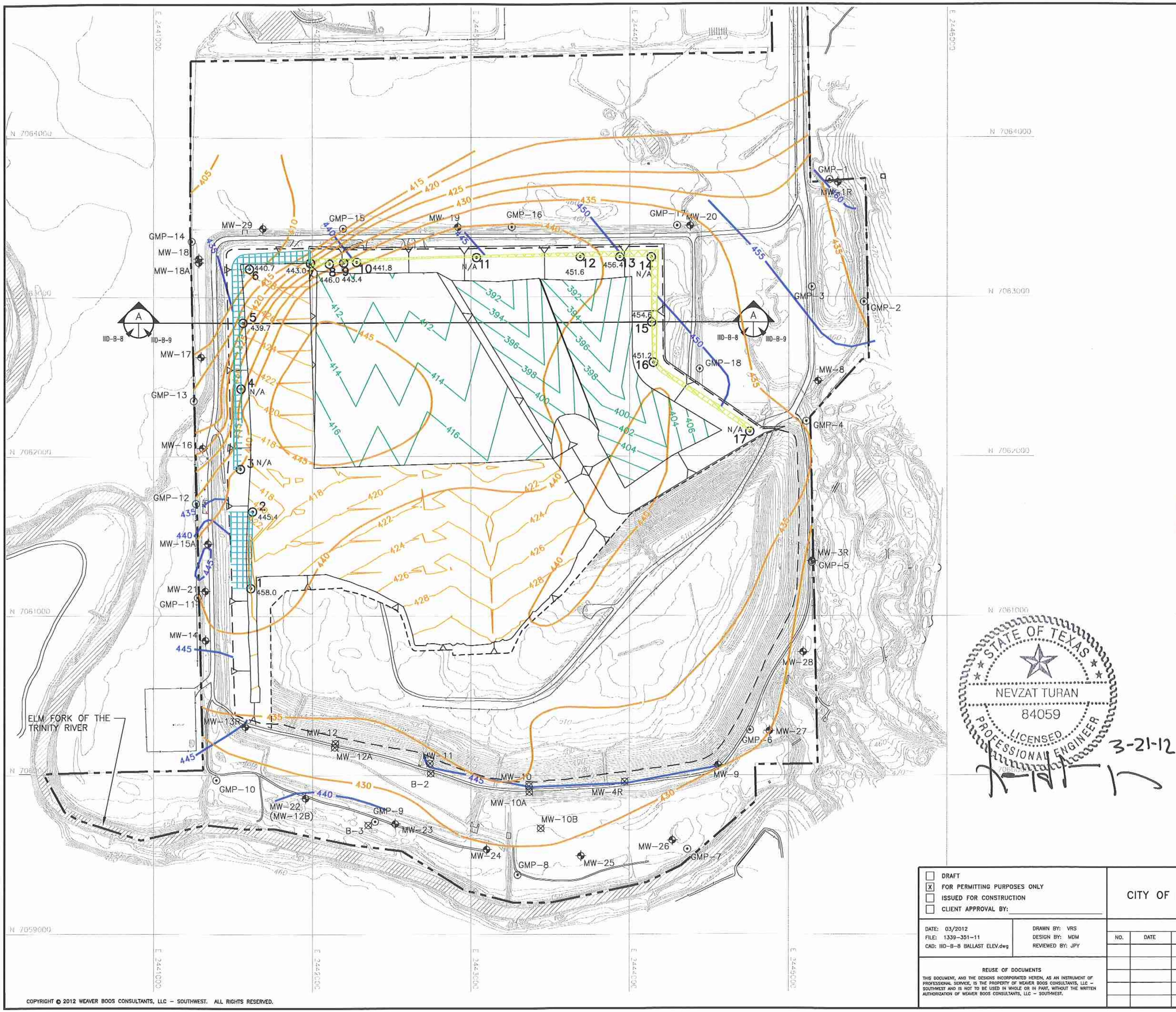
Thickness of Protective Cover - Vertical = 2.1 ft
Thickness of Protective Cover - Normal = 2.0 ft

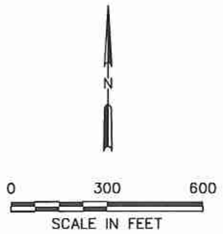
Evaluation Point	Highest Potentiometric Surface Elevation[2] E_{H2O} (ft-msl)	Elevation of Top of Clay Liner E_{liner} (ft-msl)	Maximum Groundwater Head Above Top of Clay Liner[3] H (ft)	Maximum Uplift Pressure Created by Groundwater Head P_{H2O} (psf)	Elevation of Top of Protective Cover - Vertical $E_{pc,v}$ (ft-msl)	Elevation of Top of Protective Cover - Normal $E_{pc,n}$ (ft-msl)	Counteracting Ballast Pressure from Protective Cover - Vertical $R_{pc,v}$ (psf)	Counteracting Ballast Pressure from Protective Cover - Normal $R_{pc,n}$ (psf)	Calculated Factor of Safety with Protective Cover Installed - Vertical	Calculated Factor of Safety with Protective Cover Installed - Normal	Factor of Safety - Vertical > 1.2?	Factor of Safety - Normal > 1.2?	Required Waste Thickness Needed for Ballast - Vertical[1] $T_{waste,v}$ (ft)	Required Waste Thickness Needed for Ballast - Normal[1] $T_{waste,n}$ (ft)	Required Top of Waste Elevation Needed for Ballast - Vertical $E_{waste,v}$ (ft-msl)	Required Top of Waste Elevation Needed for Ballast - Normal $E_{waste,n}$ (ft-msl)	Design Top of Waste Elevation - Vertical $E_{top\ waste,v}$ (ft-msl)	Design Top of Waste Elevation - Normal $E_{top\ waste,n}$ (ft-msl)	Required Waste Needed for Ballast Elevation < Design Top of Waste Elevation - Vertical?	Required Waste Needed for Ballast Elevation < Design Top of Waste Elevation - Normal?
1	441.6	423.8	17.8	1,110.7	425.9	425.8	242	230	0.2	0.2	NO	NO	32.1	32.3	458.0	458.1	492.5	499.1	YES	YES
2	434.2	421.1	13.1	817.4	423.2	423.1	242	230	0.3	0.3	NO	NO	22.2	22.4	445.4	445.5	501.5	509.1	YES	YES
3	433.0	434.8	N/A	N/A	436.9	436.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	434.0	435.3	N/A	N/A	437.4	437.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	435.2	428.1	7.1	443.0	430.2	430.1	242	230	0.5	0.5	NO	NO	9.5	9.8	439.7	439.9	487.8	493.5	YES	YES
6	436.1	428.9	7.2	449.3	431.0	430.9	242	230	0.5	0.5	NO	NO	9.7	10.0	440.7	440.9	494.3	500.6	YES	YES
7	438.6	431.6	7.0	436.3	433.7	433.6	242	230	0.6	0.5	NO	NO	9.3	9.5	443.0	443.2	488.5	494.0	YES	YES
8	439.2	430.0	9.2	573.6	432.1	432.0	242	230	0.4	0.4	NO	NO	13.9	14.2	446.0	446.2	489.3	495.0	YES	YES
9	439.7	433.3	6.4	398.8	435.4	435.3	242	230	0.6	0.6	NO	NO	8.0	8.3	443.4	443.6	487.1	492.3	YES	YES
10	440.1	435.5	4.6	286.5	437.6	437.5	242	230	0.8	0.8	NO	NO	4.2	4.5	441.8	442.0	485.5	490.4	YES	YES
11	444.7	442.9	1.8	111.8	445.0	444.9	242	230	2.2	2.1	YES	YES	-	-	-	-	-	-	-	-
12	448.4	442.5	5.9	367.6	444.6	444.5	242	230	0.7	0.6	NO	NO	7.0	7.2	451.6	451.7	480.3	484.2	YES	YES
13	449.9	441.0	8.9	554.8	443.1	443.0	242	230	0.4	0.4	NO	NO	13.3	13.6	456.4	456.6	481.4	485.4	YES	YES
14	451.1	453.6	N/A	N/A	455.7	455.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	449.0	440.9	8.1	504.9	443.0	442.9	242	230	0.5	0.5	NO	NO	11.6	11.9	454.6	454.8	484.5	489.0	YES	YES
16	447.9	441.9	6.0	373.9	444.0	443.9	242	230	0.6	0.6	NO	NO	7.2	7.4	451.2	451.4	484.9	489.1	YES	YES
17	451.6	456.6	N/A	N/A	458.7	458.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] The required waste thickness needed for ballast in the vertical and normal direction, $T_{waste,v}$ and $T_{waste,n}$, was calculated using the minimum required factor of safety of 1.5 for waste and protective cover as ballast. See page IIID-B-6 for formula used for this calculation. In addition, ballast calculations will be adjusted for updated highest measured potentiometric surface. The highest measured potentiometric surface can only be adjusted upward.

[2] Refer to Section 6.2 for discussion on highest measured groundwater. Also see Drawing IIID-A-1 in Appendix IIID-A.

[3] The highest measured groundwater contours are compared to excavation contours to verify the impact of groundwater. The ballast evaluation has been performed for the geomembrane liner elevations (i.e., top of compacted clay liner); therefore if the groundwater head is below the geomembrane elevation ballast is not applicable.





LEGEND

— - —	PERMIT BOUNDARY
— — —	LIMIT OF WASTE
- - - - -	LIMITS OF PRE-SUBTITLE D WASTE
N 7063000	STATE PLANE COORDINATE SYSTEM
500	EXISTING CONTOUR
MW-8	GROUNDWATER MONITORING WELL
GMP-1	GAS MONITORING PROBE
☒ MW-12	OBSERVATION WELL
420	EXISTING TOP OF LINER
394	PROPOSED EXCAVATION CONTOUR
450	GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 3)
440	TOP OF SHALE ELEVATION CONTOUR IN FT-MSL (SEE NOTE 6)
◉ 3 443.1	BALLAST EVALUATION POINT (SEE NOTE 4)
▨	GROUNDWATER SEEPAGE SURFACE (SEE NOTE 7)
▦	EXTENT OF EXISTING GEOCOMPOSITE UNDERDRAIN

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.
3. GROUNDWATER CONTOURS WERE PRODUCED USING EACH WELL'S HIGHEST RECORDED GROUNDWATER ELEVATION AND DO NOT REPRESENT A SINGLE GROUNDWATER MONITORING EVENT OR ACTUAL GROUNDWATER SURFACE.
4. BALLAST EVALUATION POINT IS SHOWN WITH CALCULATED TOP OF WASTE ELEVATION REQUIRED FOR BALLAST IN THE VERTICAL DIRECTION (IN FT-MSL). N/A INDICATES THAT PROTECTIVE COVER IS SUFFICIENT BALLAST.
5. REFER TO APPENDIX IIID-C FOR DEWATERING SYSTEM INFORMATION.
6. TOP OF UNWEATHERED SHALE CONTOURS HAVE BEEN REPRODUCED FROM TOP OF SHALE MAP INCLUDED IN APPENDIX IIIG-C.
7. THE SHADED AREA INDICATES THE AREA FROM THE TOP OF HIGHEST MEASURED GROUNDWATER TO THE TOP OF THE UNWEATHERED SHALE AS DEFINED IN APPENDIX IIIG.

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DATE: 03/2012
FILE: 1339-351-11
CAD: IIID-B-8 BALLAST ELEV.dwg

DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
BALLAST ELEVATION SITE PLAN

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants

TBPE REGISTRATION NO. F-3727

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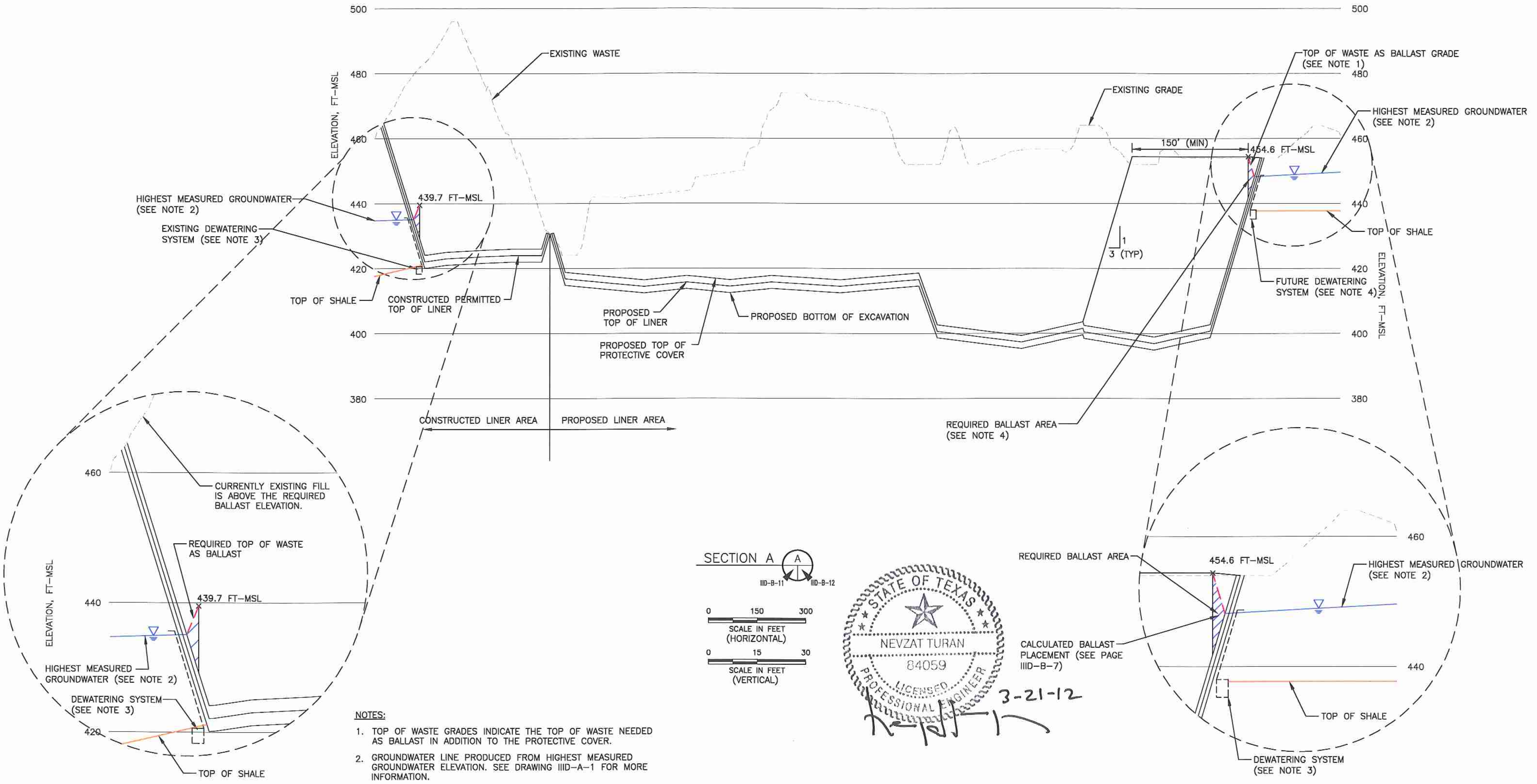
SHEET IIID-B-8

O:\1339\351\EXPANSION 2009\PART III-SDP\IIID\IIID-B-8 BALLAST ELEVATION.dwg, jwilson, 1:2



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NOTES:

1. TOP OF WASTE GRADES INDICATE THE TOP OF WASTE NEEDED AS BALLAST IN ADDITION TO THE PROTECTIVE COVER.
2. GROUNDWATER LINE PRODUCED FROM HIGHEST MEASURED GROUNDWATER ELEVATION. SEE DRAWING IIID–A–1 FOR MORE INFORMATION.
3. THE EXISTING DEWATERING SYSTEM CAN BE DECOMMISSIONED UPON APPROVAL OF A BALLAST EVALUATION REPORT BY TCEQ SINCE THE TOP OF EXISTING WASTE IS ABOVE THE REQUIRED TOP OF WASTE AS BALLAST.
4. FUTURE DEWATERING SYSTEM WILL BE INSTALLED ON THE SIDESLOPES TO DRAIN GROUNDWATER ABOVE THE SHALE. ADDITIONAL WASTE MAY BE REQUIRED OVER THE FLOOR GRADES TO FACILITATE FILLING OF THE WASTE AS BALLAST.

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SHEET IIID–B–9

0:\1339\351\EXPANSION 2009\PART III–SDP\IIID\IIID–B–9 BALLAST SEC.dwg, jwilson, 1:2

APPENDIX IIID-C

TEMPORARY DEWATERING SYSTEM DESIGN

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED PROFESSIONAL ENGINEER

3-21-12

Includes pages IIID-C-1 through IIID-C-45

TEMPORARY DEWATERING SYSTEM DESIGN

Temporary Dewatering System for the Uppermost Groundwater Zone

This appendix includes the design of the temporary dewatering system that will collect groundwater in the portions of the site that are excavated below the highest measured groundwater levels. This design is applicable to the undeveloped liner area. The dewatering trench will be constructed at the contact of the alluvium and Shale Strata with a minimum depth of 3 feet (minimum 2 feet into the shale) and a minimum width of 6 inches. The trench will be lined with a geotextile and contain a 4-inch-diameter perforated pipe, enveloped with gravel. A geocomposite drainage layer will extend up the slope to above the seasonal high water table to maintain the drawdown conditions produced by the open excavation.

Groundwater collected by the dewatering system will drain to the nearest open excavation or sumps located as shown on Sheet IIID-C-4. Any groundwater collected in the sumps will be removed using an 18-inch-diameter HDPE riser pipe and will be pumped to the perimeter stormwater system and discharged from the site consistent with TPDES Stormwater Permit. The dewatering system will be activated upon installation of the dewatering system and will remain operational until the BER is approved. Calculations and design information for the dewatering system design begin on page IIID-C-3.

Woodbine Water Level Verification Procedure

The temporary dewatering system design discussed above has been developed to collect groundwater in the Alluvial Strata (Lower Sand Zone discussed in Appendix IIIG, Section 2.1.1.2 – Lower Sand Zone). Below the uppermost groundwater zone, the Shale Strata provides a bottom layer (or aquiclude) to the groundwater in the Woodbine Strata (refer to Appendix IIIG, Section 2.1.3 – Woodbine Strata). The top of Woodbine is discussed in Appendix IIIG and depicted on Figure IIIG-C-12. A section that shows the top of Woodbine Strata is shown on Figure IIIG-C-2. The Shale Strata acts as the barrier layer between the bottom of the landfill and the Woodbine Strata. As shown on Sheet IIID-C-5, the bottom of future excavation areas extend below the top of the Shale Strata. Cells 12 and 13 are significantly deeper than the other undeveloped cells and the EDE for these cells is 387 ft-msl. The top of Woodbine elevation in the Cell 12 and 13 area ranges from about 340 ft-msl to 350 ft-msl.

As part of site exploration, borehole WB-4 was drilled to the Woodbine Formation (refer to Figure IIIG-C-2 in Appendix IIIG). The water level in the Woodbine Formation was observed to be about 2.5 feet below the bottom of the Shale Strata. Based on this information, the Woodbine is unconfined below the Cell 12 and 13 area. However, two piezometers will be installed at least two months prior to construction of Cells 12 and 13 to verify that hydrostatic head on the Woodbine Strata does not adversely impact the overlying Shale Strata. The locations of the piezometers are shown on Sheet IIID-C-5.

The POR will ensure that the piezometers are properly installed in the Woodbine Strata and sealed to prevent any interference from the groundwater found in the upper Alluvial Strata. The POR will evaluate the water level data from the installed piezometers following the procedure outlined in Table 1.

Table 1
Woodbine Water Level Verification Procedure for Cells 12 and 13

Terms	**Formulas**
E_{H2O} = Potentiometric surface elevation, ft-msl E_{ex} = Elevation of bottom of excavation, ft-msl E_{shale} = Elevation of bottom of shale, ft-msl T_{shale} = Thickness of shale, ft H = Groundwater head above bottom of excavation, ft γ_{H2O} = Unit weight of water, pcf P_{H2O} = Uplift pressure created by groundwater head, psf γ_{shale} = Unit weight of shale, pcf (average moist unit weight determined from geotechnical data presented in Appendix IIIJ-C) R_{shale} = Counteracting pressure from weight of shale, psf FS_{shale} = Calculated factor of safety with shale thickness after excavation	$T_{shale} = E_{ex} - E_{shale}$ $H = E_{H2O} - (E_{ex} - T_{shale})$ $R_{shale} = \gamma_{shale} \times T_{shale}$ $P_{H2O} = \gamma_{H2O} \times H$ $FS_{shale} = R_{shale} / P_{H2O}$
Determine Factor of Safety if Potentiometric Surface Matches EDE (387 ft-msl)	**Elevation of Potentiometric Surface that Results in a Factor of Safety of 1.3**
E_{H2O} = 387 ft-msl E_{ex} = 387 ft-msl Calculate Factor of Safety: T_{shale} = 387 ft-msl – 349 ft-msl = 38 ft H = 387 ft-msl – (387 ft-msl – 38 ft) = 38 ft R_{shale} = 129.7 pcf x 38 ft = 4,929 psf P_{H2O} = 62.4 pcf x 38 ft = 2,371 psf FS_{shale} = 4,929 psf / 2,371 psf = 2.1	FS_{shale} = 1.3 E_{ex} = 387 ft-msl Calculate Potentiometric Surface Elevation: T_{shale} = 387 ft-msl – 349 ft-msl = 38 ft R_{shale} = 129.7 pcf x 38 ft = 4,929 psf P_{H2O} = 4,929 psf / 1.3 = 3,791 psf H = 3,791 psf/62.4 pcf = 61 ft E_{H2O} = 61 ft + (387 ft-msl – 38 ft) = 410 ft-msl

POR must verify that the water levels measured in the piezometers will not result in an uplift stability issue. If an adequate factor of safety is not achieved, a permit modification will be submitted to TCEQ to either permit a hydrostatic pressure relief system or modify the exaction grades in Cells 12 and 13. As shown in Table 1, an elevation of 410 ft-msl results in a factor of safety of 1.3, which is a standard factor of safety for short-term conditions. As liner and protective cover are placed on excavation grades, the factor of safety against uplift will increase. POR will include water level measurements and the verification procedure outlined in Table 1 in the SLERs for Cell 12 and 13.

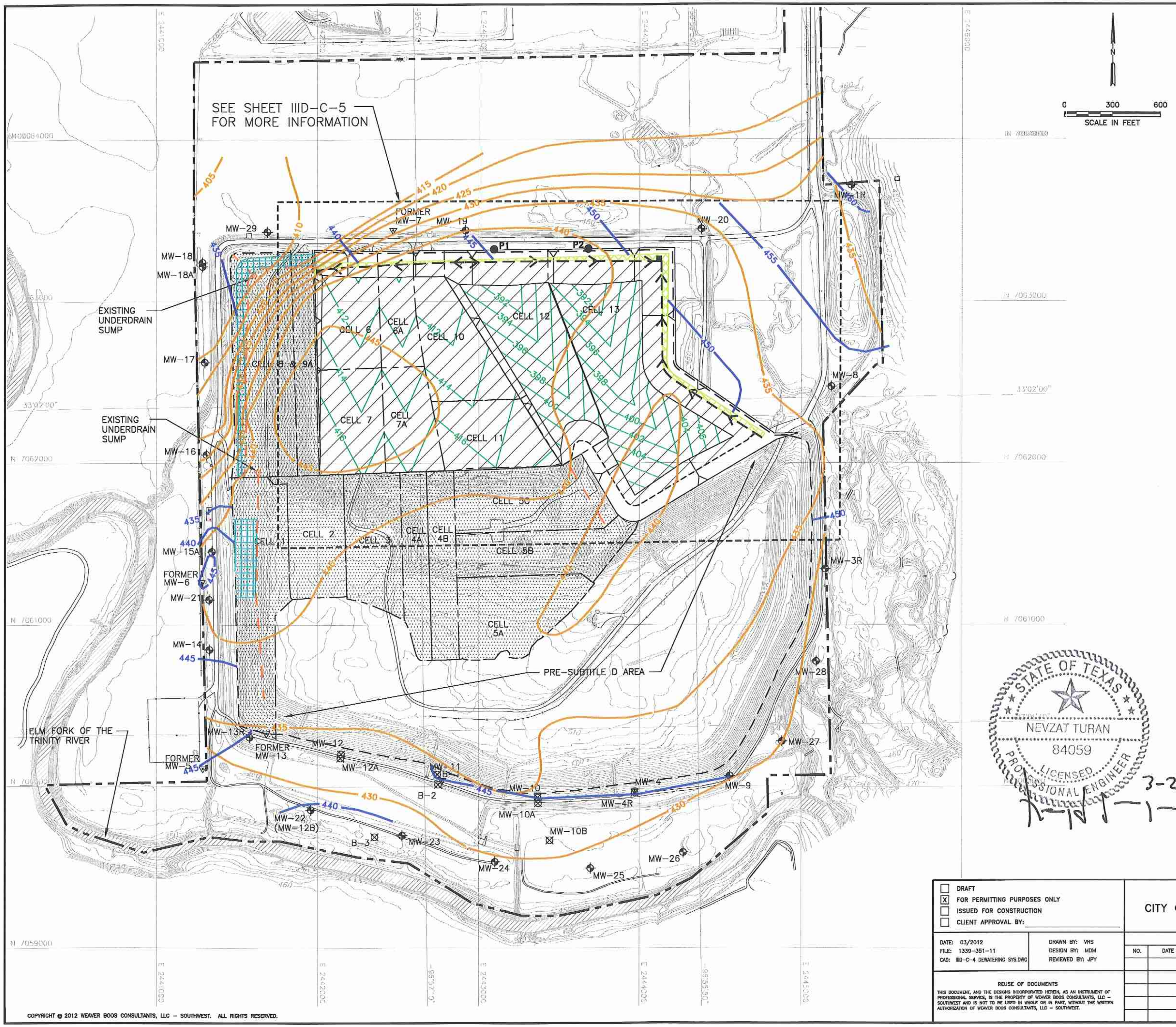
Required: Design the temporary dewatering trench system.

Method:

1. Design the temporary dewatering trench and determine pump size.
2. Design the temporary dewatering trench pipe.
3. Determine the stability of the temporary dewatering trench pipe and riser pipe.
4. Determine the properties of the drainage geocomposite.
5. Determine the geotextile properties around the granular drainage material.

References:

1. NAVFAC P-418/AFM 88-5
2. Camelot Landfill, Subtitle D Upgrade, Attachments 4 and 5, prepared by Reed Engineering Group, Inc., March 1996.
3. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems,* Pollution Technology Review No. 138, Noyles Data Corporation, 1986.
4. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.
5. Koerner, R.M., *Designing with Geosynthetics*, Second Edition, Prentice Hall, Inc., 1990.
6. Phillips 66 Driscopipe, *System Design*, 1991.



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3-21-12

LEGEND

— · — · —	PERMIT BOUNDARY
— — — —	LIMIT OF WASTE
N 7063000	STATE PLANE COORDINATE SYSTEM
500	EXISTING CONTOUR
— · · —	SECTOR BOUNDARY
398	EXCAVATION CONTOUR
MW-8	GROUNDWATER MONITORING WELL
☒ MW-12	OBSERVATION WELL
▽ FORMER MW-5	FORMER MONITORING WELL
▨	CONSTRUCTED SUBTITLE D LINED AREA
440	TOP OF SHALE ELEVATION CONTOUR IN FT-MSL
450	GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 4)
■	DEWATERING SUMP
● P1	OBSERVATION PIEZOMETER
← — — — ←	PROPOSED 4-INCH HDPE SDR-17 DEWATERING PIPE
🟩	GROUNDWATER SEEPAGE SURFACE (SEE NOTE 5)
▦	EXTENT OF EXISTING GEOCOMPOSITE UNDERDRAIN
▨	APPROXIMATE AREA OF EXCAVATION FOUNDED IN THE UNWEATHERED SHALE
— · — · —	LOCATION OF EXISTING DEWATERING TRENCH

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8-28-2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.
3. TOP OF UNWEATHERED SHALE CONTOURS HAVE BEEN REPRODUCED FROM TOP OF SHALE MAP INCLUDED IN APPENDIX IIIG-C.
4. GROUNDWATER CONTOURS WERE PRODUCED USING EACH WELL'S HIGHEST RECORDED GROUNDWATER ELEVATION AND DO NOT REPRESENT A SINGLE GROUNDWATER MONITORING EVENT OR ACTUAL GROUNDWATER SURFACE.
5. THE SHADED AREA INDICATES THE AREA FROM THE TOP OF HIGHEST MEASURED GROUNDWATER TO THE TOP OF THE UNWEATHERED SHALE AS DEFINED IN APPENDIX IIIG.
6. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (E.G., CHANNELS) ARE TYPICALLY 3(H):1(V).

