CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS
TCEQ PERMIT NO. MSW-358C

MAJOR PERMIT AMENDMENT APPLICATION

VOLUME 2 OF 6

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Prepared for

City of Arlington
and
Republic Waste Services of Texas, Ltd.

May 2022

Prepared by

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

Project No. 0023-404-11-104

This document is intended for permitting purposes only.

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TARRANT COUNTY, TEXAS
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MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIB
OVERLINER POINT OF COMPLIANCE DEMONSTRATION

STATE OF TEXAS
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CONTENTS (Continued)

TABLES

1 INTRODUCTION

1.1 Purpose and Scope

The proposed continued development of the City of Arlington Landfill includes an overliner system that will be constructed over the pre-Subtitle D West Disposal Area (WDA) 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) requirement set forth in Title 30 TAC §330.331(a), which is:

> *"a design that ensures that the concentration values listed in Table 1 of this paragraph will not be exceeded in the uppermost aquifer at the point of compliance."*

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 provides an overview of the POC demonstration.

1.2 Containment System Design

The existing WDA is approximately 128 acres, of which approximately 23.3 acres of overliner have been constructed to date (as of the end of 2021) under Permit No. MSW-358B. The overliner will be constructed over the remaining pre-Subtitle D area to separate the existing waste and the vertical waste fill area. The overliner areas will consist of overliner Sectors 1 through 6, which comprise approximately 110 acres of the total proposed 390.5-acre solid waste disposal area footprint.

The waste containment system design is shown on Figure 1-3. As shown on Figure 1-3, the overliner system will consist of a reinforced GCL and a 40-mil LLDPE geomembrane (textured on both sides) overlain by a geocomposite leachate collection layer. The leachate collection layer placed above the geomembrane will consist of an HDPE geonet with 6 oz/sy non-woven geotextiles heat-bonded to both sides. A 24-inch-thick protective cover layer will be placed above the leachate collection layer.

Details for the overliner system are provided in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. Design of the overliner leachate collection is presented in Appendix IIIC – Leachate and Contaminated Water Management Plan. Stability of the overliner system is analyzed in Appendix IIIE-A. Overliner settlement analysis is provided in Appendix IIIE-B-3.

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 does not exceed allowable values at the POC.

The POC demonstration will show that once the overliner is installed, leachate infiltration into the waste below the overliner will be virtually eliminated. Once the Subtitle D final cover is in place, leachate generation rates will decrease in the overliner area.

If the proposed "design" (i.e., separatory overliner system shown on Figure 1-3), will eliminate leachate generation into the waste below the overliner, then current groundwater conditions at the site will be unaffected and will remain below the constituent parameters listed in Table 1 of §330.331(a)(1).

The existing groundwater monitoring system, prior to relocating historic waste, is shown on Figure 1-4. As discussed in Appendix IIIH – Groundwater Monitoring, Sampling, and Analysis Plan, the existing POC will not change under TCEQ Permit No. 358C until the existing historic waste fill area located south of the WDA is removed. The limits of the historic waste shown on Figure 1-4 was estimated based on subsurface investigations. The average thickness of waste in this area is approximately 7 feet, with the waste thickness ranging from 3 to 15 feet. As shown on Figure 1-5, the existing historic waste fill area will be relocated prior to relocating the POC and development of Sectors 8 through 12.

Section 2 provides a discussion of the history of the WDA, site geology, and the site's groundwater quality. The POC demonstration methods are discussed in Section 3. Landfill configurations analyzed and model input parameters are discussed in Sections 4 and 5. A summary of the point of compliance demonstration is provided in Section 6. Additional considerations are discussed in Section 7.

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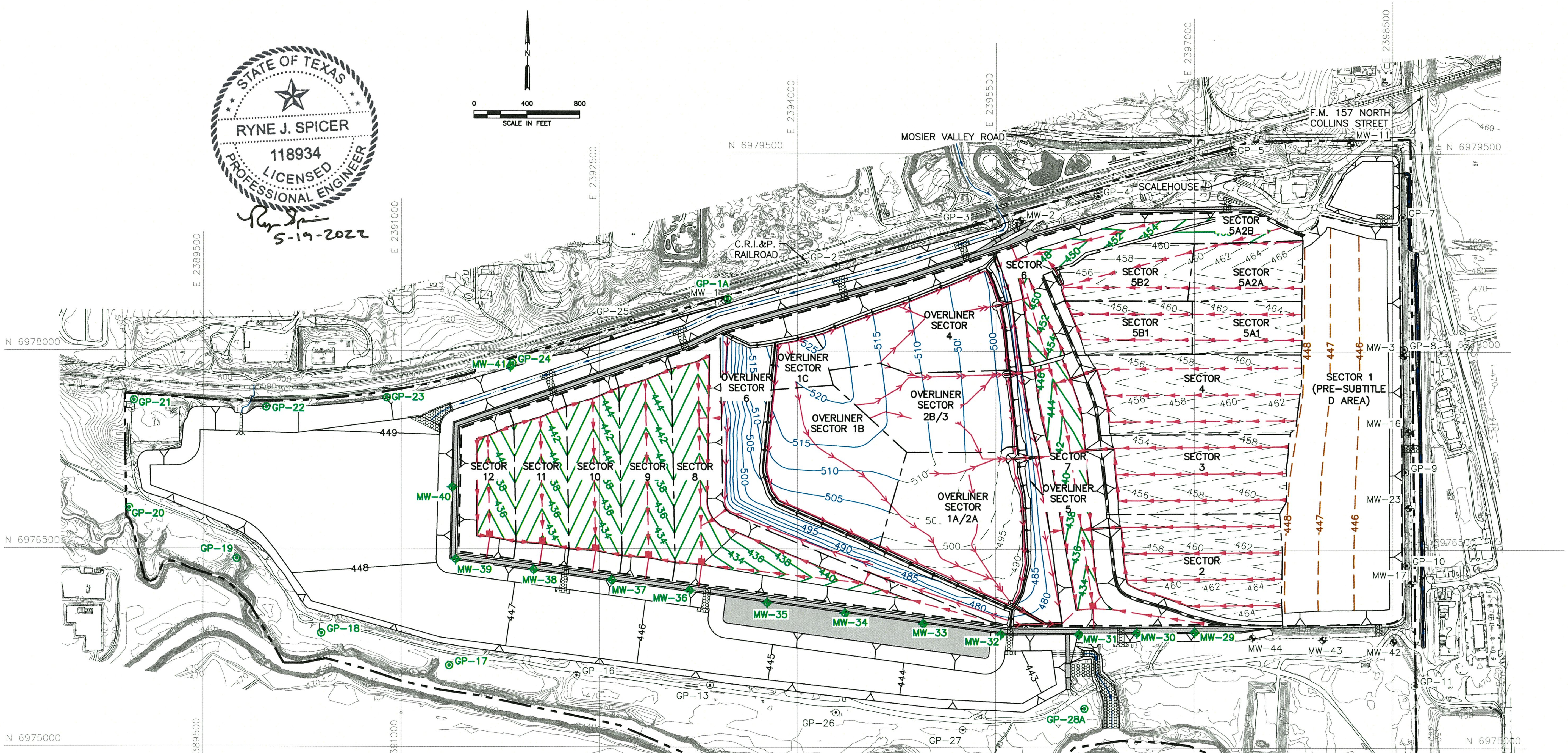

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (e.g., CHANNELS) ARE TYPICALLY 3H:1V.
3. REFER TO APPENDIX IIIC FOR LEACHATE STORAGE INFORMATION.
4. ELEVATION of DEEPEST EXCAVATION AT THE LCS SUMP IS 424.5 FT-MSL.
5. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA DRAWINGS I/IIA.4 THROUGH I/IIA.7.
6. REFER TO APPENDIX IIIF FOR DRAINAGE DESIGN INFORMATION.

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- SECTOR BOUNDARY
- 500 EXISTING CONTOUR
- N 6975000 STATE PLANE COORDINATE
- 440 TOP OF LINER CONTOUR
- 506 TOP OF OVERLINER CONTOUR
- 510 AS-BUILT TOP OF LINER CONTOUR
- LEACHATE COLLECTION PIPE
- LEACHATE COLLECTION SUMP
- LEACHATE RISER PIPE
- OVERLINER LEACHATE DRAINAGE PIPE
- OVERLINER LEACHATE DRAINAGE PIPE (MULTIPLE PIPES IN TRENCH)
- MW-8 EXISTING GROUNDWATER MONITORING WELL
- MW-40 PROPOSED GROUNDWATER MONITORING WELL
- GP-2 EXISTING LANDFILL GAS MONITORING PROBE
- GP-17 PROPOSED LANDFILL GAS MONITORING PROBE

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DATE: 05/2022
FILE: 0023-404-11
CAD: 1-1 PROPOSED LINER PLAN.DWG

DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

Weaver Consultants Group
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CITY OF ARLINGTON
AND
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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
TOP OF LINER PLAN

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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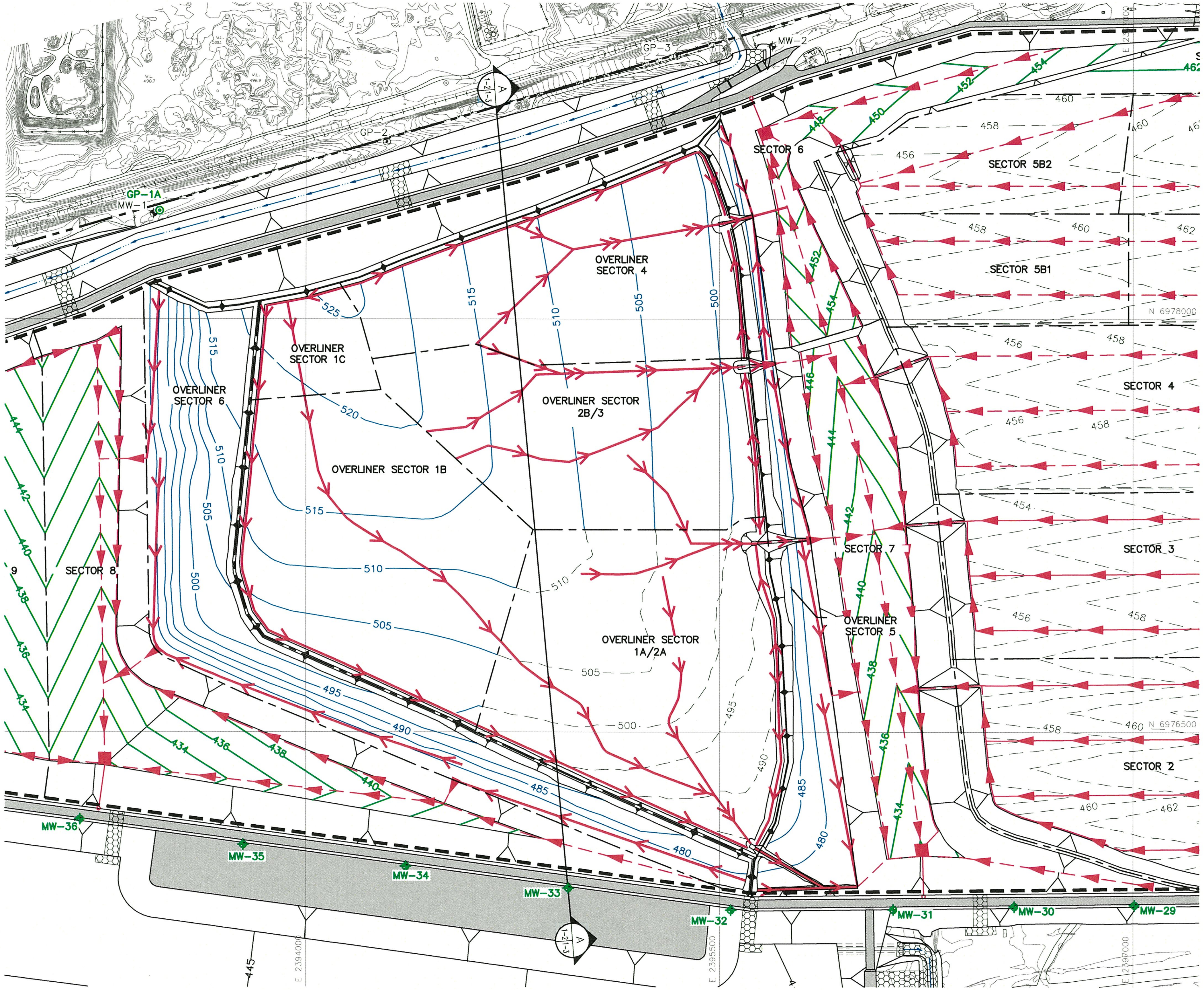
FIGURE 1-1

O:\0023\404\EXPANSION 2021\PART III\IIIB\1-1 PROPOSED TOP OF LINER PLAN.dwg, jwilson, 1:2



0 200 400
SCALE IN FEET

N

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- SECTOR BOUNDARY
- 500 EXISTING CONTOUR
- N 6975000 STATE PLANE COORDINATE
- 440 TOP OF LINER CONTOUR
- 506 TOP OF OVERLINER CONTOUR
- 510 AS-BUILT TOP OF LINER CONTOUR
- LEACHATE COLLECTION PIPE
- LEACHATE COLLECTION SUMP
- LEACHATE RISER PIPE
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- OVERLINER LEACHATE DRAINAGE PIPE (MULTIPLE PIPES IN TRENCH)
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NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (e.g., CHANNELS) ARE TYPICALLY 3H:1V.
3. REFER TO APPENDIX IIIC FOR LEACHATE STORAGE INFORMATION.
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5. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA DRAWINGS I/IIA.4 THROUGH I/IIA.7.
6. REFER TO APPENDIX IIIF FOR DRAINAGE DESIGN INFORMATION.

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

☐ DRAFT ☒ FOR PERMITTING PURPOSES ONLY ☐ ISSUED FOR CONSTRUCTION	PREPARED FOR CITY OF ARLINGTON AND REPUBLIC WASTE SERVICES OF TEXAS, LTD	MAJOR PERMIT AMENDMENT TOP OF OVERLINER PLAN	
DATE: 05/2022 FILE: 0023-404-11 CAD: 1-2 OVER LINER PLAN.DWG	DRAWN BY: JDW DESIGN BY: JBM REVIEWED BY: RJS	CITY OF ARLINGTON LANDFILL TARRANT COUNTY, TEXAS	
Weaver Consultants Group TBPE REGISTRATION NO. F-3727		WWW.WCGRP.COM	FIGURE 1-2

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NO.	DATE	DESCRIPTION

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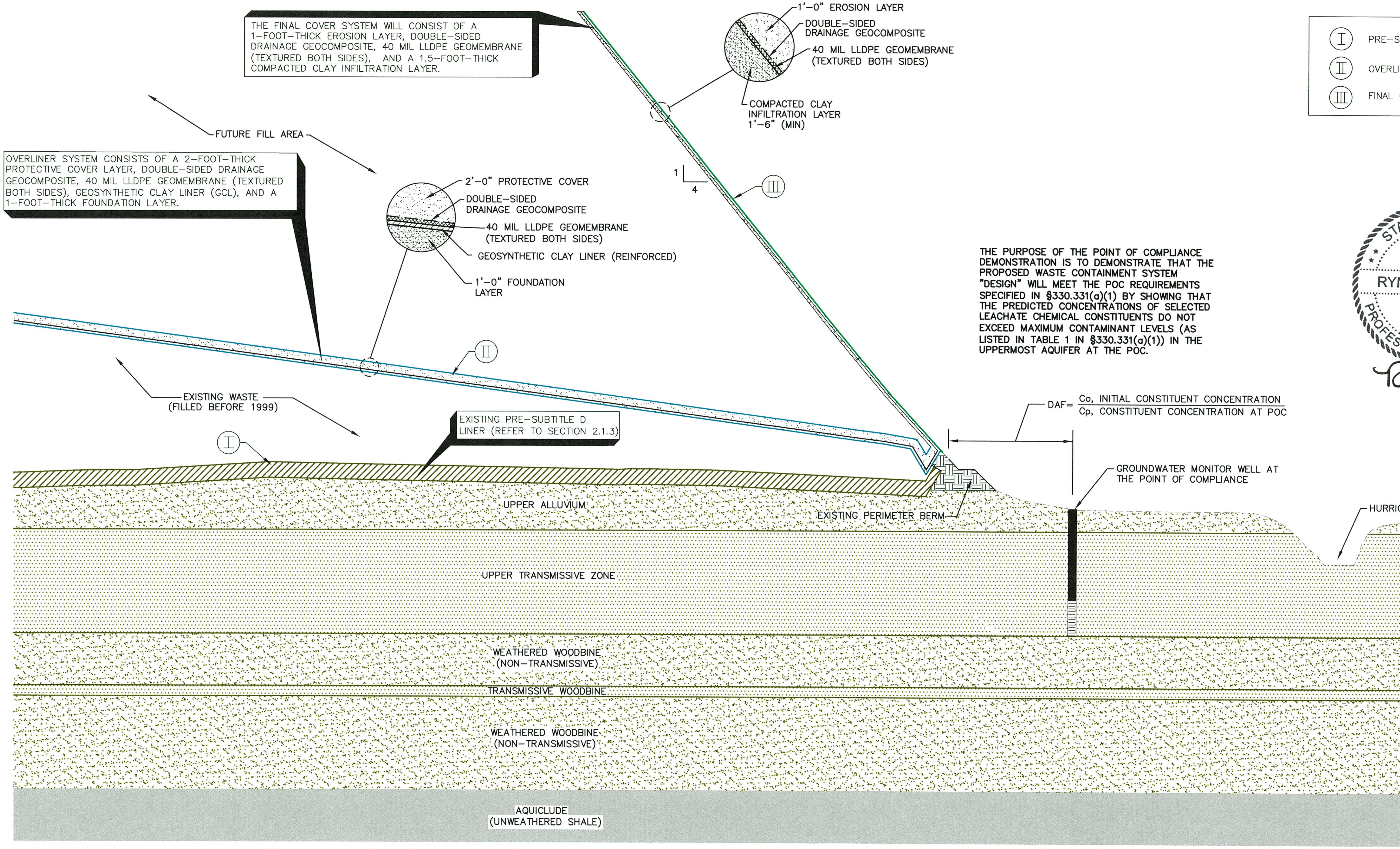
WASTE CONTAINMENT SYSTEM DESIGN



I	PRE-SUBTITLE D LINER SYSTEM
II	OVERLINER SYSTEM
III	FINAL COVER SYSTEMS

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.

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TYPICAL SECTION 1 (1-2 | 1-3)
(NOT TO SCALE, SEE NOTE 2)

NOTES:

1. TYPICAL GEOLOGIC PROFILE DEVELOPED FROM CROSS-SECTIONS INCLUDED IN APPENDIX IIIG.
2. THIS FIGURE HAS BEEN DEVELOPED FOR ILLUSTRATION PURPOSES WITHOUT A SCALE.

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- [x] FOR PERMITTING PURPOSES ONLY
- [ ] ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: 1-3 TYPICAL EXIST SECTION.DWG

DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

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MAJOR PERMIT AMENDMENT
TYPICAL LANDFILL SECTION

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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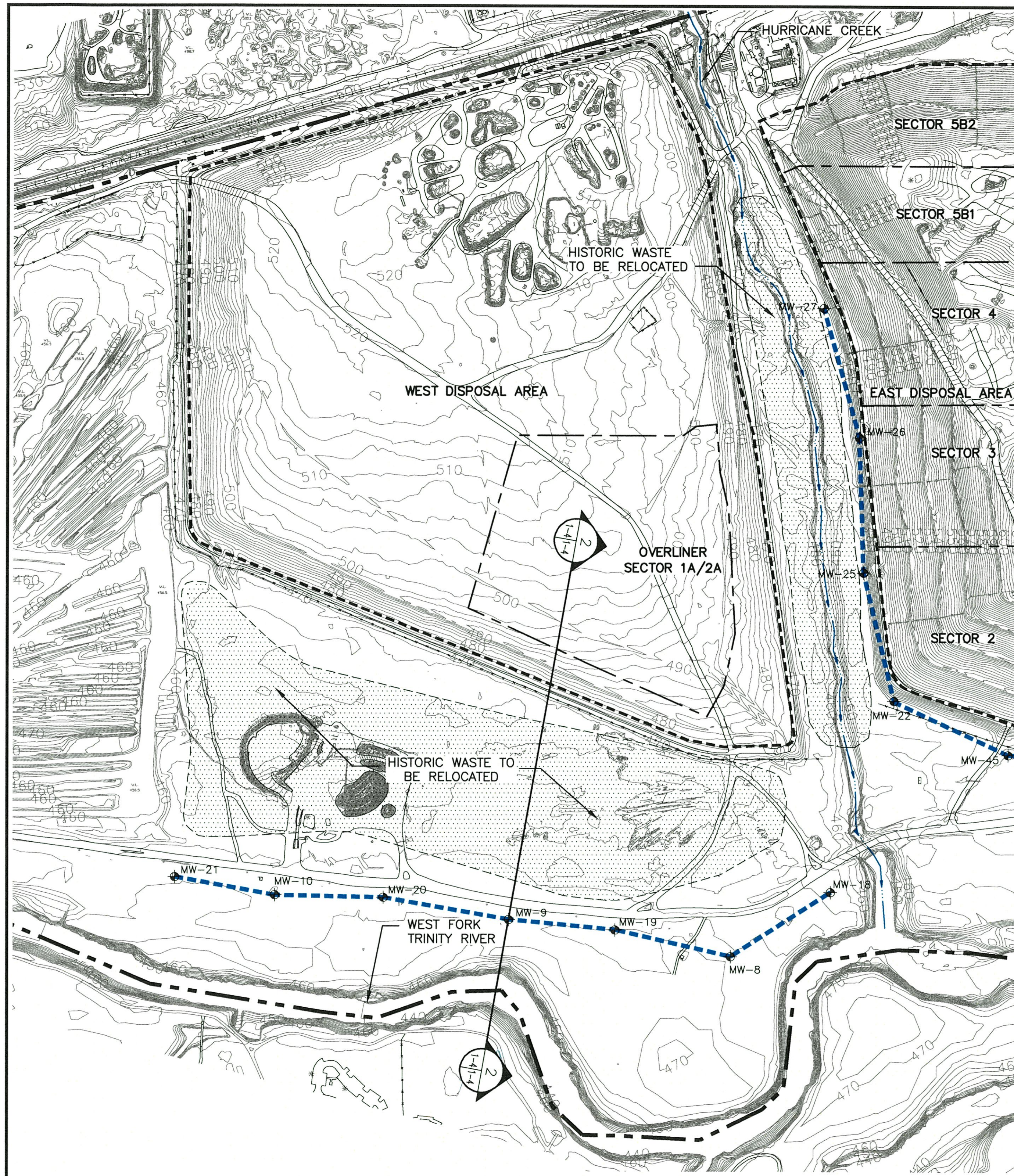
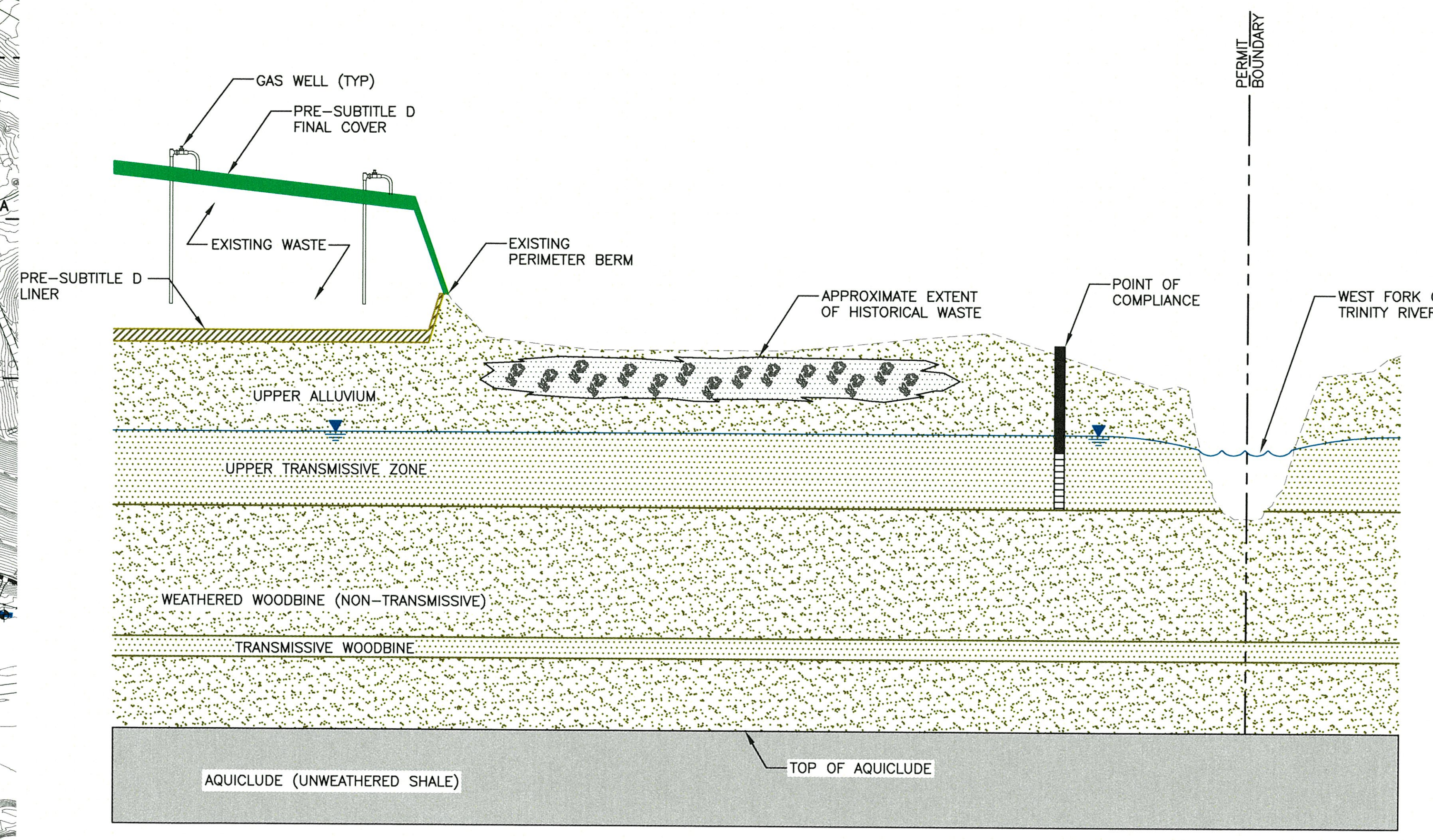
FIGURE 1-3



EXISTING SITE CONDITIONS



TYPICAL SECTION–EXISTING CONDITION

(NOT TO SCALE, SEE NOTE 4)

LEGEND

- PERMIT BOUNDARY
- EXISTING LIMIT OF WASTE
- SECTOR BOUNDARY
- 500 EXISTING CONTOUR
- N 6975000 STATE PLANE COORDINATE
- EXISTING POINT OF COMPLIANCE (TCEQ PERMIT NO. MSW-358B)
- MW-20 EXISTING POINT OF COMPLIANCE GROUNDWATER MONITOR WELL
- HISTORIC WASTE TO BE RELOCATED

N

0 300 600

SCALE IN FEET

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. LIMIT OF WASTE FOR THE EDA PROVIDED BY GOLDER ASSOCIATES, INC. LIMIT OF WASTE FOR THE WDA ESTABLISHED FROM HISTORICAL SLERs AND PERMIT INFORMATION.
3. TYPICAL GEOLOGIC PROFILE DEVELOPED FROM CROSS-SECTIONS INCLUDED IN APPENDIX IIIG.
4. THIS FIGURE HAS BEEN DEVELOPED FOR ILLUSTRATION PURPOSES WITHOUT A SCALE. SIMILAR SECTIONS ARE PROVIDED ON SCALED DRAWINGS IN APPENDIX IIIB.

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FILE: 0023-404-11	DESIGN BY: JBM
CAD: 1-4 SITE PLAN.DWG	REVIEWED BY: RJS

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AND

REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT

SITE PLAN AND SECTION

EXISTING CONDITION

CITY OF ARLINGTON LANDFILL

TARRANT COUNTY, TEXAS

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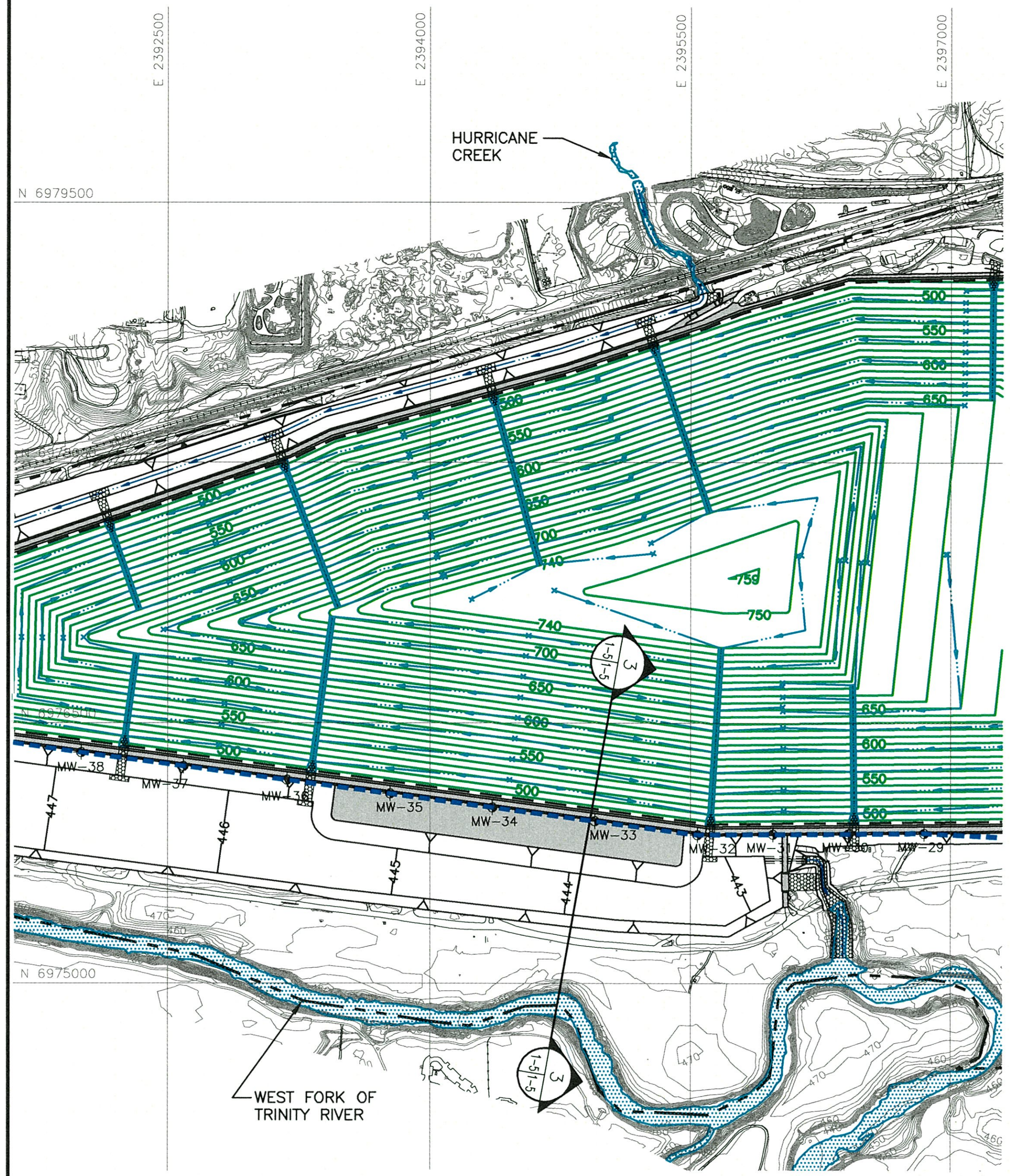
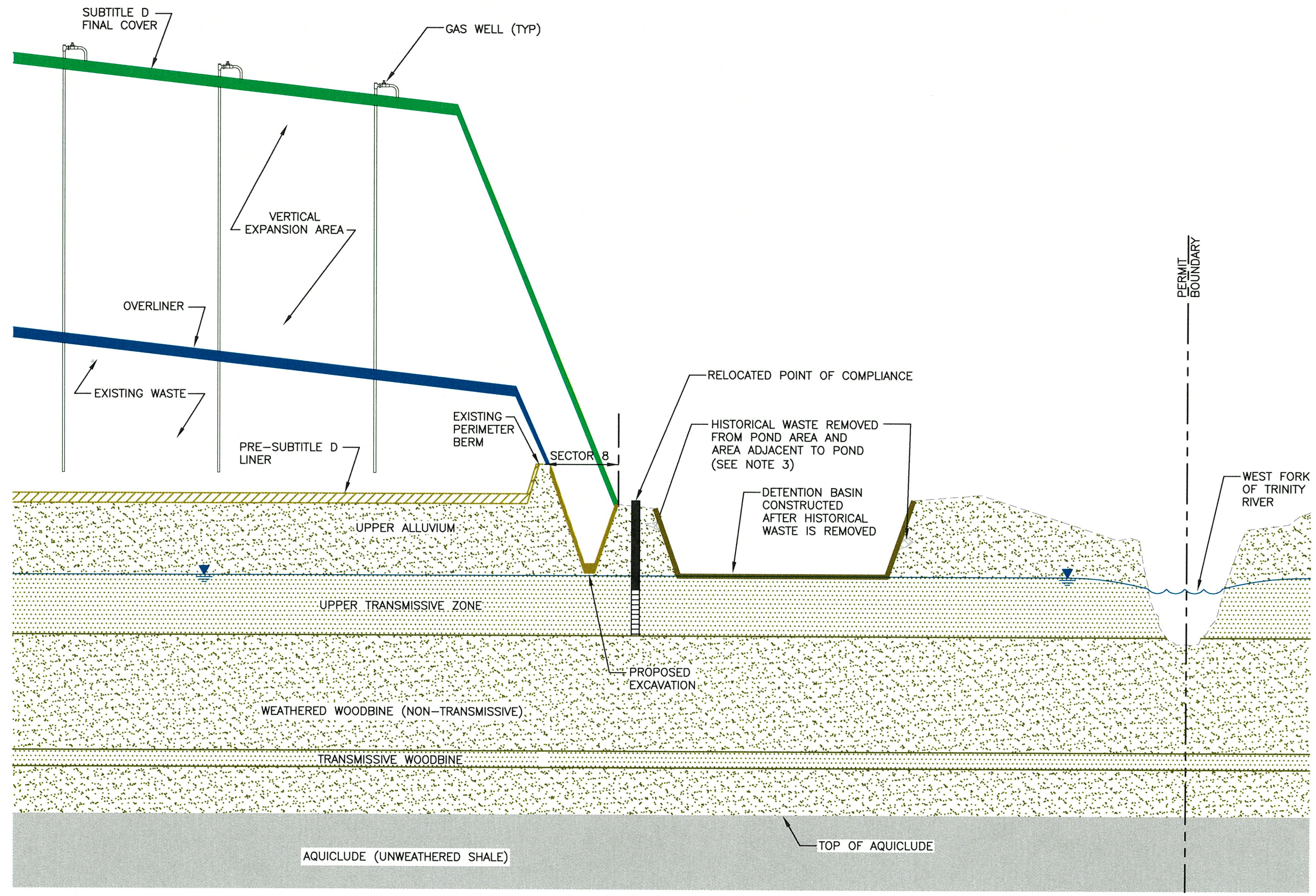
FIGURE 1-4

O:\0023\404\EXPANSION 2021\PART III\IIB\1-4-SITE PLAN.dwg, jwilson, 1:2





3 / 1-5 | 1-5

TYPICAL SECTION–PROPOSED CONDITION

(NOT TO SCALE, SEE NOTE 4)

LEGEND

N

0 500 1000

SCALE IN FEET

- PERMIT BOUNDARY
- LIMIT OF WASTE
- 500 EXISTING CONTOUR
- 500 PROPOSED FINAL CONTOUR
- N 6767200 STATE PLANE COORDINATE
- PROPOSED POINT OF COMPLIANCE
- MW-38 GROUNDWATER MONITOR WELL

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. TYPICAL GEOLOGIC PROFILE DEVELOPED FROM CROSS-SECTIONS INCLUDED IN APPENDIX IIIG.
3. THE HISTORICAL WASTE REMOVED FROM THIS AREA WILL BE DISPOSED OF IN A SUBTITLE D WASTE DISPOSAL AREA (AT THE LANDFILL WORKING FACE).
4. THIS FIGURE HAS BEEN DEVELOPED FOR ILLUSTRATION PURPOSES WITHOUT A SCALE. SIMILAR SECTIONS ARE PROVIDED ON SCALED DRAWINGS IN APPENDIX IIIB.
5. THE LOCATION OF SECTION 3 ON THIS FIGURE IS THE SAME AS SECTION 2 ON FIGURE 1-4.

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☐ DRAFT ☒ FOR PERMITTING PURPOSES ONLY ☐ ISSUED FOR CONSTRUCTION DATE: 05/2022 FILE: 0023-404-11 CAD: 1-5 PROPOSED SITE PLAN.DWG DRAWN BY: JDW DESIGN BY: JBM REVIEWED BY: RJS Weaver Consultants Group TBPE REGISTRATION NO. F-3727	PREPARED FOR CITY OF ARLINGTON AND REPUBLIC WASTE SERVICES OF TEXAS, LTD REVISIONS NO. / DATE / DESCRIPTION	MAJOR PERMIT AMENDMENT SITE PLAN AND SECTION PROPOSED CONDITION CITY OF ARLINGTON LANDFILL TARRANT COUNTY, TEXAS WWW.WCGRP.COM FIGURE 1-5

O:\0023\404\EXPANSION 2021\PART III\IIIB\1-5_PROPOSED SITE PLAN_SECTION.dwg, jwilson, 1:2

2 EXISTING SITE INFORMATION

This section describes the existing site information including the history of the pre-Subtitle D West Disposal Area (WDA), geologic conditions and groundwater quality.

2.1 History of the WDA

2.1.1 Operational History

The original Texas Department of Health permit (Permit No. 358) was issued on March 14, 1978. The current configuration of the WDA is shown on Figure 2-1. The WDA was filled to the permitted grades and the existing pre-Subtitle D final cover system was installed in 1999, prior to the issuance of TCEQ Permit No. 358A in 2003.

Figures 2-2 and 2-3 were developed based on drawings included in the permit application for Permit No. 358 (dated November 1977, prepared by Henningson, Durham, & Richardson, Inc.). Based on this information, it appears the WDA was over 50 percent developed by the time the permit application was submitted in 1977. As shown on Figure 2-2, the permit documents indicate a levee or perimeter berm was to be constructed around the east, south, and west perimeter of the waste disposal area.

The existing levees or perimeter berms are also shown on Figure 2-3. The cross-sections shown on Figure 2-3 are also based on information included in the 1977 permit application. The levee system surrounding the eastern, southern, and western sides of the WDA was permitted to include an impermeable 5-foot-wide keyway, extending to an impervious strata. According to details in the 1977 permit application, the crest of the levee was permitted at 8 feet wide with a maximum elevation of 12 feet above natural grade with 3H:1V sideslopes. The crest elevation of the levee was designed to be one foot above the 100-year flood elevations obtained from "Preliminary Studies for the Dallas Flood Insurance Program, West Fork, Trinity River" (United States Army Corps of Engineers, 1977). As shown on Figure 2-3, the levee system shown on 1977 permit drawings is consistent with a recent topographic map of this area.

The Sectors 14 through 18 areas of the existing WDA pre-Subtitle D unit shown on Figure 2-2 were constructed between 1990 and 1993. A pre-Subtitle D final cover was constructed over the WDA in 1999 as further discussed in the next section.

2.1.2 Existing Final Cover System and GCCS

As noted in Section 2.1.1 and shown on Figure 2-3, a pre-Subtitle D final cover was constructed over the WDA in 1999. The pre-Subtitle D final cover system included an 18-inch-thick low-permeability compacted clay infiltration layer overlain by a 6-inch-thick erosion layer.

An active landfill gas collection and control system (GCCS) has been installed in the WDA. The GCCS for the WDA includes a system of vertical extraction wells, horizontal collection trenches, and a flare, as shown on Figure 2-4 – WDA Existing Final Cover/GCCS.

2.1.3 Pre-Subtitle D Liner System

As noted in Section 2.1, the northern portion of the WDA was constructed in the early 1990s. As-built information is available for these sectors and is reproduced on Figure 2-5. Figure 2-5 also shows the estimated bottom of waste for the southern portion of the WDA. These contours were developed assuming existing LFG extraction wells were drilled to within 10 feet from the bottom of waste. This results in average excavation depths between 10 feet and 20 feet, which is consistent with typical practice for landfill development during this time frame. The horizontal limits of the WDA shown on Figure 2-5 were approximated by using the as-built SLER information and historical permit drawings included in the 1977 permit application (Permit No. 358).

According to the as-built information for the northern portion of the site, a 3-foot-thick compacted clay liner was constructed in the 33-acre northern portion of the WDA. The compacted clay liner was required to have a permeability of no greater than $1x10^{-7}$ cm/s. The SLERs indicate that the permeability of the compacted clay liner typically ranged from $5x10^{-8}$ cm/s to $2x10^{-8}$ cm/s.

Since 1970, the Texas State Board of Health MSW Regulations required that a natural or artificial barrier be in place, which most commonly was the placement of a 3-foot-thick compacted clay or in-situ clay liner ($k \leq 1x10^{-7}$ cm/s). However, no liner as-built documentation was required. In addition, the Texas Department of Health (TDH) permit for the site was issued in March 1978 (Permit No. 358). Detailed liner requirements were listed in this permit for either a 3-foot-thick low-permeability compacted clay or in-situ liner ($k \leq 1x10^{-7}$ cm/s). Site records contain minimal information regarding the date of initial operations in the WDA. There is some indication that the site was "established" in 1965; however, there is no additional information to indicate when waste was initially placed in the WDA.