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DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

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PREPARED FOR

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REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT DEWATERING SYSTEM LAYOUT

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants

TBPE REGISTRATION NO. F-3727

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NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

FORT WORTH, TX
(817) 735-9770

GRIFFITH, IN
SOUTH BEND, IN
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ST. LOUIS, MO

SHEET IIID-C-4

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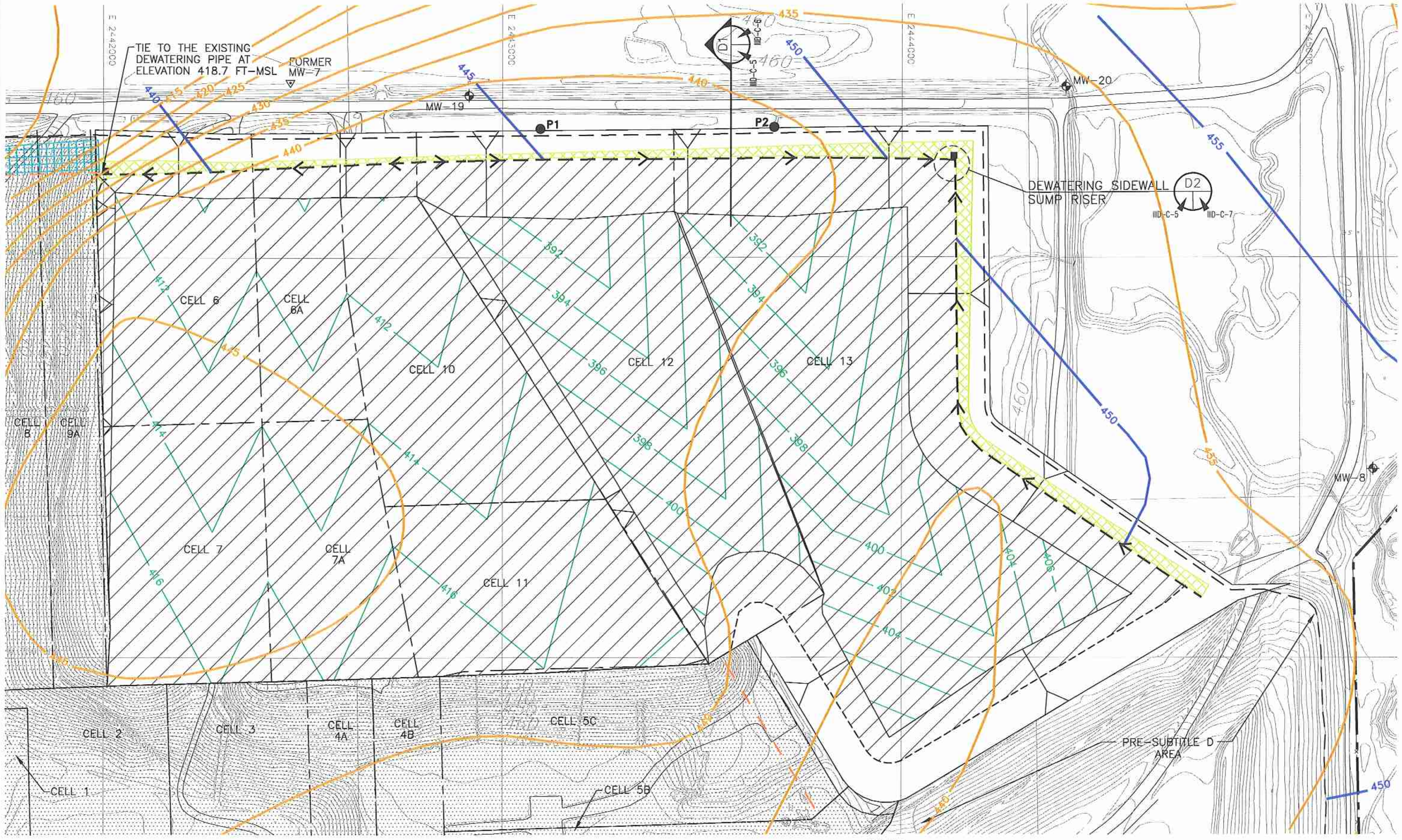

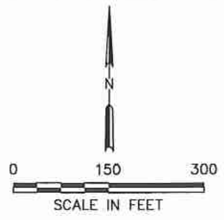

LEGEND

— · —	PERMIT BOUNDARY
— — —	LIMIT OF WASTE
N 7063000	STATE PLANE COORDINATE SYSTEM
500	EXISTING CONTOUR
— - —	SECTOR BOUNDARY
398	EXCAVATION CONTOUR
MW–3R	EXISTING GROUNDWATER MONITORING WELL
⊠ MW–10	EXISTING OBSERVATION WELL
FORMER MW–7	FORMER MONITORING WELL
▨	CONSTRUCTED SUBTITLE D LINED AREA
440	TOP OF SHALE ELEVATION CONTOUR IN FT–MSL (SEE NOTE 2)
450	GROUNDWATER ELEVATION CONTOUR IN FT–MSL (SEE NOTE 3)
■	DEWATERING SUMP
● P1	OBSERVATION PIEZOMETER (SEE NOTE 6)
←– – – –←	PROPOSED 4–INCH HDPE SDR–17 DEWATERING PIPE
▨	GROUNDWATER SEEPAGE SURFACE (SEE NOTE 4)
▦	EXTENT OF EXISTING GEOCOMPOSITE UNDERDRAIN
▨	APPROXIMATE AREA OF EXCAVATION FOUNDED IN THE UNWEATHERED SHALE
— · —	LOCATION OF EXISTING DEWATERING TRENCH

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8–28–10. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. TOP OF UNWEATHERED SHALE CONTOURS HAVE BEEN REPRODUCED FROM TOP OF SHALE MAP INCLUDED IN APPENDIX IIIG–C.
3. GROUNDWATER CONTOURS WERE PRODUCED USING EACH WELL'S HIGHEST RECORDED GROUNDWATER ELEVATION AND DO NOT REPRESENT A SINGLE GROUNDWATER MONITORING EVENT OR ACTUAL GROUNDWATER SURFACE.
4. THE SHADED AREA INDICATES THE AREA FROM THE TOP OF HIGHEST MEASURED GROUNDWATER TO THE TOP OF THE UNWEATHERED SHALE AS DEFINED IN APPENDIX IIIG.
5. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (E.G., CHANNELS) ARE TYPICALLY 3(H):1(V).
6. P1 AND P2 OBSERVATION PIEZOMETERS WILL BE INSTALLED TO MONITOR GROUNDWATER LEVELS IN THE WOODBINE FORMATION DURING CELL CONSTRUCTION. P1 WILL BE INSTALLED ON THE LANDFILL SIDE EDGE OF THE PERIMETER ROAD TWO MONTHS PRIOR TO COMMENCEMENT OF LINER CONSTRUCTION FOR CELL 12 SUMP AREA AND WILL BE DECOMMISSIONED UPON APPROVAL OF CELL 12 SLER BY TCEQ. P2 WILL BE INSTALLED TWO MONTHS PRIOR TO COMMENCEMENT OF LINER CONSTRUCTION FOR THE SUMP AREA OF CELL 13 AND WILL BE DECOMMISSIONED UPON APPROVAL OF CELL 13 SLER BY TCEQ. REFER TO PAGE IIID–C–1 FOR ADDITIONAL DISCUSSION.

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DATE: 03/2012
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MAJOR PERMIT AMENDMENT DEWATERING SYSTEM LAYOUT

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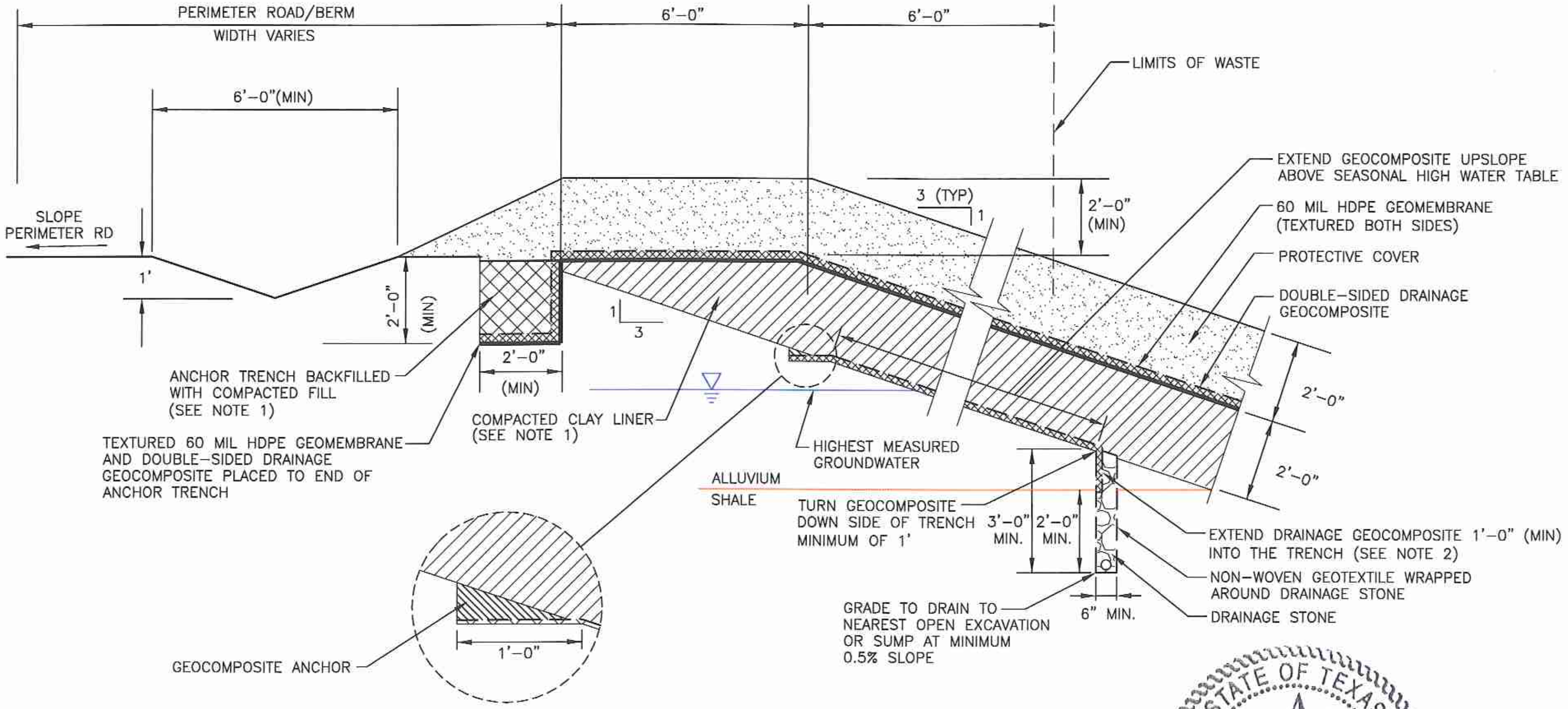

SIDEWALL DEWATERING TRENCH DETAIL D1 IIID-C-5 IIID-C-6

0 2 4
SCALE IN FEET

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84059

3-21-12

NOTES:

1. SUBGRADE PREPARATION, CONSTRUCTION OF THE COMPACTED CLAY LINER, GEOMEMBRANE LINER, AND PLACEMENT OF PROTECTIVE COVER WILL BE IN ACCORDANCE WITH LINER QUALITY CONTROL PLAN.
2. DRAINAGE GEOCOMPOSITE FOR THE DEWATERING LAYER CONSISTS OF A 200–MIL GEONET WITH 6 OZ/SY GEOTEXTILE HEAT BONDED ON BOTH SIDES.

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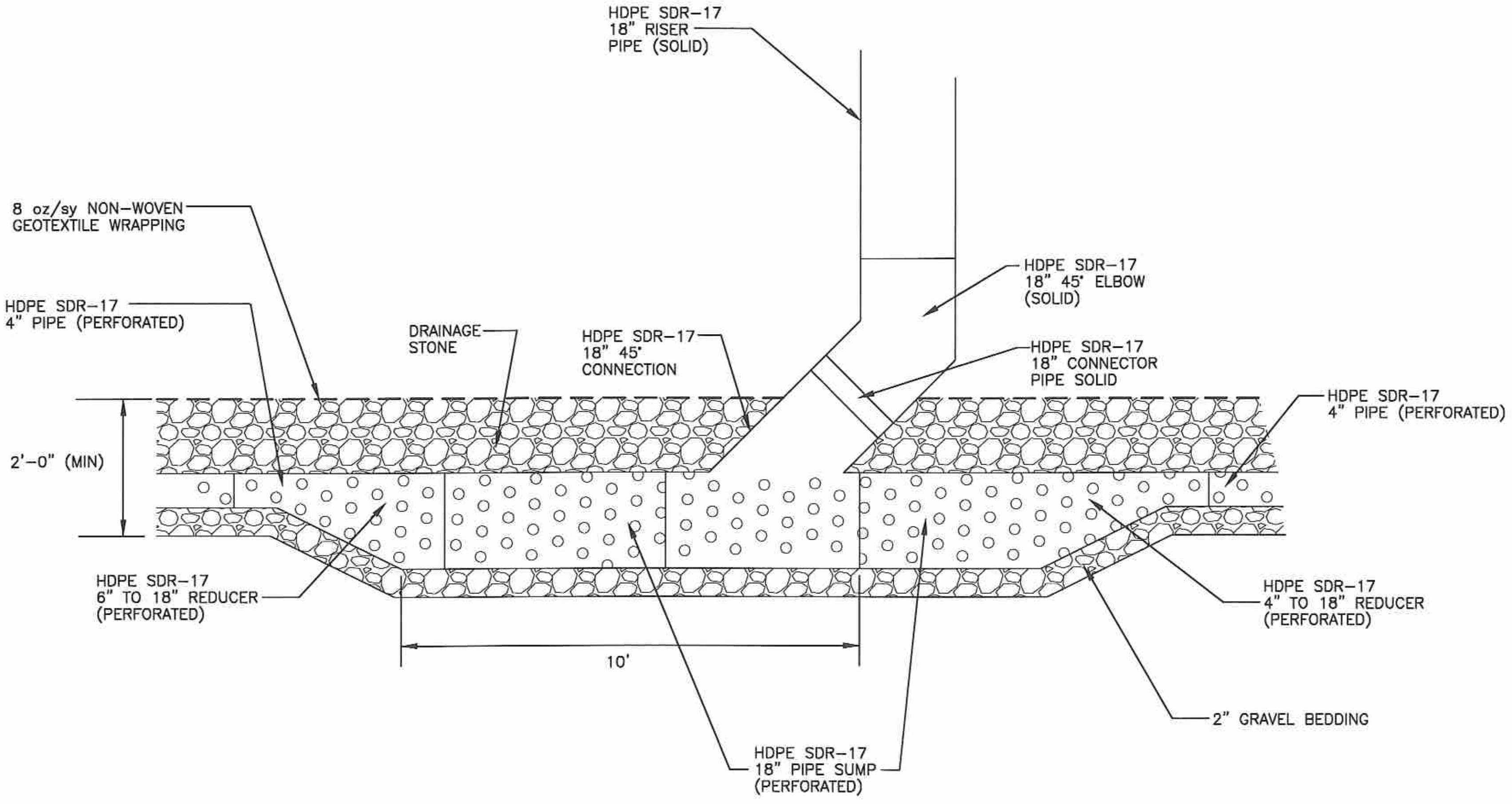

UNDERDRAIN TRENCH PROFILE D2

IIID-C-5 IIID-C-7

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CAD: IIID-C-7 DEWATERING DETS.DWG

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PREPARED FOR

CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
DEWATERING SYSTEM DETAILS

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

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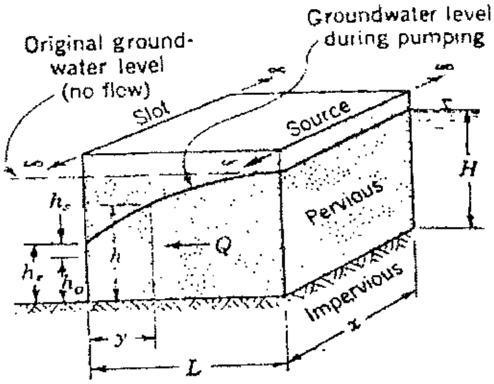
SHEET IIID-C-7

O:\1339\351\EXPANSION 2009\PART III-SDP\IIID\IIID-C-7 DEWATERING DETAILS.dwg, jwilson, 1:2

Solution:

1. **Design the temporary dewatering trench and determine pump size.**



$$Q = \frac{kx}{2L}\left(H^2 - h_o^2\right)$$

K = Hydraulic conductivity (cm/s)
L = Length of drawdown (ft)
H = Height from bottom of trench to highest groundwater level.
(Assuming a trench depth to elevation 434.5 ft-msl and groundwater elevation at 451 ft-msl.)

For 3H:1V excavation slope

K = 1.00E-04 cm/s
3.28E-06 ft/s
X = 1 ft
H = 16.5 ft
h_o = 0.5 ft
L = 50 ft

Based on highest measured in-situ hydraulic conductivity for alluvial soils.

Determine the flow into the trench, Q.

$$Q = (K * X) / (2 * L) * (H^2 - h_o^2)$$

Q = 8.92E-06 $ft^3/s/ft$
Q = 4.01E-03 gpm/ft

Determine pump size based on longest length of trench, L_{max}, to dewatering sump.

L_{max} = 1365 ft

$$Q_{max} = Q * L_{max}$$

Q_{max} = 5 gpm

Therefore, a 20 gpm pump will be sufficient for groundwater removal. A different pump size may be used if justified by POR and must be incorporated into the SLER.

2. Design the temporary dewatering trench pipe.

Use the flow rate determined in Step 1 to size the dewatering trench pipe.

Q_{max} = 5 gpm = 1.22E-02 $ft^3/s/ft$

Determine the flow capacity, Q_{full}, for the 4-inch perforated pipe.

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where: A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions

Using a 4-inch SDR 17 pipe: ID = 3.97 in
= 0.331 ft

$A = \frac{(\pi \times d^2)}{4}$ A = 0.086 sq ft

R = d / 4 R = 0.083 ft

The 4-inch in diameter dewatering pipe will be placed at the locations shown on Sheet IIID-C-4. The slope is calculated as follows.

Slope Calculation (see Sheet IIID-C-4):
Excavation contour at the sump area = 437.5 ft-msl
Excavation contour at the upgradient end of dewatering pipe = 440.5 ft-msl
Total length of dewatering pipe (between sump and upgradient of pipe) = 1365 ft

$$\text{Slope (S)} = \frac{440.5 - 437.5}{1365} = 0.22\%$$

S = Design slope of pipe S = 0.0022 ft / ft
n = Manning's number n = 0.009 from Ref. 6

Q_{full} = 0.126 cfs > Q_{max} = 0.0122 cfs

The capacity of the 4-inch-diameter pipe is larger than the maximum calculated flow into the dewatering trench. Therefore, the design is acceptable.

Determine required pipe perforation based on characteristics of the surrounding drainage media.

Pipe perforations must allow free passage of groundwater and also prevent migration of drainage media into dewatering pipes. Therefore, size of perforations depends on media particle size.

For dewatering pipes with circular holes:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} > 1.7$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is a minimum ASTM D 448 number 57 aggregate
(ASTM D 448 Size 467 can also be used)

D_{85} = 19 mm
= 0.748 in

Hole diameter d = 0.438 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 1.71 > 1.7 \quad \text{(acceptable)}$$

Required: **3. Determine the stability of the temporary dewatering trench pipe and riser pipe.**

Method: A. Determine the critical load under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

References:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.
2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.
3. Phillips 66 Driscopipe, *System Design*, 1991.
4. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Prep By: MDM
Date: 3/16/2012

CAMELOT LANDFILL
1339-351-11
TEMPORARY DEWATERING TRENCH PIPE STABILITY
4" DIA PIPE

Chkd By: JLG
Date: 3/16/2012

Solution:

A. Critical Load on the 4-inch-diameter HDPE perforated temporary dewatering trench pipe

A.1. Maximum construction loading

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight = 190,500 lb
Tire pressure = 80 psi
Number of tires = 4

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

$F =$ 47,625 lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

$r =$ 13.8 in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

$$y = p\,(1 - ((r/z)^2+1)^{-3/2})$$

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Trench depth to top of pipe (in)

$z =$ 29 in (minimum trench depth is 3 feet, bedding depth is 3 inches, and pipe diameter is 4 inches)

$y =$ 21.0 psi

CAMELOT LANDFILL
1339-351-11
TEMPORARY DEWATERING TRENCH PIPE STABILITY
4" DIA PIPE

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L = 31.5 psi

P_D = (zw)/1728

Where: P_D = Maximum dead load (psi)
z = Liner and protective cover thickness (in)
w = Unit weight of liner and protective cover (pcf)

z = 48 in
w = 120 pcf

P_D = 3.33 psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T = 34.9 psi

A.2. Overburden loading

For maximum fill load on pipe:

6.4	ft gravel, liner & cover @	120	pcf =	770	psf	(4 feet liner and protective cover + 2.4 feet gravel in trench)
75	ft solid waste & daily cover @	53	pcf =	3,975	psf	(Unit weight of waste/daily cover obtained from Ref. 5 based on midpoint of waste thickness)
			Σ =	4,745	psf	

P_T = 33.0 psi

Determine critical loading condition:

Construction loading:	P_T =	34.9	psi
Overburden loading:	P_T =	33.0	psi

Construction loading is most critical to the structural stability of the pipe
and will be used to determine the design pipe stress.

A.2.a. Determine the Design Stress

Adjust critical stress to account for loss of strength in the pipe due to perforations:

$P_{DES1} = 12P_T / (12 - l_p)$

Where:

l_p = Cumulative length of perforations per foot of pipe
P_T = Critical pipe stress (psi)
P_{DES1} = Pipe stress adjusted for loss of strength (psi)

9	holes / foot
0.375	in / hole

l_p =	3.4	in/ft

From determination of critical loading:

P_T =	34.9	psi
P_{DES1} =	48.5	psi

Adjust pipe stress determined above to account for effects of soil arching:

The design pipe stress is estimated by accounting for the soil structure interaction between the buried underdrain pipe and its backfill to obtain a realistic loading condition on the pipe.

A.2.a.1. The pipe is assumed to be a positive projecting conduit.

A.2.a.2. Because the pipe is flexible and will deflect in the vertical plane the pipe will experience a reduction in loading due to soil arching. Soil arching is present when the soil column over the pipe settles and creates shear stresses in the surrounding soil. Those shear stresses will support the soil column, thereby reducing the load experienced by the pipe (see Figure 3, page IIID-C-33).

A.2.a.3. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\ 2} \qquad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} \qquad (2)$$

Where:
W_c = Load per unit length of conduit (lb/ft)
γ = Unit weight of soil above conduit (pcf)
B_c = Outer diameter of conduit (ft)
H = Height of fill above conduit (ft)
H_e = Height of plane of equal settlement above critical plane (ft)
k = Lateral pressure ratio (earth pressure coefficient)
μ = tan ϕ
ϕ = Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p\left(\frac{H}{B_c}\right) \qquad (3)$$

Where:
r_{sd} = Settlement ratio
p = Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{\left(S_m + S_g\right) - \left(S_f + dc\right)}{S_m} \qquad (4)$$

Where:
S_m = Compression deformation of soil column adjacent to conduit
S_g = Settlement of natural ground adjacent to conduit
S_f = Settlement of conduit into foundation material
dc = Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \qquad (5)$$

Since the PZB is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and the lower sign to a negative rsd.

A.2.a.4. Load analysis solution by trial and error.

Step 1: Assume a value for the settlement ratio, r_{sd}.

$r_{sd} =$ -0.59

Step 2: Calculate S_m based on the estimated vertical stress at the level of the pipe and the deformation modulus E of the PZB.

$$S_m = P_{DES1} D / E_s$$

Where:
P_{DES1} = Pipe stress adjusted for loss of strength (psi)
D = Pipe diameter (in)
E_s = PZB soil modulus (psi)

$P_{DES1} =$ 48.5 psi
D = 4.5 in
$E_s =$ 3,000 psi

$S_m =$ 0.073 in

Step 3: Calculate dc using Equation (5):

$$dc = S_m (1 - r_{sd})$$

dc = 0.115 in

Step 4: Use the Iowa Formula (provided below) to calculate W_c.

$$W_c = \frac{dc}{(DL)k}\left(\frac{EI}{r^3} + 0.061E'\right)$$

Where:
DL = Deflection lag factor
k = Bedding factor
E = Young's modulus for pipe material (psi)
I = Moment of inertia for pipe wall = $t^3/12$ (in^4/in)
r = Pipe radius (in)
E' = Modulus of soil reaction (psi)

DL = 2.5
k = 0.1
E = 33,000 psi for 50 years @ P_{DES1} (see chart page IIID-C-35)
t = 0.265 in (4" SDR 17 pipe)
I = 0.002 in^4/in
r = 2.3 in
E' = 3,000 psi

$W_c =$ 86 lb/in

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{2}}$$

Composite unit weight for waste and soil:

75	ft waste & cover @	53	pcf =	3,975	psf
6.4	ft soil @	120	pcf =	770	psf
			Total =	4,745	psf

γ = 58.3 pcf (weighted average based on above table)
B_c = 4.5 in

C_c = 126.6 (unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H = 81 ft
H/B_c = 217.1

Assume: H_e/B_c = 2.08

$k\mu$ = 0.13 (Ref 4)
$e^{-2k\mu(He/Bc)}-1$ = -0.42
$-2k\mu$ = -0.26
$(H/B_c - H_e/B_c)$ = 215.0
$e^{-2k\mu(He/Bc)}$ = 0.58

Left-hand-side of equation (LHS) = 127
Right-hand-side of equation (RHS) = 127

Step 7: Substitute H_e/B_c into equation given below to determine if proper value for rsd was used.

$$\left[\frac{1}{2k\mu} \pm \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) \pm \frac{r_{sd}\,p}{3}\right] \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} \pm \frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$
$$\pm \frac{r_{sd}\,p}{3}\left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} - \frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right) \mp \left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right) = \pm r_{sd}\,p\left(\frac{H}{B_c}\right)$$

Because r_{sd} is negative for the incomplete ditch condition, the lower signs in the above equation are used.

p =	1
kμ =	0.13
H/B_c =	217.1
H_e/B_c =	2.08
r_{sd} =	-0.59
LHS =	127
RHS =	127

If LHS is not approximately equal to RHS, adjust value for r_{sd} in Step 1 and repeat solution procedure.

A.2.a.5. Once the solutions to the above equations are determined, the design pipe stress may be calculated and the deflection of the pipe determined.

P_{DES2} = W_c / D

Where: P_{DES2} = Load on pipe adjusted to account for effects of soil arching (psi)

W_c =	86	lb/in
D =	4.500	in
P_{DES2} =	19	psi

Prep By: MDM
Date: 3/16/2012

Chkd By: JLG
Date: 3/16/2012

CAMELOT LANDFILL
1339-351-11
TEMPORARY DEWATERING TRENCH PIPE STABILITY
4" DIA PIPE

B. Check Structural Stability of SDR 17 pipe

SDR = Standard dimension ratio = 17.0
S_Y = Compressive yield strength = 1,500 psi
RD_{all} = Allowable ring deflection = 4.2 %

B.1. Wall crushing (Ref 3)

S_A = P_{DES2} (SDR - 1) / 2 FS = S_Y / S_A

Where:
S_A = Actual compressive stress (psi)
SDR = Standard dimension ratio
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
S_Y = Compressive yield strength (psi)
FS = Factor of safety against wall crushing

P_{DES2} = 19 psi

S_A = 153.7 psi
FS = 9.8

Compare calculated and suggested factor of safety: 9.8 > 1.0

B.2. Wall buckling (Ref 3)

P_{cb} = $0.8\ (E'\ (2.32E / SDR^3))^{1/2}$ FS = P_{cb} / P_{DES2}

Where:
P_{cb} = Critical buckling pressure at top of pipe (psi)
E' = Soil modulus (psi)
E = Stress/time dependent tensile modulus for design loading conditions (psi)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
FS = Factor of safety against wall buckling

E' = 3,000 psi (see E' values on page IIID-C-34)
E = 30,500 psi for 50 years @ S_A (see chart page IIID-C-35)
P_{DES2} = 19 psi

P_{cb} = 166.3 psi
FS = 8.7

Compare calculated and suggested factor of safety: 8.7 > 1.0

B.3. Ring deflection (Ref 3)

$E_S = P_{DES2} / E'$

Where:

E_S = Soil strain (%)

P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)

E' = Soil modulus (psi)

P_{DES2} =	19	psi
E' =	3,000	psi

$\boxed{E_S = 0.6 \ \%}$

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RD_{act}) is equal to soil strain.