2.2 Site Geology

Various investigations have been conducted at the City of Arlington Landfill facility to characterize the subsurface conditions at the site. As presented in Appendix IIIG – Geology Report, the site-specific geologic deposits have been designated in five stratigraphic strata. The properties of these strata are summarized below.

- Stratum A — Alluvium: The upper portion of the profile ranging from the ground surface to an approximate elevation of 468 ft-msl consists of interbedded fine- and coarse-grained soils. A majority of the soils are fine-grained and classified as low and high plasticity clays and silts. The coarse-grained soils were found in discontinuous pockets and classified as clayey sand, silty sand, and sand. The landfill is designed to generally penetrate Stratum A.
- Stratum B — Alluvium with gravel: This laterally discontinuous stratum comprises the first water-bearing zone. Stratum B primarily consists of coarse-grained soils with an increasing amount of gravel sized particles. These soils are primarily classified as clayey sand, silty sand, and sand. Discontinuous pockets of well-graded and poorly-graded gravel were also identified. The landfill is designed with a portion of the bottom to be founded on Stratum B and a portion to penetrate Stratum B.
- Stratum C — Weathered Woodbine, Non-Transmissive: This stratum is identified as the weathered upper, non-transmissive portion of the Woodbine formation. The top of this unit is generally identified by a layer of shaley clay, the top of which represents the unconformity surface between the Quaternary age alluvium and the underlying Cretaceous age Woodbine. The materials encountered within this stratum exhibit characteristics of both soil and rock depending on the amount of weathering the materials have experienced. The shale portion of the Woodbine is weathered into a shaley clay or shaley silt. The western expansion of the landfill is designed with a portion of the bottom to be founded on Stratum C and a portion to penetrate Stratum C.
- Stratum D — Transmissive Woodbine: This stratum is composed of sands, sandstone and interbedded sandstone and shale units of the Woodbine. The sandstone portions is variably weathered, with some portions weathered to sand.
- Stratum E – Unweathered/Competent Woodbine Shale: This stratum is composed of the unweathered/competent shale of the Woodbine formation. The bedrock materials were identified as a laterally continuous shale and discontinuous zones of siltstone with a few pockets of limestone at depth. The westernmost portion of the landfill is designed to be primarily founded on Stratum E.

2.2.1 Uppermost Aquifer

As discussed in Appendix IIIG – Geology Report, there are two shallow water-bearing strata at the site. The uppermost water-bearing stratum is generally found in the lower portion of the alluvial deposits consisting of coarse-grained materials with an increasing amount of gravel-sized particles (Stratum B); the second is the weathered and unweathered sandstone of the Woodbine Group (Stratum D). These two water-bearing stratums are locally interconnected and define the uppermost transmissive zone

2.3 Groundwater Quality

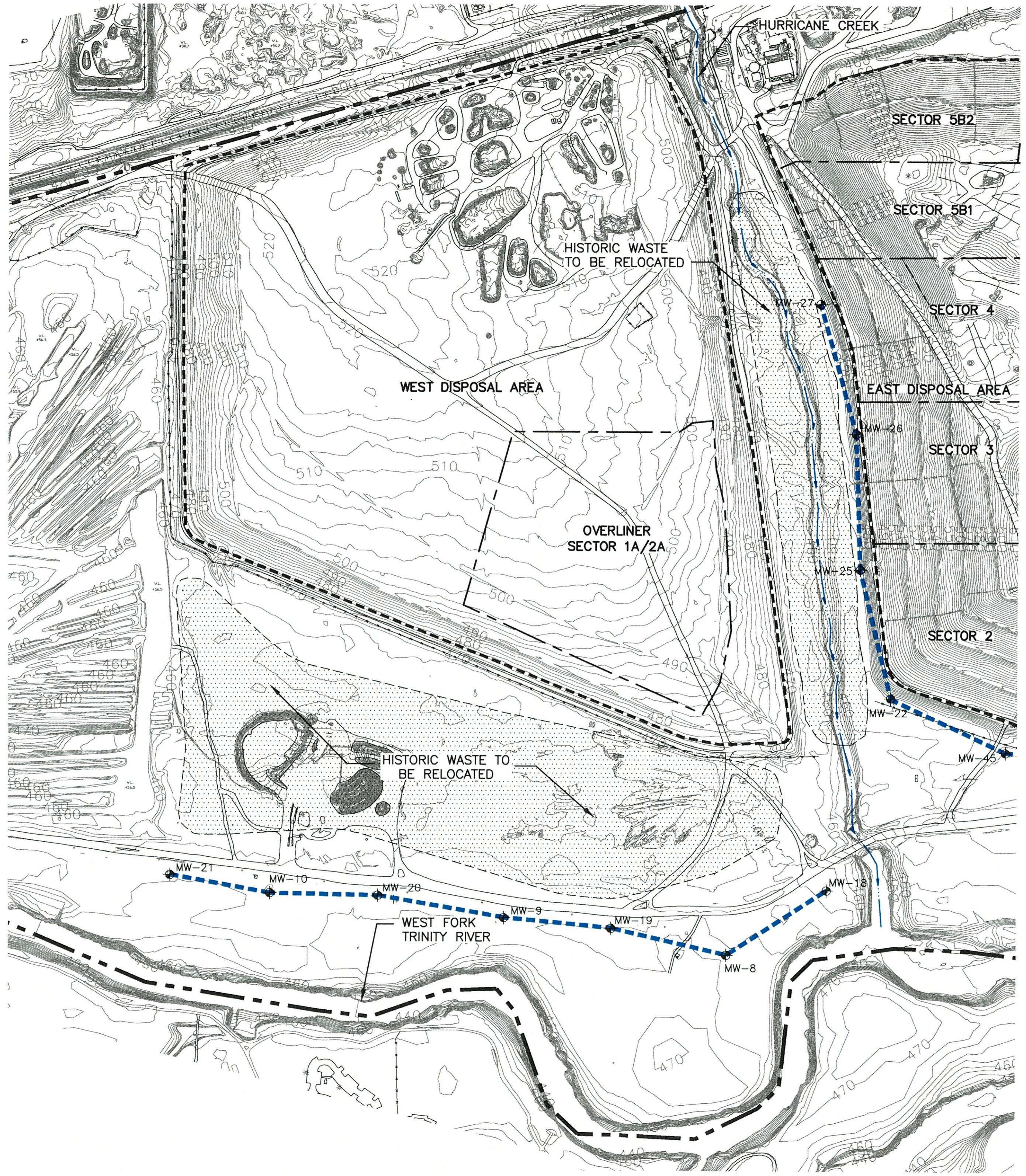
The facility's historical groundwater analytical data for all existing monitoring and observation wells are presented in Table IIIH-B-1 (total metals constituents) and Table IIIH-B-2 (Volatile Organic Compound constituents) in Appendix IIIH.

Table 2-1 presents a summary of the MCLs listed in Table 1 of §330.331(a)(1), as well as the groundwater quality information obtained from analytical results performed on historical samples of groundwater collected from the City of Arlington Landfill.

Table 2-1
Chemical Constituent MCLs and Current Groundwater Conditions

Constituent	MCL Listed in §330.331(a)(1) (mg/l)	Current Site Groundwater Conditions[1] (mg/l)	Maximum Historical Site Groundwater Conditions[1,2] (mg/l)
Arsenic	0.05	0.013	0.0512
Barium	1.0	0.082	0.63
Benzene	0.005	0.0005	0.00129
Cadmium	0.01	0.001	0.0054
Carbon tetrachloride	0.005	0.0025	0.0025
Chromium (hexavalent)	0.05	0.01	0.01
2,4-Dichlorophenoxy acetic acid	0.1	--	--
1,4-Dichlorobenzene	0.075	0.001	0.001
1,2-Dichloroethane	0.005	0.0005	0.00378
1,1-Dichloroethylene	0.007	0.0005	0.0021
Endrin	0.0002	--	--
Fluoride	4	--	--
Lindane	0.004	--	--
Lead	0.05	0.0075	0.0025
Mercury	0.002	--	--
Methoxychlor	0.1	--	--
Nitrate	10	--	--
Selenium	0.01	0.025	0.025
Silver	0.05	0.005	0.005
Toxaphene	0.005	--	--
1,1,1-Trichloroethane	0.2	0.0005	0.0005
Trichloroethylene	0.005	0.0025	0.0025
2,4,5-Trichlorophenoxy acetic acid	0.01	--	--
Vinyl Chloride	0.002	0.001	0.001

1 Current Groundwater Conditions based on analytical results from tests performed between March 2021 and September 2021. The reported values represent average groundwater conditions over this period.
2 For constituents not detected at reporting limits, one-half of the reporting limit is listed.
3 Only groundwater data from Subtitle D monitoring events are included as maximum historical concentrations.



EXISTING SITE CONDITIONS

0 300 600
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- SECTOR BOUNDARY
- 500 EXISTING CONTOUR
- N 6975000 STATE PLANE COORDINATE
- EXISTING POINT OF COMPLIANCE (TCEQ PERMIT NO. MSW-358B)
- MW-20 EXISTING POINT OF COMPLIANCE GROUNDWATER MONITOR WELL
- HISTORIC WASTE TO BE RELOCATED

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.

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DATE: 05/2022
FILE: 0023-404-11
CAD: 2-1 SITE PLAN.DWG

DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

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REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
CURRENT WDA CONFIGURATION

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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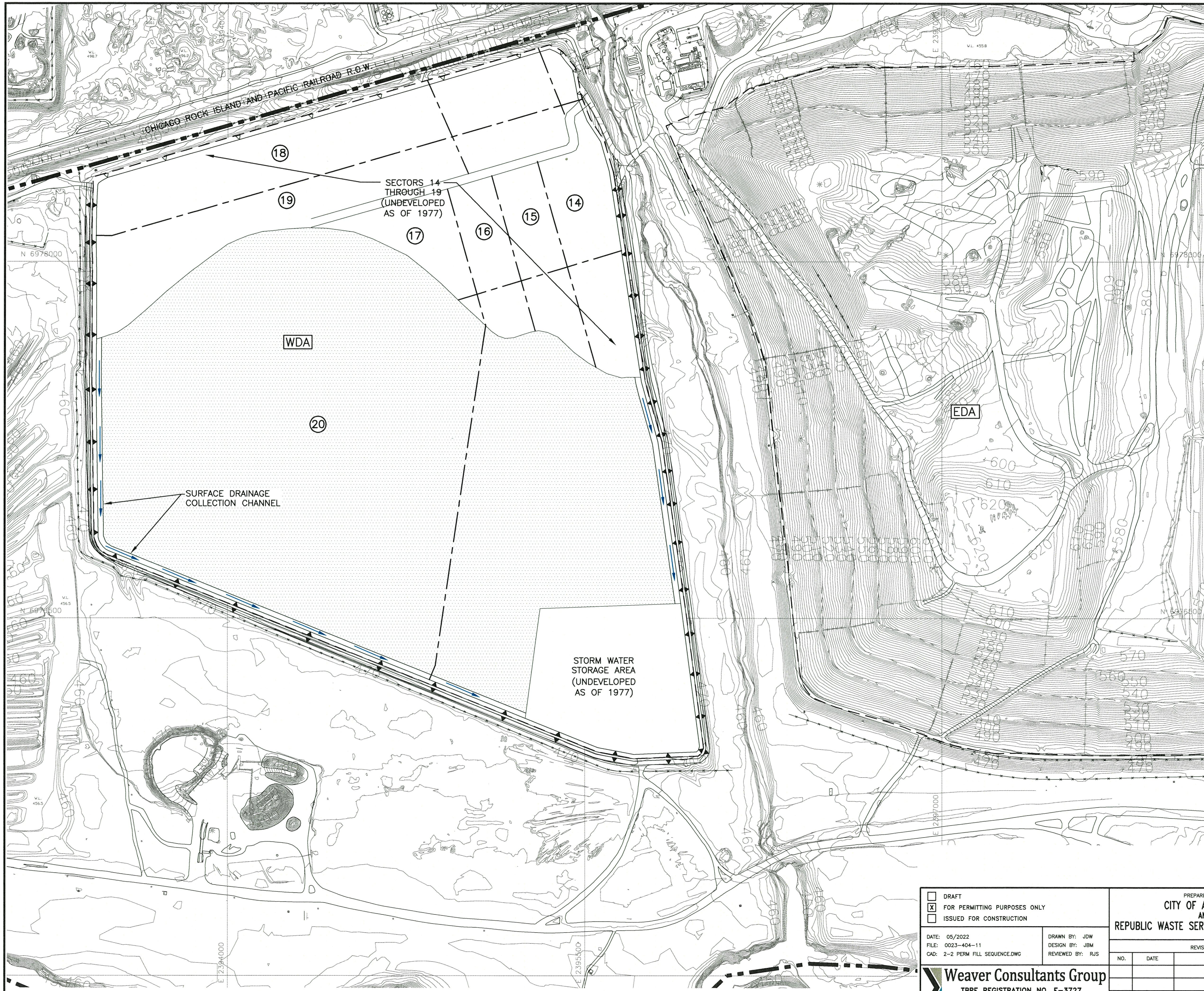
FIGURE 2-1



0 200 400
SCALE IN FEET

LEGEND

— · — ·	PERMIT BOUNDARY
— — —	LIMIT OF WASTE
500	EXISTING CONTOUR
N 6767200	STATE PLANE COORDINATE
▲ ▼	PERIMETER BERM (SEE NOTE 3)
(shaded)	PREVIOUSLY FILLED AREAS
16	SECTOR DESIGNATION (SEE NOTE 4)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. LIMIT OF WASTE FOR THE WDA ESTABLISHED FROM HISTORICAL SLERs AND PERMIT INFORMATION.
3. PERIMETER BERM DEVELOPED BASED ON INFORMATION INCLUDED IN THE NOVEMBER 1977 PERMIT APPLICATION FOR PERMIT NO. 358 PREPARED BY HDR, INC.
4. SECTOR DESIGNATIONS REPRODUCED FROM ATTACHMENT NO. 6 OF THE NOVEMBER 1977 PERMIT APPLICATION FOR PERMIT NO. 358 PREPARED BY HDR, INC. SECTOR DESIGNATION SHOWN HAS BEEN REPRODUCED FROM THE 1977 APPLICATION, AND DOES NOT REFLECT ANY SECTOR DESIGNATION PROPOSED IN THE APPLICATION. PREVIOUSLY FILLED AREAS INDICATE THE AREAS THAT WERE FILLED AS OF 1977 (i.e. SECTORS 14 THROUGH 19 WERE UNDEVELOPED IN 1977).

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DRAWN BY: JDW
DESIGN BY: JBM
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MAJOR PERMIT AMENDMENT
HISTORIC FILL SEQUENCE OF WDA

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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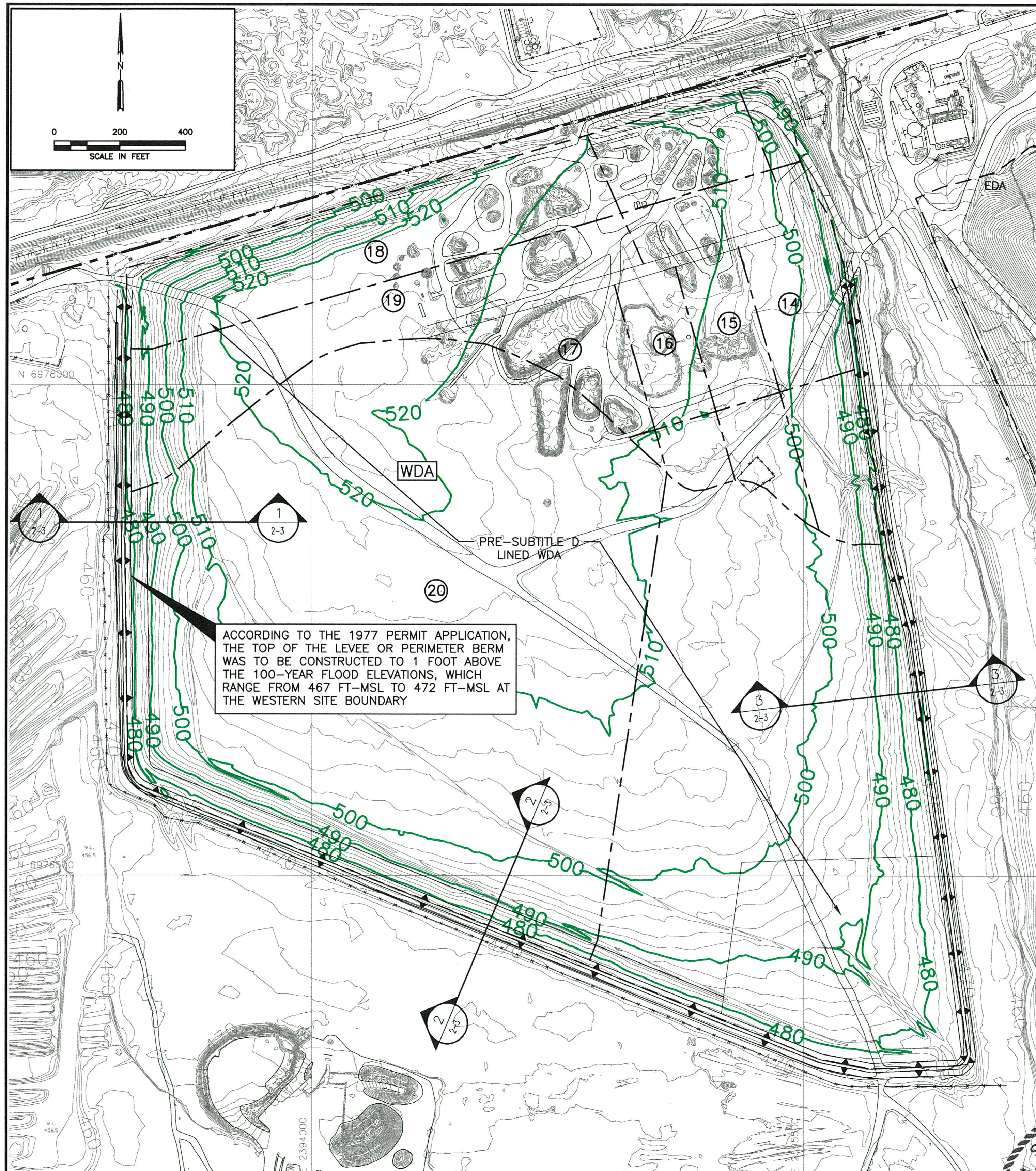
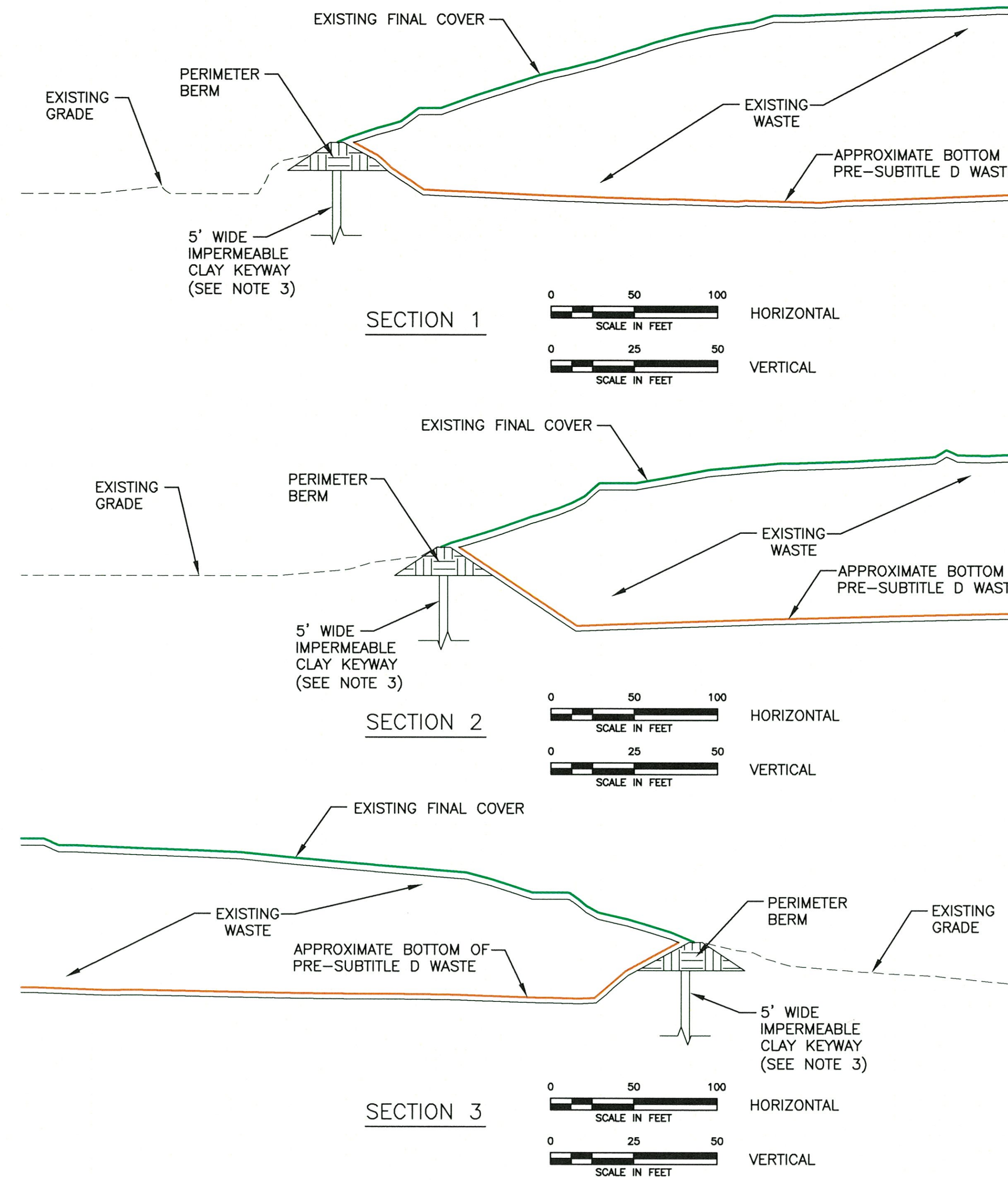
FIGURE 2-2

O:\0023\404\EXPANSION 2021\PART III\IIIB\2-2_PERM FILL SEQUENCE.dwg, jwilson, 1:2





NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. LIMIT OF WASTE FOR THE WDA ESTABLISHED FROM HISTORICAL SLERs AND PERMIT INFORMATION.
3. PERIMETER BERM (INCLUDING 5' WIDE IMPERMEABLE CLAY KEYWAY) DEVELOPED BASED ON INFORMATION INCLUDED IN THE NOVEMBER 1977 PERMIT APPLICATION FOR PERMIT NO. 358 PREPARED BY HDR, INC.
4. SECTOR DESIGNATIONS REPRODUCED FROM ATTACHMENT NO. 6 OF THE NOVEMBER 1977 PERMIT APPLICATION FOR PERMIT NO. 358 PREPARED BY HDR, INC. SECTOR DESIGNATION SHOWN HAS BEEN REPRODUCED FROM THE 1977 APPLICATION, AND DOES NOT REFLECT ANY SECTOR DESIGNATION PROPOSED IN THE APPLICATION.