RD_{act} = 0.6 %

Allowable ring deflection, RD_{all} = 4.20 %

$\boxed{RD_{act} < RD_{all}\text{, design is acceptable}}$

Note: An additional factor of safety is inherent to the design of the temporary dewatering trench pipe system due to the presence of a gravel envelope surrounding the temporary dewatering trench pipe. The gravel layer will transmit groundwater in the event that the temporary dewatering trench pipe becomes plugged or crushed.

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CAMELOT LANDFILL
1339-351-11
TEMPORARY DEWATERING TRENCH PIPE STABILITY
4" DIA PIPE

Adjusted load to account for soil arching = 19 psi

SDR	Wall Crushing			Wall Buckling				Ring Deflection			
	S_Y	S_A	FS_{WC}	E^2	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
32.5	1,500	302.7	5.0	25,000	3,000	57.0	3.0	8.1	3,000	0.6	12.6
26.0	1,500	240.2	6.2	26,500	3,000	82.0	4.3	6.5	3,000	0.6	10.1
21.0	1,500	192.2	7.8	28,500	3,000	117.1	6.1	5.2	3,000	0.6	8.1
19.0	1,500	173.0	8.7	29,500	3,000	138.4	7.2	4.7	3,000	0.6	7.3
17.0[1]	1,500	153.7	9.8	30,500	3,000	166.3	8.7	4.2	3,000	0.6	6.6
15.5	1,500	139.3	10.8	31,000	3,000	192.6	10.0	3.9	3,000	0.6	6.1
13.5	1,500	120.2	12.5	32,000	3,000	240.4	12.5	3.4	3,000	0.6	5.3
11.0	1,500	96.1	15.6	33,000	3,000	332.3	17.3	2.7	3,000	0.6	4.2

▨ denotes standard size

[1] Select 4-inch-diameter HDPE SDR 17 pipe for use in the temporary dewatering system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the attached chart (page IIID-C-35), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50-year duration (maximum loading is the overburden load on the pipe).

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Date: 3/16/2012

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Date: 3/16/2012

CAMELOT LANDFILL
1339-351-11
TEMPORARY DEWATERING TRENCH PIPE STABILITY
18" DIA PIPE

Required: Determine the stability of the temporary dewatering trench pipe and riser pipe.

Method:

A. Determine the critical load under the following two conditions:

   1. Construction loading
   2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

   1. Wall crushing
   2. Wall buckling
   3. Ring deflection

References:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.
2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.
3. Phillips 66 Driscopipe, *System Design*, 1991.
4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage*, Appendix A, 1993.
5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

Solution:

A. Critical Load on the 18-inch-diameter HDPE perforated temporary dewatering trench pipe

A.1. Maximum construction loading

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight = 190,500 lb
Tire pressure = 80 psi
Number of tires = 4

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F =	47,625	lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

r =	13.8	in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

$$y = p\,(1 - ((r/z)^2+1)^{-3/2})$$

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Trench depth to top of pipe (in)

z = 15 in (minimum trench depth is 3 feet, bedding depth is 3 inches, and pipe is 18 inches)

y =	48.0	psi

CAMELOT LANDFILL
1339-351-11
TEMPORARY DEWATERING TRENCH PIPE STABILITY
18" DIA PIPE

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L = 72.0 psi

P_D = (zw)/1728

Where:
P_D = Maximum dead load (psi)
z = Liner and protective cover thickness (in)
w = Unit weight of liner and protective cover (pcf)

z = 48 in
w = 120 pcf

P_D = 3.33 psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T = 75.3 psi

A.2. Overburden loading (postclosure load)

For maximum fill load on pipe:

5.25	ft gravel, liner, & cover @	120	pcf =	630	psf	(4 feet liner and protective cover + 1.25 feet gravel and general fill in sump in trench)
75	ft solid waste & daily cover @	53	pcf =	3,975	psf	
			Σ =	4,605	psf	

P_T = 32.0 psi

Determine critical loading condition:

Construction loading:	P_T =	75.3	psi
Overburden loading:	P_T =	32.0	psi

Construction loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

A.2.a. Determine the Design Stress

Adjust critical stress to account for loss of strength in the pipe due to perforations:

$$P_{DES1} = 12P_T / (12 - l_p)$$

Where:
l_p = Cumulative length of perforations per foot of pipe
P_T = Critical pipe stress (psi)
P_{DES1} = Pipe stress adjusted for loss of strength (psi)

6	holes / foot
0.5	in / hole

$l_p =$	3.0	in/ft

From determination of critical loading:

$P_T =$	75.3	psi
$P_{DES1} =$	100.5	psi

Adjust pipe stress determined above to account for effects of soil arching:

The design pipe stress is estimated by accounting for the soil structure interaction between the buried underdrain pipe and its backfill to obtain a realistic loading condition on the pipe.

A.2.a.1. The pipe is assumed to be a positive projecting conduit.

A.2.a.2. Because the pipe is flexible and will deflect in the vertical plane the pipe will experience a reduction in loading due to soil arching. Soil arching is present when the soil column over the pipe settles and creates shear stresses in the surrounding soil. Those shear stresses will support the soil column, thereby reducing the load experienced by the pipe (see Figure 3, page IIID-C-33).

A.2.a.3. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\,2} \qquad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} \qquad (2)$$

Where:	W_c	= Load per unit length of conduit (lb/ft)
	γ	= Unit weight of soil above conduit (pcf)
	B_c	= Outer diameter of conduit (ft)
	H	= Height of fill above conduit (ft)
	H_e	= Height of plane of equal settlement above critical plane (ft)
	k	= Lateral pressure ratio (earth pressure coefficient)
	μ	= tan ϕ
	ϕ	= Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p\left(\frac{H}{B_c}\right) \qquad (3)$$

Where:	r_{sd}	= Settlement ratio
	p	= Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{\left(S_m + S_g\right) - \left(S_f + dc\right)}{S_m} \qquad (4)$$

Where:	S_m	= Compression deformation of soil column adjacent to conduit
	S_g	= Settlement of natural ground adjacent to conduit
	S_f	= Settlement of conduit into foundation material
	dc	= Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \qquad (5)$$

Since the PZB is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and the lower sign to a negative r_{sd}.

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1339-351-11
TEMPORARY DEWATERING TRENCH PIPE STABILITY
18" DIA PIPE

A.2.a.4. Load analysis solution by trial and error

Step 1: Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.08

Step 2: Calculate S_m based on the estimated vertical stress at the level of the pipe and the deformation modulus E of the PZB.

$S_m = P_{DES1} D / E_s$

Where:
P_{DES1} = Pipe stress adjusted for loss of strength (psi)
D = Pipe diameter (in)
E_s = PZB soil modulus (psi)

P_{DES1} = 100.5 psi
D = 18 in
E_s = 3,000 psi

S_m = 0.603 in

Step 3: Calculate dc using Equation (5):

$dc = S_m (1 - r_{sd})$

dc = 0.651 in

Step 4: Use the Iowa Formula (provided below) to calculate W_c.

$$W_c = \frac{dc}{(DL)k}\left(\frac{EI}{r^3} + 0.061E'\right)$$

Where:
DL = Deflection lag factor
k = Bedding factor
E = Young's modulus for pipe material (psi)
I = Moment of inertia for pipe wall = $t^3/12$ (in^4/in)
r = Pipe radius (in)
E' = Modulus of soil reaction (psi)

DL = 2.5
k = 0.1
E = 33,000 psi for 50 years @ P_{DES1} (see chart page IIID-C-35)
t = 1.059 in (18" SDR 17 pipe)
I = 0.099 in^4/in
r = 9.0 in
E' = 3,000 psi

W_c = 488 lb/in

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Date: 3/16/2012

Chkd By: JLG
Date: 3/16/2012

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Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\,2}}$$

Composite unit weight for waste and soil:

75	ft waste & cover @	53	pcf =	3,975	psf
5.3	ft soil @	120	pcf =	630	psf
			Total =	4,605	psf

$\gamma =$ 57.4 pcf (weighted average based on above table)

$B_c =$ 18 in

$\boxed{C_c = 45.4 \quad \text{(unitless)}}$

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

$H =$ 80 ft

$H/B_c =$ 53.5

Assume: $H_e/B_c =$ 0.70

$k\mu =$ 0.13 (Ref 4)

$e^{-2k\mu(He/Bc)}-1 =$ -0.17

$-2k\mu =$ -0.26

$(H/B_c - H_e/B_c)$ 52.8

$e^{-2k\mu(He/Bc)} =$ 0.83

Left-hand-side of equation (LHS) = 45

Right-hand-side of equation (RHS) = 45

Step 7: Substitute H_e/B_c into equation given below to determine if proper value for r_{sd} was used.

$$\left[\frac{1}{2k\mu} \pm \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) \pm \frac{r_{sd}\,p}{3}\right] \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} \pm \frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$

$$\pm \frac{r_{sd}\,p}{3}\left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} - \frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right) \mp \left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right) = \pm r_{sd}\,p\left(\frac{H}{B_c}\right)$$

Because r_{sd} is negative for the incomplete ditch condition, the lower signs in the above equation are used.

$p =$ 1
$k\mu =$ 0.13
$H/B_c =$ 53.5
$H_e/B_c =$ 0.7
$r_{sd} =$ -0.08

LHS = 4
RHS = 4

If LHS is not approximately equal to RHS, adjust value for r_{sd} in Step 1 and repeat solution procedure.

A.2.a.5. Once the solutions to the above equations are determined, the design pipe stress may be calculated and the deflection of the pipe determined.

P_{DES2} $= W_c / D$

Where: P_{DES2} = Load on pipe adjusted to account for effects of soil arching (psi)

$W_c =$ 488 lb/in
$D =$ 18.000 in

$P_{DES2} =$ 27 psi

B. Check Structural Stability of SDR 17 pipe

SDR = Standard dimension ratio = 17.0
S_Y = Compressive yield strength = 1,500 psi
RD_{all} = Allowable ring deflection = 4.2 %

B.1. Wall crushing (Ref 3)

$S_A = P_{DES2}\,(SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
S_A = Actual compressive stress (psi)
SDR = Standard dimension ratio
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
S_Y = Compressive yield strength (psi)
FS = Factor of safety against wall crushing

P_{DES2} = 27 psi

S_A = 217.0 psi
FS = 6.9

Compare calculated and suggested factor of safety: 6.9 > 1.0

B.2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES2}$

Where:
P_{cb} = Critical buckling pressure at top of pipe (psi)
E' = Soil modulus (psi)
E = Stress/time dependent tensile modulus for design loading conditions (psi)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
FS = Factor of safety against wall buckling

E' = 3,000 psi (see E' values on page IIID-C-34)
E = 27,500 psi for 50 years @ S_A psi (see chart page IIID-C-35)
P_{DES2} = 27 psi

P_{cb} = 157.9 psi
FS = 5.8

Compare calculated and suggested factor of safety: 5.8 > 1.0

B.3. Ring deflection (Ref 3)

$E_S = P_{DES2} / E'$

Where:
E_S = Soil strain (%)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
E' = Soil modulus (psi)

$P_{DES2} =$ 27 psi
$E' =$ 3,000 psi

$E_S =$	0.9	%

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RD_{act}) is equal to soil strain.

$RD_{act} =$ 0.9 %

Allowable ring deflection, $RD_{all} =$ 4.20 %

$RD_{act} < RD_{all}$, design is acceptable

Note: An additional factor of safety is inherent to the design of the temporary dewatering trench pipe system due to the presence of a gravel envelope surrounding the temporary dewatering trench pipe. The gravel layer will transmit groundwater in the event that the temporary dewatering trench pipe becomes plugged or crushed.

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18" DIA PIPE

Adjusted load to account for soil arching = 27 psi

	Wall Crushing			Wall Buckling				Ring Deflection			
SDR	S_Y	S_A	FS_{WC}	E^2	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
32.5	1,500	427.1	3.5	21,000	3,000	52.2	1.9	8.1	3,000	0.9	9.0
26.0	1,500	339.0	4.4	23,000	3,000	76.3	2.8	6.5	3,000	0.9	7.2
21.0	1,500	271.2	5.5	25,500	3,000	110.7	4.1	5.2	3,000	0.9	5.8
19.0	1,500	244.1	6.1	26,500	3,000	131.2	4.8	4.7	3,000	0.9	5.2
17.0 [1]	1,500	217.0	6.9	27,500	3,000	157.9	5.8	4.2	3,000	0.9	4.6
15.5	1,500	196.6	7.6	28,500	3,000	184.6	6.8	3.9	3,000	0.9	4.3
13.5	1,500	169.6	8.8	30,000	3,000	232.8	8.6	3.4	3,000	0.9	3.8
11.0	1,500	135.6	11.1	31,500	3,000	324.7	12.0	2.7	3,000	0.9	3.0

▨ denotes standard size

[1] Select 18-inch-diameter HDPE SDR 17 pipe for use in the temporary dewatering system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the attached chart (page IIID-C-35), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50 year duration (maximum loading is the overburden load on the pipe).

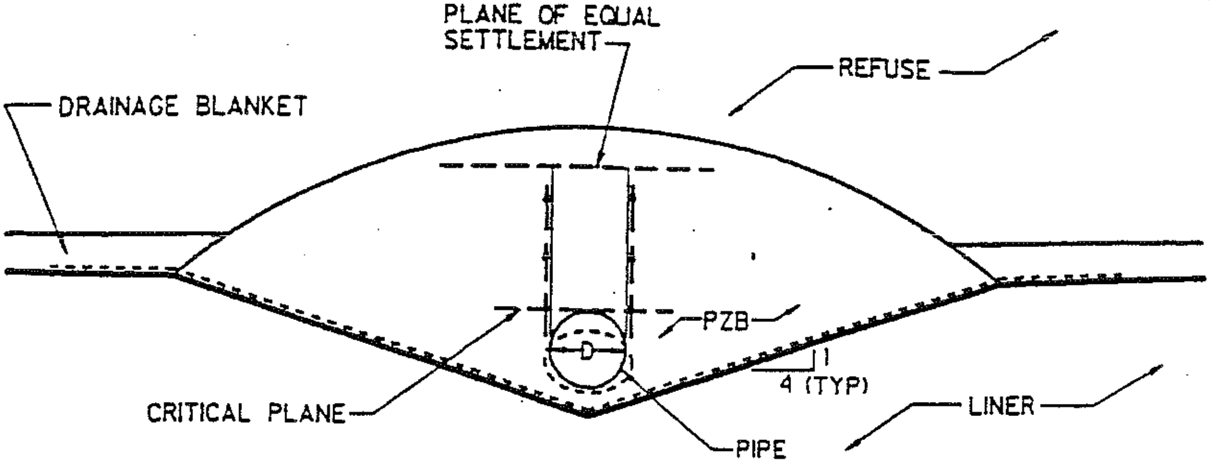


FIGURE 2: SETTLEMENT OF LEACHATE PIPE INDUCING SHEAR STRESSES IN PZB

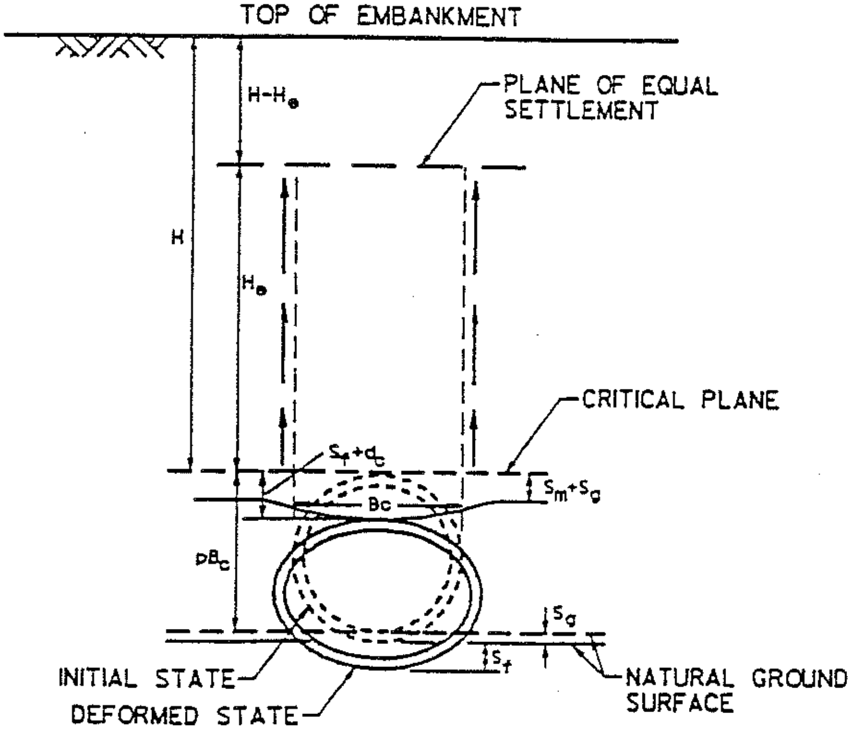


FIGURE 3: CASE OF AN INCOMPLETE DITCH CONDITION FOR A POSITIVE PROJECTING CONDUIT

/di/users/jow/prgetren.dgn

Simplified Burial Design: A conservative estimate of the ability of Driscopipe pipelines to perform in a buried environment is found in Chart 24. It is based on a minimum 2:1 safety factor and 50 year design service life. A detailed burial design starts on page 37. The detailed design should be used for critical or marginal applications or whenever a more precise solution is desired.

Detailed Burial Design:

Design by Wall Crushing: Wall crushing would theoretically occur when the stress in a pipe wall, due to the external vertical pressure, exceeded the long-term compressive strength of the pipe material. To ensure that the Driscopipe wall is strong enough to endure the external pressure the following check should be made:

$$S_A = \frac{(SDR - 1)}{2} P_T$$

Values of E′

Based on Soil Type (ASTM D2321) and Degree of Compaction

Soil Type of Initial Backfill Embedment Material	Description	E′ (psi) for Degree of Compaction (Proctor Density, %)			
		Loose	Slight (70-85%)	Moderate (85-95%)	High (95%)
I	Manufactured angular, granular materials (crushed stone or rock, broken coral, cinders, etc.)	1,000	3,000	3,000	3,000
II	Coarse grained soils with little or no fines	N.R.	1,000	2,000	3,000
III	Coarse grained soils with fines	N.R.	N.R.	1,000	2,000
IV	Fine-grained soils	N.R.	N.R.	N.R.	N.R.
V	Organic soils (peat, muck, clay, etc.)	N.R.	N.R.	N.R.	N.R.

N.R. = Not Recommended for use by ASTM D2321 for pipe wall support

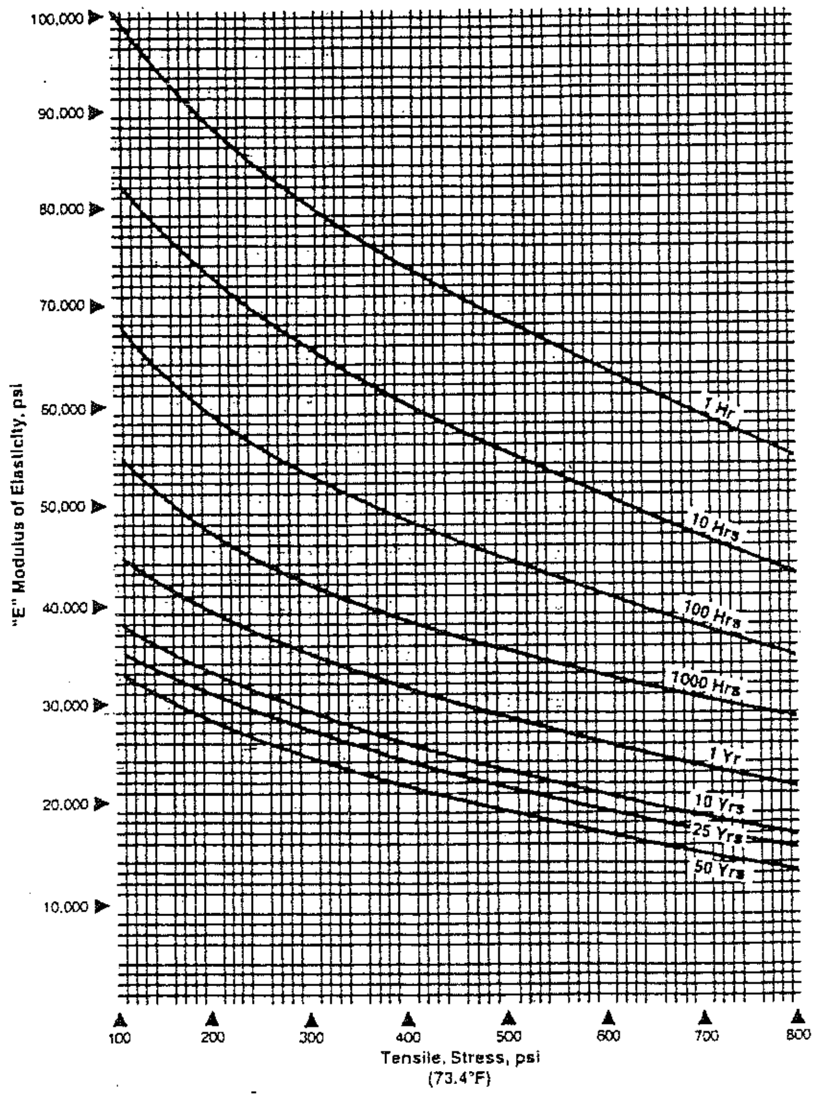
Chart 24

SDR	Maximum Burial Depth, ft. in dry soil of 100 lbs/cu. ft.			Maximum External Pressure psi			Maximum Deflection, % after installation		
	Soil Modulus, psi*			Soil Modulus, psi*			Soil Modulus, psi*		
	1000	2000	3000	1000	2000	3000	1000	2000	3000
32.5	25	32	37	17	22	26	1.7	0.9	0.6
26	33	45	52	23	31	36	2.3	1.2	0.8
21	46	61	71	32	42	49	3.2	1.6	1.1
19	52	69	81	36	48	56	3.6	1.8	1.2
17	61	121	181	42	84	126	4.2	2.1	1.4
15.5	56	112	168	39	78	117	3.9	2.0	1.3
13.5	49	98	147	34	68	102	3.4	1.7	1.1
11	39	78	117	27	54	81	2.7	1.4	0.9
9.3	33	68	101	23	47	70	2.3	1.2	0.8
8.3	30	61	89	21	42	62	2.1	1.1	0.7
7.3	26	52	79	18	36	55	1.8	0.9	0.6

*assumes no external loads

Chart 25

Time Dependent Modulus of Elasticity for Polyethylene Pipe vs. Stress Intensity (73.4°F)



NOTE: The short term modulus of elasticity of Driscopipe per ASTM D 638 is approximately 100,000 psi. Due to the cold flow (creep) characteristic of the pipe material, this modulus is dependent upon the stress intensity and the time duration of the applied stress.

3. Phillips 66 Driscopipe, "System Design", 1991.

Required: 4. **Determine the properties of the drainage geocomposite.**

Method:

A. Estimate the flow into the geocomposite drainage layer.
B. Determine the flow capacity of the geocomposite drainage layer.

References:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986
2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.
3. Koerner, R.M., *Designing with Geosynthetics*, Second Edition, Prentice Hall, Inc., 1990.
4. *Dewatering and Groundwater Control,* TM5-818-5, November 1983
5. GSE Drainage Design Manual, May 2004.
6. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.
7. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
8. Geosynthetic Institute, GRI Standard GC-8, 2001.

A. Estimate the flow into the geocomposite drainage layer.

From page IIID-C-8, the seepage of the 3H:1V slope is:

Q = 8.92E-06 cfs/ft

B. Determine the flow capacity of the geocomposite drainage layer.

Assume the geocomposite drainage layer will undergo linear compression due to the weight of soil (in the form of liner and protective cover) and waste.

Unloaded Geocomposite Thickness = 0.20 in
Unit Weight of Waste[6] = 53 pcf
Unit Weight of Soil = 120 pcf

Table 1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	P[3] (psf)	t[4] (in)
Liner and Protective Cover Installed	0	4	480	0.191
Maximum Waste Thickness[5]	75	4	4,455	0.169

[1] d_W is the depth of waste and daily cover soil above the geocomposite.

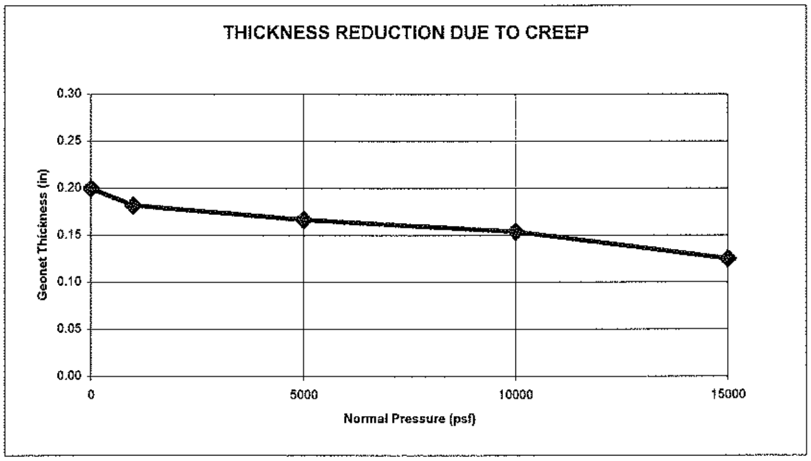
[2] d_S is the depth of soil (protective cover) above the geocomposite.

[3] P is the pressure on the geocomposite due to the weight of the waste and soil.

[4] t is the thickness of the geocomposite after being subjected to linear compression. based on the graph below adapted from Ref. 5.

[5] Maximum waste thickness is determined by subtracting minimum elevation of geocomposite (as shown on Sheet IIID-C-4) from bottom of final cover elevation.

[6] For conservative purposes, the unit weight of waste is based on the maximum waste column and was obtained from Ref 6.



Reduction Factors for Strength and Environmental Conditions

Table 2 - Reduction Factors

Reduction Factors[1]		Fill Condition	
		Open (0' Waste)	Interim (75' Waste)
RF_{IN}	Delayed Intrusion	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.5
RF_{BC}	Biological Clogging	1.0	1.2
Total Reduction Factor[2]		1.10	1.98

Overall Factor of Safety to Account For Uncertainties	2.0	2.0
Overall Reduction Factor (ORF)[3]	2.20	3.96

[1] Values are obtained from References 3, 7, and 8.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

Required Transmissivity Data

The required minimum transmissivity for the 200-mil-thick double-sided geocomposite is shown on Sheet IIID-C-40.

Compute the design transmissivity (T) of the geocomposite.

Table 3 - Design Transmissivity

Fill Condition	t[1] (in)	T[2] (m^2/s)	ORF[3]	T_{DES}[4] (m^2/s)	T_{DES}[5] (cfs/ft)
Liner and Protective Cover Installed	0.191	1.56E-04	2.20	7.09E-05	7.63E-04
Maximum Waste Thickness	0.169	1.18E-04	3.96	2.98E-05	3.21E-04

[1] t is the calculated geocomposite thickness from Table 1.

[2] T is obtained from the specified transmissivity values for a representative geocomposite (6 oz/sy double-sided polypropylene geotextile with 200-mil-thick geonet) as shown on Sheet IIID-C-40.

[3] ORF is the Overall Reduction Factor obtained from Table 2.

[4] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / (\text{FS Factor})$$

[5] The conversion factor used was:

$$T_{DES} = m^2/s \times (ft^2/(0.3048m)^2) \times (ft/ft)$$

Design Flow Capacity

From Table 3 above, the minimum design transmissivity of the geocomposite drainage layer is:

T_{DES} = 3.21E-04 cfs/ft

From Step A above, the maximum flow to the geocomposite is:

Q_{max} = 8.92E-06 cfs/ft

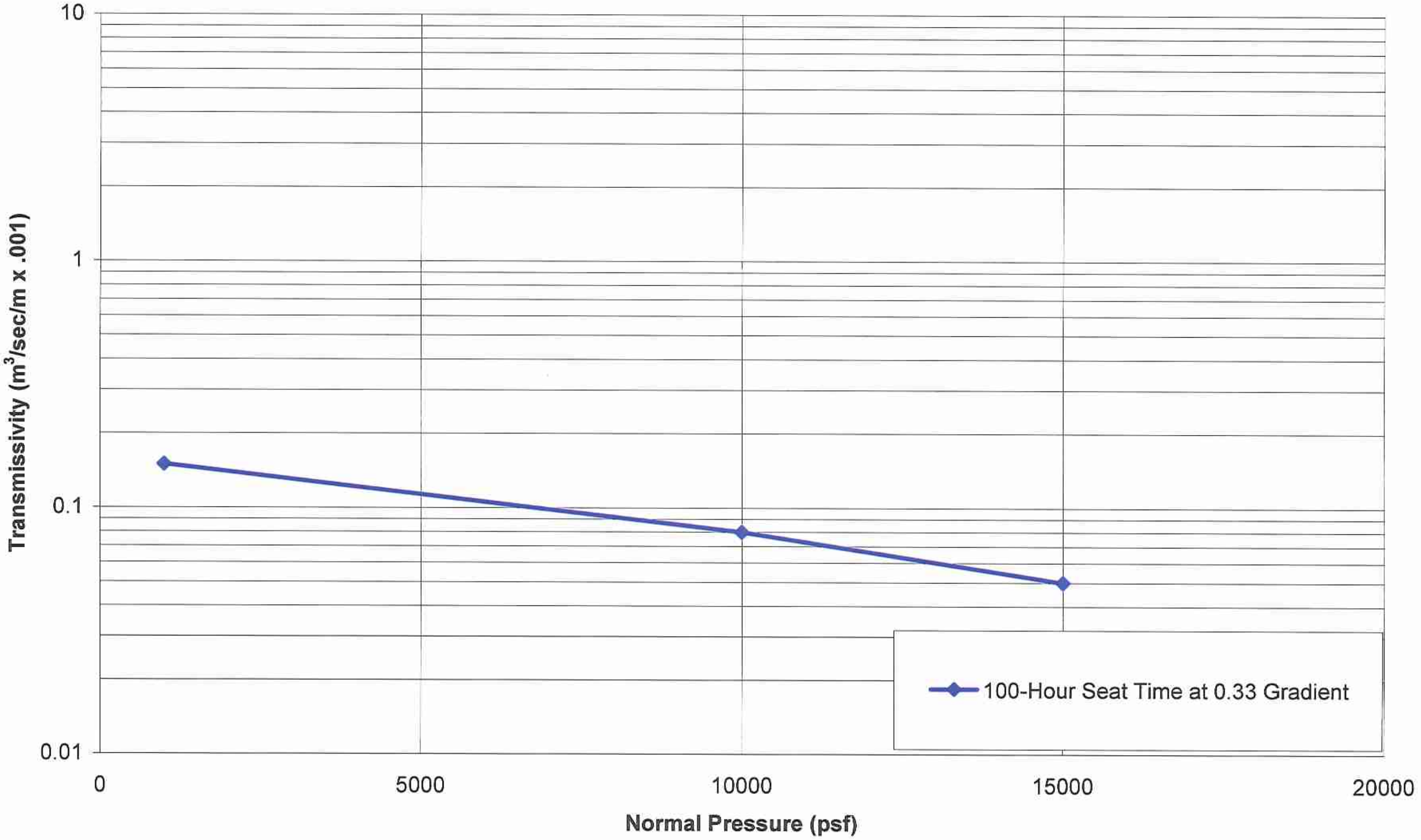
T_{DES} = 3.21E-04 cfs/ft >> Q_{max} = 8.92E-06 cfs/ft

The capacity of the geocomposite ($3.21x10^{-4}$ cfs) is greater than the estimate of flow into the geocomposite ($8.92x10^{-6}$ cfs). Therefore the design is acceptable.

The conditions identified on Sheet IIID-C-40 will be tested in accordance with ASTM 4716 using a 100-hour seat time. As noted in Appendix IIID, one test will be completed per ASTM D 4716 for every 100,000 square feet of dewatering system construction. The load will be equal to or greater than 4,455 psf at a gradient of 0.33.

TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE

6 oz/sy Polypropylene Geotextiles with 200 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



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Date: 3/16/2012

CAMELOT LANDFILL
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TEMPORARY DEWATERING TRENCH SYSTEM
GEOTEXTILE DESIGN

Chkd By: JLG
Date: 3/16/2012

REQUIRE] **5. Determine the geotextile properties around the granular drainage material.**

METHOD: Design geotextile and determine material property requirements.

REFERENCES:

1. MIRAFI, *Geotextile Filter Design, Application, and Product Selection Guide* , 1991, http://www.tcmirafi.com/pdf/brochures/ef_guidelines.pdf.
2. Koerner, R.M., *Designing With Geosynthetics* , Fifth Edition, 2005.
3. AASHTO Designation: M288-06.
4. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.

Prep By: MDM
Date: 3/16/2012

Chkd By: JLG
Date: 3/16/2012

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TEMPORARY DEWATERING TRENCH SYSTEM
GEOTEXTILE DESIGN

SOLUTION:

The design calculations assume that the granular drainage material will consist of ASTM No. 467 aggregate with a hydraulic gradient greater than 1.0 cm/s and more than 90 percent gravel.

Retention:

Based on Chart 1 - "Soil Retention Criteria," given on page IIID-C-44, the apparent opening size (O_{95}) is determined as follows.

$d'_0 =$ 0.1 in
$d'_{50} =$ 0.5 in
$d'_{100} =$ 1.5 in

$C'_u = (d'_{100}/d'_0)^{1/2} =$ 3.87 > 3

C'_u is greater than 3; therefore the granular drainage material is widely graded and it is also assumed that the relative density of the soil is less than 35%.

$O_{95} < (9/C'_u)*d'_{50} =$ 1.16 mm

Permeability:

The required permeability is determined by comparing the permeability of the alluvial soils (1.0×10^{-4} cm/s based on previous data) with the permeability of the geotextile after the appropriate reduction factors are applied to the laboratory permeability of the geotextile.

Minimum Laboratory Permeability Specified (k_{ult}) = 0.2 cm/s

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TEMPORARY DEWATERING TRENCH SYSTEM
GEOTEXTILE DESIGN

To determine the allowable permeability (k_{allow}) of the geotextile, the following reduction factors are used:

Table 1 - Reduction Factors[1]

RF_{SCB} = Reduction factor for soil clogging and blinding	2.0
RF_{CR} = Reduction factor for creep reduction of void space	2.0
RF_{IN} = Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} = Reduction factor for chemical clogging	1.5
RF_{BC} = Reduction factor for biological clogging	2.0
Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 4.

$k_{allow} = k_{ult}$ / ORF = (0.2 cm/s) / 14.4

k_{allow} = 1.4E-02 cm/s

$k_{allow} >> k_{alluvial}$ (1.0×10^{-4} cm/s).

Specification: Permeability of geotextile around the trench pipe shall be equal to or greater than 0.2 cm/s as determined by ASTM D 4491.

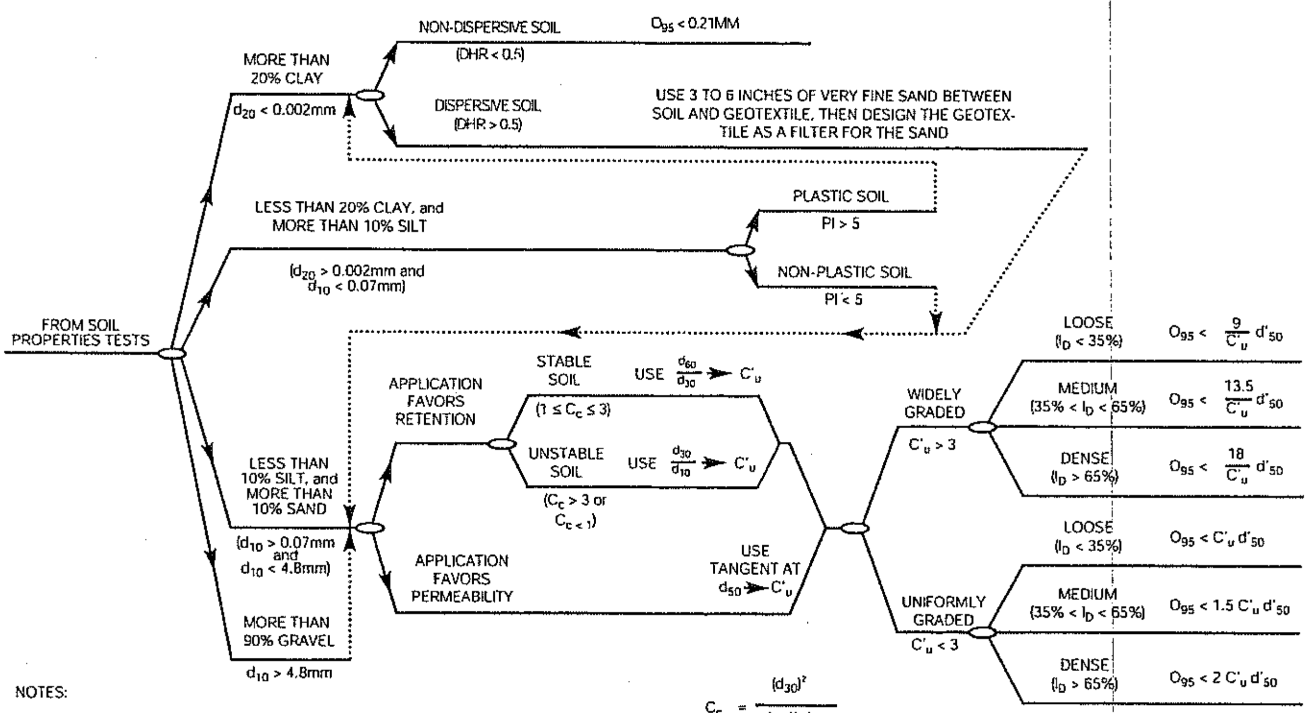
Survivability:

Based on Table 2, "Survivability Strength Requirements," provided on page IIID-C-45, geotextile properties should be selected considering high contact stresses (i.e., heavy confining stresses).

Summary of required properties for geotextile around the dewatering trench pipe:

Apparent opening size	<	1.16	mm
Grab tensile strength	>	157	lbs
Elongation	>=	50	%
Puncture strength	>	56	lbs
Trapezoid tear	>	56	lbs
Permeability	>=	0.2	cm/s

Chart 1. Soil Retention Criteria of Steady-State Flow Conditions



NOTES:

$$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$$

d_x = particle diameter of which size *x* percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremeties of a straight line drawn through the particle-size distribution, as directed above and d'_{50} is the midpoint of this line

I_D = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil
O_{95} = geotextile opening size

Table 2. Survivability Strength Requirements (after AASHTO, 1996)

		GRAB STRENGTH (LBS)	ELONGATION (%)	SEWN SEAM STRENGTH (LBS)	PUNCTURE STRENTH (LBS)	BURST STRENTH (LBS)	TRAPEZOID TEAR (LBS)
SUBSURFACE DRAINAGE	HIGH CONTACT STRESSES (ANGULAR DRAINAGE MEDIA) (HEAVY COMPACTION) or (HEAVY CONFINING STRESSES)	247	< 50% *	222	90	392	56
		157	≥ 50%	142	56	189	56
	LOW CONTACT STRESSES (ROUNDED DRAINAGE MEDIA) (LIGHT COMPACTION) or (LIGHT CONFINING STRESSES)	180	< 50% *	162	67	305	56
		112	≥ 50%	101	40	138	40
ARMORED EROSION CONTROL	HIGH CONTACT STRESSES (DIRECT STONE PLACEMENT) (DROP HEIGHT > 3 FT)	247	< 50% *	222	90	392	56
		202	≥ 50%	182	79	247	79
	LOW CONTACT STRESSES (SAND OR GEOTEXTILE CUSHION) and (DROP HEIGHT < 3 FT)	247	< 50% *	222	90	292	56
		157	≥ 50%	142	56	189	56

* Only woven monofilament geotextiles are acceptable as < 50% elongation filtration geotextiles. No woven slit film geotextiles are permitted.

APPENDIX IIID-D

WASTE-AS-BALLAST PLACEMENT RECORD

Includes pages IIID-D-1 through IIID-D-2

WASTE-AS-BALLAST PLACEMENT RECORD

This form is to be completed by the Site Manager or designated representative for all landfill areas utilizing waste as ballast. One form will be developed for each area (or combination of areas) described by approved liner evaluation reports. This form is to be submitted with the Ballast Evaluation Report (BER) for the evaluated area and may be referenced by the Professional of Record (POR) in order to verify that the placement of ballast is in compliance with the Liner Quality Control Plan (LQCP). The site operator must prepare and sign supporting documentation on a daily basis verifying the area of waste placement, the waste material in the first 5 feet of waste was free of large bulky items, daily operation of the pressure relief/dewatering system, and a wheeled trash compactor having a minimum weight of 40,000 pounds was used.

A. GENERAL INFORMATION

Area documented by this record (provide site grid coordinates of each corner) ____________
____

Soils and Liner Evaluation Report document date(s) and approval date(s) for this area ______

Date of initial waste placement ____________

Date of completion of first 5 feet of waste in place over entire area ________________

Total required waste-as-ballast thickness for this area (Note: Calculations for determining the required thickness of waste as ballast are included with the LQCP/BER for this area.) ________________

Date when minimum required thickness of waste was achieved ____________________

B. WASTE EQUIPMENT USED

What type of compaction equipment was used? ______________________________

Did the compactor have a minimum gross weight of 40,000 pounds? ________________

Was this compactor used throughout the entire period covered by this record? ___________

If a minimum 40,000-pound wheeled trash compactor was not used throughout the period covered by this record, attach documentation of initial and final survey data (if not previously provided as part of the BER) of the ballasted area and measurements of truck weights at the scalehouse for the time period covered by the BER for use in determining in-place waste density. Is this documentation complete and accurate? __________________________

C. FIRST WASTE LIFT CONSIDERATIONS

Describe type(s) of waste placed in first 5 feet of waste over the top of the liner protective cover ____________________

Does the first 5 feet of waste contain any large bulky waste items which would damage the underlying liner system or which cannot be compacted to the required density? ____________________

D. WASTE COMPACTION METHODS

Approximate loose waste layer thickness prior to compaction ________________

Minimum number of compactor passes for each waste layer ________________

Maximum slope of compacted waste layers ______________________________

E. PRESSURE RELIEF/DEWATERING SYSTEM

Was the pressure relief/dewatering system (if required) operated continuously during the period covered by this record? __________ Is the pressure relief/dewatering system presently in operation? ____

SIGNATURE OF PERMITTEE OR OPERATOR

The waste overlying the area described in this record has been placed and compacted as described in this record and in accordance with the Liner quality control plan and Site Operating Plan.

____________________ (Signature)	Camelot Landfill (Business Name or Facility)
____________________ (Typed or Printed Name)	____________________
____________________ (Title)	____________________ (Address, City, Zip Code)
____________________ (Date Signed)	____________________ (Phone No.)

Note: This completed form must be submitted with the BER and placed in the Operating Record and available for review.

CAMELOT LANDFILL
CITY OF LEWISVILLE, DENTON COUNTY
TCEQ PERMIT NO. MSW-1312B

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIE
FINAL COVER SYSTEM QUALITY CONTROL PLAN

Prepared for

City of Farmers Branch

March 2012

NEVZAT TURAN
84059

3-21-12

Prepared by

Weaver Boos Consultants, LLC–Southwest
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Project No. 1339-351-11-02-6B.5

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STATE OF TEXAS
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CONTENTS (Continued)

STATE OF TEXAS
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TABLES

1 INTRODUCTION

1.1 Purpose

This Final Cover System Quality Control Plan (FCSQCP) has been prepared for the standard Subtitle D final cover system to provide the Owner, Operator, Design Engineer, Construction Quality Assurance Professional of Record, and the Contractor the means to govern the construction quality and to satisfy the environmental protection requirements under current Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Regulations (MSWR). More specifically, the FCSQCP addresses the soil and geosynthetic components of the final cover system.

This FCSQCP is divided into the following parts:

- Section 1 – Introduction
- Section 2 – Construction Quality Assurance for Soil Infiltration Layer
- Section 3 – Construction Quality Assurance for Geosynthetics
- Section 4 – Construction Quality Assurance for Erosion Layer
- Section 5 – Documentation

1.2 Definitions

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

ASTM

American Society for Testing and Materials.

Atterburg Limits

A series of six "limits of consistency" of fine-grained soils defined by Swedish soil scientist Albert Atterberg, two of which are frequently used today to establish a soil's physical boundaries dealing with its plasticity characteristics. These soil boundaries or limits used most frequently in geotechnical engineering are based upon the numerical difference of the Liquid Limit and the Plastic Limit as defined below:

Liquid Limit (LL) – The percentage of moisture in a soil, subjected to a prescribed test, that defines the upper point at which the soil's consistency changes from the plastic to the liquid state.

Plastic Limit (PL) – The percentage of moisture in a soil, subjected to a prescribed test, that defines the lower point at which the soil's consistency changes from the plastic to the semi-solid state.

Plasticity Index (PI) – The numerical difference between the LL and the PL of a fine-grained soil that denotes the soils plastic range. The larger the PI the greater a soil's plasticity range and the greater it's plasticity characteristics.

Compactive Effort

The amount of compaction energy held constant, and usually transferred into a soil sample with a compaction hammer device, used on soil samples in various laboratory test procedures to establish a soil's density at various moisture contents.

Construction Quality Assurance (CQA)

A planned system of activities that provides the Operator and permitting agency assurance that the facility was constructed as specified in the design (EPA, 1986). Construction quality assurance includes observations and evaluations of materials, and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for a project.

Construction Quality Assurance (CQA) Monitors

These are representatives of the POR who work under direct supervision of the POR. The CQA monitor is responsible for quality assurance monitoring and performing onsite tests and observations. The CQA monitor is on site full-time during construction and reports directly to the POR. The CQA monitor performing daily QA/QC observation and testing shall be NICET-certified in geotechnical engineering technology at level two or higher for soils and FML testing; a CQA monitor with a minimum of four years of directly related experience; or a graduate engineer or geologist with one year of directly related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA monitor(s) under the direction of the POR. Additional CQA monitors may be used. If working under the direction of a CQA monitor, the second CQA monitor will have a minimum of one year of directly related experience.

Construction Quality Assurance Professional of Record (POR)

The POR is an authorized representative of the Operator and has overall responsibility for construction quality assurance and confirming that the facility was constructed in general accordance with plans and specifications approved by the permitting agency. The POR must be licensed as a Professional Engineer in Texas and experienced in geotechnical testing and its interpretations. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance, and quality control testing, and hydrogeology. The POR must show competency and experience in certifying like installations, and be approved by the permitting agency, and be presently employed by or practicing as a geotechnical engineer in a recognized geotechnical/environmental engineering organization. The credentials of the POR must meet or exceed the minimum requirements of the permitting agency. Any references to monitoring, testing, or observations to be performed by the POR should be interpreted to mean the POR or CQA monitors working under the POR's direction. The POR or his designated representative will be on-site during all final cover system construction.

The POR may also be known in applicable regulations and guidelines as the CQA Engineer, Resident Project Representative, or the Geotechnical Professional (GP).

Contract Documents

These are the official set of documents issued by the Operator. The documents include bidding requirements, contract forms, contract conditions, specifications, contract drawings, addenda, and contract modifications.

Contract Specifications

These are the qualitative requirements for products, materials, and workmanship upon which the contract is based.

Contractor

This is the person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered into a contract with the Operator and who is referred to throughout the contract documents by singular number and masculine gender.

Design Engineer

These individuals or firms are responsible for the design and preparation of the project construction drawings and specifications. Also referred to as "designer" or "engineer."

Earthwork

This is a construction activity involving the use of soil materials as defined in the construction drawings and specifications and Section 2 of this plan.

Film Tear Bond (FTB)

A failure in the geomembrane sheet material on either side of the seam and not within the seam itself.

Final Cover System Evaluation Report (FCSER)

Upon completion of closure activities, the certification will be in the form of the FCSER which will be signed by the POR and include all the documentation necessary for certification of closure.

Fish Mouth

A semi-conical opening of the seam that is formed by an edge wrinkle in one sheet of the geomembrane.

Geomembrane Liner (GM)

This is a synthetic lining material, also referred to as geomembrane, membrane liner, or sheet. The term Flexible Membrane Liner (FML) is also used for GM.

Geosynthetics Contractor

This individual is also referred to as the "contractor" or "installer," and is the person or firm responsible for geosynthetic construction. This definition applies to any person installing FML or other geosynthetic materials, even if not his primary function.

Independent Testing Laboratory

A laboratory that is independent of ownership or control by the permittee or any party to the construction of the final cover or the manufacturer of the final cover products used.

Manufacturing Quality Assurance (MQA)

A planned system of activities that provides assurance that the raw materials were constructed (manufactured) as specified.

Manufacturing Quality Control (MQC)

A planned system of inspection that is used to directly monitor and control the manufacture of a material.

Nonconformance

This is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

Operator

The organization that will operate the disposal unit.

Operator's Representative

This is the person that is an official representative of the operator responsible for planning, organizing, and controlling the design and construction activities.

Panel

This is a unit area of the GM or FML, which will be seamed in the field.

Permeant Fluid

Fluid used in a laboratory coefficient of permeability test and limited to tap water or 0.05 Normal solution of $CaSO_4$. Distilled water will not be used in these test procedures.

Quality Assurance

This is a planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents. Quality assurance includes quality control. Quality assurance will be performed by the POR and CQA monitor.

Quality Control

These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. Quality control will be performed by the contractor:

Representative Sample

A representative sample of FML material consists of 1 or more specimens (commonly referred to as coupons) from the same rectangular portion of FML material, oriented along a seam, that is removed for field or laboratory testing purposes.

Slip Direction

The direction in which translational slip will occur (i.e., the direction oriented parallel to the sideslope or top slope of the landfill).

Soil Borrow Source

Soils in which the Liquid Limit (LL) and Plasticity Index (PI) do not vary by 10 points. A soil that varies by 10 or more points from the originally established LL or PI is considered as a separate soil source for the purpose of this FCSQCP and requires a separate soils test series.

Soil Test Series

Tests performed to determine a soil's physical characteristics and to document its ability to satisfy the MSWR soil infiltration layer requirements. These tests include sieve analysis (gradation), Atterberg Limits, moisture/density, and coefficient of permeability.

Specimen

(With respect to FML destructive testing) – A specimen is the individual test strip (sometimes called coupon) from a sample location. A sample location usually consists of many specimens.

2 CONSTRUCTION QUALITY ASSURANCE FOR SOIL INFILTRATION LAYER

2.1 Introduction

This section of the FCSQCP addresses the construction of the soil infiltration layer component of the final cover system and outlines the FCSQCP program to be implemented with regard to materials selection and evaluation, laboratory test requirements, field test requirements and treatment of problems.

The scope of soil infiltration layer related construction quality assurance includes the following elements:

- Subgrade preparation
- Soil infiltration layer stockpile
- Soil infiltration layer placement
- General fill

2.2 Composite Final Cover

The landfill is designed to include a composite final cover. The composite final cover system includes an 18-inch-thick compacted clay infiltration layer, 40-mil LLDPE geomembrane (smooth on topdeck and textured on both sides on sideslopes), drainage geocomposite, and a 24-inch-thick erosion layer. The final cover system is designed to minimize the amount of precipitation that infiltrates the deposited waste, thus minimizing the amount of leachate generated. The final cover system is designed to convey stormwater to detention ponds via final cover erosion control structures and perimeter channels and to prevent water and wind erosion.

2.3 Soil Infiltration Layer Construction

Sections 2.3.1 and 2.3.2 describe general construction procedures to be used for the soil infiltration layer and the preparation of the intermediate cover layer.

2.3.1 Intermediate Cover

The surface of the intermediate cover will be compacted to prepare the working surface for the first lift of infiltration layer soil. The CQA monitor will visually inspect and approve the prepared intermediate cover prior to the placement of the soil infiltration layer or structural fill. Approval will be based on a review of test information, if applicable, and CQA monitoring of the intermediate cover preparation.

Surveying will be preformed to verify that the finished intermediate cover is completed consistent with the lines and grades specified in the design.

2.3.2 Soil Infiltration Layer

The soil infiltration layer will consist of a minimum 18-inch-thick compacted soil barrier (measured perpendicular to the subgrade surface) that will extend along the sideslopes and topslopes of the landfill. All soils used in soil infiltration layers will have the following minimum values verified by testing in a third party soil laboratory:

- Plasticity Index equal to or greater than 15.
- Liquid Limit equal to or greater than 30.
- Percent passing the No. 200 mesh sieve equal to or greater than 30 percent.
- Percent passing the 1-inch screen equal to 100 percent.
- Coefficient of permeability of less than or equal to $1x10^{-5}$ cm/s.

The soil infiltration layer material will consist of relatively homogeneous clay, and clayey soils. The soil will be free of debris, rock greater than 1 inch in diameter, vegetative matter, frozen materials, foreign objects, and organics. Testing will be performed in accordance with Section 2.4 (refer to Table 2-1 for test methods) for each borrow source. A permeability test will be conducted on samples from each borrow source. The permeability test specimens will be prepared by laboratory compaction to a dry density of approximately 95 percent of the Standard Proctor (ASTM D 698) maximum dry density at a moisture content at or above the optimum moisture content. One Proctor moisture-density relationship and remolded permeability test will be required for each different material as determined by a change in the liquid limit or plasticity index of more than 10 points.

The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of previously compacted lift; therefore, the compacted lift thickness will not be greater than the pad or prong length. The material will be compacted to a minimum of 95 percent of the maximum dry density determined by Standard Proctor (ASTM D 698) at a moisture content at or above optimum. The CQA monitor, earthwork contractor, and/or Operator will identify the clay material during excavation, and the clay material will be stockpiled separately, if stockpiling is required.

Because of possible variability of the available clay materials, additional stockpile testing will be performed if different physical properties of the borrow soil (color, texture, etc.) are observed by the CQA monitor, and the materials vary by more than ten points in either liquid limit or plasticity index from previously evaluated materials.

The clay materials to be used for infiltration layer will require processing to achieve the required moisture content for compaction. The physical characteristics of the clay materials will be evaluated through visual observation before and during construction. To add moisture to the material properly, the clod sizes will first be crushed into manageable sizes of 1 inch in diameter or less. Rocks within the infiltration layer should be less than 1 inch in diameter and will not total more than 10 percent by weight. The prepared infiltration layer will be observed such that rock content will not be a detriment to the integrity of the overlying geomembrane.

Clod-size reduction, if necessary, may be achieved using a disc harrow or soil pulverizer. In order to efficiently break down the clods and pieces of shale, multiple passes of the processing equipment in two directions are recommended. Water will be applied as necessary to the material and worked into the material with the processing or compacting equipment. If necessary to achieve even moisture distribution or break down clod, the material will be watered and processed in the stockpile prior to placing in the infiltration layer to allow the soil adequate time to hydrate. Water used for the soil infiltration layer must be clean and not contaminated by waste or any objectionable material. Collected onsite stormwater may be utilized if it has not come into contact with the solid waste.

The soil infiltration layer must be compacted with a pad/tamping-foot (preferable) or prong-foot (sheepsfoot) roller. The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of the previously compacted lift; therefore, the lift thickness must not be greater than the pad or prong length. The top of intermediate cover will be scarified a minimum of two inches prior to placement of the first lift of soil infiltration layer. Use of pad/tamping foot or prong-foot rollers will provide sufficient roughening of soil infiltration layer lift's surface for bonding between lifts. These procedures are necessary to achieve adequate bonding between lifts and reduce seepage pathways. Adequate cleaning devices must be in place and maintained on the compaction roller so that the prongs or pad feet do not become clogged with clay soils to the point that they cannot achieve full penetration during initial compaction. The footed roller is necessary to achieve this bonding and to reduce the individual clods and achieve a blending of the soil matrix through its kneading action. In addition to the kneading action, weight of the compaction equipment is important. The minimum weight of the compactor should be 40,000 pounds, and a minimum of four passes are recommended for the compaction process. A pass is defined as one pass (1 direction) of the compactor, not just an axle, over a given area. The recommended minimum of four passes is for a vehicle with front and rear drums. The Caterpillar 815B and 825C are examples of equipment typically used to achieve satisfactory results.