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE (SEE NOTE 2)
- 500 EXISTING CONTOUR
- N 6767200 STATE PLANE COORDINATE
- 16 SECTOR DESIGNATION (SEE NOTE 4)
- 500 EXISTING FINAL COVER CONTOUR WITHIN THE WDA (ONLY 10' INTERVAL CONTOURS HIGHLIGHTED)
- PERMITTED PERIMETER BERM (SEE NOTE 3)

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FILE: 0023-404-11
CAD: 2-3 PERMITTED WDA LEVEE.dwg

DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

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MAJOR PERMIT AMENDMENT
EXISTING WDA PERIMETER BERM

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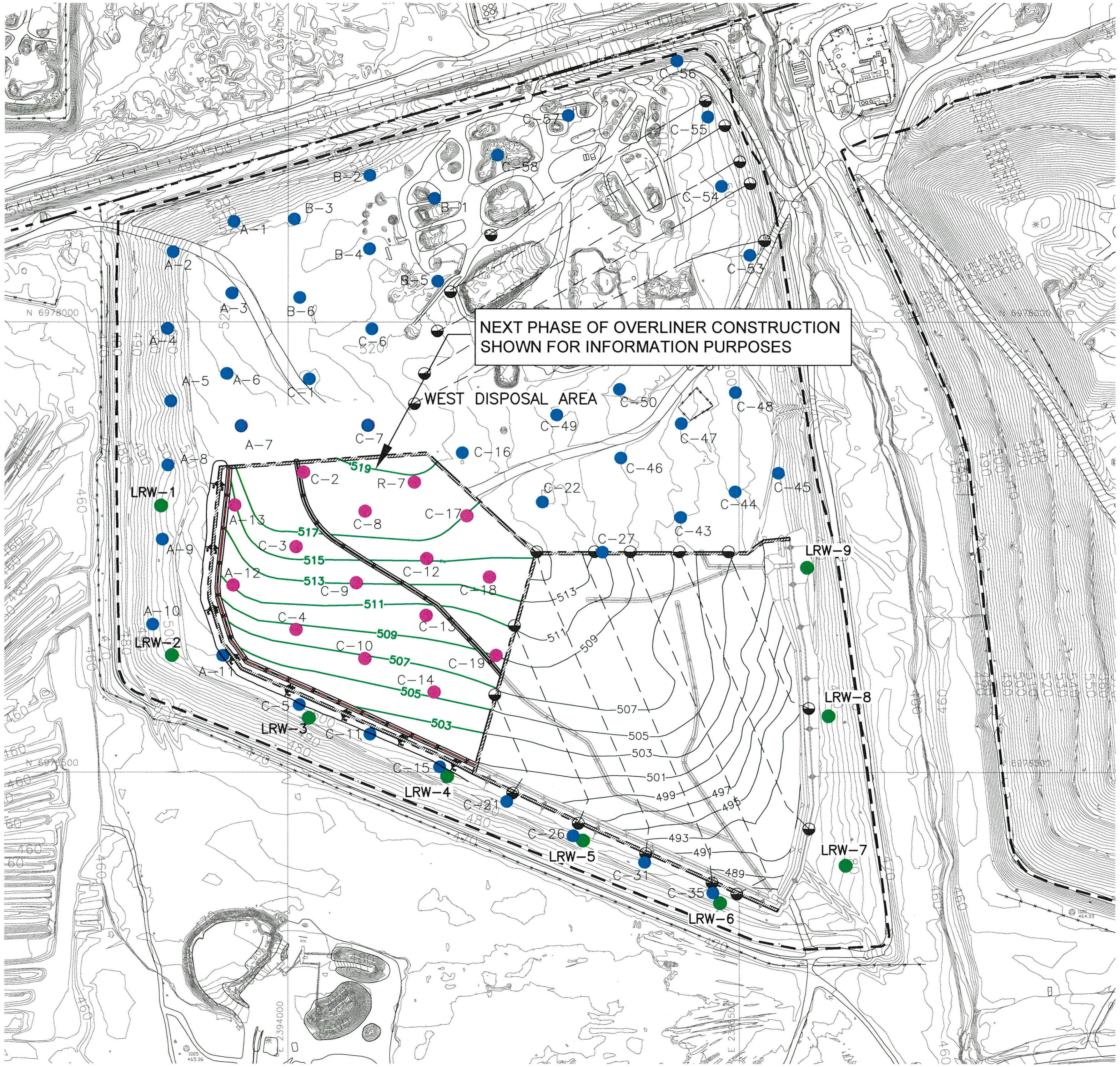
FIGURE 2-3



N

0 200 400
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- SECTOR BOUNDARY
- N 6767200 — STATE PLANE COORDINATE
- 500 — EXISTING CONTOUR
- 501 — CONSTRUCTED OVERLINER
- 509 — OVERLINER TOP OF PROTECTIVE COVER CONTOUR
- EXISTING HORIZONTAL LFG COLLECTION PIPE
- LRW-1 — EXISTING DEDICATED LEACHATE REMOVAL WELL (LIQUID MONITORING/REMOVAL LOCATION)
- A-1 — EXISTING LFG EXTRACTION WELL (LIQUID MONITORING/REMOVAL LOCATION)
- C-8 — EXISTING LFG EXTRACTION WELL (TO BE CONVERTED TO HORIZONTAL GAS COLLECTION)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.

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CAD: 2-4 LEACHATE REMOVAL PLAN.DWG

DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
WDA EXISTING FINAL COVER/GCCS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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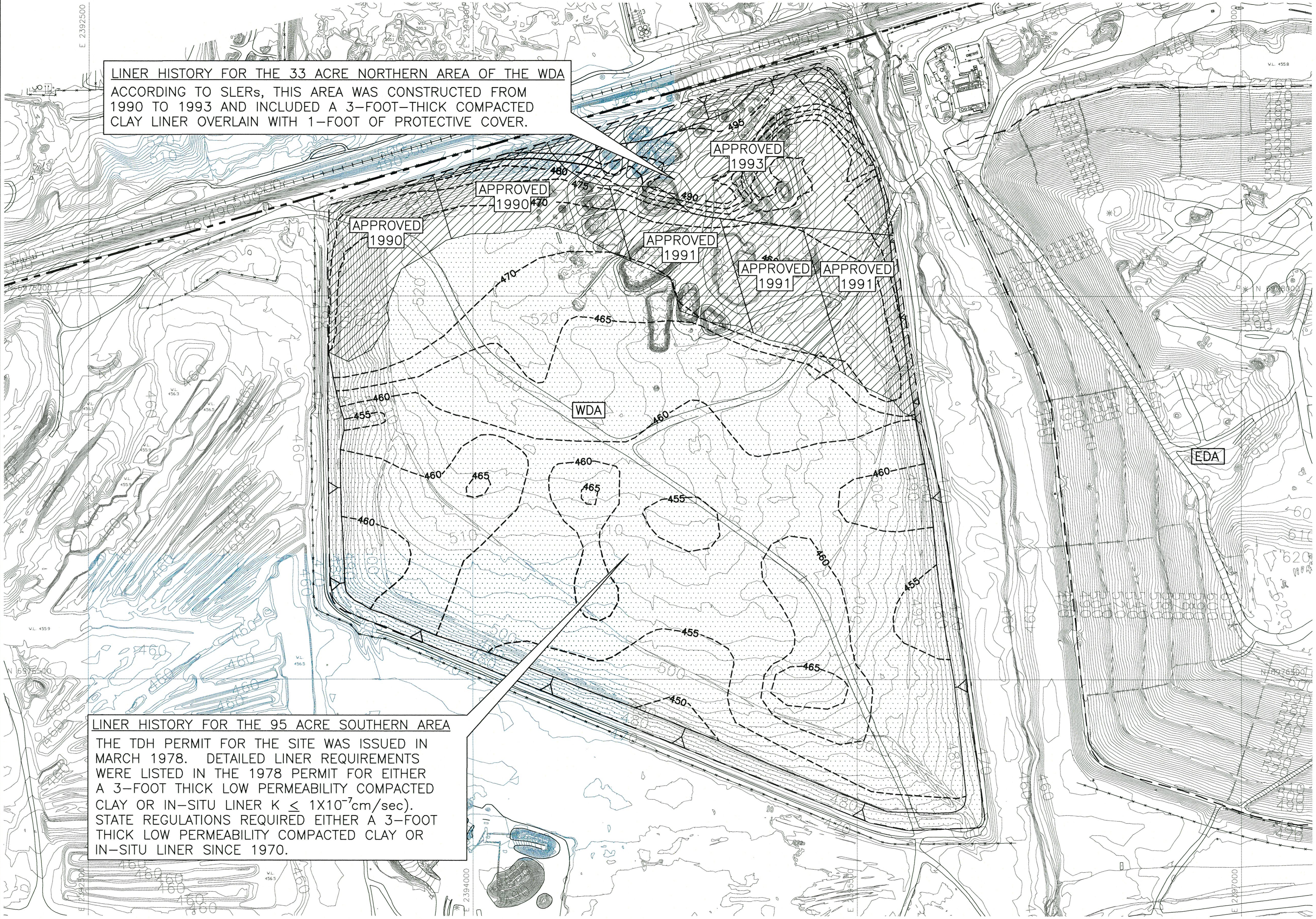
FIGURE 2-4

O:\0023\404\EXPANSION 2021\PART III\IIIB\2-4-WDA PRESUBTITLE D AREA LEACHATE REMOVAL PLAN.dwg, jwilson, 1:2



LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE (SEE NOTE 2)
- 500 — EXISTING CONTOUR
- N 6978000 — STATE PLANE COORDINATE
- 470 — APPROXIMATE BOTTOM OF WASTE OR TOP OF PRE-SUBTITLE D LINER SYSTEM (SEE NOTE 3)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. LIMIT OF WASTE FOR THE WDA ESTABLISHED FROM HISTORICAL SLERs AND PERMIT INFORMATION.
3. TOP OF PRE-SUBTITLE D LINER SYSTEM GRADING DEVELOPED FROM AVAILABLE SLERS AND GAS WELL INSTALLATION INFORMATION. REFER TO SECTION 2.1.3 FOR MORE INFORMATION. THE CONTOURS SHOWN INDICATE BOTTOM OF EXISTING WASTE.

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O:\0023\404\EXPANSION 2021\PART III\IIIB\2-5 WDA BOTTOM OF WASTE MAP.dwg, jwilson, 1:2

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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
TOP OF PRE-SUBTITLE D WDA LINER SYSTEM

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FIGURE 2-5

3 POINT OF COMPLIANCE DEMONSTRATION METHODS

This point of compliance (POC) demonstration has been developed using (1) the HELP model to estimate leachate percolation from 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. In addition, a flow chart summarizing the demonstration process is presented on Figure 3-1.

3.1 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, proposed Subtitle D final cover system, and existing pre-Subtitle D final cover system, 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 4.

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 IIIB-A – HELP Model Analysis.

3.2 MODFLOW

Various computer programs are available to model contaminant transport for point of compliance (POC) demonstrations. The model selected to support this demonstration is MODFLOW. 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. Visual MODFLOW, developed by Schlumberger Water Services, has been used for the simulations included in this appendix.

3.2.1 Leachate Quality

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 mg/l, 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.

3.2.2 Groundwater Flow Analysis

The Preconditioned Conjugate-Gradient 2 (PCG2) solver was selected for the POC demonstration to solve transient (i.e., non-steady state) flow produced with varying 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, storability) 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). PCG2 is a numerical engine in MODFLOW that solves the groundwater flow portion of the MODFLOW simulation. MODFLOW processes the data sets by combining similar durations of input (e.g., recharge and percolation) into "stress periods." A stress period represents a time period of constant input data. For this demonstration, the stress periods consist of the following:

- Active Landfill Condition (2021 – 2028) – 7 Years. The year of initial waste filling operations in the overliner area (i.e., 2021) through the projected year overliner completion (i.e., 2028).
- Active Landfill Condition (2028 – 2054) – 26 Years. The year of overliner completion (i.e., 2028) through the projected year of closure (i.e., 2054).
- Closed Landfill Condition – 30 Years. The projected year of closure (i.e., 2054) through the end of the postclosure care period for the landfill (i.e., 2084).

The model divides each stress period into "time steps" which are incremental steps between each landfill condition. The time step factor of 10, default factor in MODFLOW, is used in the simulations. For example, the time step for 50-year stress period is 5 years, which is calculated by MODFLOW by dividing the stress period of 50 years by 10. During each time step, the model applies percolation and recharge to the groundwater surface. Percolation and recharge is input into the model by defining cells in the uppermost grid layer; however, the model applies the percolating water to the existing groundwater surface, bypassing unsaturated zones. The upper most grid layer represents the plan view of the two-dimensional model; therefore, the model receives any percolation from this layer. PCG2 achieves a mass balance for each time step by performing simultaneous iterations for each saturated cell until the program converges. For example, mass balance is achieved when the resulting drain boundary discharge is equal to the drain boundary capacity which is established by the program utilizing the hydrogeologic characteristics of the model. Additionally, at each time step, the program establishes the groundwater surface that is in balance with (1) the groundwater surface in the previous time step, (2) percolating water entering the model, and (3) water leaving the cell during the time step or water draining out of the model at the drain boundary cells. Once this step is complete for each cell and for the entire model simulation period, the model is ready to run the fate and transport module.

3.2.3 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. 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., percolation). Note that various decay processes were not included in this demonstration to provide a conservative analysis. These decay processes include chemical and biological decay as well as adsorption.

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.

For this demonstration, the amount of leachate (i.e., source) that percolates from the landfill to the subsurface is established using the HELP model (discussed in Section 3). An initial constituent concentration is then assigned to the leachate that is predicted to percolate from the landfill (refer to Appendix IIIB-A for the HELP model simulations).

MODFLOW uses a water balance methodology for the saturated soils within the area defined by the groundwater surface at the top, no flow boundary at the bottom, and upgradient and downgradient boundary conditions to determine the final concentration of the leachate constituents at the POC. The leachate that is modeled to percolate from the landfill enters the subsurface. The constituents in the leachate are modeled to mix with groundwater and are simulated to change in concentration due to leachate moving into groundwater (i.e., advection) and dispersion. It is important to note that the leachate constituents will also be reduced or attenuated during the time that the leachate is modeled to travel from the landfill to the POC due to (1) adsorption within the subsurface soil matrix and (2) biological and chemical decay. However, these factors were not included in the demonstration to provide a conservative analysis.

Fate and Transport Output

The resulting DAF contours were developed using the model output and are presented on Figures 6-2 and 6-3 of Section 6. The MT3DMS fate and transport modeling was performed for a period of 63 years (33 years active and 30 years closed landfill condition). The resulting DAF contours represent the ratio of dilution factor of 260 to represent the extent of 260 DAF contours, which stands for the minimum acceptable DAF value. The DAF contours are the result of attenuation of constituents due to (1) advective flow and (2) dispersion of constituents in the groundwater.

POINT OF COMPLIANCE DEMONSTRATION FLOW CHART

STEP 1 – HELP MODEL ANALYSIS. THE HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL WAS USED TO ESTIMATE THE RATE OF LEACHATE PERCOLATION THROUGH VARIOUS LANDFILL COMPONENTS AS WELL AS GROUNDWATER RECHARGE BETWEEN THE LIMITS OF WASTE AND THE POINT OF COMPLIANCE (POC). PERCOLATION AND RECHARGE VALUES FROM THE HELP MODEL WERE INPUT INTO MODFLOW IN STEP 2 AS ZONES. PERCOLATION ZONE I VARIES OVER TIME TO REPRESENT THE AN ACTIVE CONDITION AND CLOSED CONDITION.

STEP 1

HELP MODEL

HELP – MODEL INPUT

THE FOLLOWING ARE THE MAJOR INPUT PARAMETERS USED TO ESTIMATE LEACHATE PERCOLATION FOR ACTIVE AND CLOSED LANDFILL CONDITIONS AS WELL AS ESTIMATING GROUNDWATER RECHARGE.

- SITE SPECIFIC PRECIPITATION DATA.
- GENERAL INFORMATION INCLUDING MODEL DURATION, GROUND COVER, SCS RUNOFF CURVE NUMBER (GENERATED BY HELP), MODEL AREA, RUNOFF AREA, MAXIMUM LEAF AREA INDEX, AND EVAPORATIVE ZONE DEPTH.
- INFORMATION FOR THE SUBTITLE D FINAL COVER SYSTEM, OVERLINER SYSTEM, PRE–SUBTITLE D FINAL COVER SYSTEM, WASTE, INTERMEDIATE COVER, AND OFFSITE AREAS (GROUNDWATER RECHARGE AREAS) INCLUDING INPUTS FOR THICKNESS, POROSITY, FIELD CAPACITY, WILTING POINT, INITIAL MOISTURE CONTENT, HYDRAULIC CONDUCTIVITY, SLOPE, SLOPE LENGTH, PINHOLE DENSITY, INSTALLATION DEFECTS, AND PLACEMENT QUALITY.

NOTES:

1. VALUES ARE SHOWN FOR THE SECTION B DESIGN CASE SIMULATION FOR DEMONSTRATION PURPOSES. REFER FIGURE 6–3 OF SECTION 6 FOR THE LOCATION OF ZONES OF PERCOLATION AND RECHARGE FOR SECTION B INCLUDING THE RESULTS OF THE DEMONSTRATION. THE RESULTS FOR SECTIONS A ARE ALSO PRESENTED IN SECTION 6 ON FIGURES 6–2.

HELP – MODEL OUTPUT/ MODFLOW – MODEL INPUT

LEACHATE PERCOLATION VALUES OBTAINED FROM HELP MODEL ANALYSIS WERE INPUT IN MODFLOW AS ZONES OF LEACHATE PERCOLATION. EACH ZONE WAS ASSIGNED A SPECIFIED DURATION BASED ON THE TWO CONDITIONS DESCRIBED BELOW. FURTHERMORE, AN INITIAL LEACHATE CONCETRATION IS ASSIGNED FOR EACH ZONE AS DESCRIBED IN SECTION 5.2 – LEACHATE QUALITY INFORMATION.

"ACTIVE CONDITION (2021–2028)"

THE ACTIVE CONDITION (2021–2028) FOR THE WDA AREA (I.E., OVERLINER AREA) WAS MODELED FOR A DURATION OF 7 YEARS. THIS TIME PERIOD REPRESENTS THE PROJECTED DURATION THAT THE WDA AREA WILL RECEIVE WASTE BEFORE THE SMALL PORTION OF PRE–SUBTITLE D AREA SURROUNDING THE OVERLINER IS CONSTRUCTED. THE MODEL SIMULATIONS WERE PERFORMED STARTING IN THE PROJECTED YEAR THAT WASTE FILLING OPERATIONS BEGIN IN THE WDA AREA AND END IN THE PROJECTED YEAR WHEN THE REMAINING OVERLINER IS CONSTRUCTED OVER THE PRE–SUBTITLE D AREA (I.E., 2021 THROUGH 2028).