The soil infiltration layer will not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed roller.

CQA testing of the soil infiltration layer will be performed as the infiltration layer is being constructed. Testing procedures, frequency, and passing criteria will be in accordance with Section 2.4.

Soil infiltration layer construction and testing will be conducted in a systematic and timely fashion on each lift. In general, delays will be avoided in infiltration layer construction (typically no more than 14 days). Reasons for any delays in infiltration layer construction (greater than 14 days) should be fully explained in the FCSER submittal.

The finished top surface of the soil infiltration layer must be rolled with a smooth, steel-wheeled roller to obtain a hard, uniform, and smooth surface. The surface of the soil infiltration layer will then be carefully inspected by the CQA monitor for any gravel, rock pieces, and deleterious materials, which might impact the integrity of the geomembrane to be placed upon it. All voids created by removing gravel, rock pieces, or other deleterious materials will be backfilled with infiltration layer material to the density specifications outlined for soil infiltration construction and tested at the discretion of the CQA monitor.

Surveying (thickness verification) will be performed to document that the finished soil infiltration layer has been constructed to a minimum thickness of 18 inches. Thickness verification may be performed by using settlement plates (e.g., plywood sheet or similar material) on a 100-foot grid. The infiltration layer will be surveyed as indicated in Table 2-1 to verify that a minimum 18-inch-thick soil layer is present at each location.

A typical settlement plate diagram is shown on Figure IIIE.1. The location of the settlement plates will be established by a Texas registered surveyor on a 100-foot grid. The shaft extending upward from the base will be marked to indicate the minimum required thickness of the infiltration layer. The infiltration layer will be constructed to the minimum thickness marked on the shaft of the settlement plate. The POR and CQA monitor will verify that the infiltration layer is placed uniformly between each settlement plate.

An infiltration layer thickness drawing at each of the survey measurement grid points will be provided. Coordinates defining the perimeter of the final cover system will be called out on the final drawings. The infiltration layer thickness drawing will be sealed by a Texas registered surveyor. After the construction of the infiltration layer is complete, the Texas registered surveyor will survey the final elevation of the infiltration layer. The infiltration layer certification drawing will be included in the FCSER. In addition, the elevations obtained for the top of the infiltration layer will be used to verify that the as-built slopes are consistent with the approved landfill completion plan (Drawing A.3 in Appendix IIIA-A). A statement that confirms that the as-built slopes are consistent with the approved landfill completion plan will be included in the FCSER.

Once the survey is complete, the settlement plate shaft will be removed and the resulting hole will be backfilled with bentonite or a bentonite/infiltration layer soil mixture consisting of at least 20 percent bentonite.

Testing and evaluation of the soil infiltration layer during construction will be in accordance with this FCSQCP. The construction methods and test procedures documented in the FCSER will be consistent with the FCSQCP.

The soil infiltration layer will be prevented from losing moisture prior to placement of geomembrane. Preserving the moisture content of the installed soil infiltration layer will be dependent on the earthwork contractors means and methods and is subject to POR approval.

Sections of the soil infiltration layer which do not pass both the density and moisture requirements will be reworked with additional passes of the compactor until the section in question passes. All field density test results will be incorporated into the FCSER.

Hydraulic conductivity samples will be obtained by pushing a sampler through the constructed infiltration layer. The sample from each test location will be sealed and transported to the laboratory. Two samples may be collected at each sample location and labeled the "A" and "B" sample. The sampling holes (e.g., samples for hydraulic conductivity) will be backfilled with bentonite or a bentonite/infiltration layer soil material mixture consisting of at least 20 percent bentonite.

If the integrity of the "A" sample appears to have been compromised during the transportation of the sample prior to testing, the "B" sample may be tested. In addition, if an "A" sample hydraulic conductivity test does not comply with the maximum allowable value, the "B" sample collected at the same location may be tested to determine compliance with the hydraulic conductivity requirements if during testing of the "A" sample, the ASTM D 5084 or EM 1110-2-1906 procedure was not followed or the permeameter malfunctioned.

The POR will provide a detailed justification of the use of the "B" sample, if applicable, in the FCSER.

If the "B" sample passes, the area will be considered in compliance. If the "B" sample fails (or sample "A" fails in such a way that there is not an option to use the "B" sample), the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location). Additional tests may be performed to further define the unsatisfactory area. The area defined unsatisfactory will be reworked and retested in accordance with this section.

Furthermore, if it is determined that the "B" sample may not be used to replace the "A" sample result, then the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location).

Once the exact area is determined, the constructed soil infiltration layer lifts will be removed to the bottom of the lift that did not pass the hydraulic conductivity test, and reconstructed until all the samples obtained from the failed area meet the hydraulic conductivity requirements. At a minimum, one hydraulic conductivity test will be performed for each repair area, given that the reconstructed soil infiltration layer area is not larger than one acre. The reconstructed soil infiltration layer area will be tied into the currently constructed soil infiltration layer with a 5H:1V transition slope. The reconstructed soil infiltration layer area is also subject to field density and moisture content testing per Table 2-1 (at least one field density and one moisture content test is required for each lift regardless of the size of the area that is reconstructed).

Reconstruction activities, including additional testing and surveying, will be incorporated into the FCSER.

2.3.3 Structural Fill

Structural fill for the construction of final cover will consist of clayey soil material and will be placed in uniform lifts which do not exceed 12 inches in loose thickness. Structural fill material will be compacted to provide unyielding firm surfaces. In certain cases such as installing perimeter road berms, final cover swales, etc., the POR may require compaction verification using Standard Proctor.

2.3.4 Surface Water Removal

The prepared intermediate cover or infiltration layer which is under construction may encounter water from storm events. Prior to placement of the soil infiltration layer, intermediate cover will be graded to provide positive drainage for the base grades of the soil infiltration layer. The soil infiltration layer will not be placed in standing water and water will not be allowed to accumulate over constructed infiltration layer. The construction area will be graded to provide for positive drainage. Temporary diversion berms will be constructed as needed to divert surface flow away from the construction area.

2.3.5 Infiltration Layer Tie-In Construction

Newly constructed infiltration layer will be tied-in with any adjoining existing infiltration layers. Additionally, terminations will be constructed for future tie-ins along edges where the infiltration layer will be extended in the future. During the construction of continuous infiltration layers, the new infiltration layer segment will not be constructed by "butting" the entire thickness of the new infiltration layer directly against the edge of the old infiltration layer. The tie-in will be constructed either by a sloped transition (typically 5 horizontal to 1 vertical) or a stair-stepped transition (typically 1 lift thickness per step). The length of the tie-in should be at least 5 feet per foot of infiltration layer thickness. The tie-ins with existing clay infiltration layer will be constructed utilizing a sloped or stair-stepped transition. In general, terminations for future tie-ins will be constructed by extending the infiltration layer approximately 7.5 feet past the limits for the final cover area under construction.

2.4 Construction Testing

2.4.1 Standard Operating Procedures

CQA monitors will perform field and laboratory tests in accordance with applicable standards specified in the project technical specifications which will be developed for each phase of final cover construction. Standard operating procedures for soil testing will be prepared that describe test procedures and methods used by site testing personnel for the test methods listed in Table 2-1. Sampling will be performed by using standard ASTM practices for recovering samples (e.g., ASTM D 1587). The sampling holes (e.g., sample for hydraulic conductivity) will be backfilled with liner soil material, bentonite or bentonite/liner soil mixture. The standard operating procedure may be prepared or modified by the POR during construction, as necessary, to address site specific construction issues. Additional geotechnical testing requirements are included in Section 5 to ensure that the installed final cover will be stable.

2.4.2 Test Frequencies

The test frequencies for the infiltration layer are listed in Table 2-1. Additional testing will be conducted whenever work or materials are suspect, marginal, or of poor quality. Further testing may also be performed to provide additional data for engineering evaluation. The minimum number of tests is interpreted to mean minimum number of passing tests, and any tests that do not meet the requirements will not contribute to the total number of tests performed to satisfy the minimum test frequency.

2.5 Reporting

The POR on behalf of the Operator will submit to the TCEQ a FCSER for approval of each final cover area. Section 6 describes the documentation requirements.

Table 2-1
Standard Tests on Infiltration Layer Soils

Soil Test Category	Type of Test	Standard Test Method	Frequency of Testing
Quality Control Testing of Source Borrow Materials	Unified Soil Classification	ASTM D 2487	Once per soil type
	Moisture/Density Relationship	ASTM D 698 or D 1557	
	Grain Size	ASTM D 422 or D 1140	
	Atterberg Limits	ASTM D 4318	
	Coefficient of Permeability	ASTM D 5084 or CoE Em1110-2-1906[2]	1/Moisture/Density Relationship
Constructed Soil Infiltration Layer	Field Density	ASTM D 6938 and D 2216[4]	1/8,000 ft^2 per 6-inch lift[1]
	Grain Size	ASTM D 422 or D 1140	1/100,000 ft^2 per 6-inch lift[1]
	Atterberg Limits	ASTM D 4318	
	Coefficient of Permeability	ASTM D 5084 or CoE EM1110-2-1906[2]	1/surface acre (evenly distributed through all lifts)[1]
	Thickness[3]	Texas Licensed Surveyor	1/10,000 ft^2

[1] A minimum of 1 of each of the designated tests must be conducted for each lift, regardless of cover area.

[2] Conduct both types of permeability tests as indicated.

[3] If the option to use settlement plates to verify the thickness of the final cover layers is utilized, the procedure outlined in Section 2.3.2 will be followed.

[4] This method is not applicable if the field measuring device (i.e., nuclear gauge) also measures moisture.

3 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

3.1 Introduction

This section describes CQA procedures for the installation of geosynthetic components.

The scope of geosynthetic-related construction quality assurance includes the following elements:

- Geomembrane Liner
  - 40-mil LLDPE – smooth on the top slopes and textured on both sides for the side slopes. Minimum required material properties for the geomembrane are listed in Table 3-2.
- Drainage Layer
  - Drainage geocomposite (single-sided on the top slopes and double-sided on the side slopes). Minimum required material properties for the drainage layer are listed in Table 3-3.

The overall goal of the geosynthetics quality assurance program is to assure that proper construction techniques and procedures are used, the geosynthetic contractor implements his quality control plan in accordance with this FCSQCP, the construction and testing of all elements of the final cover are performed in accordance with this FCSQCP and the Closure Plan (Appendix IIIK), and that the project is built in accordance with the project construction drawings and technical specifications. The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are avoided and/or corrected before construction is complete. The FCSER, prepared after project completion, will document that the constructed facility meets design intent and specifications and that all final cover construction and QA/QC testing are performed in accordance with this FCSQCP.

3.2 Geosynthetics Quality Assurance

3.2.1 General

A geomembrane and a drainage geocomposite are the geosynthetic components of the composite final cover system. All testing requirements and minimum required properties are listed in Tables 3-1, 3-2, and 3-3. Construction quality control for the geosynthetic installation will be performed by the geosynthetic installation contractor. Construction quality assurance for the geosynthetic installation will be performed by the POR to assure the geosynthetic is constructed as specified in the design. Construction must be conducted in accordance with the project construction drawings, which will be developed in accordance with this FCSQCP and the Closure Plan (Appendix IIIK) at the time of each final cover construction and in accordance with specifications outlined in this FCSQCP. To monitor compliance, a quality assurance program will include the following:

- A review of the manufacturer's quality control submittals;
- Material conformance testing;
- Field and construction testing; and
- Construction monitoring.

The manufacturer's quality control submittals will include resin and physical material testings. Conformance testing refers to verification tests conducted by an independent third party laboratory to confirm the material meets the required specification prior to acceptance of the geosynthetic from the manufacturer. Field and construction testing includes testing that occurs during geosynthetics installation.

Quality assurance testing will be conducted in accordance with this FCSQCP, the project construction drawings, and specifications. Field testing will be observed by the CQA monitor. Documentation must meet the requirements of this FCSQCP.

3.3 Geomembrane

3.3.1 General

This section describes material types, handling, installation, and testing of geomembrane. Smooth geomembrane will be used on top slopes (e.g., 4 percent slopes) and textured geomembrane will be used on sideslopes (e.g., 25 percent slopes).

3.3.2 Delivery

Upon delivery of the geomembrane, the CQA monitor will observe that:

- The geomembrane is delivered in rolls and is not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the geomembrane will be damaged if it is folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.

- The geomembrane is stored in an acceptable location in accordance with the specifications and stacked not more than five rolls high. The geomembrane is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.
- Manufacturing documentation required by the specifications has been received and reviewed for compliance with the specifications. This documentation will be included in the FCSER.
- The geosynthetics receipt log form has been completed for materials received.

Damaged geomembrane may be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until documentation has been received, reviewed, and accepted.

3.3.3 Conformance Testing

Tests. One geomembrane sample will be obtained for every resin lot of material supplied and for each 100,000 square feet of geomembrane installed. The material will be sampled at the site by the CQA monitor. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Specific gravity/Density (ASTM D 1505 or alternate ASTM D 792, Method A if approved by the POR)
- Carbon black content (ASTM D 1603)
- Carbon black dispersion (ASTM D 5596)
- Thickness (ASTM D 5199 for smooth geomembrane and ASTM D 5994 for textured geomembrane)
- Tensile properties (ASTM D 638/Type IV Specimen)

The density of the geomembrane must be less than 0.939 g/cc; the carbon black content must be between 2 percent and 3 percent; and recycled or reclaimed material must not be used in the manufacturing process.

The design engineer may require additional test procedures and will inform the third party laboratory in writing. The POR must review all test results and report any nonconformance to the design engineer prior to product installation. In addition to the conformance thickness tests shown above, field thickness measurements must be taken at maximum 5-foot intervals along the leading edge of each geomembrane panel. No single measurement may be less than 10 percent below the required nominal thickness for the panel to be accepted (i.e., for 40 mil geomembrane a minimum thickness of 36 mils is required), and the average must be at least 40 mils.

Table 3-1
Required Testing for Geomembranes

Responsible Party	Type of Test		Standard Test Method	Frequency of Testing
Resin Manufacturer	Resin	Density	ASTM D 1505 / D 792	Per 100,000 ft^2 and every resin lot
		Melt Flow Index	ASTM D 1238 (Condition E)	
	Resin/Compound Evaluation		Per manufacturer's quality control specifications	Per manufacturer's quality control specifications
Geomembrane Manufacturer	Manufacturer's Quality Control		Testing per GRI Standard, GRI Test Method GM17 for 40 mil LLDPE[1]	
Conformance Testing by 3rd Party Independent Laboratory	Thickness[2]		ASTM D 5199 (smooth LLDPE), or D 5994 (textured LLDPE)	Per 100,000 ft^2 and every resin lot
	Specific Gravity/Density		ASTM D 1505/D 792	
	Carbon Black Content		ASTM D 4218	
	Carbon Black Dispersion		ASTM D 5596	
	Tensile Properties		ASTM D 6693 Type IV	
3rd Party CQA	Destructive Seam Field Testing[4]	Shear & Peel	ASTM D 6392	Various for field, lab, and archive
3rd Party CQA	Non-Destructive Seam Field Testing	Air Pressure	ASTM D 5820	All dual-track fusion weld seams
		Vacuum	ASTM D 5641	All non-air pressure tested seams when possible

[1] UV Resistance testing not required for geomembrane, which is to be immediately covered.

[2] Field thickness measurements for each panel must be conducted. Use ASTM D 5199/D 5994 and perform 1 series of measurements among the leading edge of each panel, with individual measurements no greater than 5 feet apart. No single measurement will be less than 10% below the required nominal thickness in order for the panel to be acceptable.

[3] Break elongation calculated using 2-inch initial gauge length at 2 inches per minute.

[4] Passing criteria for seams are listed in Table 3-2.

Table 3-2
Minimum Required Properties of 40-mil-thick Smooth and Textured (Both Sides) LLDPE Geomembrane

Property	Test Method	Minimum Required Property[6]	
		Smooth	Textured
Thickness, mils Minimum average Lowest individual reading Lowest individual of 8 of 10 readings	ASTM D 5199 (smooth) ASTM D 5994 (textured)	40 36 NA	38 34 36
Density, g/cc (maximum)	ASTM D 1505/D 792	0.939	0.939
Asperity Height, mils	D 7466	NA	10
Tensile Properties[1] Break Strength, lb/in Break Elongation, %	ASTM D 6693, Type IV	152 800	60 250
Tear Resistance, lb	ASTM D 1004	22	22
Puncture Resistance, lb	ASTM D 4833	56	44
Break Resistance Strain, % (min)	ASTM D 5617	30	30
Carbon Black Content[2], %	ASTM D 4218	2.0-3.0	2.0 – 3.0
Carbon Black Dispersion[3], Category	ASTM D 5596	1 or 2 and 3	1 or 2 and 3
Oxidative Induction Time (OIT), minimum average Standard OIT (minutes) or High Pressure OIT (minutes)	ASTM D 3895 ASTM D 5885	100 400	100 400
Oven Aging at 85°C, minimum average Standard OIT – % retained after 90 days or High Pressure OIT – % retained after 90 days	ASTM D 5721 ASTM D 3895 ASTM D 5885	35 60	35 60
UV Resistance[4], minimum average High Pressure OIT[5] – % retained after 1600 hrs	GRI GM 11 ASTM D 5885	35	35
Seam Properties Shear Strength, lb/in Peel Strength, lb/in	ASTM D 6392	60 50 (44, Extrusion Weld)	60 50 (44, Extrusion Weld)

[1] Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.

[2] Other methods such as ASTM D 1603 (tube furnace) or D6570 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.

[3] Carbon black dispersion for 10 different views; 9 in Categories 1 or 2 and 1 in Category 3.

[4] The condition of the test should be 20 hr UV cycle at 75°C followed by 4 hr. condensation at 60°C.

[5] UV resistance is based on percent retained value regardless of the original HP-OIT value.

[6] Minimum Required Property values are based on GRI GM17, except for Seam Properties, which are based on GRI GM19.

Sampling Procedure. Samples will be taken across the entire roll width. Unless otherwise specified, samples should be approximately 15 inches long by the roll width. The CQA monitor must mark the machine direction and the manufacturer's roll identification number on the sample. The CQA monitor must also assign a conformance test number to the sample and mark the sample with that number.

3.3.4 Anchor Trench Backfill

General fill material placed in anchor trenches will be placed in uniform lifts, which do not exceed 12 inches in loose thickness and are compacted. In-place moisture/density tests may be taken at the discretion of the CQA monitor to evaluate the quality of the backfill. The test results will not be required as part of the FCSER. Slightly rounded corners will be provided in anchor trenches where the geomembrane enters the trench so as to avoid sharp bends in the geomembrane. No loose soil (e.g., excessive water content) will be allowed to underlie the anchored components of final cover system.

3.3.5 Geomembrane Installation

Surface Preparation. Prior to any geomembrane installation, the subgrade (e.g., soil infiltration layer) should be inspected by the CQA and geosynthetics contractor. The POR or CQA monitor must observe the following:

- Lines and grades for the infiltration layer have been verified by the contractor and surveying of top of soil infiltration grades has been completed in accordance with Section 2.
- Soil infiltration layer construction has been completed in areas with no ponded water.
- The infiltration layer has been placed in accordance with the specification.
- No signs of desiccation exist, and the moisture content of the infiltration layer surface was controlled. A smooth drum roller will be used, as necessary, to minimize desiccation.
- The infiltration layer is free of surface irregularities and protrusions.
- The infiltration layer surface does not contain stones or other objects that could damage the geomembrane and underlain infiltration layer. The surface will be smooth and free of foreign and organic material, sharp objects, stones greater than 3/4 inches, or other deleterious material.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.
- The geomembrane will not be placed during inclement weather such as rain or high winds.
- Construction stakes and hubs have been removed and the resultant holes have been backfilled. There are no rocks, debris, or any other objects on the infiltration layer surface.
- The geosynthetics contractor, POR or his representative, and the permittee or his representative have certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Prior to the installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings. The POR must review field conditions and approve revised panel layout plan if the field conditions vary from the original plan layout.

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations.

During panel placement, the POR or CQA monitor must:

- Observe that the geomembrane is placed in direct and uniform contact with underlying soil infiltration layer.
- Record roll numbers, panel numbers, and dimensions on the panel or seam logs. Measure and record thickness of leading edge of each panel at 5-foot maximum intervals. No single thickness measurement can be less than 10 percent below the required nominal thickness.
- Observe the sheet surface as it is deployed and record panel defects and repair of the defects (panel rejected, patch installed, extradite placed over the defect, etc.) on the repair sheet. Repairs must be made in accordance with the specifications and located on a repair drawing.
- Observe that support equipment is not allowed on the geomembrane during handling (see Section 3.5 also).
- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance.
- Observe that there are no stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.
- Observe that the geomembrane is not dragged across a surface that could damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, as necessary.
- Record weather conditions including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, geomembrane seaming operation should not be performed when the air temperature is less than 41°F or greater than 104°F, or when standing water or frost is on the ground, unless these requirements are waived by the design engineer. Excessive wind is that which can lift and move the geomembrane panels.
- Observe that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.

- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown geomembrane). Excessive wrinkles should be walked-out or removed at the discretion of the CQA monitor.
- Observe that no more panels are deployed than can be seamed on the same day.
- Observe that seams on side slopes are oriented parallel to the slip direction, and the textured material extends a minimum of approximately 5 feet out past the side slope.

The CQA monitor must inform both the contractor and the POR of the above conditions.

Field Seaming. The contractor must provide the POR with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels should be seamed until the panel layout drawing has been accepted by the POR. A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Prior to geomembrane welding, each welder and welding apparatus (both wedge and extrusion welder) must be tested, at a minimum, at daily start-up and immediately after any break, and/or anytime the machine is turned off for more than 30 minutes in accordance with the specifications to determine if the equipment is functioning properly. The FCSER should include the names for each seamer and the time and the temperatures for each seaming apparatus used each day. One trial weld will be taken prior to the start of work and when the type of geomembrane seam (e.g., smooth to smooth, smooth to textured, etc.) is changed. In addition, a trial weld will also be obtained prior to seaming the tie-in. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required). Trial weld samples must comply with "Passing Criteria for Welds" included in Section 3.3.6 – Construction Testing. The CQA monitor must observe welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. The trial weld will be completed under conditions similar to those under which the panels will be welded. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392:

Hot Wedge:	AD and AD-Brk>25%
Extrusion Fillet:	AD1, AD2, AD-WLD (unless strength is achieved)

Additionally, there should be no apparent weld separation (i.e., greater than 1/8 inch). The third party strength tests must meet the manufacturer's specifications for the sample sheets, or percentage of the manufacturer's parent sheet strength as determined by the manufacturer. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. If, at any time, the CQA monitor believes that an operator or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (±30° Fahrenheit), humidity, or wind speed, the test weld should be repeated. The test weld must be allowed to cool to ambient temperature before testing. If a weld test fails the shear or peel test, the length of the non-passing weld will be identified at a 10-foot interval, and the failed area will be patched. Patching will be performed by placing additional geomembrane material over the failed area or removing the failed geomembrane weld and patching it with additional geomembrane per POR's direction. The welding for patches must comply with the welding passing criteria requirements outlined in this section.

Construction quality assurance documentation of trial seam procedures will include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday.
- The welder, the welding apparatus number, time, date, ambient air temperature, and welding machine temperatures.

During geomembrane welding operations, the CQA monitor must observe the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.
- The extrusion welder is purged prior to beginning a weld until the heat-degraded extradite is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).
- The ambient temperature, measured 6 inches above the geomembrane surface, is between 41°F and 104°F, or manufacturer's recommended temperature limits if they are more stringent.
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding.
- The weld is free of dust, rocks, and other debris.
- The seams are overlapped a minimum of 3 inches for extrusion and hot-wedge welding, or in accordance with manufacturer's recommendations, whichever is

more stringent. Panels should be overlapped (shingled) in the downgrade direction.

- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- The panels are being welded in accordance with the plans and specification. Seams should be oriented parallel to the line of maximum slope with no horizontal seams on side slopes or top slopes. In corners and odd-shaped geometric locations, the number of field seams should be minimized.
- There is no free moisture in the weld area.
- Measure surface sheet temperature every two hours.
- Observe that at the end of each day or installation segment, unseamed edges are anchored with sandbags or other approved device. Penetration anchors will not be used to secure the geomembrane.

3.3.6 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests for geomembrane include vacuum testing for extrusion welds and air pressure testing for dual-track fusion welds. Nondestructive testing must be performed over the entire length of the seam.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to observe and document that testing performance is in compliance with the specifications and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

- For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section that has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is reduced to approximately 3 to 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than ten seconds.
- Air pressure testing is used to test double seams with an enclosed air space. Both ends of the air channel should be sealed. The pressure feed device, usually a

needle equipped with a pressure gauge, is inserted into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive testing, the CQA monitor must perform the following work:

- Review technical specifications regarding test procedures.
- Observe that equipment operators are fully trained and qualified to perform their work.
- Observe that test equipment meets project specifications.
- Observe that the entire length of each seam is tested in accordance with the specifications.
- Observe all continuity testing and record results on the appropriate log.
- Observe that testing is completed in accordance with the project specifications.
- Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane and inform the contractor of any required repairs, then record the repair area on the repair log.
- Observe that repairs are completed and tested in accordance with the project specifications.
- Record completed and tested repairs on the repair log and the repair drawing.

Destructive Seam Testing. Destructive seam tests for geomembrane seams will be performed at a frequency of at least one test for each 500 linear feet of seam length. At a minimum, a destructive test will be completed for each welding machine used for seaming. A destructive test will also be completed for individual repairs (or additional seaming for the failed welds) of more than 10 feet of seam length. The CQA monitor must perform additional tests if he suspects a seam does not meet specification requirements. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination
- Insufficient overlap

- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear) in accordance with ASTM D 6392. The purpose of peel and shear tests is to evaluate seam strength and to evaluate long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature prior to testing.

The CQA monitor selects locations where seam samples will be cut for laboratory testing. Select these locations as follows:

- A minimum of one stratified location for every 500 feet of field seam length or major fraction thereof.
- Sample locations should not be disclosed to the contractor prior to completion of the seam.
- A maximum frequency must be agreed to by the contractor, POR, and the Operator at the preconstruction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the POR. Samples taken as the result of failed tests do not count toward the total number of required tests.

Sampling Procedures. The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number that contains the seam number and destructive test number.
- Record sample location on the panel layout drawing and destructive seam log.
- Record the sample location, weather conditions, and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.).

For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. Cut two 1-inch-wide coupons from each end of the sample (a total of 4 coupons). The contractor must test two of these coupons in shear and two in peel (one shear and one peel from each end) using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of the air channel will be tested in peel. The CQA monitor must observe the tests and record the results on the destructive seam test log. A geomembrane seam sample passes the field testing when the break is a film tear bond (FTB) and the seam strength meets the required strength values for peel and shear given previously in Table 3-2 and below in the subsection "Passing Criteria for Welds" for both field testing and third party laboratory testing. As previously discussed, both welds have to pass for dual-track welds. Also, it is recommended that additional samples be obtained as discussed in the following paragraph if there is apparent separation of the weld (i.e., greater than 1/8 inch) during peel testing.

If one or both of the 1-inch specimens fail in either peel or shear, the contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations, or (2) take two additional test samples 10 feet or more in either direction from the point of the failed test and repeat this procedure. For tracking purposes the additional samples should be identified by assigning an identifying letter to the initial destructive test sample number (e.g., DS-6A and B). Only satisfactory tests count toward the required minimum number, and additional tests (i.e., A and B) count as one test, if passing. If the second set of tests pass, the contractor can reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly, and appropriate corrective action must be taken immediately.

If the field test coupons are satisfactory, divide the remaining sample into three parts: one 12-inch by 12-inch section for the contractor, one 12-inch by 16-inch section for the third party laboratory for testing, and one 12-inch by 12-inch section for the Operator to archive. The laboratory sample will be shipped to the third party laboratory for delivery and subsequent testing.