- PERCOLATION ZONE I
  OVERLINER AREA PERCOLATION =0.001 MM/YEAR
  ASSIGNED CONCENTRATION =1 mg/L
- PERCOLATION ZONE II
  PRE–SUBTITLE D FINAL COVER AREA PERCOLATION =50.7 MM/YEAR
  ASSIGNED CONCENTRATION=0.028 mg/L
- PERCOLATION ZONE III
  PERIMETER BERM PERCOLATION =0 MM/YEAR
  ASSIGNED CONCENTRATION =N/A
- RECHARGE ZONE IV
  AREA BETWEEN WDA AND POC PERCOLATION =7.0 MM/YEAR
  ASSIGNED CONCENTRATION=0 mg/L

"ACTIVE CONDITION (2028–2054)"

THE ACTIVE CONDITION (2028–2054) FOR THE WDA AREA (I.E., OVERLINER AREA) WAS MODELED FOR A DURATION OF 26 YEARS. THIS TIME PERIOD REPRESENTS THE REMAINING DURATION THAT THE WDA AREA WILL RECEIVE WASTE. THE MODEL SIMULATIONS WERE PERFORMED STARTING IN THE PROJECTED YEAR THAT WASTE FILLING OPERATIONS CONTINUED IN THE WDA AREA AND END IN THE PROJECTED YEAR OF SUBTITLE D FINAL COVER CONSTRUCTION OVER THE WDA VERTICAL EXPANSION AREA (I.E., 2028 THROUGH 2054).

- PERCOLATION ZONE I
  OVERLINER AREA PERCOLATION =0.001 MM/YEAR
  ASSIGNED CONCENTRATION =1 MG/L
- PERCOLATION ZONE II
  OVERLINER AREA PERCOLATION =0.001 MM/YEAR
  ASSIGNED CONCENTRATION =1 MG/L
- PERCOLATION ZONE III
  PERIMETER BERM PERCOLATION =0 MM/YEAR
  ASSIGNED CONCENTRATION =N/A
- RECHARGE ZONE IV
  AREA BETWEEN WDA AND POC PERCOLATION =7.0 MM/YEAR
  ASSIGNED CONCENTRATION=0 MG/L

"CLOSED CONDITION"

THE CLOSED CONDITION FOR THE WDA AREA WAS MODELED FOR A DURATION OF 30 YEARS. THIS TIME PERIOD REPRESENTS THE PROJECTED YEAR OF SUBTITLE FINAL COVER CONSTRUCTION OVER THE WDA VERTICAL EXPANSION AREA THROUGH THE END OF THE POST–CLOSURE CARE PERIOD (I.E., 2054 THROUGH 2084).

PERCOLATION ZONE I
OVERLINER AND FINAL COVER PERCOLATION =0.001 MM/YEAR
ASSIGNED CONCENTRATION =1 mg/L

PERCOLATION ZONE II
OVERLINER AND FINAL COVER PERCOLATION =0.001 MM/YEAR
ASSIGNED CONCENTRATION =1 mg/L

PERCOLATION ZONE III
PERIMETER BERM PERCOLATION =0 MM/YEAR
ASSIGNED CONCENTRATION=N/A

RECHARGE ZONE IV
AREA BETWEEN WDA AND POC PERCOLATION =7.0 MM/YEAR
ASSIGNED CONCENTRATION =0 mg/L

LEACHATE HEAD ON THE OVERLINER AND PRE–SUBTITLE D LINER WAS ESTIMATED USING THE HELP MODEL FOR THE TWO CONDITIONS DISCUSSED ABOVE AND ARE INCLUDED IN THE HELP MODEL SUMMARY ON PAGE IIIB–A–4 OF APPENDIX IIIB–A INCLUDING THE MODEL INPUTS AND OUTPUTS FOR EACH ZONE AND EACH CONDITION.

STEP 2 – MODFLOW MODEL. VARIOUS MODFLOW INPUT PARAMETERS WERE SELECTED TO DEVELOP THREE TYPICAL CROSS–SECTIONS TO REPRESENT THE AREA BETWEEN THE WDA AND THE POC. SITE SPECIFIC SUBSURFACE SOILS AND HYDROGEOLOGIC INFORMATION WAS OBTAINED FROM APPENDIX IIIG AND IIIH. THE MODEL GEOMETRY FOR THE SECTIONS HAVE BEEN DEVELOPED FROM EXISTING AND PROPOSED LANDFILL CONFIGURATIONS, SOIL STRATA INFORMATION PROVIDED IN APPENDIX IIIG, AND THE MONITORING WELL LOCATIONS (APPENDIX IIIH).

STEP 2

MODFLOW MODEL

MODFLOW – GROUNDWATER MODEL INPUT

THE FOLLOWING ARE THE MAJOR INPUT PARAMETERS USED FOR THIS DEMONSTRATION.

- MODEL GRID (X,Y,Z).
- MODEL LAYERS (STRATA) REPRESENTATIVE OF SITE SPECIFIC GEOLOGY REPRODUCED FROM APPENDIX IIIG.
- STRATA PROPERTIES INCLUDING HORIZONTAL AND VERTICAL HYDRAULIC CONDUCTIVITIES, SPECIFIC STORAGE, SPECIFIC YIELD, EFFECTIVE POROSITY, AND TOTAL POROSITY.
- GROUNDWATER TABLE REPRODUCED FROM APPENDIX IIIH TO REPRESENT SITE SPECIFIC GROUNDWATER LEVELS.
- ZONES OF LEACHATE PERCOLATION. EACH ZONE OF PERCOLATION IS ASSIGNED A DURATION TO REPRESENT THE VARIOUS STAGES OF LANDFILL DEVELOPMENT. PERCOLATION VALUES ARE INPUT FROM HELP MODEL SIMULATIONS.
- ZONES OF GROUNDWATER RECHARGE. GROUNDWATER RECHARGE VALUES ARE INPUT FROM HELP MODEL SIMULATIONS.
- MODEL SIMULATION DURATION. THE MODEL WAS PERFROMED FROM THE PROJECTED DURATION OF WASTE FILLING OPERATIONS IN THE WDA EXPANSION AREA (OVERLINER AREA) AND THROUGH THE PROJECTED END OF THE POST–CLOSURE CARE PERIOD.
- MONITORING WELL LOCATIONS REPRODUCED FROM APPENDIX IIIH.
- MODEL NO FLOW BOUNDARY. THE MODEL NO FLOW BOUNDARY WAS ESTABLISHED AT THE BOTTOM OF STRATUM C.

- MODFLOW – FATE AND TRANSPORT MODEL INPUT
- LEACHATE PERCOLATION CONCENTRATIONS. AN ASSUMED LEACHATE CONCETRATION IS ASSIGNED TO SPECIFIC ZONES BASED ON THE INFORMATION INCLUDED IN SECTION 5.2 – LEACHATE QUALITY INFORMATION.

STEP 3

PCG2, GROUNDWATER FLOW ANALYSIS

STEP 3 – PCG2, GROUNDWATER FLOW ANALYSIS. THE PRECONDITIONED CONJUGATE–GRADIENT 2 (PCG2) SOLVER UTILIZES INPUT PARAMETERS IN STEP 2 TO SOLVE TRANSIENT FLOW PRODUCED WITH VARYING RECHARGE AND PERCOLATION VALUES WITH RESPECT TO TIME.

STEP 4

MT3DMS, FATE AND TRANSPORT ANALYSIS

STEP 4 – MT3DMS, FATE AND TRANSPORT ANALYSIS. THE MODULAR 3–DIMENSIONAL TRANSPORT MODEL (MT3DMS) SOLVES THE TRANSPORT EQUATION AFTER THE FLOW SOLUTION HAS BEEN OBTAINED FROM THE GROUNDWATER FLOW MODEL IN STEP 3.

STEP 5

CONCENTRATION OUTPUT

STEP 5 – CONCENTRATION OUTPUT. THE CONCENTRATION OUTPUT AT POC IS OBTAINED AT THE END OF MODEL SIMULATION (I.E., END OF THE POST–CLOSURE CARE PERIOD).

CONCENTRATION OUTPUT = $2.16\text{x}10^{-5}$ mg/L

STEP 6

DILUTION ATTENUATION FACTOR

STEP 6 – DILUTION ATTENUATION FACTOR. UTILIZING THE CONCENTRATION OUTPUT IN STEP 5, THE CONCENTRATIONS OF VARIOUS CONSTITUENTS AT THE POC ARE DETERMINED BY CALCULATING A DILUTION ATTENUATION FACTOR (DAF).

$$DAF = \frac{1 \text{ mg/L}}{2.16\text{x}10^{-5} \text{ mg/L}} = 46{,}296$$

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DATE: 05/2022 FILE: 0023–404–11 CAD: FIG 3–1 FLOW CHART.dwg	DRAWN BY: BPY DESIGN BY: BPY REVIEWED BY: RJS	
Weaver Consultants Group TBPE REGISTRATION NO. F–3727	REVISIONS: NO. / DATE / DESCRIPTION	WWW.WCGRP.COM — FIGURE 3–1

4 LANDFILL CONFIGURATIONS ANALYZED AND PERCOLATION ESTIMATES

4.1 Section Locations and Model Development

The locations of the two typical sections (Sections A and B) were developed to represent the area between the overliner and the POC are shown on Figure 4-1. Each section is located on the downgradient portion of the overliner and the distance between the limits of waste and the POC varies between 70 feet and 90 feet. Section A was developed to evaluate the potential impact on the West Fork of the Trinity River. Sections B was developed to evaluate the impact on Hurricane Creek.

Figure 4-2 is presented to show how each section is developed. In the waste disposal area, Figure 4-2 shows each element of the containment system (e.g., overliner, Subtitle D final cover system and existing pre-Subtitle D final cover system). In addition, the site specific subsurface soils and hydrogeologic information reproduced from Appendix IIIM are shown in the section for the area between the landfill and the POC. The information shown is input into the MODFLOW model to estimate the fate and transport of leachate constituents in the unlikely event that there is a release from the landfill.

As shown on Figure 4-2, the model is divided into four zones to estimate percolation and groundwater recharge throughout the life of the overliner area and the postclosure period. Zones I and II are located within limits of the WDA. The estimated percolation rate during the life of the WDA is discussed in detail in Section 4-2. However, one conservative assumption similar with each case is the percolation through the overliner, Subtitle D Liner and the existing pre-Subtitle D final cover system was assumed to flow directly to groundwater. This assumption ignores travel time, absorption, and consumption of water that occurs within the solid waste fill area as well as the travel time through the pre-Subtitle D liner and in-situ subsurface soils.

As shown on Figure 4-2, groundwater recharge is modeled between the landfill and the POC. An estimate of recharge was developed using the HELP model. It is assumed that no recharge occurs in Zone III (i.e., perimeter berm), located between the groundwater recharge zone and Zone II.

4.2 Landfill Configurations Analyzed

The HELP model was used to estimate the rate of percolation through the overliner system to be installed in the pre-Subtitle D area, the Subtitle D liner area (Sector 8), the existing pre-Subtitle D final cover, the Subtitle D final cover, and the groundwater recharge between the limits of waste and the POC. The various HELP model simulations were analyzed in Table 4-1.

Table 4-1
HELP Model Configurations

Area	Case	Description
Overliner (Zone I)	Active, 280 ft waste	The design case models the impact of percolation through the overliner system under expected filling conditions for both active and closed conditions.
	Closed, 280 ft waste	
Subtitle D Area (Zone II-Section A)	Active, 310 ft waste	The Subtitle D area was modeled to simulate the percolation through the Subtitle D areas.
Pre-Subtitle D Final Cover (Zone II-Section B)	2 ft final cover	The pre-Subtitle D final cover was modeled to simulate the percolation through the pre-Subtitle D areas.
Off-Site Recharge (Zone IV)	30 ft alluvial soil	The off-site recharge area between the limits of waste and the point of compliance was modeled.

The active condition for the overliner was modeled for 33 years based on the expected active life of waste placement over the overliner, as discussed in Section 4.3. The closed case was modeled for 30 years to represent the postclosure period. The pre-Subtitle D final cover was modeled for 7 years based on the expected time before overliner is constructed over the existing pre-Subtitle D area as discussed in Section 4.3. The off-site recharge was modeled for 30 years.

4.2.1 HELP Model Summary

The results for the HELP cases listed in Table 4-1 are summarized below in Table 4-2. The output files and HELP summary table for the overliner, pre-subtitle D final cover and off-site recharge are included in Appendix IIIB-A. Additionally, results and output files for the Subtitle D areas are presented in Appendix IIIB-C.

Table 4-2
Summary of HELP Modeling

Area	Case	Leachate Generation Rate[1]	Percolation Rate
Overliner (Zone I)	Active, 280 ft waste	226,998 gallon/yr	0.00003 in/yr
	Closed, 280 ft waste	155,271 gallon/yr	0.00004 in/yr
Subtitle D Area (Zone II-Section A)[2]	Active 310 ft waste	36,571 gallon/yr	0.00001 in/yr
Existing Pre-Subtitle D Final Cover (Zone II-Section B)	2 ft final cover	N/A	2.00339 in/yr
Off-Site Recharge (Zone IV)	30 ft alluvial soil	N/A	0.27665 in/yr

1 Leachate generation rate (i.e., lateral drainage collected) and percolation rate values are reproduced from the HELP Version 3.07 output included in Appendix IIIB-A.
2 The leachate generation rate and percolation rates for the Subtitle D area are presented in Appendix IIIB-C. The maximum percolation rate for the compacted clay liner simulation was used for the point of compliance demonstration.

As shown in the results included in Table 4-2, there is a small amount of percolation predicted by the HELP model through the existing pre-Subtitle D final cover. Once the overliner system is installed above the pre-Subtitle D final cover, the additional barriers (i.e., FML and GCL) will further reduce the potential for percolation as leachate generated above the overliner will be collected. In addition, as discussed in Section 4.3, once the final cover is installed in this area, leachate generation will further diminish.

4.3 Sequence of Site Development

The key site development activities, including relocation of the groundwater monitoring network, are described in Appendix IIIH and also summarized on Figure 4-3.

Figure 4-4 shows how the percolation rate in each zone varies over the life of the WDA. As shown, the modeling begins on the year of waste filling operations in the WDA (i.e., 2021). As the site constructs the overliner system, the percolation rate into the existing waste disposal area below the overliner decreases significantly. As discussed in Appendix IIIC, the overliner system includes a leachate collection system that will remove leachate that is generated from the waste that is placed above the overliner system, virtually eliminating the potential for infiltration into the existing pre-Subtitle D area.

As shown on Figure 4-4, the overliner area is expected to receive waste between 2021 and 2054. During this time period the overliner area is considered to be in the "active condition." For the first 7 years (2021 through 2028), a small portion of pre-Subtitle D final cover area adjacent to the overliner development will remain in place (see Zone II of Section B on Figure 4-1). During this time period percolation rates from the pre-Subtitle D HELP model analysis will be used. After 2028, it is projected that overliner will be constructed over the pre-Subtitle D area and overliner percolation rates will be used. Final cover construction (i.e., landfill closure) is projected to be complete in 2054, and the site will be in the "closed condition" for the remainder of the site's postclosure period (i.e., 2054 through 2084).

Percolation and recharge rates obtained from the HELP model were input into MODFLOW as zones of percolation or recharge.

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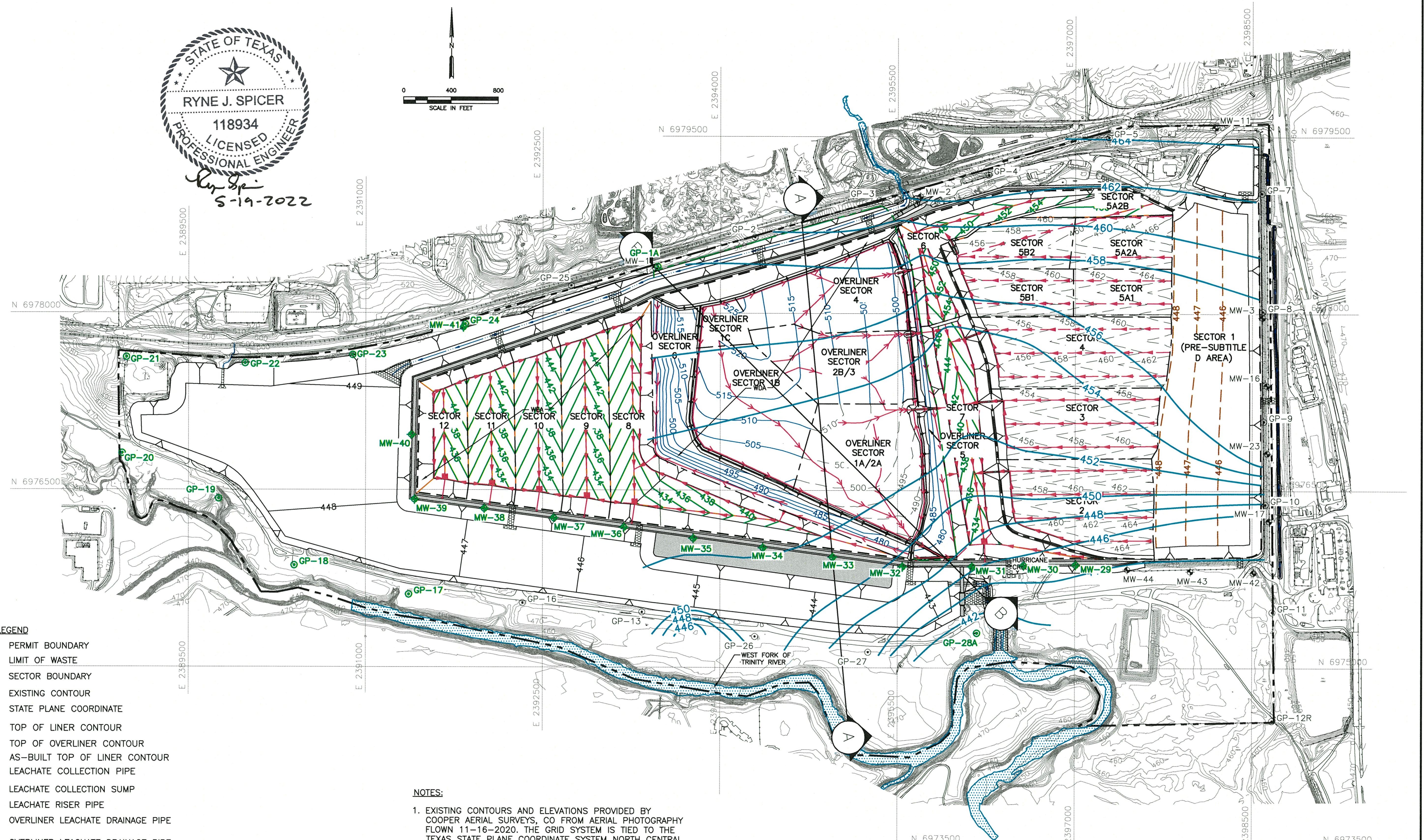

LEGEND

— · — · —	PERMIT BOUNDARY
— — — —	LIMIT OF WASTE
—— - ——	SECTOR BOUNDARY
——500——	EXISTING CONTOUR
N 6975000	STATE PLANE COORDINATE
——440——	TOP OF LINER CONTOUR
——506——	TOP OF OVERLINER CONTOUR
— —510— —	AS-BUILT TOP OF LINER CONTOUR
	LEACHATE COLLECTION PIPE
	LEACHATE COLLECTION SUMP
	LEACHATE RISER PIPE
	OVERLINER LEACHATE DRAINAGE PIPE
	OVERLINER LEACHATE DRAINAGE PIPE (MULTIPLE PIPES IN TRENCH)
MW-8	EXISTING GROUNDWATER MONITORING WELL
MW-40	PROPOSED GROUNDWATER MONITORING WELL
GP-2	EXISTING LANDFILL GAS MONITORING PROBE
GP-17	PROPOSED LANDFILL GAS MONITORING PROBE
——450——	POTENTIOMETRIC CONTOUR (FT-MSL) (SEE NOTE 2)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. GROUNDWATER ELEVATIONS MEASURED BY THE CAREL CORPORATION IN SEPTEMBER 2021 AND MEASUREMENTS SHOWN IN FT-MSL. GROUNDWATER CONTOURS OBTAINED FROM THE CAREL CORPORATION SEPTEMBER 2021 GROUNDWATER CONTOUR MAP.
3. GROUNDWATER MONITOR WELLS AND POINT OF COMPLIANCE REPRODUCED FROM THE PROPOSED GROUNDWATER MONITORING SYSTEM PLAN POST WASTE REMOVAL INCLUDED IN APPENDIX IIIH.

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FILE: 0023-404-11 DESIGN BY: JBM
CAD: FIG 4-1-SECTION LOCS.dwg REVIEWED BY: RJS

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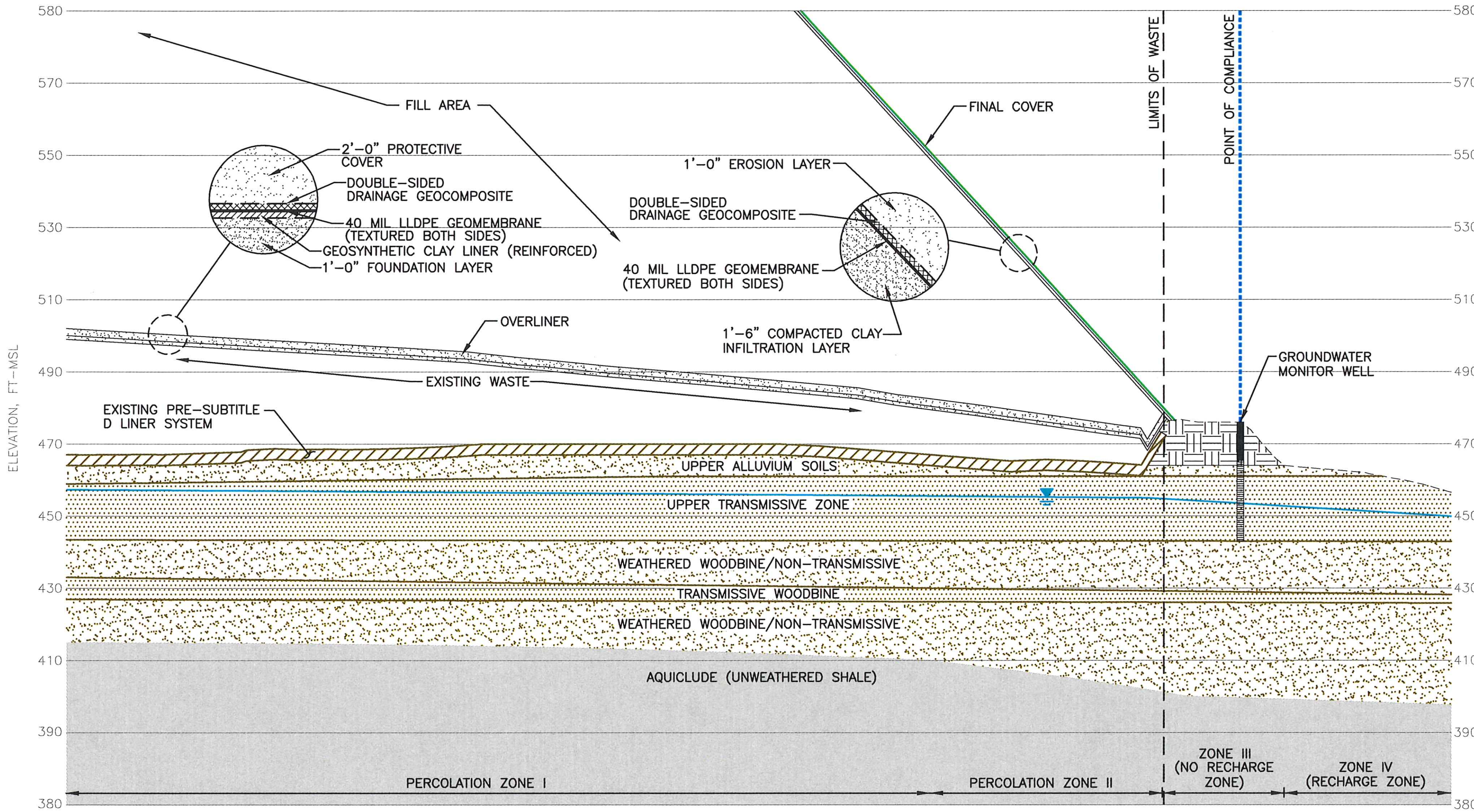
FIGURE 4-1

O:\0023\404\EXPANSION 2021\PART III\IIIB\4-1 SECTION LOCATIONS.dwg, jwilson, 1:2



SECTION B

0 10 20
VERTICAL SCALE IN FEET
0 100 200
HORIZONTAL SCALE IN FEET

LEGEND

- LIMITS OF WASTE
- GROUNDWATER TABLE
- EXISTING GRADE
- POINT OF COMPLIANCE

NOTES:

1. GEOLOGIC CROSS SECTION BASED ON GEOLOGIC CROSS SECTIONS A-A', C-C', F-F', AND G-G' INCLUDED IN APPENDIX IIIG.
2. REFER TO FIGURE 4-1 AND 6-1 FOR SECTION LOCATION.

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FIGURE 4-2

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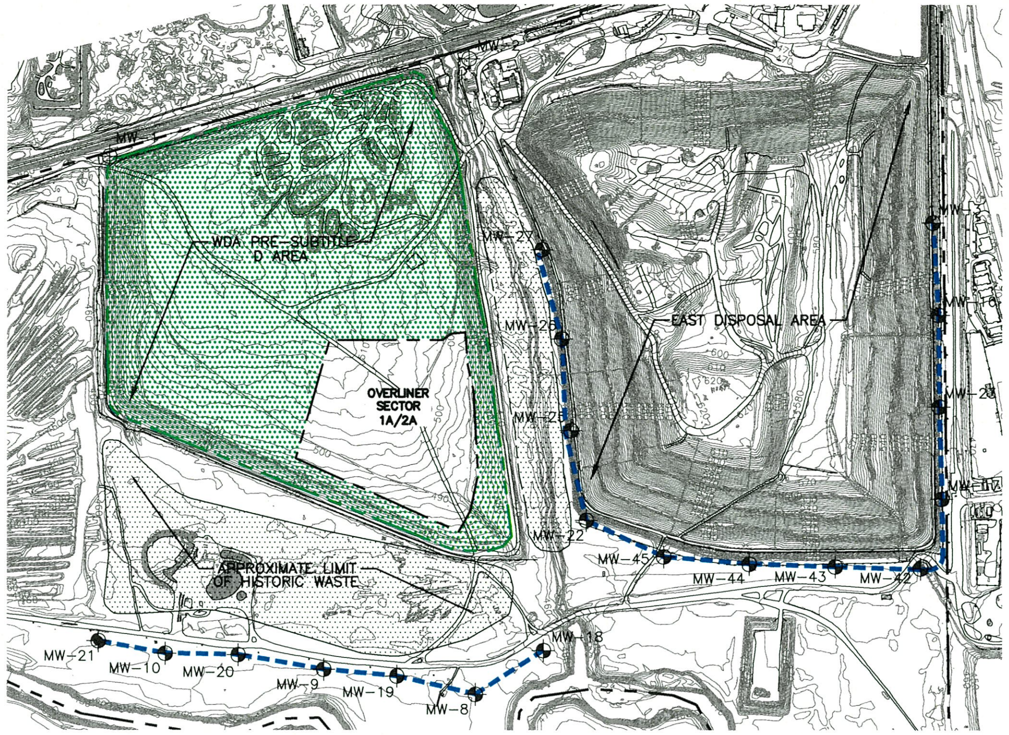
YEAR 2021



(I) FILLING OPERATION IN THE WDA BEGAN IN 2021 FOLLOWING THE CONSTRUCTION OF FIRST OVERLINER SECTORS 1A/2A.

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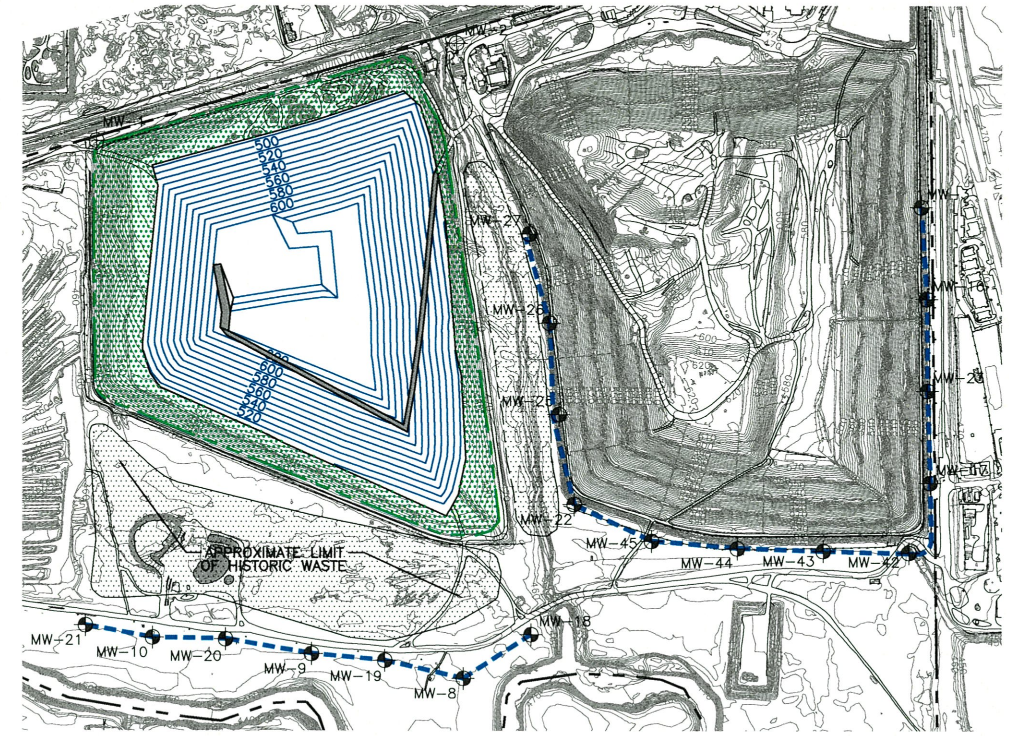
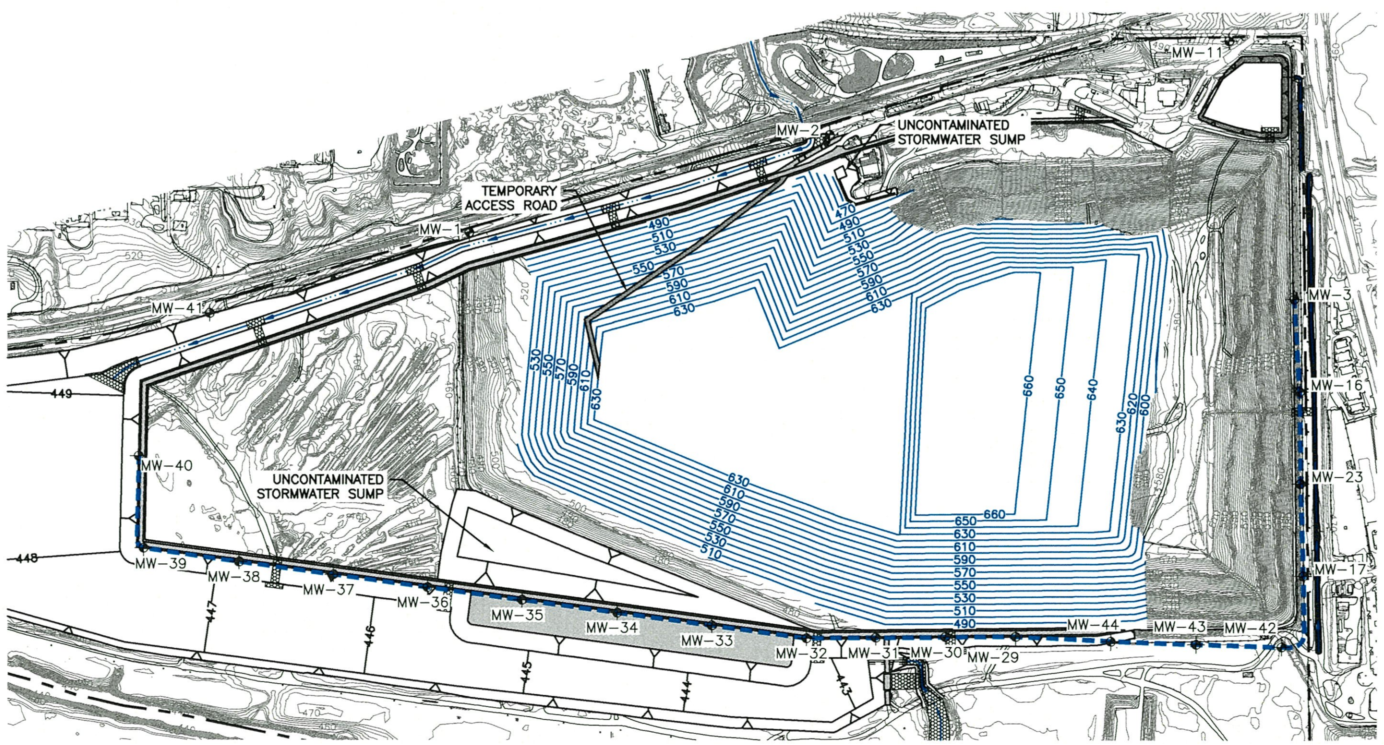
YEARS 2021-2028



(II) FILLING OPERATIONS WILL CONTINUE IN THE WDA FOR APPROXIMATELY 7 YEARS (2021 THROUGH 2028). DURING THE 7 YEAR PERIOD, OVERLINER SECTORS 3 THROUGH 5 WILL BE CONSTRUCTED, AND EXISTING PRE-SUBTITLE D FINAL COVER WILL REMAIN IN PLACE SURROUNDING THE OVERLINER AREA.

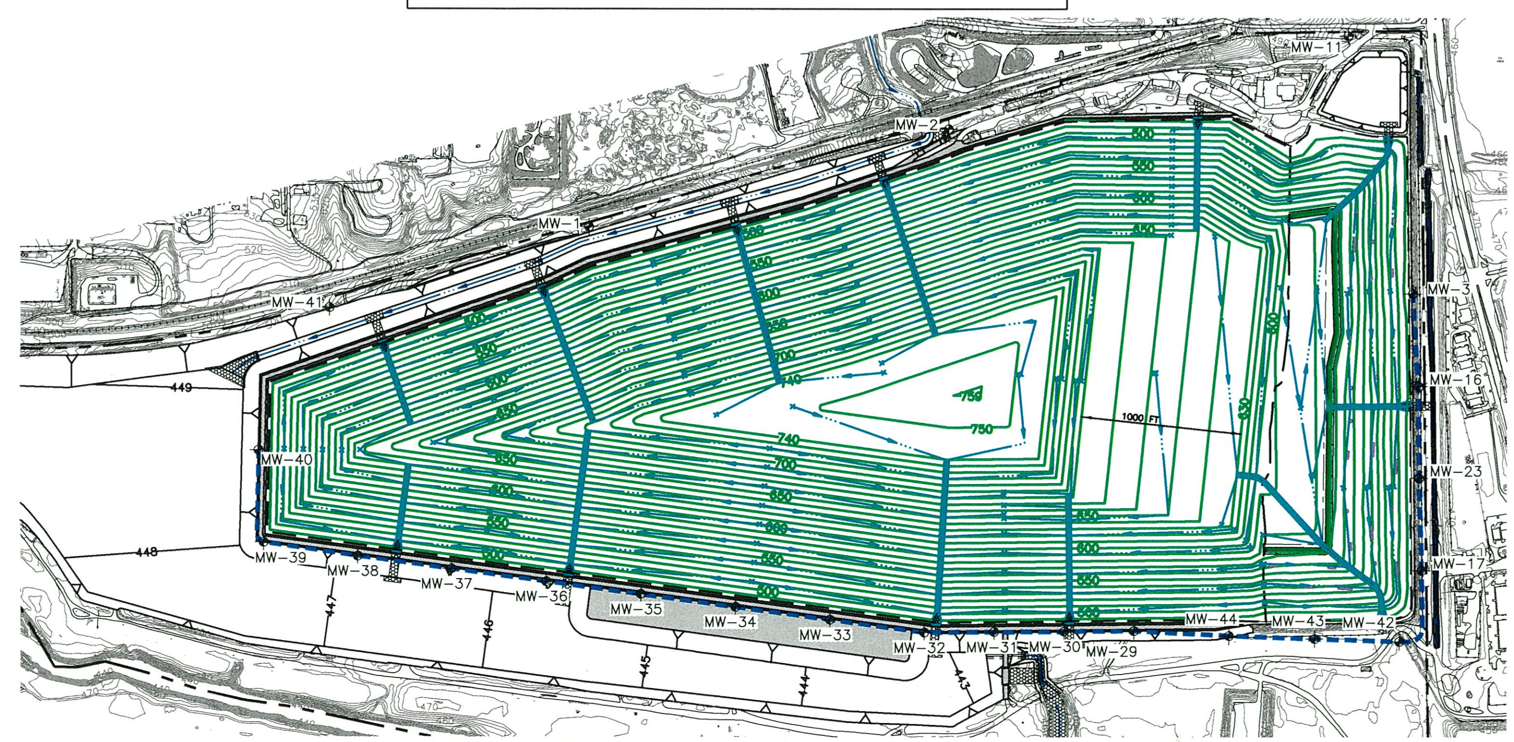
YEARS 2028-2035(ESTIMATED)



(III) THE RELOCATION OF THE HISTORIC WASTE WILL BE COMPLETED AS THE RELOCATION OF HURRICANE CREEK IS DEVELOPED. THE POST WASTE REMOVAL GROUNDWATER MONITORING SYSTEM WILL BE INSTALLED. REFER TO APPENDIX IIIH FOR A DETAILED DISCUSSION OF THE POC ESTABLISHMENT TIMELINE.

FOLLOWING THE RELOCATION OF HURRICANE CREEK, THE EDA AND WDA WILL BE COMBINED AND THE REMAINING LANDFILL FOOTPRINT WILL BE DEVELOPED UNTIL THE PROJECTED YEAR OF CLOSURE (2054).

YEARS 2054-2084



(IV) BETWEEN 2054 AND 2084 THE SITE WILL BE IN THE 30-YEAR POSTCLOSURE PERIOD.

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DATE: 05/2022 FILE: 0023-404-11 CAD: FIG 4.3-SEQUENCE.dwg	DRAWN BY: BPY DESIGN BY: BPY REVIEWED BY: RJS	REVISIONS NO. / DATE / DESCRIPTION	
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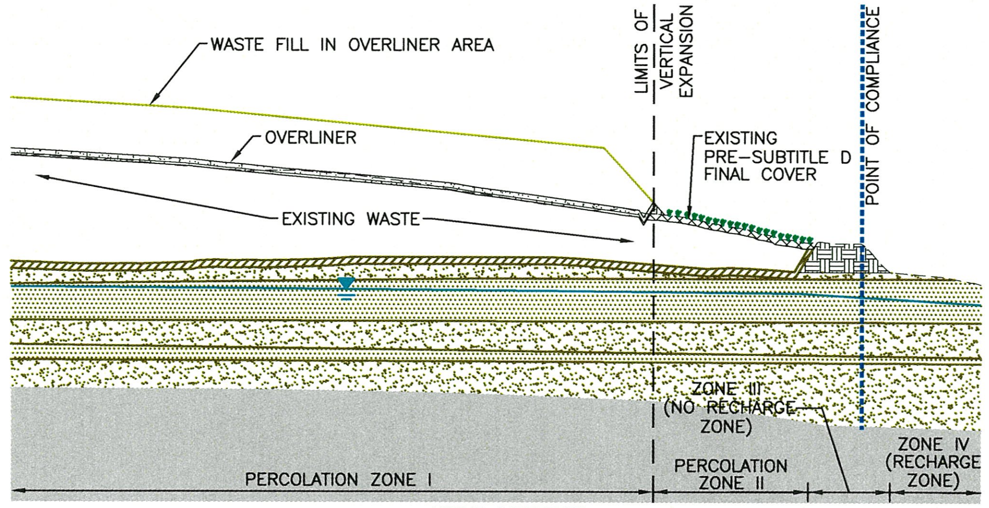
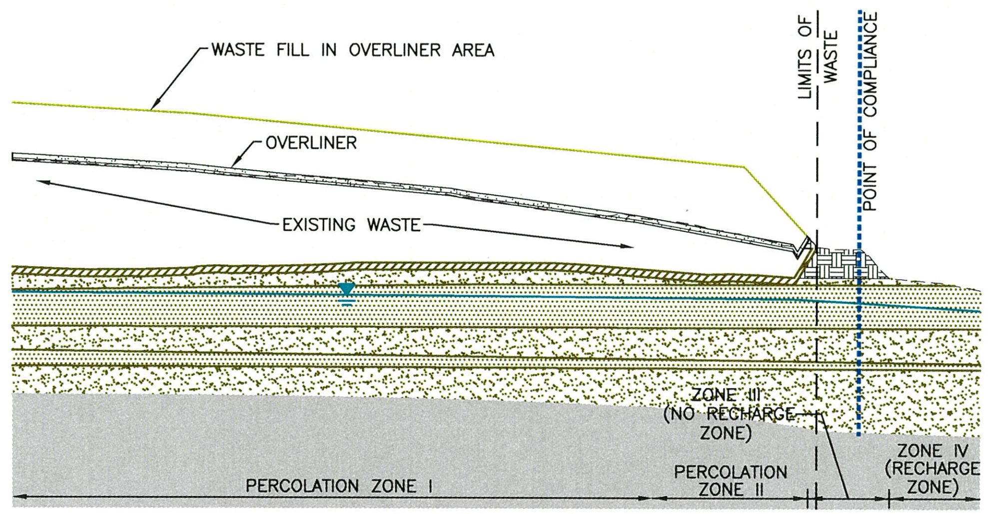
O:\0023\404\EXPANSION 2021\PART III\IIIH\4-3-SEQUENCE OF DEVELOPMENT.dwg, rspicer, 1:2



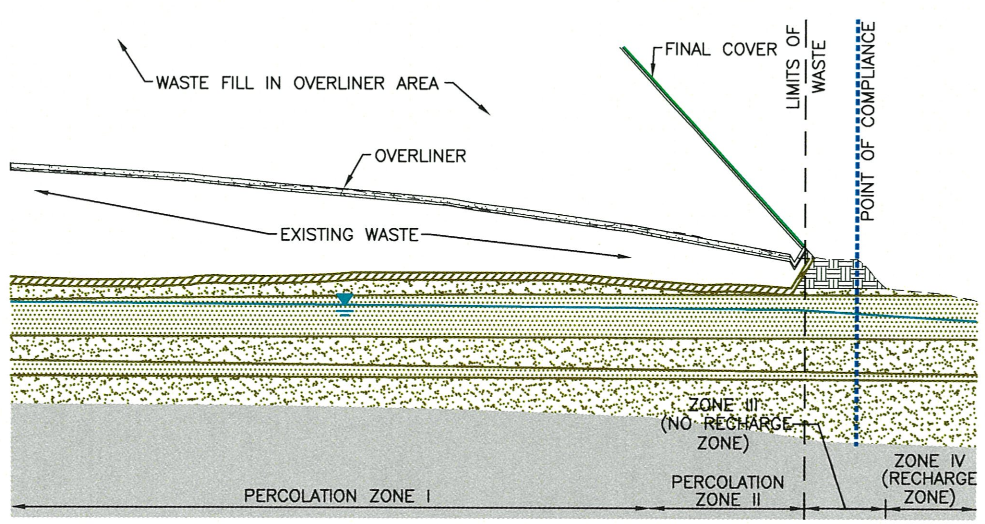
ACTIVE CONDITION

WASTE FILLING OPERATIONS IN THE WDA BEGIN IN 2021. BETWEEN 2021 AND 2028 THE SITE WILL PLACE WASTE IN THE WDA OVERLINER AREA WITH EXISTING PRE-SUBTITLE D FIANL COVER SURROUNDING THE OVERLINER AREA (SEE PHASE II ON FIGURE 3-3).