If the laboratory test fails in either peel or shear, the contractor must either reconstruct the entire seam between passing test locations or recover additional samples at least 10 feet on either side of the failed sample for retesting. Sample size and disposition must be as described in the preceding paragraph. This process is repeated until passed tests bracket the failed seam section. Seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

Third Party Laboratory Testing. Destructive samples must be shipped to the third party laboratory for seam testing. Testing for each sample will include five bonded seam shear strength tests and five peel adhesion tests (ten for dual-track welds). For dual-track welds each peel test specimen (coupon) will be tested on both sides of the air channel (i.e., the inner and outer welds). At least four of the five specimens tested in peel and shear will meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the manufacturer's specifications. Additionally, 4 of 5 of the peel test coupons must have no greater than 25 percent seam separation. For dual-track welds if either weld exhibits greater than 25 percent separation or does not meet the required strength, that coupon is considered out of compliance and two out of compliance coupons cause the weld to fail. The third party laboratory must provide test results in timely manner, in writing or via telephone, to the POR. Certified test results are to be provided within five days. The CQA monitor must immediately notify the POR in the event of a calibration discrepancy or failed test results.

Passing Criteria for Welds. Passing criteria are established by Geosynthetic Institute GRI Test Method GM-19 for geomembrane seams. A passing extrusion or fusion welded seam will be achieved when the following values are tested. The following values listed for shear and peel strengths are for 4 out of 5 test specimens (the 5th specimen can be as low as 80 percent of the listed values) for 40-mil smooth and textured LLDPE. Elongation measurements should be omitted for field testing.

• Shear strength (lb/in)	60
• Shear elongation at break (%)	50
• Peel strength (lb/in)	44
• Peel separation (%)	25

3.3.7 Repairs

Any portion of the geomembrane with a detected flaw, or which fails a nondestructive or destructive test, or where destructive tests were cut, or where nondestructive tests left cuts or holes, must be repaired in accordance with the specifications developed for each phase of final cover construction and consistent with application parts (e.g., material requirements, installation, testing, etc.) of Section 3 of this FCSQCP. The CQA monitor must locate and record all repairs on the repair sheet and panel layout drawing. Repair techniques include the following:

- Patching – used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion – used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 3/8-inch in the largest dimension.
- Capping – used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.
- Removal – used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal will be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one hour prior to the repair.
- Clean and dry surfaces at the time of repair.

- Extend patches or caps at least 6 inches beyond the edge of the defect, and round corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches prior to extrusion welding.
- Perform testing on repair seams consistent with Section 4.3.6 – Construction Testing.

3.3.8 Wrinkles

Wrinkles must be walked-out or removed as much as possible prior to field seaming. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane which could result in the geomembrane folding. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being covered by soil. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

3.3.9 Folded Material

Folded geomembrane must be removed. Remnant folds evident after deployment of the roll that are due to manufacturing process are acceptable.

3.3.10 Geomembrane Anchor Trench

The geomembrane anchor trench will be left open until seaming is completed. Expansion and contraction of the geomembrane should be accounted for in the geomembrane placement. Prior to backfilling, the depth of penetration of the geomembrane into the anchor trench must be verified by the CQA monitor at a minimum of 100-foot spacing along the anchor trench. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

3.3.11 Geomembrane Acceptance

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the Operator. In the event the contractor is responsible for placing cover over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete, and the cover material is placed. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be walked by the Operator's and contractor's representatives. Any damage or defect found during this inspection will be repaired properly by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the geomembrane will be accepted by the POR only when the following has been completed:

- The installation is finished.

- Seams have been inspected and verified to be acceptable.
- Required laboratory and field tests have been completed and reviewed.
- Required contractor-supplied documentation has been received and reviewed.
- As-built record drawings have been completed and verified by the POR. The as-built drawings show the true panel dimensions, the location of seams, trenches, pipes, appurtenances, and repairs.
- Acceptance of the FCSER by TCEQ.

3.3.12 Bridging

Bridging must be removed.

3.4 Drainage Geocomposite – Geonet and Geotextile

3.4.1 General

The drainage layer consists of a drainage geocomposite overlying the geomembrane and infiltration layer on the topslopes and sideslopes of the Subtitle D composite final cover areas. The CQA monitor will provide on-site observation of drainage layer installation. The POR will make sufficient site visits during the drainage layer installation to document the installation in the FCSER.

Double-sided drainage geocomposite (non-woven geotextile bonded to the top and bottom of HDPE drainage net) will be installed on the sideslopes and single-sided drainage geocomposite (non-woven geotextile bonded to the top of the HDPE drainage net) will be installed on the top slope. The drainage geocomposite will have the minimum properties listed in Table 3-3.

Manufacturer quality control testing procedures and frequencies for drainage geocomposite are discussed in Section 3.4.3 and Table 3-3.

The drainage layer has been designed to include a network of drainage pipes that will convey flow from the drainage geocomposite to either the final cover drainage letdowns or the perimeter drainage systems. The final cover drainage layer component design, including the design and specification of the pipes, are included in Appendix IIIE-A.

3.4.2 Delivery

Upon delivery the CQA monitor must observe the following:

- The drainage geocomposite is wrapped in rolls with protective covering.
- The rolls are not damaged during unloading.

- Protect the drainage geocomposite from mud, soil, dirt, dust, debris, cutting, or impact forces.
- Each roll must be marked or tagged with proper identification.

Any damaged rolls will be rejected and removed from the site or stored at a location separate from accepted rolls, designated by the Operator. Rolls that do not have proper manufacturer's documentation will also be stored at a separate location until documentation has been received and approved. The references herein to drainage geocomposite also apply to geonet and geotextile as applicable.

3.4.3 Testing

The drainage geocomposite manufacturer (or supplier) will conduct quality control testing and certify that materials delivered to the site comply with project specifications for each phase of final cover construction. The minimum testing frequency will be one test sample per 100,000 square feet of drainage geocomposite (or geonet/geotextile). The material certifications will be reviewed by the POR to verify that the drainage geocomposite meets the values given in the FCSQCP or specifications. Third party laboratory testing will be required for drainage layer geocomposite transmissivity. Additionally, material strength parameters used for geotechnical analysis in Appendix IIIJ will be verified by a third party laboratory prior to construction, and slope stability analysis will be updated as necessary based on site-specific material data.

Geonet will be tested by the manufacturer for thickness, tensile strength, and carbon black content. Geotextile will be tested for mass per unit area, grab tensile strength, and Apparent Opening Size (AOS). The finished drainage geocomposite will be tested for peel adhesion and transmissivity. Table 3-3 summarizes testing requirements for drainage geocomposite and geotextile.

Where optional procedures are noted in the test method, the specification requirements will prevail. The CQA monitor will review test results and will report any nonconformance to the POR and to the contractor.

3.4.4 Installation

Surface Preparation. Prior to drainage geocomposite installation, the CQA monitor must observe the following:

- Lines and grades have been verified by the surveyor (where required).
- The subgrade has been prepared in accordance with the specifications and the geomembrane has been installed as outlined in Section 3.3.5.
- The geomembrane installation, including required documentation, has been completed.
- The supporting surface (i.e., the geomembrane) does not contain stones that could damage the drainage geocomposite or the geomembrane.

Table 3-3
Geotextile and Drainage Geocomposite Required Testing and Properties[1]

Responsible Party	Material	Test	Standard	Required Property
Manufacturer	Geotextile	Unit Weight Apparent Opening Size Grab Strength Tear Strength Puncture Strength Permeability	ASTM D 5261 ASTM D 4751 ASTM D 4632 ASTM D 4533 ASTM D 4833 ASTM D 4491	6 oz/sy 80 sieve 157 lbs 56 lbs 56 lbs 0.2 cm/s
Manufacturer	HDPE Geonet	Specific Gravity Thickness Carbon Black Tensile Strength	ASTM D 1505 ASTM D 5199 ASTM D 1603 ASTM D 7179	0.939 g/cm^3 0.25 inch 2% 45 lb/in (Peak)
Third Party Laboratory[4]	Drainage Geocomposite	Transmissivity[2, 3]	ASTM D 4716	2.20 x 10^{-3} m^2/s (Topslope) 5.69 x 10^{-4} m^2/s (Sideslope)
Manufacturer		Peel Adhesion	ASTM D 7005	1.0 lb/in

[1] The minimum testing frequency will be one test sample per 100,000 square feet.

[2] As noted in Appendix IIIE-A, the transmissivity of the single-sided geocomposite shall be measured at a minimum gradient of 0.04 ft/ft under a minimum normal pressure of 239 psf, boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours. The transmissivity of the double-sided geocomposite shall be measured at a minimum gradient of 0.25 ft/ft under a minimum normal pressure of 232 psf, boundary conditions consisting of soil/geocomposite/geomembrane with a minimum seating time of 100 hours.

[3] Different testing gradients for the geocomposite may be specified by the POR for specific construction events if the gradients specified in Note 2 are no longer conservative in view of existing or expected slope conditions.

[4] Refer to Section 5 for additional geotechnical testing information.

Drainage Geocomposite Placement. During placement, the CQA monitor must:

- Observe the drainage geocomposite as it is deployed and record defects and disposition of the defects (panel rejected, patch installed, etc.). Repairs are to be made in accordance with the specifications.
- Verify that equipment used does not damage the drainage geocomposite or underlying geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.
- Verify that people working on the drainage geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite or underlying geomembrane.
- Verify that the drainage geocomposite is anchored to prevent movement by the wind (the contractor is responsible for any damage resulting to or from wind blown geocomposite).

- Verify that the drainage geocomposite remains free of contaminants such as soil, grease, fuel, etc.
- Observe that the drainage geocomposite is laid smooth and free of tension, stress, folds, wrinkles, or creases.
- Observe that on slopes the drainage geocomposite is secured with sand bag anchoring at the top of the slope and then rolled down the slope.
- Observe that adjacent rolls of drainage geocomposite are overlapped, tied, and seamed in accordance with the specifications and manufacturer's recommendations.
- Observe that tying is with plastic fasteners in accordance with the manufactures recommendations. In the absence of other specifications the geonet panels will be tied approximately every 5 feet along the roll length (edges) and every 1 foot along the roll width (ends).
- Observe that geotextile component is overlapped and either heat bonded or sewn together.

3.4.5 Repairs

Repair procedures include:

- Holes or tears in the drainage geocomposite will be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
- Secure patch to the originally installed drainage geocomposite by tying every 6 inches.
- Where the hole or tear width across the roll is more than 50 percent of the roll width, the damaged area will be cut out across the entire roll, and the two portions of the drainage geocomposite will be jointed.
- Patches will be installed in accordance with "Drainage Geocomposite Placement" under Section 3.4.4.

3.5 Equipment on Geosynthetic Materials

Construction equipment on the composite final cover system will be minimized to reduce the potential for geosynthetic material puncture. The CQA monitor will verify that small equipment such as generators are placed on scrap geomembrane material (rub sheets) above geosynthetic materials in the final cover system. The erosion layer will be placed using low ground pressure equipment. The CQA monitor will verify that the geosynthetics are not displaced while the soil layers (e.g., erosion layer) are being placed.

Unless otherwise specified by the POR, lifts of soil material placed over geosynthetics will conform to the following guidelines:

Equipment Ground Pressure (psi)	Minimum Lift Thickness (in.)
< 5.0	12 and under
5.1 - 8.0	18
8.1 - 16.0	24
>16.0	36

No equipment will be left running and unattended over the constructed geosynthetics.

3.6 Reporting

The POR on behalf of the Operator will submit to the TCEQ a FCSER for approval of the constructed final cover system. Section 6 describes the documentation requirements.

4 CONSTRUCTION QUALITY ASSURANCE FOR EROSION LAYER

The erosion layer will consist of a minimum of 24 inches of earthen material. The erosion layer will be capable of sustaining native and introduced vegetative growth and must be seeded immediately after completion of the final cover. Temporary or permanent erosion control materials may be used to minimize erosion and aid establishment of vegetation. The physical characteristics of the erosion layer will be evaluated through visual observation (and laboratory testing if deemed necessary by the POR) before construction and visual observation during construction. Additional testing during construction will be at the discretion of the POR.

The erosion layer may be placed using any appropriate equipment capable of completing the work and should only receive minimal compaction required for stability. Under no circumstances will the construction equipment come in direct contact with the installed geosynthetics. Equipment used to install the erosion layer must meet the requirement of Section 3.5.

The thickness of the erosion layer will be verified with surveying procedures at a minimum of one survey point per 10,000 square feet of constructed area by a licensed Texas surveyor with a minimum of one reference point. The survey results for the erosion layer will be included in the FCSER.

During construction the CQA monitor will:

- Verify that grade control is performed prior to work.
- Verify that underlying geosynthetic installations are not damaged during placement operations or by survey grade controls. Mark damaged geosynthetics and verify that damage is repaired.
- Monitor haul-road thickness over installed geosynthetics and verify that equipment hauling and material placement meet equipment specifications. (See Section 3.5).
- The POR will coordinate with the project surveyor to perform a thickness verification survey of the erosion layer materials upon completion of placement operations. Verify corrective action measures as determined by the verification survey. Thickness surveying to determine the minimum erosion layer thickness will be performed similar to the infiltration layer thickness verification shown in Table 2-1.

5 GEOTECHNICAL STRENGTH TESTING REQUIREMENTS

This section of the FSQCP addresses the geotechnical strength requirements for the Subtitle D final cover system. Each component of the final cover system is subject to the material testing requirements outlined in Sections 2 through 4 of this FSQCP, as applicable. Prior to each final cover construction event, the geotechnical testing outlined in Table 5-1 will be performed using actual materials to verify that the final cover meets the material strength requirements. A geotechnical analysis using the strength parameters listed in Table 5-1 is presented in Appendix IIIJ.

The testing outlined in Table 5-1 will be performed under the supervision of the POR by a third party independent geotechnical laboratory. The POR will ensure that (1) the strength values are met, or (2) provide an updated geotechnical analysis in the FCSER that will be submitted to TCEQ after each final cover construction event. If the geotechnical analysis is updated, the resulting factor of safety values must meet the recommended minimum factor of safety values established in Appendix IIIJ.

Table 5-1
Minimum Required Strength for Various Final Cover Components[1]

Final Cover System Component Interface	Peak Strength		Residual Strength	
	Adhesion (psf)	Friction Angle (degree)	Adhesion (psf)	Friction Angle (degree)
Erosion Layer/Double-sided Geocomposite Interface	100	18	80	14
Geocomposite/Textured LLDPE Geomembrane Interface	100	21	80	10
Textured LLDPE Geomembrane/Clay Infiltration Layer Interface	200	15	80	10
Erosion Layer/Single-sided Geocomposite-Geotextile Interface	100	18	80	14
Single-sided Geocomposite-Geonet/Smooth LLDPE Geomembrane Interface	100	13	80	8
Smooth LLDPE Geomembrane/Clay Infiltration Layer Interface	100	13	80	8

[1] The adhesion and interface friction angle of final cover components will be determined using ASTM D5321 by a third party verified geotechnical laboratory to verify they meet the values used in the slope stability analysis included in IIIJ-A. This test may be performed using stack testing (i.e., performing a single test combining all components of the final cover). Refer to Appendix IIIJ for detailed strength information and procedures for calculating factors of safety.

6 DOCUMENTATION

The quality assurance plan depends on thorough monitoring and documentation of construction activities. Therefore, the POR and CQA monitor will document that quality assurance requirements have been addressed and satisfied. Documentation will consist of daily recordkeeping, testing and installation reports, nonconformance reports, progress reports, photographic records, and design and specification revisions. The appropriate documentation will be included in the FCSER. Standard report forms will be provided by the POR prior to construction.

6.1 Preparation of FCSER

The POR, on behalf of the Operator, will submit to the TCEQ a FCSER for approval of each portion of final cover system constructed.

Testing, evaluation, and submission of the FCSER for the final cover system during construction will be in accordance with this FCSQCP. The construction methods and test procedures documented in the FCSER will be consistent with this FCSQCP.

At a minimum, the FCSER will contain:

- A summary of all construction activities.
- All laboratory and field test results.
- Third party conformance test results for geocomposite transmissivity and strength parameters.
- Manufacturer's certifications for all geosynthetics.
- Documentation of thickness of the subgrade and erosion layers by a Texas registered Surveyor.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- As-built record drawings, including all previous FCSER submittals and dates of TCEQ approval.
- A statement of compliance with the permit FCSQCP and construction plans.

- The reports will be signed and sealed by a professional engineer(s) licensed in the State of Texas.

The as-built record drawings will accurately site the constructed location of work items, including the anchor trenches. The POR will review and verify that as-built drawings are correct. As-built drawings will be included in the FCSER.

6.2 Reporting Requirements

The FCSER will be signed and sealed by the POR, signed by the site operator, and submitted to the MSW Permits Section of the Waste Permits Division of the TCEQ for approval.

APPENDIX IIIE-A

COMPOSITE FINAL COVER DRAINAGE LAYER DESIGN

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED PROFESSIONAL ENGINEER

3-21-12

Includes pages IIIE-A-1 through IIIE-A-40

CAMELOT LANDFILL
1339-351-11-02
APPENDIX IIIE-A
COMPOSITE FINAL COVER DRAINAGE LAYER DESIGN

Required:

The purpose of this appendix is to design the drainage layer that is located between the geomembrane and erosion layer. As shown on Drawing A.7 in Appendix IIIA-A (Details FC1 and FC2), the drainage layer will consist of a single-sided drainage geocomposite on the topslope and a double-sided geocomposite on the sideslope at this site. In addition, a network of drainage pipes will convey flow from the drainage geocomposite to either a drainage letdown structure (refer to Sheet IIIE-A-20) or to the perimeter drainage system (as shown on Drawing A.8-Detail FC5). A detail of the drainage pipe in the final cover is provided on Drawing A.7-Detail FC4. The following design criteria are used to design the geocomposite drainage layers.

1. Sideslope. The sideslope drainage layer is designed to prevent uplift forces from occurring on the erosion layer. This will ensure the stability of the erosion layer.

2. Topslope. The topslope drainage layer is designed so that the erosion layer located on the topslope does not become completely saturated and to withstand potential estimated hydrostatic uplift forces.

3. Topslope/Sideslope Transition. This drainage layer is designed to prevent uplift forces from occurring on the erosion layer along the grade break. This will ensure the stability of the erosion layer.

4. Final Cover Bench on Southeast Side. The final cover bench drainage layer is designed so that the erosion layer located on the 4 percent bench does not become completely saturated and to withstand potential estimated hydrostatic uplift forces.

Method:

1. Sideslope

1. Estimate the percolation into the drainage geocomposite from the erosion layer. To provide for a conservative analysis, it is assumed that the permeability of the cover soils is equal to the percolation rate into the drainage geocomposite.

2. Determine the transmissivity of the specified drainage geocomposite. The laboratory transmissivity is reduced to simulate the actual transmissivity after strength and environmental factors are taken into consideration.

3. Determine pipe size required to convey the design flow for the specified pipe length and pipe outlet spacing.

2. Topslope

1. Determine the transmissivity of the specified drainage geocomposite. The laboratory transmissivity is reduced to simulate the actual transmissivity after strength and environmental factors are taken into consideration.

2. Use HELP to demonstrate that the proposed pipe spacing and single-sided drainage geocomposite are adequate to keep the erosion layer from becoming completely saturated. Also, verify that potential uplift forces will not cause a stability issue with the erosion layer.

3. Determine pipe size required to convey the design flow for the specified pipe length and pipe outlet spacing.

3. Topslope/Sideslope Transition

1. Estimate the percolation into the drainage geocomposite from the erosion layer. To provide for a conservative analysis, it is assumed that the permeability of the cover soils is equal to the percolation rate into the drainage geocomposite.

2. Determine the transmissivity of the specified drainage geocomposite. The laboratory transmissivity is reduced to simulate the actual transmissivity after strength and environmental factors are taken into consideration.

3. Determine pipe size required to convey the design flow for the specified pipe length and pipe outlet spacing.

4. Southeast Final Cover Bench

1. Determine the transmissivity of the specified drainage geocomposite. The laboratory transmissivity is reduced to simulate the actual transmissivity after strength and environmental factors are taken into consideration.

2. Use HELP to demonstrate that the proposed double-sided drainage geocomposite is adequate to prevent the erosion layer from becoming completely saturated. Also, verify that potential uplift forces will not cause a stability issue with the erosion layer.

3. Determine pipe size required to convey the design flow for the specified pipe length for the down gradient pipe.

References:

1. Koerner, R.M., *Designing With Geosynthetics*, third edition, 1994.
2. Maidment, David R., *Handbook of Hydrology*. McGraw-Hill, Inc. 1993.
3. *The Hydrologic Evaluation of Landfill Performance (HELP) Model, User's Guide for Version 3.* EPA/600/R-94/168a, September 1994.
4. Giroud, J.P., Zornberg, J.G., Zhao, A., *Hydraulic Design of Geosynthetic and Granular Liquid Collection Layer*, 2000.
5. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
6. Geosynthetic Institute, GRI Standard GC-8, 2001.
7. GSE Drainage Design Manual, May 2004.

Solution:

1. Sideslope

1.1 Estimate the percolation into the drainage geocomposite from the erosion layer.

Calculate the flow entering the geocomposite from unit area of erosion layer (q_f):

k_{cover} = 1.2E-04 cm/s

$q_f = k_{cover} * i$ (i is the gradient of water percolating within the drainage layer, and it is equal to 1 for vertical percolation.)

q_f = 1.2E-4 cm/s * 1 / (30.48 cm/ 1 ft)

q_f = 3.94E-06 cfs/sf

Calculate the maximum flow in drainage geocomposite on sideslope:

L = 120 ft, longest flow length between two drain pipes on sideslope.

$q_p = q_f * L$

q_p = 0.00047 sf/s

1.2 Determine the transmissivity of the specified drainage geocomposite.

Final Cover Drainage Layer Thickness:

Specified Design:
Drainage layer consists of geocomposite drainage layer - double-sided 250 mil geonet with 6 oz/sy geotextiles.

Assume the final cover drainage layer will undergo compression due to the weight of soil (erosion layer).

Unloaded Geocomposite Drainage Layer Thickness = 0.250 in
Unit Weight of Erosion Layer Soil = 116 pcf
Thickness of Erosion Layer = 2 ft

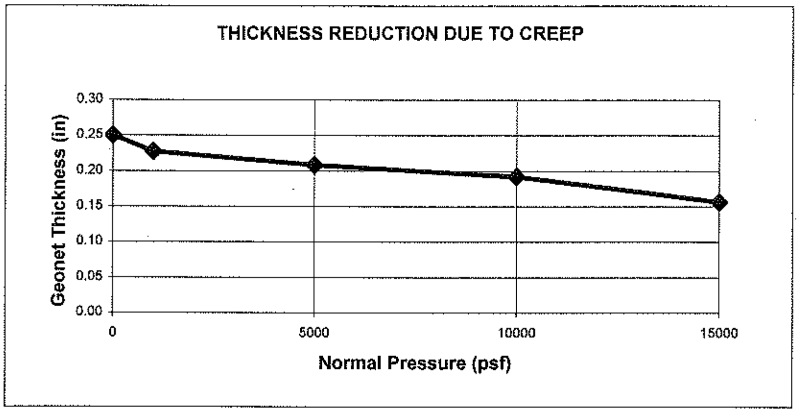
Table 1.1 - Final Cover Drainage Layer Thickness

Fill Condition	Slope %	d_S[1] (ft)	P[2] (psf)	t[3] (in)	t[3] (m)
Closed (sideslope)	25	2.064	239	0.245	0.006

[1] d_S is the vertical thickness of soil above the final cover drainage layer.

[2] P is the pressure on the final cover drainage layer due to the weight of the erosion layer soil.

[3] t is the thickness of the final cover drainage layer after being subjected to compression based on the chart in the next page adapted from Reference 7.



Reduction Factors for Strength and Environmental Conditions:

Table 1.2 - Reduction Factors

Reduction Factors		Closed Condition
RF_{IN}	Delayed Intrusion	1.1
RF_{CC}	Chemical Clogging	1.2
RF_{BC}	Biological Clogging	2.0
Total Reduction Factor[2]		2.64

Overall Factor of Safety to Account For Uncertainties	2.0
Overall Reduction Factor (ORF)[3]	5.28

[1] Values are obtained from References 1, 5, and 6.

[2] The Total Reduction Factor is the product of all the reduction factors.

[3] The Overall Reduction Factor is the product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties.

Required Transmissivity Data:

The required minimum transmissivity for the 250-mil-thick double-sided geocomposite is shown on Sheet IIIE-A-18.

Calculate the Design Transmissivity (T_{DES}):

Table 1.3 - Transmissivity of the Specified Geocomposite Material

Fill Condition	P^1 (psf)	t^2 (in)	T^3 (m^2/s)	ORF^4	$T_{DES}{}^5$ (m^2/s)	T_{DES} (sf/s)
Closed (sideslope)	239	0.245	5.69E-04	5.28	1.08E-04	1.16E-03

[1] P is the pressure on the final cover drainage layer due to the weight of erosion layer from Table 1.1.

[2] t is the drainage layer thickness from Table 1.1.

[3] T is obtained from the specified transmissivity values for a representative geocomposite drainage layer (250-mil-thick geonet with 6 oz/sy geotextiles) as shown on Sheet IIIE-A-18.

[4] ORF is the Overall Reduction Factor obtained from Table 1.2.

[5] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

Determine the capacity of the drainage geocomposite based on the estimated transmissivity and compare to the estimated flow rate that occurs due to infiltration.

T_{DES}	>	q_p
(flow capacity of the drainage geocomposite per unit width)		(estimated flow in the drainage geocomposite per unit width)
0.00116 sf/s	>	0.00047 sf/s

Since the capacity of the drainage geocomposite is greater than the estimated flow in the geocomposite, the actual flow depth is contained within the geocomposite and the design is acceptable. Therefore, the maximum spacing between the drain pipes located on the sideslopes may be up to 120 feet. The distance between the pipes is no more than 120 feet as shown on Sheet IIIE-A-20.

1.3 Determine pipe size required to convey the design flow for the specified pipe length and pipe outlet spacing.

Maximum Flow to Collection Pipe for Various Pipe Lengths:

$$Q_{max} = L_{p\text{-}max} \times q_p$$

Pipe Length, $L_{p\text{-}max}$ (ft)	Flow per Unit Length of Pipe, q_p (cfs/ft)	Maximum Pipe Flow, $Q_{max}{}^1$ (cfs)
< 350	0.00047	0.165
350-1050	0.00047	0.496
1050-1100	0.00047	0.520

[1] Maximum pipe flow is calculated using the maximum pipe length in each range.

Capacity of collection pipe:

Use Manning Equation to determine the pipe capacity.

Pipe Capacity (Q_{pc}):

$$Q_{pc}=\frac{1.49AR^{2/3}S^{1/2}}{n}$$ (from Chapter 10 of Ref 2)

where:

Q_{pc}: Full flow pipe capacity (cfs)
d: Diameter (inches), HDPE ADS collection pipe
A: Flow area (sf), Cross section of pipe
P: Perimeter (ft)
R: Hydraulic radius (ft) = Cross section (A) / Perimeter (P)
S: Pipe slope (ft/ft)
n: Manning roughness coefficient

Pipe Capacity for Different Pipe Sizes

d (inches)	A (sf)	P (ft)	R (ft)	S (ft/ft)	n	Q_{pc} (cfs)
4	0.09	1.05	0.08	0.005	0.010	0.175
6	0.20	1.57	0.13	0.005	0.010	0.517
8	0.35	2.09	0.17	0.005	0.010	1.114

Fullness Ratio of Pipe (f):

$f = Q_{max}/Q_{pc}$

Fullness Ratio of Pipe (f)

Fill Condition	Pipe Length (ft)	d (inches)	Q_{max} (cfs)	Q_{pc} (cfs)	f
Closed (sideslope)	< 350	4	0.165	0.175	0.94
	350-1050	6	0.496	0.517	0.96
	1050-1100	8	0.520	1.114	0.47

Conclusion: A pipe size of 4, 6 or 8 inches is acceptable for the sideslope area when the flow length is between 0 - 120 feet.

2. Topslope

2.1 Determine the transmissivity of the specified drainage geocomposite.

Final Cover Drainage Layer Thickness:

Specified Design:
Drainage layer consists of geocomposite drainage layer - single-sided 250 mil geonet with 6 oz/sy geotextile.

Assume the final cover drainage layer will undergo compression due to the weight of soil (erosion layer).

Unloaded Geocomposite Drainage Layer Thickness = 0.250 in
Unit Weight of Erosion Layer Soil = 116 pcf
Thickness of Erosion Layer = 2 ft

Table 2.1 - Final Cover Drainage Layer Thickness

Fill Condition	Slope %	d_S[1] (ft)	P[2] (psf)	t[3] (in)	t[3] (m)
Closed (topslope)	4	2.002	232	0.245	0.006

[1] d_S is the vertical thickness of soil above the final cover drainage layer.

[2] P is the pressure on the final cover drainage layer due to the weight of the erosion layer soil.

[3] t is the thickness of the final cover drainage layer after being subjected to compression based on the chart shown above in Step 1.2 adapted from Reference 7.

Reduction Factors for Strength and Environmental Conditions:

Table 2.2 - Factors of Safety

Reduction Factors		Closed Condition
RF_{IN}	Delayed Intrusion	1.1
RF_{CC}	Chemical Clogging	1.2
RF_{BC}	Biological Clogging	2.0
Total Reduction Factor[2]		2.64

Overall Factor of Safety to Account For Uncertainties	2.0
Overall Reduction Factor (ORF)[3]	5.28

[1] Values are obtained from References 1, 5, and 6.

[2] The Total Reduction Factor is the product of all the reduction factors.

[3] The Overall Reduction Factor is the product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties.

Required Transmissivity Data:

The required minimum transmissivity for the 250-mil-thick single-sided geocomposite is shown on Sheet IIIE-A-19.

Calculate the Design Transmissivity (T_{DES}):

Table 2.3 - Required Transmissivity

Fill Condition	P^1 (psf)	t^2 (in)	T^3 (m^2/s)	ORF^4	$T_{DES}{}^5$ (m^2/s)	k^6 (cm/s)
Closed (topslope)	232	0.245	2.20E-03	5.28	4.17E-04	6.70

[1] P is the pressure on the final cover drainage layer due to the weight of erosion layer from Table 2.1.

[2] t is the drainage layer thickness from Table 2.1.

[3] T is obtained from the specified transmissivity values for a representative geocomposite drainage layer (250-mil-thick geonet with 6 oz/sy polypropylene geotextile) as shown on Sheet IIIE-A-19.

[4] ORF is the Overall Reduction Factor obtained from Table 2.2.

[5] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / (\text{FS Factor})$$

[6] k is the hydraulic conductivity and calculated using the following equation:

$$k = T_{DES} / t$$

2.2 Use HELP to demonstrate that the proposed pipe spacing and single-sided drainage geocomposite are adequate to prevent the erosion layer from becoming completely saturated. The maximum pipe spacing ($L_{s\text{-}max}$) for the closed 4% topslope scenario is 330 feet. The scenario analyzed in the HELP model used a model area of 4.6 acres which represents the largest estimated area that would contribute to a particular drainage collection pipe. Additionally, based on this maximum spacing and as shown in the HELP model results, the maximum head on the final cover geomembrane is 22.24 inches. In this situation, the 24-inch erosion layer above the geocomposite/liner does not become entirely saturated. Final cover stability calculations are provided in Appendix IIIJ.

Verify that the Erosion Layer will not be impacted by uplift.

Uplift may occur if the depth of water in the geocomposite exceeds the thickness of the geocomposite. As noted above, the maximum water depth on the geomembrane is 22.24 inches. If this occurs, the potential for uplift exists. Therefore to prevent uplift, the weight of erosion layer must be higher than the uplift exerted by the maximum head in drainage geocomposite.

Maximum Head Estimated by HELP Model, h_{max}= 22.24 inches (refer to page IIIE-A-27)
Unit Weight of Erosion Layer, γ_{EL}= 116 pcf
Unit Weight of Water, γ_W= 62.4 pcf
Thickness of Erosion Layer, h_{EL}= 24 inches

Uplift Force, UF= $h_{max} \times \gamma_W$ psf
Weight of Erosion Layer, W_{EL}= $h_{EL} \times \gamma_{EL}$ psf

UF= (22.24/12)*62.4 psf
W_{EL}= 2 ft x 116 pcf psf

UF= 115.6 psf
W_{EL}= 232 psf

Factor of Safety, FS= W_{EL} / UF

FS= 232 / 115.6
FS= 2.0

Conclusion:
A factor of safety of more than one indicates that the erosion layer will not be impacted by uplift force caused by the maximum head in the geocomposite estimated by the HELP Model. Therefore, the erosion layer is stable as designed. As shown on page IIIE-A-26, under normal conditions the head in the geocomposite is 0.023 inches, which is less than the thickness of the geocomposite. Therefore, the thickness of the water on the geomembrane will not exceed the thickness of the geocomposite under normal conditions.

2.3 Verify that a 6-inch diameter pipe will convey the design flow for the specified spacing.

Maximum flow to a collection pipe has been estimated by using the HELP model. From the HELP model, the lateral drainage collected from the geocomposite is:

HELP Model Area= 4.6 acres, Largest area draining to a pipe
Maximum Daily Flow= 18,825 cf/day
Q_{max}= 0.218 cfs

Capacity of 6-inch Collection Pipe:

Use Manning Equation to determine the pipe size.

Pipe Capacity (Q_{pc}):

$$Q_{pc} = \frac{1.49AR^{2/3}S^{1/2}}{n}$$ (from Chapter 10 of Ref 2)

where:

Q_{pc}: Full Flow Pipe Capacity (cfs)
d: Diameter (inches), HDPE ADS collection pipe diameter
A: Flow area (sf), Cross section of pipe
P: Perimeter (ft)
R: Hydraulic radius (ft) = Cross Section (A) / Perimeter (P)
S: Pipe slope (ft/ft)
n: Manning roughness coefficient

Pipe Capacity for Different Pipe Sizes						
d (inches)	A (sf)	P (ft)	R (ft)	S (ft/ft)	n	Q_{pc} (cfs)
6	0.20	1.57	0.13	0.005	0.010	0.517

Fullness Ratio of Pipe (f):

$$f = Q_{max}/Q_{pc}$$

Fullness ratio of pipe (f)				
Fill Condition	d (inches)	Q_{max} (cfs)	Q_{pc} (cfs)	f
Closed (topslope)	6	0.218	0.517	0.42

Conclusion: A pipe size of 6 inches is acceptable for the topslope area.

3. Topslope/Sideslope Transition

3.1 Estimate the percolation into the drainage geocomposite from the erosion layer.

Calculate the flow entering the geocomposite from unit area of erosion layer (q_f):

k_{cover} = 1.2E-04 cm/s

q_f = k_{cover} * i (i is the gradient of water percolating within the drainage layer, and it is equal to 1 for vertical percolation.)

q_f= 1.2E-4 cm/s * 1 / (30.48 cm/ 1 ft)

q_f= 3.94E-06 cfs/sf

Calculate the maximum flow in drainage geocomposite on 4H:1V sideslope.
Consider the flow coming from the topdeck:

L (4H:1V)= 10 ft
L (4%)= 100 ft, length between the topdeck drain pipe and the grade break.
L (total)= 110 ft

q_p = q_f * L (total)

q_p = 0.00043 sf/s

3.2 Determine the transmissivity of the specified drainage geocomposite.

Final Cover Drainage Layer Thickness:

Specified Design:
Drainage layer consists of geocomposite drainage layer - double-sided 250 mil geonet with 6 oz/sy geotextiles.

Assume the final cover drainage layer will undergo compression due to the weight of soil (erosion layer).

Unloaded Geocomposite Drainage Layer Thickness = 0.250 in
Unit Weight of Erosion Layer Soil = 116 pcf
Thickness of Erosion Layer = 2 ft

Table 3.1 - Final Cover Drainage Layer Thickness

Fill Condition	Slope %	d_S[1] (ft)	P[2] (psf)	t[3] (in)	t[3] (m)
Closed (sideslope)	25	2.06	239	0.245	0.006

[1] d_S is the vertical thickness of soil above the final cover drainage layer.

[2] P is the pressure on the final cover drainage layer due to the weight of the erosion layer soil.

[3] t is the thickness of the final cover drainage layer after being subjected to compression based on the chart shown above in Step 1.2 adapted from Reference 7.

Reduction Factors for Strength and Environmental Conditions:

Table 3.2 - Reduction Factors

Reduction Factors		Closed Condition
RF_{IN}	Delayed Intrusion	1.1
RF_{CC}	Chemical Clogging	1.2
RF_{BC}	Biological Clogging	2.0
Total Reduction Factor[2]		2.64

Overall Factor of Safety to Account For Uncertainties	2.0
Overall Reduction Factor (ORF)[3]	5.28

[1] Values are obtained from References 1, 5, and 6.

[2] The Total Reduction Factor is the product of all the reduction factors.

[3] The Overall Reduction Factor is the product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties.

Required Transmissivity Data:

The required minimum transmissivity for the 250-mil-thick double-sided geocomposite is shown on Sheet IIIE-A-18.

Calculate the Design Transmissivity (T_{DES}):

Table 3.3 - Transmissivity of the Specified Geocomposite Material

Fill Condition	P[1] (psf)	t[2] (in)	T[3] (m^2/s)	FS Factor[4]	T_{DES}[5] (m^2/s)	T_{DES} (sf/s)
Closed (sideslope)	239	0.245	5.69E-04	5.28	1.08E-04	1.16E-03

[1] P is the pressure on the final cover drainage layer due to the weight of erosion layer from Table 3.1.

[2] t is the drainage layer thickness from Table 3.1.

[3] T is obtained from the specified transmissivity values for a representative geocomposite drainage layer (250-mil-thick geonet with 6 oz/sy polypropylene geotextiles) as shown on Sheet IIIE-A-18 .

[4] ORF is the Overall Reduction Factor obtained from Table 3.2.

[5] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / (\text{FS Factor})$$

Determine the capacity of the drainage geocomposite based on the estimated transmissivity and compare to the estimated flow rate that occurs due to infiltration.

T_{DES}	>	q_p
(flow capacity of the drainage geocomposite per unit width)		(estimated flow in the drainage geocomposite per unit width)
0.00116 sf/s	>	0.00043 sf/s

Since the capacity of the drainage geocomposite is greater than the estimated flow in the geocomposite, the actual flow depth is contained within the geocomposite and the design is acceptable. Therefore, the maximum spacing between the pipe located just below the grade break on the 4H:1V slope and the pipe located just above the grade break on the topdeck is 110 feet. As shown on Sheet IIIE-A-20, the distance between these two pipes is no more than 110 feet.

3.3 Verify that a 6-inch diameter pipe will convey the design flow for the specified spacing.

Maximum Flow to Collection Pipe:

Maximum pipe length ($L_{p\text{-}max}$) specified = 1135 ft
Flow per unit length of collection pipe (q_p) = 0.00043 cfs/ft
Maximum pipe flow (Q_{max}):

$Q_{max} = L_{p\text{-}max} \times q_p =$ 0.492 cfs

Capacity of 6-inch Collection Pipe:

Use Manning Equation to determine the pipe capacity.

Pipe Capacity (Q_{pc}):

$$Q_{pc} = \frac{1.49AR^{2/3}S^{1/2}}{n}$$ (from Chapter 10 of Ref 2)

where:

Q_{pc}: Full flow pipe capacity (cfs)
d: Diameter (inches), HDPE ADS collection pipe
A: Flow area (sf), Cross section of pipe
P: Perimeter (ft)
R: Hydraulic radius (ft) = Cross section (A) / Perimeter (P)
S: Pipe slope (ft/ft)
n: Manning roughness coefficient

Pipe Capacity for Different Pipe Sizes

d (inches)	A (sf)	P (ft)	R (ft)	S (ft/ft)	n	Q_{pc} (cfs)
6	0.20	1.57	0.13	0.005	0.010	0.517

Fullness Ratio of Pipe (f):

$f = Q_{max}/Q_{pc}$

Fullness Ratio of Pipe (f)

Fill Condition	Pipe Length (ft)	d (inches)	Q_{max} (cfs)	Q_{pc} (cfs)	f
Closed (sideslope)	1135	6	0.492	0.517	0.95

Conclusion: A pipe size of 6 inches is acceptable.

4. Final Cover Bench on Southeast Side

4.1 Determine the transmissivity of the specified drainage geocomposite.

Final Cover Drainage Layer Thickness:

Specified Design:
Drainage layer consists of geocomposite drainage layer - double-sided 250 mil geonet with 6 oz/sy geotextile.

(Note that two double-sided drainage geocomposites will be provided; however this analysis conservatively assumes only one double-sided drainage geocomposite will be available for flow.)

Assume the final cover drainage layer will undergo compression due to the weight of soil (erosion layer).

Unloaded Geocomposite Drainage Layer Thickness = 0.250 in
Unit Weight of Erosion Layer Soil = 116 pcf
Thickness of Erosion Layer = 4 ft

Table 4.1 - Final Cover Drainage Layer Thickness

Fill Condition	Slope %	d_S[1] (ft)	P[2] (psf)	t[3] (in)	t[3] (m)
Closed (bench)	4	4.003	464	0.239	0.006

[1] d_S is the vertical thickness of soil above the final cover drainage layer.

[2] P is the pressure on the final cover drainage layer due to the weight of the erosion layer soil.

[3] t is the thickness of the final cover drainage layer after being subjected to compression based on the chart shown above in Step 1.2 adapted from Reference 7.

Reduction Factors for Strength and Environmental Conditions:

Table 4.2 - Factors of Safety

Reduction Factors		Closed Condition
RF_{IN}	Delayed Intrusion	1.1
RF_{CC}	Chemical Clogging	1.2
RF_{BC}	Biological Clogging	2.0
Total Reduction Factor[2]		2.64

Overall Factor of Safety to Account For Uncertainties	2.0
Overall Reduction Factor (ORF)[3]	5.28

[1] Values are obtained from References 1, 5, and 6.

[2] The Total Reduction Factor is the product of all the reduction factors.

[3] The Overall Reduction Factor is the product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties.

Required Transmissivity Data:

The required minimum transmissivity for the 250-mil-thick double-sided geocomposite is shown on Sheet IIIE-A-18.

Calculate the Design Transmissivity (T_{DES}):

Table 4.3 - Required Transmissivity

Fill Condition	P[1] (psf)	t[2] (in)	T[3] (m^2/s)	ORF[4]	T_{DES}[5] (m^2/s)	k[6] (cm/s)
Closed (topslope)	464	0.239	1.06E-03	5.28	2.01E-04	3.31

[1] P is the pressure on the final cover drainage layer due to the weight of erosion layer from Table 4.1.

[2] t is the drainage layer thickness from Table 4.1.

[3] T is obtained from the specified transmissivity values for a representative geocomposite drainage layer (250-mil-thick geonet with 6 oz/sy polypropylene geotextiles) as shown on Sheet IIIE-A-18.

[4] ORF is the Overall Reduction Factor obtained from Table 4.2.

[5] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / (\text{FS Factor})$$

[6] k is the hydraulic conductivity and calculated using the following equation:

$$k = T_{DES} / t$$

4.2 Use HELP to demonstrate that the double-sided drainage geocomposite is adequate to prevent the erosion layer from becoming completely saturated on the southeast bench. The maximum drainage length across the 4% slope bench is 115 feet. The scenario analyzed in the HELP model used a model area of 2.9 acres which represents the largest estimated area that would drains to the bench area. Additionally, based on this maximum length and as shown in the HELP model results, the maximum head on the final cover geomembrane is 6.86 inches. In this situation, the 48-inch erosion layer above the geocomposite/liner does not become entirely saturated.

Verify that the Erosion Layer will not be impacted by uplift.

Uplift may occur if the depth of water in the geocomposite exceeds the thickness of the geocomposite. As noted above, the maximum water depth on the geomembrane is 6.86 inches. If this occurs, the potential for uplift exists. Therefore to prevent uplift, the weight of erosion layer must be higher than the uplift exerted by the maximum head in drainage geocomposite.

Maximum Head Estimated by HELP Model, h_{max}=	6.86	inches (refer to page IIIE-A-34)
Unit Weight of Erosion Layer, γ_{EL}=	116	pcf
Unit Weight of Water, γ_W=	62.4	pcf
Thickness of Erosion Layer, h_{EL}=	48	inches

Uplift Force, UF=	$h_{max} \times \gamma_W$	psf
Weight of Erosion Layer, W_{EL}=	$h_{EL} \times \gamma_{EL}$	psf
UF=	(6.86/12)*62.4	psf
W_{EL}=	4 ft x 116 pcf	psf
UF=	35.7	psf
W_{EL}=	464	psf
Factor of Safety, FS=	W_{EL} / UF	
FS=	464 / 35.7	
FS=	13.0	

Conclusion:

A factor of safety of more than one indicates that the erosion layer will not be impacted by uplift force caused by the maximum head in the geocomposite estimated by the HELP Model. Therefore, the erosion layer is stable as designed. As shown on page IIIE-A-33, under normal conditions the head in the geocomposite is 0.003 inches, which is less than the thickness of the geocomposite. Therefore, the thickness of the water on the geomembrane will not exceed the thickness of the geocomposite under normal conditions.

4.3 Verify that a 6-inch diameter down gradient pipe will convey the design flow for the specified spacing.

Maximum flow to a collection pipe has been estimated by using the HELP model. From the HELP model, the lateral drainage collected from the geocomposite is:

HELP Model Area= 2.9 acres, Largest area draining to a pipe
Maximum Daily Flow= 12,547 cf/day
Q_{max}= 0.145 cfs

Capacity of 6-inch Collection Pipe:

Use Manning Equation to determine the pipe size.

Pipe Capacity (Q_{pc}):

$$Q_{pc} = \frac{1.49AR^{2/3}S^{1/2}}{n}$$ (from Chapter 10 of Ref 2)

where:
Q_{pc}: Full Flow Pipe Capacity (cfs)
d: Diameter (inches), HDPE ADS collection pipe diameter
A: Flow area (sf), Cross section of pipe
P: Perimeter (ft)
R: Hydraulic radius (ft) = Cross Section (A) / Perimeter (P)
S: Pipe slope (ft/ft)
n: Manning roughness coefficient

Pipe Capacity for Different Pipe Sizes						
d (inches)	A (sf)	P (ft)	R (ft)	S (ft/ft)	n	Q_{pc} (cfs)
6	0.20	1.57	0.13	0.002	0.010	0.327

Fullness Ratio of Pipe (f):

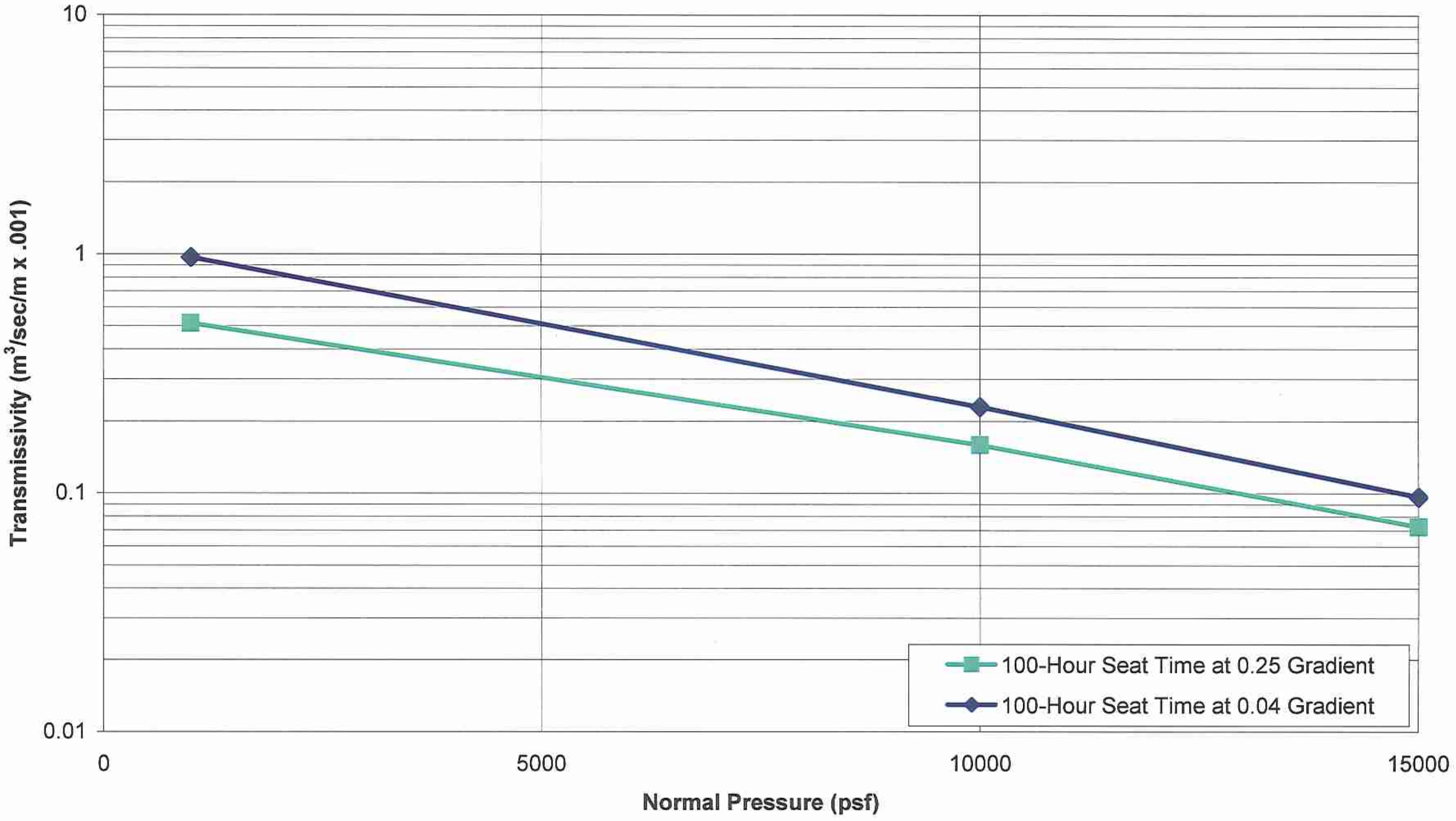
$$f = Q_{max}/Q_{pc}$$

Fullness ratio of pipe (f)				
Fill Condition	d (inches)	Q_{max} (cfs)	Q_{pc} (cfs)	f
Closed (topslope)	6	0.145	0.327	0.44

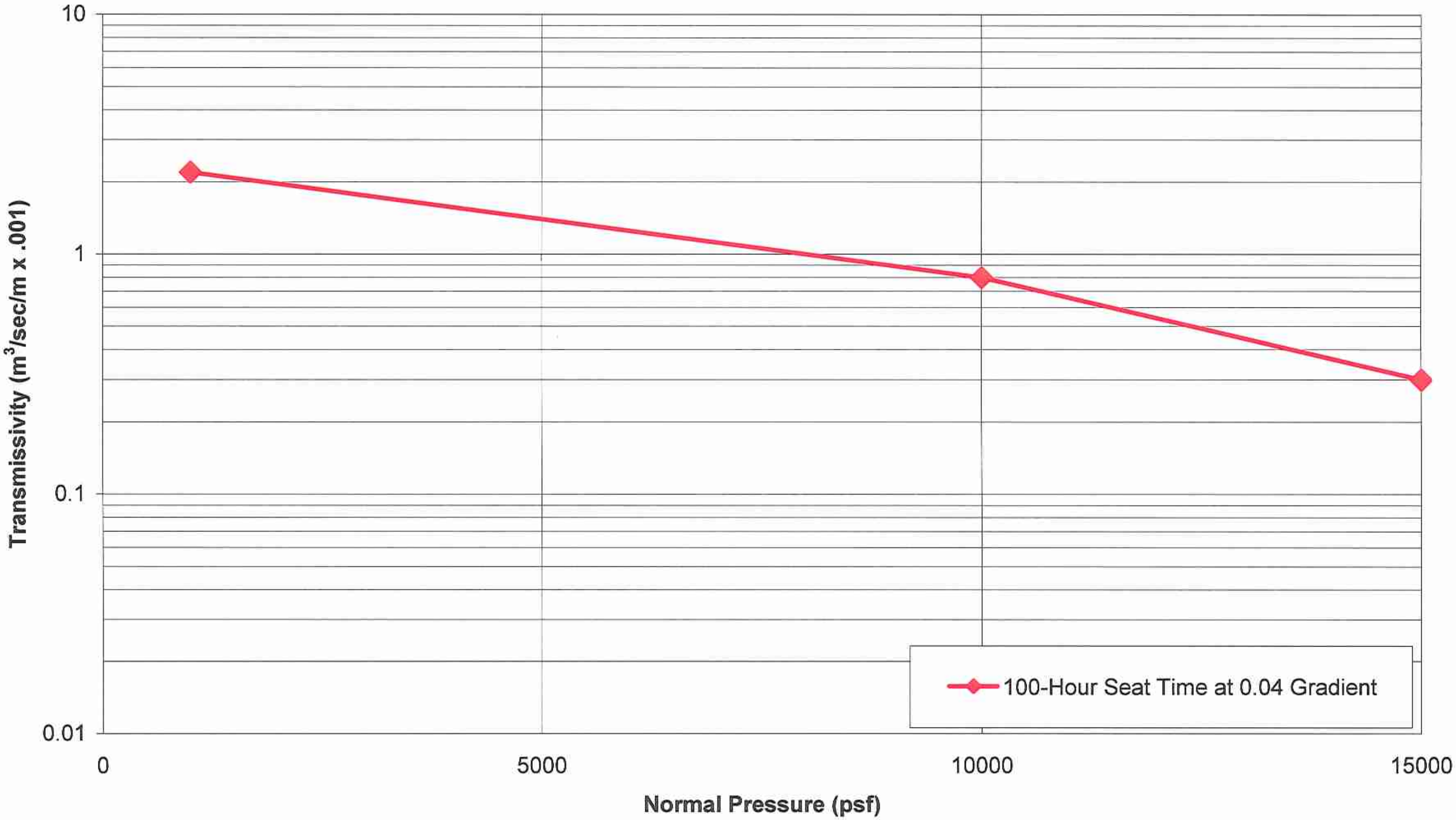
Conclusion: A pipe size of 6 inches is acceptable for the pipe down gradient of the bench.