ACTIVE CONDITION

BETWEEN 2022 AND THE SITE CLOSURE IN 2054 THE SITE WILL CONTINUE TO PLACE WASTE IN THE WDA OVERLINER AREA.



CLOSED CONDITION

FINAL COVER CONSTRUCTION AND LANDFILL CLOSURE IS PROJECTED TO BE IN 2054. BETWEEN 2054 AND 2084 THE SITE WILL BE IN THE 30-YEAR POSTCLOSURE PERIOD.

YEAR 2021-2028 (ACTIVE CONDITION)		
ZONE #	DESCRIPTION	PERCOLATION (GCL OVERLINER OPTION)
PERCOLATION ZONE I	OVERLINER & FINAL COVER	0.001 MM/YR
PERCOLATION ZONE II	EXISTING PRE-SUBTITLE D FINAL COVER	50.9 MM/YR
ZONE III (NO RECHARGE ZONE)	PERIMETER BERM	0 MM/YR
ZONE IV (RECHARGE ZONE)	OUTSIDE LANDFILL	7.0 MM/YR

YEAR 2028-2054 (ACTIVE CONDITION)		
ZONE #	DESCRIPTION	PERCOLATION (GCL OVERLINER OPTION)
PERCOLATION ZONE I	OVERLINER & FINAL COVER	0.001 MM/YR
PERCOLATION ZONE II	OVERLINER & FINAL COVER	0.001 MM/YR
ZONE III (NO RECHARGE ZONE)	PERIMETER BERM	0 MM/YR
ZONE IV (RECHARGE ZONE)	OUTSIDE LANDFILL	7.0 MM/YR

YEAR 2054-2084 (CLOSED CONDITION)		
ZONE #	DESCRIPTION	PERCOLATION (GCL OVERLINER OPTION)
PERCOLATION ZONE I	OVERLINER & FINAL COVER	0.001 MM/YR
PERCOLATION ZONE II	OVERLINER & FINAL COVER	0.001 MM/YR
ZONE III (NO RECHARGE ZONE)	PERIMETER BERM	0 MM/YR
ZONE IV (RECHARGE ZONE)	OUTSIDE LANDFILL	7.0 MM/YR

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FIGURE 4-4

5 MODFLOW INPUT PARAMETERS

5.1 Subsurface Information

The input parameters for the subsurface soils between the landfill and the POC are summarized on Table 5-1 and Figure 5-1. This information is based on site-specific geology and hydrogeologic information discussed in Section 2.2. In general, the site hydrogeology can be characterized as having five (5) separate strata, which are as follows starting at the surface.

- Stratum A is a surficial clay or silt with occasional sands and sandy clays.
- Stratum B is a shallow, sometimes discontinuous sand, gravel, or clayey sand which is the uppermost water bearing stratum. This lower portion of the alluvium rests uncomformably on the underlying Woodbine.
- Stratum C includes weathered (less competent) portions of the underlying shale and weathered/unweathered siltstones of the Woodbine. These units within Stratum C are generally of low permeability, especially vertically.
- Stratum D includes the more permeable sand, interbedded sand and shale and sandstone units within the Woodbine. As noted in Appendix IIIG, these units appear to be discontinuous and in many areas lack hydraulic connectivity with other sands due to being surrounded by low permeability materials.
- Stratum E consists of competent shale underlying Stratum C and Stratum D, where it is present. This stratum represents the aquiclude underlying the site and is an effective, low permeability barrier to both horizontal and vertical groundwater flow.

The model grid and model limits for each section (i.e., Sections A and B) were defined in MODFLOW using columns and layers. Sections A and B utilize separate model grids that are oriented along the section lines shown on Figures 4-1 and 6-1. The 1-foot-thick model layers situated along the z axis represent elevations in feet mean sea level (ft-msl) that range from the groundwater surface in the Upper Alluvium Soils to the no-flow boundary. The model columns situated along the x-axis represent the distance from the upgradient side of the landfill to the West Fork of the Trinity River (Section A) or Hurricane Creek (Section B). The model grid along the x-axis was assigned a width of 8 feet. Therefore, the model is established using 1-foot-high and 8-foot-long cells. Total of 80 layers and 500 columns (total of 40,000 cells) are used. The MODFLOW model development information is provided on Figure 5-1. The MODFLOW model grid for each section is shown on Figures 6-2, 6-3, and 6-4 for the design case.

As discussed in Appendix IIIG, there are two shallow water-bearing strata at the site. The uppermost water-bearing stratum is generally found in the lower portion of the alluvial deposits consisting of coarse-grained materials with an increasing amount of gravel-sized particles (Stratum B); the second is the weathered and unweathered sandstone of the Woodbine Group (Stratum D). These two water-bearing stratums are locally interconnected and define the uppermost transmissive zone (refer to Appendix IIIG for more information).

The information listed on Figure 5-1 and Table 5-1 was used as input into MODFLOW to develop the three representative sections at the locations shown on Figures 4-1 and 6-1 in Section 4 and Section 6, respectfully (note that the two sections are also shown on Figures 6-2 through 6-4 in Section 6). As noted on Figure 5-1, a no-flow boundary was established at the bottom of Stratum C. Establishing the no-flow boundary at the bottom of Stratum C identifies the downward transport of constituents. This restriction to the vertical flow of groundwater provides a conservative simulation by reducing the amount of groundwater that can be stored in the aquifer. In addition, this assumption also allows for less dilution in the aquifer by limiting the flow area.

5.2 Leachate Quality Information

The demonstration was conducted by showing that the overliner design will not allow the concentrations of the 24 EPA constituents shown in Table 5-2 (the same constituents listed in Table 1 of Title 30 TAC §330.331(a)(1)) to be exceeded at the relevant point of compliance. This is done by modeling a Dilution Attenuation Factor (DAF), defined as the initial input leachate concentration, C_O, divided by the concentration at the POC, C_P:

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

Table 5-2 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 City of Arlington Landfill, and (2) the leachate quality input data historically used for POC demonstrations in Texas. As noted in Table 5-2, the DAFs range from 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, 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 $\left(DAF = \frac{\frac{1.3mg}{l}}{\frac{0.005mg}{l}} = 260 \right)$. 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 not less than 260 will be used as the acceptable minimum DAF value, 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). In addition, the other site specific leachate constituents listed in Table 5-2 have concentrations that are much less than the concentrations used historically for POC demonstrations. As listed on Table 5-2, the site specific leachate concentration information obtained from the leachate sumps in the active area of the EDA between December 2018 and December 2021 (refer to footnote 1 on Table 5-2).

For the existing pre-Subtitle D final cover area (i.e., Percolation Zone II shown on Figure 5-1), this area was also considered a potential source of leachate percolation into groundwater. For this percolation zone, it was assumed that stormwater that percolates through the existing pre-Subtitle D final cover flows directly to groundwater (as stated previously, this is a conservative assumption given that the travel time and adsorption through the existing WDA disposal area is not accounted for). The percolation in this zone is assigned a conservative constituent concentration value of 0.028 mg/L. This value is representative of leachate quality from the existing EDA and is calculated by the following equation.

$$\begin{aligned} &Site\ Specific\ Zone\ II\ Leachate\ Quality\ Input \\ &\qquad = 1.0\ \text{mg/L}\left(\frac{Site\ Specific\ Leachate\ Quality}{Historically\ Used\ Leachate\ Quality}\right) \end{aligned}$$

As shown on Table 5-2, Chromium (Hexavalent) was the highest constituent in most recent leachate quality data obtained from the EDA that exceeded the MCL listed in §330.331(a)(1). Therefore, applying the equation above for Chromium, the MODFLOW input for site specific leachate quality was calculated to be 0.028.

$$Site\ Specific\ Zone\ II\ Leachate\ Quality\ Input = 1.0mg/L\left(\frac{0.14mg/L}{5.0mg/L}\right) = 0.028\ mg/L$$

This leachate concentration was selected for Zone II, as it represents a conservative leachate concentration for the situation where percolation through the existing pre-Subtitle D final cover system only contacts waste that has been in-place between 30 and over 50 years.

Table 5-1
Hydraulic Properties of Subsurface Soils and Landfill Components

Stratum/Landfill Component	Maximum		Average		Number of Hydraulic Conductivity Tests[7]	Specific Storage (1/ft)[2]	Specific Yield (S_y)[3]	Effective Porosity (η_e)[4]	Total Porosity (η_T)[4]
	Horizontal Hydraulic Conductivity (cm/s)[1]	Vertical Hydraulic Conductivity (cm/s)[1]	Horizontal Hydraulic Conductivity (cm/s)[1,5]	Vertical Hydraulic Conductivity (cm/s)[1,5]					
A Upper Alluvium Soils	6.3E-08	5.7E-07[6]	A. 1.8E-08 G. 1.0E-08	-	H. 7 V. 1	2.1E-04	0.02	0.06	0.42
B Upper Transmissive Zone	5.23E-2		A. 1.4×10^{-2} G. 5.62×10^{-3}		8 Slug Tests[8]	2.1E-04	0.26	0.30	0.39
C Weathered Woodbine/ Non-Transmissive	3.2E-07	1.7E-07	A. 8.8E-08 G. 1.8E-08	A. 4.8E-08 G. 2.3E-08	H. 4 V. 5	1.0E-06	0.01	0.136	0.272
D Transmissive Woodbine	6.2E-04	4.7E-04	A. 2.6E-04 G. 3.8E-06	A. 9.5E-05 G. 1.0E-07	H. 4 V. 5	2.1E-04	0.27	0.27	0.34
E Aquiclude (Unweathered Shale)	1.5E-06	3.5E-07	A. 5.0E-07 G. 1.7E-08	A. 1.0E-07 G. 4.3E-08	H. 3 V. 5	-	-	-	-

1 Maximum and average hydraulic conductivity values for subsurface soils obtained from Appendix IIIG – Geology Report.
2 Specific storage value for Stratum C was estimated using the procedure from Domenico (1972). Specific storage values for Strata A, B, and D were obtained from Northern Trinity/Woodbine Aquifer Groundwater Availability Model report prepared for the Texas Water Development Board.
3 Specific yield values for subsurface soils obtained from Johnson, A.I. (1967).
4 Effective porosity and total porosity values for subsurface soils obtained from McWorter and Sunada (1977).
5 Both the arithmetic (A.) and geometric (G.) means of the vertical and horizontal permeability are reported for the average.
6 As reported in Appendix IIIG – Geology Report, one test result is available for this stratum.
7 Number of horizontal and vertical hydraulic conductivity tests were obtained from Appendix IIIG – Geology Report. H = Horizontal and V = Vertical.
8 As discussed in Appendix IIIG – Geology Report, the slug tests include both falling head and rising head slug tests.

Table 5-2
Chemical Constituent Concentrations in Leachate

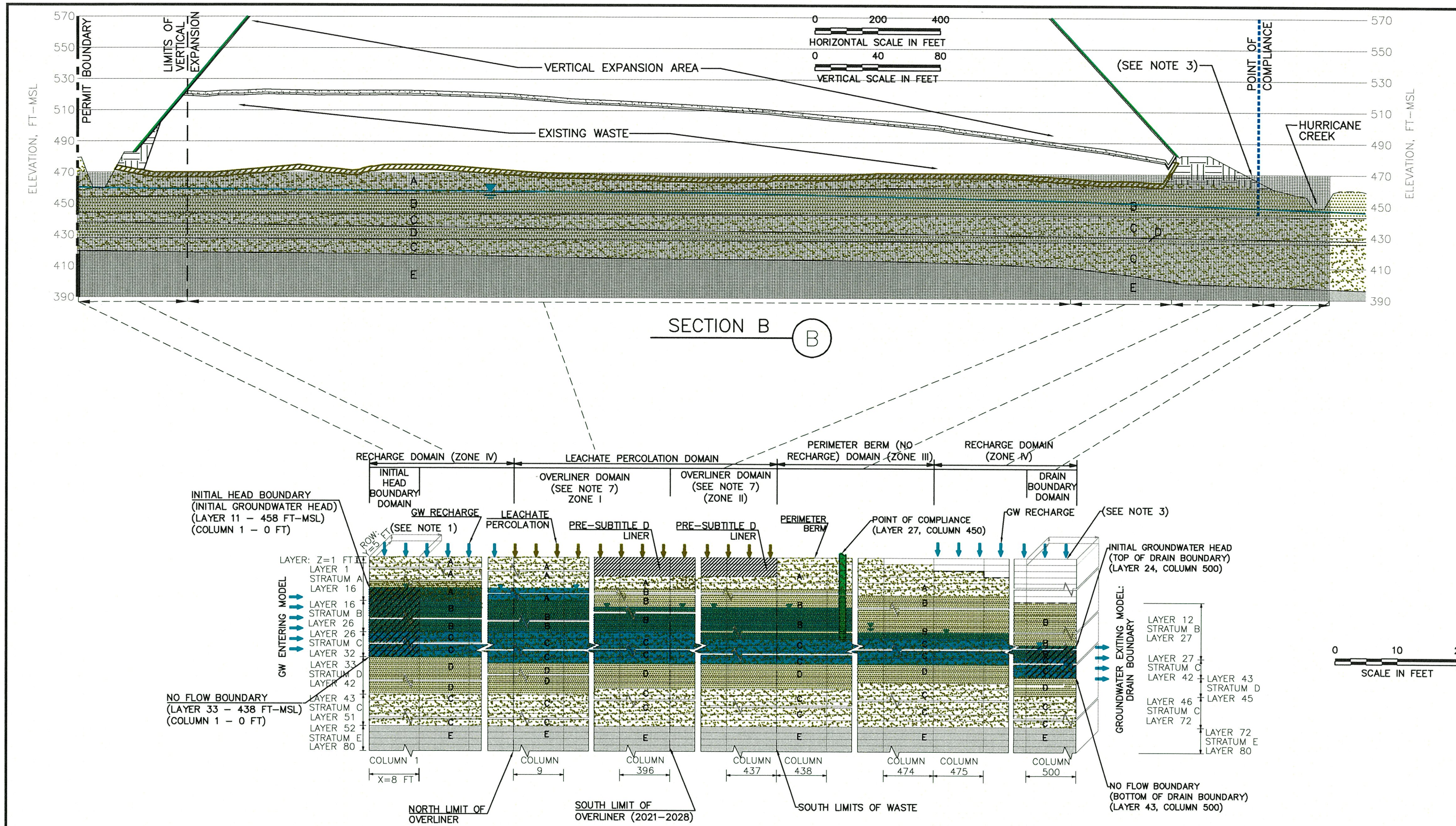
Constituent	MCL (mg/L) Listed in §330.331(a)(1)	Site Specific[1,2] Leachate Quality (mg/L)	Leachate Quality Information Historically Used for POC Demonstrations in Texas (mg/L)	DAF Range (from Site Specific Data to Historically Used Data)[4]	Minimum Required DAF in Guidance[3]
Arsenic	0.05	0.148	5.0	1 to 100	100
Barium	1.0	0.5	100.0	100	100
Benzene	0.005	0.0025	0.814	1 to 163	163
Cadmium	0.01	0.003	1.0	1 to 100	100
Carbon tetrachloride	0.005	0.0025	0.5	1 to 100	100
Chromium (hexavalent)	0.05	0.14	5.0	1 to 100	100
2,4-Dichlorophenoxy acetic acid	0.1	0.05	10.0	100	100
1,4-Dichlorobenzene	0.075	0.007	7.5	1 to 100	100
1,2-Dichloroethane	0.005	0.0025	0.5	1 to 100	100
1-1-Dichloroethylene	0.007	0.0035	0.7	1 to 100	100
Endrin	0.0002	0.0001	0.05	250	250
Fluoride	4	2			
Lindane	0.004	0.002	0.4	100	100
Lead	0.05	0.014	5.0	1 to 100	100
Mercury	0.002	0.001	0.2	1 to 100	100
Methoxychlor	0.1	0.05			
Nitrate	10	5			
Selenium	0.01	0.016	1.0	1.3 to 100	100
Silver	0.05	0.025	5.0	1 to 100	100
Toxaphene	0.005	0.0025	0.5	100	100
1,1,1-Trichloroethane	0.2	0.1			
Trichloroethylene	0.005	0.0025	1.3	1 to 260	260
2,4,5-Trichlorophenoxy acetic acid	0.01	0.005	1.0	100	100
Vinyl Chloride	0.002	0.001	0.2	1 to 100	100

1 Leachate concentrations listed represent maximum concentrations from semi-annual leachate samples collected between 2018 and 2021 from leachate sumps located in the active area of the EDA. (No leachate data is available from WDA).

2 For constituents not detected at reporting limits, one-half of the reporting limit is listed.

3 Minimum DAF required for each constituent based on the input concentrations recommended in the 1993 Texas Water Commission Alternate Liner Design Handbook referenced in Section 5.2 (Leachate Quality Information) of Appendix IIIB.

4 This column illustrates the range of DAFs needed for each constituent using both site specific data and information from historically used sources. A DAF of 1 is reflective of the fact that the site specific leachate constituent concentration is less than the maximum allowable constituent concentration.



SUBSURFACE SOILS INFORMATION
(SEE NOTE 5)

A – UPPER ALLUVIUM SOILS
(HORIZ. $K_{MAX}=6.3\times10^{-8}$ cm/s)
(VERT. $K_{MAX}=5.7\times10^{-7}$ cm/s)

B – UPPER TRANSMISSIVE ZONE
(HORIZ. $K_{MAX}=5.23\times10^{-2}$ cm/s)
(VERT. $K_{MAX}=5.23\times10^{-2}$ cm/s)

C – WEATHERED WOODBINE/ NON-TRANSMISSIVE
(HORIZ. $K_{MAX}=3.2\times10^{-7}$ cm/s)
(VERT. $K_{MAX}=1.7\times10^{-7}$ cm/s)

D – TRANSMISSIVE WOODBINE
(HORIZ. $K_{MAX}=6.2\times10^{-4}$ cm/s)
(VERT. $K_{MAX}=4.7\times10^{-4}$ cm/s)

E – AQUICLUDE (UNWEATHERED SHALE)
(HORIZ. $K_{MAX}=1.5\times10^{-6}$ cm/s)
(VERT. $K_{MAX}=3.5\times10^{-7}$ cm/s)

LEGEND
- PERMIT BOUNDARY
- LIMITS OF WASTE
- GROUNDWATER SURFACE (SEE NOTE 5)
- EXISTING GRADE
- POINT OF COMPLIANCE
- MODFLOW MODEL GRID
- ① MODFLOW MODEL DEVELOPMENT STEP

NOTES:
1. THE FIRST CELL IS SHOWN THREE DIMENSIONAL TO PROVIDE INFORMATION FOR ROW, COLUMN LAYER. REFER TO MODFLOW DEVELOPMENT STEP 1 FOR CELL DISCUSSION. LAYER 1 MAY NOT BE SHOWN ON ALL COLUMNS EXCEPT COLUMN 1 FOR CLARITY.
2. DUE TO THE SCALE OF THE ACTUAL SECTION (UPPER FIGURE), LOWER FIGURE IS DEVELOPED FOR COLUMNS WITH SIGNIFICANT COMPONENTS INCLUDING SLURRY WALL AND MODEL BOUNDARIES.
3. MODFLOW MODEL GRID IS SHOWN FOR THE SECTION (UPPER FIGURE) AND DETAILED GRID IS SHOWN FOR VARIOUS COMPONENTS (E.G., POC, SLURRY WALL) IN THE LOWER FIGURE WITH REFERENCE LINES TO ACTUAL SECTION ABOVE.
4. GROUNDWATER CONTOURS ARE SHOWN AFTER THE END OF MODEL SIMULATION FOR SECTION B DESIGN CASE.
5. GROUNDWATER SURFACE SHOWS THE AFTER MODEL SIMULATION ELEVATIONS THROUGH THE SECTION AND IS REPRODUCED FROM FIGURE 6-3.
6. ZONE I THROUGH ZONE IV CORRESPOND TO ZONES SHOWN ON EACH MODFLOW OUTPUT FIGURE INCLUDED IN SECTIONS 6 AND 7.
7. REFER TO FIGURE 3-3 FOR SEQUENCE DEVELOPMENT OF THE PRE-SUBTITLE D AREA.