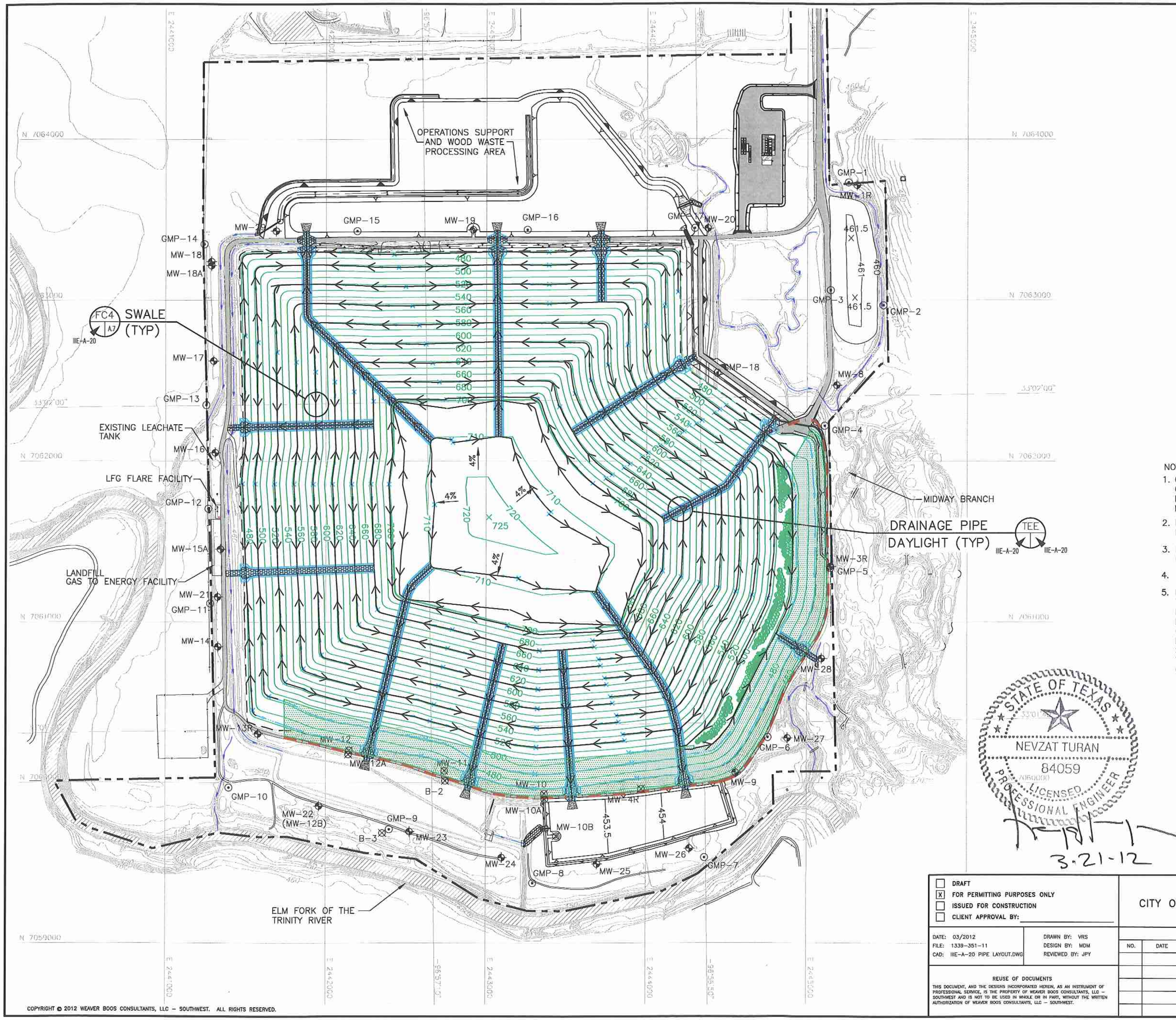
TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE

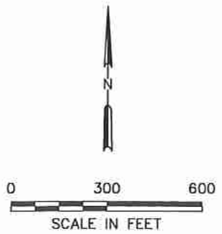
6 oz/sy Polypropylene Geotextile with 250 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE
6 oz/sy Polypropylene Geotextile with 250 mil Drainage Net
(Soil/Geocomposite/Geomembrane)







LEGEND

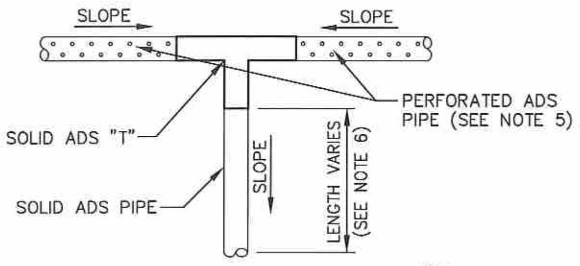
— - —	PERMIT BOUNDARY (SEE NOTE 2)
— — —	LIMIT OF WASTE
N 7064000	STATE PLANE COORDINATE SYSTEM
33°02'00"	GEODETIC COORDINATE SYSTEM
500	EXISTING CONTOUR
600	FINAL COVER CONTOUR
600	REGRADED BUFFER ZONE AREA
▨	DRAINAGE LETDOWN
×	DRAINAGE SWALE
MW–8	GROUNDWATER MONITORING WELL
GMP–1	GAS MONITORING PROBE
MW–12	OBSERVATION WELL
→	PERFORATED DRAINAGE PIPE
▨	CONSTRUCTED FINAL COVER
🟩	LANDSCAPE BENCH
— · —	APPROXIMATE LOCATION OF PROPOSED SLURRY WALL

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY METROPOLITAN AERIAL SURVEYS COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 8–28–2010. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83. ELEVATIONS ARE BASED ON NAVD 88.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY PEISER SURVEYING CO. DATED NOVEMBER 2010.
3. REFER TO APPENDIX IIIF–SURFACE WATER DRAINAGE PLAN FOR DRAINAGE DESIGN INFORMATION.
4. TYPICAL TOPSLOPE IS 4.0%.
5. DRAINAGE PIPE WILL BE PLACED WITH A 0.5% FLOW LINE SLOPE PARALLEL TO THE SWALES ON THE TOPSLOPES AND SIDESLOPES OF THE FILL. THE PIPE WILL BE PLACED WITH A 0.5% FLOW SLOPE AT THE TOE OF THE FINAL COVER AND DAYLIGHTED AS NECESSARY WITH A SOLID PIPE TEE CONNECTION TO THE PERIMETER DRAINAGE STRUCTURES. THE TWO PIPES DOWN GRADIENT OF FINAL COVER BENCH WILL BE PLACED AT A 0.2% SLOPE. PERFORATED PIPE AT THE TOE OF THE FINAL COVER WILL BE WRAPPED WITH GEOCOMPOSITE AS SHOWN IN APPENDIX IIIA–A – LINER, OVERLINER, AND FINAL COVER SYSTEM DETAILS.

NEVZAT TURAN
84059

3-21-12



DRAINAGE PIPE
DAYLIGHT (TYP)
TEE
IIIE–A–20 IIIE–A–20

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION
☐ CLIENT APPROVAL BY: ____

DATE: 03/2012
FILE: 1339–351–11
CAD: IIIE–A–20 PIPE LAYOUT.DWG

DRAWN BY: VRS
DESIGN BY: MDM
REVIEWED BY: JPY

REUSE OF DOCUMENTS

PREPARED FOR
CITY OF FARMERS BRANCH

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
FINAL COVER DRAINAGE PIPE LAYOUT

CAMELOT LANDFILL
DENTON COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F–3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

FORT WORTH, TX
(817) 735–9770

GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

SHEET IIIE–A–20

O:\1339\351\EXPANSION 2009\PART III–SDP\IIIE\IIIE–A–20 DRAINAGE PIPE LAYOUT.dwg, sford, 1:2

Prep By: MDM
Date: 3/21/2012

CAMELOT LANDFILL
1339-351-11-02
HELP VERSION 3.07 SUMMARY SHEET

Chkd By: JLG
Date: 3/21/2012

		CLOSED 4% TOPSLOPE	CLOSED SOUTHEAST BENCH
GENERAL	Case No.	1	2
INFORMATION	No. of Years	30	30
	Ground Cover	GOOD	GOOD
	SCS Runoff Curve No.	80.6	81.7
	Model Area (acre)	4.6	2.9
	Runoff Area (%)	100	100
	Maximum Leaf Area Index	4.5	4.5
	Evaporative Zone Depth (inch)	18	18
EROSION	Thickness (in)	24	48
LAYER	Porosity (vol/vol)	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04
DRAINAGE	Thickness (in)	0.245	0.239
LAYER	Porosity (vol/vol)	0.8500	0.8500
(Texture = 0)	Field Capacity (vol/vol)	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100
	Hyd. Conductivity (cm/s)	6.70	3.31
	Slope (%)	4	4
	Slope Length (ft)	330	115
FLEXIBLE	Thickness (in)	0.04	0.04
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	0	0
(Texture = 36)	Install. Defects (holes/acre)	0	0
	Placement Quality	GOOD	GOOD
INFILTRATION	Thickness (in)	18	18
LAYER	Porosity (vol/vol)	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-05	1.0E-05
PRECIPITATION	Average Annual (in)	34.26	34.26
RUNOFF	Average Annual (in)	1.14	1.36
EVAPOTRANSPIRATION	Average Annual (in)	27.40	27.40
LATERAL	Average Annual (cf/year)	95,891	58,116
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	18,825	12,547
HEAD ON FINAL	Average Annual (in)	0.023	0.003
COVER GEOMEMBRANE	Peak Daily (in)	22.24	6.86

[1] This is the lateral drainage collected in the drainage geocomposite in the final cover system.

```
*******************************************************************************
*******************************************************************************
**                                                                           **
**                                                                           **
**              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               **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP 307\CAMELOT\IIIE\DATA4.D4
TEMPERATURE DATA FILE:      C:\HELP 307\CAMELOT\IIIE\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\HELP 307\CAMELOT\IIIE\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\HELP 307\CAMELOT\IIIE\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\HELP 307\CAMELOT\IIIE\DATA10.D10
OUTPUT DATA FILE:           C:\HELP 307\CAMELOT\IIIE\CLOSED.OUT


TIME:   9:14     DATE:  12/ 8/2010


*******************************************************************************

     TITLE:  CAMELOT LANDFILL-FINAL COVER DRAINAGE DESIGN-4% TOPSLOPE

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                    =    24.00   INCHES
           POROSITY                     =     0.3980 VOL/VOL
           FIELD CAPACITY               =     0.2440 VOL/VOL
           WILTING POINT                =     0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    = 0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                            LAYER  2
                            --------

                  TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   0
        THICKNESS                   =        0.25    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.   =     6.69999981000       CM/SEC
        SLOPE                       =        4.00    PERCENT
        DRAINAGE LENGTH             =      330.0     FEET


                            LAYER  3
                            --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  36
        THICKNESS                   =        0.04    INCHES
        POROSITY                    =        0.0000 VOL/VOL
        FIELD CAPACITY              =        0.0000 VOL/VOL
        WILTING POINT               =        0.0000 VOL/VOL
        INITIAL SOIL WATER CONTENT  =        0.0000 VOL/VOL
        EFFECTIVE SAT. HYD. COND.   =    0.399999993000E-12 CM/SEC
        FML PINHOLE DENSITY         =        0.00    HOLES/ACRE
        FML INSTALLATION DEFECTS    =        0.00    HOLES/ACRE
        FML PLACEMENT QUALITY       =    3 - GOOD


                            LAYER  4
                            --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   0
        THICKNESS                   =       18.00    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.   =    0.999999975000E-05 CM/SEC


                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------
```

```
     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
              SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
              GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
              AND A SLOPE LENGTH OF  330. FEET.

    SCS RUNOFF CURVE NUMBER             =     80.60
    FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE  =      4.600  ACRES
    EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
    INITIAL WATER IN EVAPORATIVE ZONE   =      4.392  INCHES
    UPPER LIMIT OF EVAPORATIVE STORAGE  =      7.164  INCHES
    LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.448  INCHES
    INITIAL SNOW WATER                  =      0.000  INCHES
    INITIAL WATER IN LAYER MATERIALS    =     13.544  INCHES
    TOTAL INITIAL WATER                 =     13.544  INCHES
    TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


                   EVAPOTRANSPIRATION AND WEATHER DATA
                   -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              DALLAS                 TEXAS

         STATION LATITUDE                            =  32.85 DEGREES
         MAXIMUM LEAF AREA INDEX                     =   4.50
         START OF GROWING SEASON (JULIAN DATE)       =     63
         END OF GROWING SEASON (JULIAN DATE)         =    329
         EVAPORATIVE ZONE DEPTH                      =  18.0   INCHES
         AVERAGE ANNUAL WIND SPEED                   =  10.80 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY       =  66.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY       =  68.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY       =  63.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY       =  66.00 %


     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    1.90        2.37        3.06        3.20        5.15        3.23
    2.12        2.03        2.42        4.11        2.57        2.57


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    DALLAS              TEXAS

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
```

```
        -------     -------     -------     -------     -------     -------
         44.10       49.40       57.40       65.00       73.10       80.90
         85.00       84.40       77.50       67.20       55.10       46.70


        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    DALLAS              TEXAS
                    AND STATION LATITUDE  =   32.85 DEGREES



*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                             JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                             -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                     1.49     2.20     2.80     3.08     4.59     3.29
                               2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS            1.02     1.27     1.67     1.89     2.17     2.13
                               2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                     0.002    0.020    0.046    0.085    0.203    0.118
                               0.131    0.019    0.026    0.375    0.069    0.049

    STD. DEVIATIONS            0.007    0.051    0.122    0.202    0.463    0.218
                               0.301    0.045    0.055    0.681    0.188    0.112

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                     1.677    1.740    2.606    2.942    3.946    3.146
                               2.678    1.859    2.367    1.840    1.127    1.470

    STD. DEVIATIONS            0.438    0.641    1.041    1.162    1.363    1.659
                               1.666    1.396    1.332    0.939    0.439    0.439

  LATERAL DRAINAGE COLLECTED FROM LAYER  2
  ----------------------------------------
    TOTALS                     0.5377   0.2218   0.4575   0.2268   0.4664   0.3194
                               0.2517   0.0245   0.0489   1.1664   0.8374   1.1842

    STD. DEVIATIONS            0.6302   0.3786   0.8213   0.3872   0.7571   0.4749
                               0.5275   0.0666   0.1866   1.7327   1.2051   1.3866

  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


-------------------------------------------------------------------------------
          AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
   AVERAGES                0.0075    0.0025    0.0102    0.0030    0.0301    0.0051
                           0.0080    0.0002    0.0004    0.1160    0.0568    0.0418

   STD. DEVIATIONS         0.0138    0.0066    0.0358    0.0073    0.0838    0.0141
                           0.0267    0.0005    0.0014    0.2307    0.1783    0.0904

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET      PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                  34.26    (   6.276)    572106.9     100.00

 RUNOFF                          1.142   (  0.8500)     19069.48     3.333

 EVAPOTRANSPIRATION             27.398   (  3.6138)    457489.56    79.966

 LATERAL DRAINAGE COLLECTED      5.74265 (  3.20534)    95890.805  16.76099
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.072    0.00001
   LAYER  4

 AVERAGE HEAD ON TOP             0.023 (    0.026)
   OF LAYER  3

 CHANGE IN WATER STORAGE        -0.021   (  0.9785)      -343.06     -0.060
*******************************************************************************
```

```
******************************************************************************

          PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------    -------------
  PRECIPITATION                                 6.00        100188.000

  RUNOFF                                        2.087        34851.2031

  DRAINAGE COLLECTED FROM LAYER  2              1.12736      18824.66800

  PERCOLATION/LEAKAGE THROUGH LAYER  4          0.000005         0.08166

  AVERAGE HEAD ON TOP OF LAYER  3              14.377

  MAXIMUM HEAD ON TOP OF LAYER  3              22.243

  LOCATION OF MAXIMUM HEAD IN LAYER  2
        (DISTANCE FROM DRAIN)                  74.3 FEET

  SNOW WATER                                    2.40         40080.4609


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.3416

  MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.1360


   ***  Maximum heads are computed using McEnroe's equations.  ***

        Reference:  Maximum Saturated Depth over Landfill Liner
                    by Bruce M. McEnroe, University of Kansas
                    ASCE Journal of Environmental Engineering
                    Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
********************************************************************************

              FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                LAYER          (INCHES)        (VOL/VOL)
                -----          --------        ---------
                  1             5.2381          0.2183

                  2             0.0039          0.0159

                  3             0.0000          0.0000

                  4             7.6860          0.4270

               SNOW WATER       0.000

********************************************************************************
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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP 307\CAMELOT\IIIE\DATA4.D4
TEMPERATURE DATA FILE:        C:\HELP 307\CAMELOT\IIIE\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\HELP 307\CAMELOT\IIIE\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\HELP 307\CAMELOT\IIIE\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\HELP 307\CAMELOT\IIIE\DATA10.D10
OUTPUT DATA FILE:             C:\HELP 307\CAMELOT\IIIE\CLOSED.OUT


TIME:  14:18     DATE:   3/ 2/2011


******************************************************************************

     TITLE:  CAMELOT LANDFILL-FINAL COVER DRAINAGE DESIGN-4% BENCH

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =     48.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                         LAYER  2
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.24    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.    =    3.30999994000      CM/SEC
SLOPE                        =       4.00    PERCENT
DRAINAGE LENGTH              =     115.0     FEET


                         LAYER  3
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
THICKNESS                    =       0.04    INCHES
POROSITY                     =       0.0000 VOL/VOL
FIELD CAPACITY               =       0.0000 VOL/VOL
WILTING POINT                =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =       0.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       0.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                         LAYER  4
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      18.00    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.    =  0.999999975000E-05 CM/SEC


        GENERAL DESIGN AND EVAPORATIVE ZONE DATA
        ----------------------------------------
```

```
       NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
                GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
                AND A SLOPE LENGTH OF  115. FEET.

      SCS RUNOFF CURVE NUMBER               =     81.70
      FRACTION OF AREA ALLOWING RUNOFF      =    100.0    PERCENT
      AREA PROJECTED ON HORIZONTAL PLANE    =      2.900  ACRES
      EVAPORATIVE ZONE DEPTH                =     18.0    INCHES
      INITIAL WATER IN EVAPORATIVE ZONE     =      4.392  INCHES
      UPPER LIMIT OF EVAPORATIVE STORAGE    =      7.164  INCHES
      LOWER LIMIT OF EVAPORATIVE STORAGE    =      2.448  INCHES
      INITIAL SNOW WATER                    =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS      =     19.400  INCHES
      TOTAL INITIAL WATER                   =     19.400  INCHES
      TOTAL SUBSURFACE INFLOW               =      0.00   INCHES/YEAR


                   EVAPOTRANSPIRATION AND WEATHER DATA
                   -----------------------------------

       NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                DALLAS                TEXAS

           STATION LATITUDE                          =  32.85 DEGREES
           MAXIMUM LEAF AREA INDEX                   =   4.50
           START OF GROWING SEASON (JULIAN DATE)     =     63
           END OF GROWING SEASON (JULIAN DATE)       =    329
           EVAPORATIVE ZONE DEPTH                    =  18.0  INCHES
           AVERAGE ANNUAL WIND SPEED                 =  10.80 MPH
           AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  66.00 %
           AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  68.00 %
           AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  63.00 %
           AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  66.00 %


       NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR     DALLAS              TEXAS

                NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

     JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
     -------      -------      -------      -------      -------      -------
       1.90         2.37         3.06         3.20         5.15         3.23
       2.12         2.03         2.42         4.11         2.57         2.57


       NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR     DALLAS              TEXAS

            NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

     JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
```

```
          -------     -------     -------     -------     -------     -------
           44.10       49.40       57.40       65.00       73.10       80.90
           85.00       84.40       77.50       67.20       55.10       46.70


        NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    DALLAS              TEXAS
                  AND STATION LATITUDE  =  32.85 DEGREES





*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                          JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                          -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                  1.49     2.20     2.80     3.08     4.59     3.29
                            2.94     1.93     2.75     4.15     2.36     2.71

    STD. DEVIATIONS         1.02     1.27     1.67     1.89     2.17     2.13
                            2.33     1.43     1.52     3.45     1.80     1.93

  RUNOFF
  ------
    TOTALS                 0.003    0.026    0.056    0.100    0.240    0.144
                           0.155    0.025    0.035    0.435    0.083    0.059

    STD. DEVIATIONS        0.010    0.062    0.144    0.230    0.502    0.249
                           0.340    0.058    0.068    0.773    0.217    0.127

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 1.677    1.743    2.606    2.966    3.952    3.144
                           2.672    1.863    2.355    1.834    1.120    1.464

    STD. DEVIATIONS        0.434    0.638    1.037    1.167    1.371    1.665
                           1.658    1.398    1.324    0.936    0.440    0.440

  LATERAL DRAINAGE COLLECTED FROM LAYER  2
  ----------------------------------------
    TOTALS                0.7778   0.3651   0.4148   0.3005   0.3878   0.2712
                          0.3326   0.1562   0.0587   0.7203   0.6770   1.0585

    STD. DEVIATIONS       0.7129   0.3768   0.5114   0.3813   0.4861   0.3138
                          0.4227   0.2194   0.1068   1.2648   0.8901   1.3014

  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


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
   AVERAGES                  0.0039    0.0020    0.0021    0.0015    0.0019    0.0014
                             0.0016    0.0008    0.0003    0.0113    0.0053    0.0052

   STD. DEVIATIONS           0.0035    0.0021    0.0025    0.0020    0.0024    0.0016
                             0.0021    0.0011    0.0005    0.0456    0.0135    0.0064

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES             CU. FEET       PERCENT
                               -------------------    -------------   ---------
 PRECIPITATION                 34.26     (   6.276)     360676.1       100.00

 RUNOFF                         1.362    (  0.9541)      14337.32       3.975

 EVAPOTRANSPIRATION            27.397    (  3.6113)     288404.78      79.962

 LATERAL DRAINAGE COLLECTED     5.52062 (  2.88414)      58115.574     16.11295
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)          0.028      0.00001
   LAYER  4

 AVERAGE HEAD ON TOP            0.003 (     0.004)
   OF LAYER  3

 CHANGE IN WATER STORAGE       -0.017    (  1.6235)       -181.53      -0.050

*******************************************************************************
```

```
*******************************************************************************

          PEAK DAILY VALUES FOR YEARS     1 THROUGH   30
------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
  PRECIPITATION                                   6.00          63162.004

  RUNOFF                                          2.252         23701.9844

  DRAINAGE COLLECTED FROM LAYER  2                1.19185       12546.64650

  PERCOLATION/LEAKAGE THROUGH LAYER  4            0.000002          0.02036

  AVERAGE HEAD ON TOP OF LAYER  3                 5.687

  MAXIMUM HEAD ON TOP OF LAYER  3                 6.864

  LOCATION OF MAXIMUM HEAD IN LAYER  2
        (DISTANCE FROM DRAIN)                    24.1 FEET

  SNOW WATER                                      2.40          25268.1172


  MAXIMUM VEG. SOIL WATER (VOL/VOL)                        0.3168

  MINIMUM VEG. SOIL WATER (VOL/VOL)                        0.1360


   ***  Maximum heads are computed using McEnroe's equations.  ***

        Reference:  Maximum Saturated Depth over Landfill Liner
                    by Bruce M. McEnroe, University of Kansas
                    ASCE Journal of Environmental Engineering
                    Vol. 119, No. 2, March 1993, pp. 262-270.

*******************************************************************************
```

```
******************************************************************************

           FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1          11.1938          0.2332

                2           0.0032          0.0133

                3           0.0000          0.0000

                4           7.6860          0.4270

           SNOW WATER       0.000

******************************************************************************
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```

CAMELOT LANDFILL
1339-351-11-02
GEOTEXTILE DESIGN

Chkd By: JLG
Date: 3/21/2012

REQUIRED: Determine the required properties for the geotextile used as the top component of the drainage geocomposite.

METHOD: Design geotextiles and determine material property requirements.

REFERENCES:

1. MIRAFI, *Geotextile Filter Design, Application, and Product Selection Guide* , 1991,
2. Koerner, R.M., *Designing With Geosynthetics* , Fifth Edition, 2005.
3. AASHTO Designation: M288-06.
4. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.

SOLUTION:

Geotextile Used as Top Component of Drainage Geocomposite.

The design calculations assume the erosion layer soil will consist of soils with a hydraulic conductivity less than $1.2\text{x}10^{-4}$ cm/s and percent fines (passing #200 sieve) greater than 20 percent.

If the erosion layer material contains less than 20 percent fines, these geotextile calculations will be revised and included in the GLER for a specific cell to demonstrate adequacy of the material used.

Retention:

Based on Chart 1 - "Soil Retention Criteria," given on page IIIE-A-39, the apparent opening size (O_{95}) may be determined.

$$O_{95} < 0.21 \text{ mm}$$

Permeability:

The required permeability is determined by comparing the permeability of the erosion layer ($1.2\text{x}10^{-4}$ cm/s) with the permeability of the geotextile after the appropriate reduction factors are applied to the laboratory permeability of the geotextile.

Minimum Laboratory Permeability Specified (k_{ult}) = 0.2 cm/s

To determine the allowable permeability (k_{allow}) of the geotextile, the following reduction factors are used:

Table 2 - Reduction Factors[1]

RF_{SCB} = Reduction factor for soil clogging and blinding	2.0
RF_{CR} = Reduction factor for creep reduction of void space	2.0
RF_{IN} = Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} = Reduction factor for chemical clogging	1.0
RF_{BC} = Reduction factor for biological clogging	2.0
Overall Reduction Factor (ORF) =	9.6

[1] Reduction factors obtained from Ref. 4.

$$k_{allow} = k_{ult} / \text{ORF} = (0.2 \text{ cm/s}) / 9.6$$

$$\boxed{k_{allow} = 2.1\text{E-}02 \text{ cm/s}}$$

$k_{allow} >> k_{erosion\ layer}$ ($1.2\text{x}10^{-4}$ cm/s).

Specification: Geotextile component of geocomposite permeability shall be equal to or greater than 0.2 cm/s as determined by ASTM D 4491.

Survivability:

Based on Table 2, "Survivability Strength Requirements," provided on page IIIE-A-40, geotextile properties should be selected considering high contact stresses (i.e., heavy confining stress).

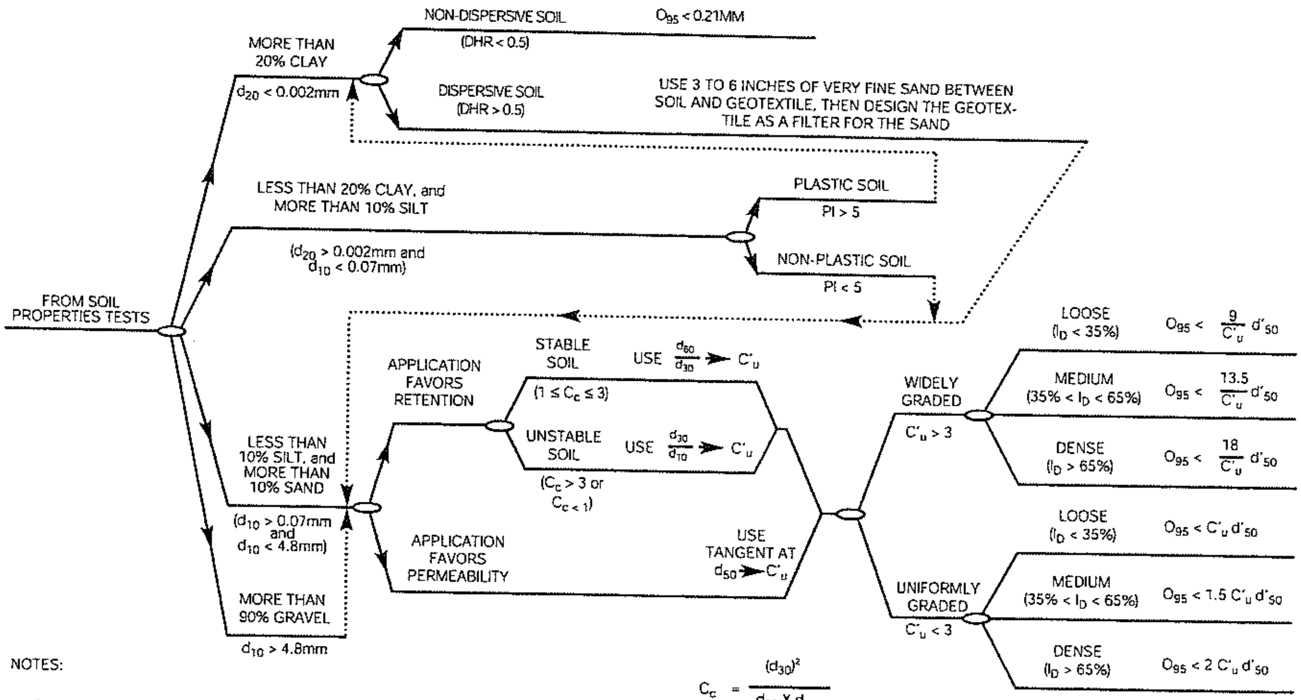
Durability:

Chemical compatibility with leachate will be considered during the selection process for the specific geotextile.

Summary of required properties for geotextile component of drainage geocomposite:

Apparent opening size	<	0.21	mm
Grab tensile strength	>	157	lbs
Elongation	>=	50	%
Puncture strength	>	56	lbs
Trapezoid tear	>	56	lbs
Burst Strength	>	80	lbs
Permeability	>=	0.2	cm/s

Chart 1. Soil Retention Criteria of Steady-State Flow Conditions



NOTES:

d_x = particle diameter of which size *x* percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremeties of a straight line drawn through the particle-size distribution, as directed above and d'_{50} is the midpoint of this line

$$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$$

I_D = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil
O_{95} = geotextile opening size

Table 2. Survivability Strength Requirements (after AASHTO, 1996)

		GRAB STRENGTH (LBS)	ELONGATION (%)	SEWN SEAM STRENGTH (LBS)	PUNCTURE STRENTH (LBS)	BURST STRENTH (LBS)	TRAPEZOID TEAR (LBS)
SUBSURFACE DRAINAGE	HIGH CONTACT STRESSES (ANGULAR DRAINAGE MEDIA) (HEAVY COMPACTION) or (HEAVY CONFINING STRESSES)	247	< 50% *	222	90	392	56
		157	≥ 50%	142	56	189	56
	LOW CONTACT STRESSES (ROUNDED DRAINAGE MEDIA) (LIGHT COMPACTION) or (LIGHT CONFINING STRESSES)	180	< 50% *	162	67	305	56
		112	≥ 50%	101	40	138	40
ARMORED EROSION CONTROL	HIGH CONTACT STRESSES (DIRECT STONE PLACEMENT) (DROP HEIGHT > 3 FT)	247	< 50% *	222	90	392	56
		202	≥ 50%	182	79	247	79
	LOW CONTACT STRESSES (SAND OR GEOTEXTILE CUSHION) and (DROP HEIGHT < 3 FT)	247	< 50% *	222	90	292	56
		157	≥ 50%	142	56	189	56

* Only woven monofilament geotextiles are acceptable as < 50% elongation filtration geotextiles. No woven slit film geotextiles are permitted.