MODFLOW MODEL DEVELOPMENT STEPS

① THE TWO-DIMENSIONAL MODFLOW MODEL MESH WAS DEVELOPED USING 8-FT-WIDE COLUMNS ALONG THE X-AXIS AND 1-FT-THICK LAYERS ALONG THE Z-AXIS. FOR EXAMPLE, SECTION A CONSISTED OF 500 8-FT WIDE COLUMNS, 80 1-FT THICK LAYERS, AND SINGLE ROW (Y=5 FT WIDE–PERPENDICULAR TO PAPER) FOR A TOTAL OF 40,000 CELLS. LAYER 1 IS AT THE TOP AND LAYER 80 IS AT THE BOTTOM. COLUMN 1 IS AT THE LEFT END (NORTH) AND COLUMN 500 AT THE RIGHT END (SOUTH) END OF EACH SECTION.

② ONCE THE MODEL MESH WAS ESTABLISHED, BASED ON LOCATION, EACH CELL WAS ASSIGNED TO A HYDRAULIC CONDUCTIVITY (VERTICAL AND HORIZONTAL) AND STORAGE VALUE INPUT GROUP SO THAT CELLS ARE GROUPED TO REPRESENT A SOIL STRATUM (i.e., PROPERTY ZONES). PROPERTY ZONE INPUT INCLUDE HORIZONTAL AND VERTICAL HYDRAULIC CONDUCTIVITY INPUT, STORAGE INPUT THAT INCLUDES SPECIFIC STORAGE, SPECIFIC YIELD, EFFECTIVE POROSITY, AND TOTAL POROSITY (REFER TO TABLE 5-1 FOR STRATA A THROUGH E).

③ AFTER GROUPING CELLS INTO STRATA, THE MODEL NO-FLOW BOUNDARY WAS ESTABLISHED AT THE BOTTOM OF STRATUM C (REFER TO SECTION 5.1 FOR MORE INFORMATION). THE UPGRADIENT BOUNDARY IS ESTABLISHED AT THE NORTH (COLUMN 1 ON LEFT SIDE) OF THE MODEL, AND DRAIN BOUNDARY IS ESTABLISHED ON THE SOUTH SIDE (COLUMN 500' ON THE RIGHT SIDE) AS SHOWN ON THE FIGURE.

④ TO MODEL SATURATED FLOW, THE POTENTIOMETRIC SURFACE WAS INPUT ALONG THE SECTION LINE TO REPRESENT THE INITIAL GROUNDWATER LEVELS AT THE SITE. REFER TO SECTION 3.2.2 FOR HOW MODFLOW UPDATES THE GROUNDWATER FOR EACH TIME STEP.

⑤ MODFLOW ALLOWS THE USER TO MODEL GROUNDWATER RECHARGE OR LEACHATE PERCOLATION BY DEFINING THE CELLS IN THE UPPERMOST GRID LAYER ALONG THE SECTION LINE. AS A RESULT, THE GROUNDWATER RECHARGE OR LEACHATE PERCOLATION IS APPLIED DIRECTLY TO THE GROUNDWATER SURFACE BYPASSING UNSATURATED ZONES. IN THE MODEL, THE UPPERMOST GRID LAYERS WERE ASSIGNED RECHARGE RATES (MM/YR) OR LEACHATE PERCOLATION RATES (MM/YR) AT SPECIFIC LOCATIONS DEPENDING ON ZONES DEFINED BY THE USER AS SHOWN IN THE MODEL RESULTS IN SECTIONS 6 AND 7.

⑥ AFTER GROUNDWATER RECHARGE OR LEACHATE PERCOLATION RATES WERE DEFINED BY THE USER IN STEP 5, INITIAL CONCENTRATIONS WERE ASSIGNED TO PERCOLATION, RECHARGE, AND GROUNDWATER. IN MODFLOW, THE DEFAULT CONCENTRATION IS 0 mg/L; THEREFORE, ONLY THE LEACHATE CONCENTRATION WAS DEFINED FOR ZONES WITHIN THE WDA.

⑦ THE MONITORING WELL LOCATION THAT REPRESENTS THE POINT OF COMPLIANCE WAS INPUT IN MODFLOW USING X, Z, AND Y (HALF OF THE 5-FT THICKNESS) COORDINATES; HOWEVER, IT REPRESENTS 5-FOOT-WIDE VERTICAL PLANE AT THIS LOCATION. THE MODFLOW RESULTS FOR THIS LOCATION IS APPLICABLE TO THE ENTIRE WIDTH (i.e., 5 FT) AS THE MODEL IS RUN TWO-DIMENSIONAL. THE MODFLOW MODEL CONCENTRATION OUTPUTS ARE PROVIDED AT THIS LOCATION AT THE END OF THE MODEL SIMULATIONS (REFER TO SECTIONS 6 AND 7).

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED PROFESSIONAL ENGINEER
5-19-2022

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☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: FIG 5-1 MODFLOW.dwg

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
MODFLOW MODEL DEVELOPMENT

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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FIGURE 5-1

6 POINT OF COMPLIANCE DEMONSTRATION

The results of the POC demonstration are summarized in Table 6-1 and graphically illustrated on Figures 6-2 through 6-4. The results demonstrate that the proposed waste containment system design, including the pre-Subtitle D liner, overliner system, Subtitle D final cover system, and existing pre-Subtitle D final cover 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 6-1
Summary of MODFLOW Design Case Simulation Results

Model Section	Design Case Calculated DAF	Minimum Required DAF	Design Compliant with §330.331(a)(1)
Section A	894,534	260	Yes
Section B	46,296	260	Yes

The overliner and final cover systems virtually eliminate leachate percolation into the WDA pre-Subtitle D areas. As shown on Figures 5-2 through 5-4, during the active life and postclosure period the maximum percolation rate through the overliner is much less than 1 mm/year.

Since virtually all of the leachate that is generated from the area above the WDA overliner system is collected and pumped to on-site tanks, recirculated, or disposed at a permitted off-site treatment facility, the moisture content of solid waste located in the pre-Subtitle D area below the overliner should continue to decrease after the overliner is constructed.

Tables 6-2 and 6-3 have been developed to further illustrate how the DAF is used to determine the constituent level at the POC. The DAF value used corresponds to Case II. As summarized on Tables 6-2 and 6-3, the concentration at the POC (combined total of background concentration and constituent concentration at the POC) is less than the MCL listed in §330.331(a)(1).

As shown in Tables 6-1 through 6-3, the waste containment system produces DAFs that are well above the required minimum value.

Table 6-2
Summary of Constituent Levels at the POC
(Using Site Specific Leachate Data)

Constituent	C_{BG}, Background Concentration[1] (mg/l)	C_O[2]	/ DAF[3] (mg/l)	=	C_P (mg/l) (Constituent Concentration at the POC due to Estimated Leachate Percolation)	$C_{BG} + C_P = C_T$ at POC (mg/l)	MCL (mg/l) Listed in §330.331(a) (1)	C_T at POC < MCL
Arsenic	0.013	0.148	/ 46,296	=	3.20E-06	0.013	0.05	Yes
Barium	0.082	0.5	/ 46,296	=	1.08E-05	0.08201	1	Yes
Benzene	0.0005	0.0025	/ 46,296	=	5.40E-08	0.0005	0.005	Yes
Cadmium	0.001	0.003	/ 46,296	=	6.48E-08	0.001	0.01	Yes
Carbon tetrachloride	0.0025	0.0025	/ 46,296	=	5.40E-08	0.0025	0.005	Yes
Chromium (hexavalent)	0.01	0.14	/ 46,296	=	3.02E-06	0.01	0.05	Yes
2,4-Dichlorophenoxy acetic acid	--	0.05	/ 46,296	=	1.08E-06	--	0.1	Yes
1,4-Dichlorobenzene	0.001	0.007	/ 46,296	=	1.51E-07	0.001	0.075	Yes
1,2-Dichloroethane	0.0005	0.0025	/ 46,296	=	5.40E-08	0.0005	0.005	Yes
1,1-Dichloroethylene	0.0005	0.0035	/ 46,296	=	7.56E-08	0.0005	0.007	Yes
Endrin	--	0.0001	/ 46,296	=	2.16E-09	--	0.0002	Yes
Fluoride	--	2	/ 46,296	=	4.32E-05	--	4	Yes
Lindane	--	0.002	/ 46,296	=	4.32E-08	--	0.004	Yes
Lead	0.0075	0.014	/ 46,296	=	3.02E-07	0.0075	0.05	Yes
Mercury	--	0.001	/ 46,296	=	2.16E-08	--	0.002	Yes
Methoxychlor	--	0.05	/ 46,296	=	1.08E-06	--	0.1	Yes
Nitrate	--	5	/ 46,296	=	1.08E-04	--	10	Yes
Selenium	0.005	0.016	/ 46,296	=	3.46E-07	0.005	0.01	Yes
Silver	0.005	0.025	/ 46,296	=	5.40E-07	0.005	0.05	Yes
Toxaphene	--	0.0025	/ 46,296	=	5.40E-08	--	0.005	Yes
1,1,1-Trichloroethane	0.0005	0.1	/ 46,296	=	2.16E-06	0.0005	0.2	Yes
Trichloroethylene	0.0025	0.0025	/ 46,296	=	5.40E-08	0.0025	0.005	Yes
2,4,5-Trichlorophenoxy acetic acid	--	0.005	/ 46,296	=	1.08E-07	--	0.01	Yes
Vinyl Chloride	0.001	0.002	/ 46,296	=	0.001	0.001	0.002	Yes

1 Background concentrations have been obtained from Table 1-1.
2 Leachate concentrations (C_O, Site Specific Concentrations) represent levels obtained from the leachate sample analysis results provided in Table 2-2.
3 DAF value for Case II presented on Figure 3-7.

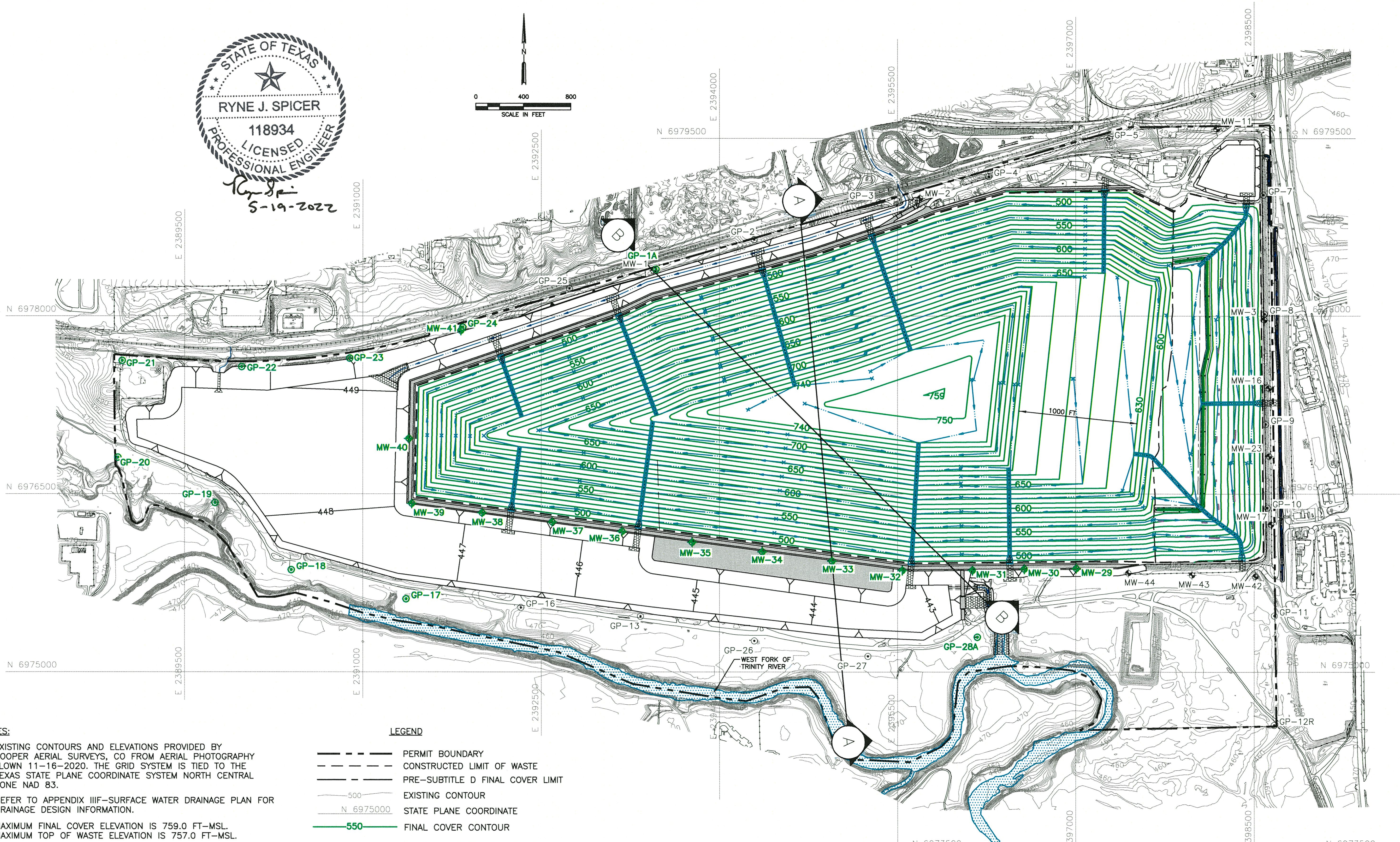
Table 6-3
Summary of Constituent Levels at the POC
(Using Historical Guidance Information)

Constituent	C_{BG}, Background Concentration[1] (mg/l)	C_P (mg/l) (Constituent Concentration at the POC)	=	C_O[2]	/ DAF[3] (mg/l)	$C_{BG} + C_P = C_T$[2] at POC (mg/l)	MCL (mg/l) Listed in §330.331(a)(1)	C_T at POC < MCL
Arsenic	0.013	3.20E-06	=	0.148	/ 46,296	0.013	0.05	Yes
Barium	0.082	1.08E-05	=	0.5	/ 46,296	0.08201	1	Yes
Benzene	0.0005	5.40E-08	=	0.0025	/ 46,296	0.0005	0.005	Yes
Cadmium	0.001	6.48E-08	=	0.003	/ 46,296	0.001	0.01	Yes
Carbon tetrachloride	0.0025	5.40E-08	=	0.0025	/ 46,296	0.0025	0.005	Yes
Chromium (hexavalent)	0.01	3.02E-06	=	0.14	/ 46,296	0.01	0.05	Yes
2,4-Dichlorophenoxy acetic acid	--	1.08E-06	=	0.05	/ 46,296	--	0.1	Yes
1,4-Dichlorobenzene	0.001	1.51E-07	=	0.007	/ 46,296	0.001	0.075	Yes
1,2-Dichloroethane	0.0005	5.40E-08	=	0.0025	/ 46,296	0.0005	0.005	Yes
1-1-Dichloroethylene	0.0005	7.56E-08	=	0.0035	/ 46,296	0.0005	0.007	Yes
Endrin	--	2.16E-09	=	0.0001	/ 46,296	--	0.0002	Yes
Fluoride	--	4.32E-05	=	2	/ 46,296	--	4	Yes
Lindane	--	4.32E-08	=	0.002	/ 46,296	--	0.004	Yes
Lead	0.0075	3.02E-07	=	0.014	/ 46,296	0.0075	0.05	Yes
Mercury	--	2.16E-08	=	0.001	/ 46,296	--	0.002	Yes
Methoxychlor[4]	--	1.08E-06	=	0.05	/ 46,296	--	0.1	Yes
Nitrate[4]	--	1.08E-04	=	5	/ 46,296	--	10	Yes
Selenium	0.005	3.46E-07	=	0.016	/ 46,296	0.005	0.01	Yes
Silver	0.005	5.40E-07	=	0.025	/ 46,296	0.005	0.05	Yes
Toxaphene	--	5.40E-08	=	0.0025	/ 46,296	--	0.005	Yes
1,1,1-Trichloroethane[4]	0.0005	2.16E-06	=	0.1	/ 46,296	0.0005	0.2	Yes
Trichloroethylene	0.0025	5.40E-08	=	0.0025	/ 46,296	0.0025	0.005	Yes
2,4,5-Trichlorophenoxy acetic acid	--	1.08E-07	=	0.005	/ 46,296	--	0.01	Yes
Vinyl Chloride	0.001	2.16E-08	=	0.001	/ 46,296	0.001	0.002	Yes

1 Background concentrations have been obtained from Table 1-1.

2 C_P represents chemical concentrations estimated by the fate and transport model or the POC. Initial concentrations, C_O, has been reproduced from historical standard information utilized by TCEQ as discussed in Section 1.3. Total concentration for each constituent at the POC is the sum of C_P and the background concentration, C_{BG}.

3 DAF value for Case II presented on Figure 3-7.



NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. REFER TO APPENDIX IIIF-SURFACE WATER DRAINAGE PLAN FOR DRAINAGE DESIGN INFORMATION.
3. MAXIMUM FINAL COVER ELEVATION IS 759.0 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 757.0 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.

LEGEND

	PERMIT BOUNDARY
	CONSTRUCTED LIMIT OF WASTE
	PRE-SUBTITLE D FINAL COVER LIMIT
500	EXISTING CONTOUR
N 6975000	STATE PLANE COORDINATE
550	FINAL COVER CONTOUR
	PROPOSED DRAINAGE SWALE
	PROPOSED DRAINAGE LETDOWN
MW-8	EXISTING GROUNDWATER MONITORING WELL
MW-40	PROPOSED GROUNDWATER MONITORING WELL
GP-2	EXISTING LANDFILL GAS MONITORING PROBE
GP-17	PROPOSED LANDFILL GAS MONITORING PROBE

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DATE: 05/2022
FILE: 0023-404-11
CAD: FIG 6-1-COMPLETION PLAN.dwg

DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
COMPLETION PLAN

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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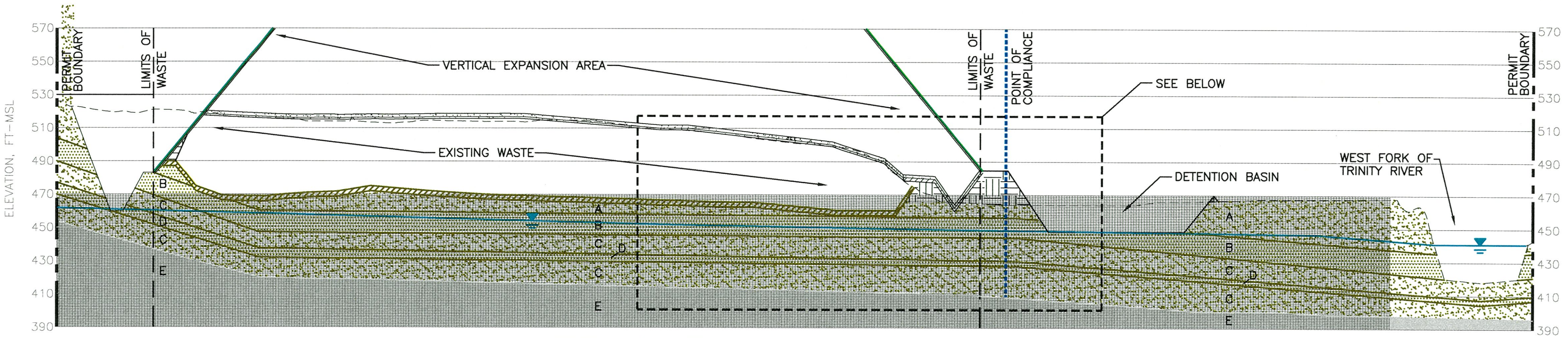
FIGURE 6-1

O:\0023\404\EXPANSION 2021\PART III\IIIB\6-1 COMPLETION PLAN.dwg, jwilson, 1:2



SECTION A

HORIZONTAL SCALE IN FEET: 0, 200, 400

VERTICAL SCALE IN FEET: 0, 40, 80

SUBSURFACE SOILS INFORMATION

(SEE NOTE 5)

A – UPPER ALLUVIUM SOILS
(HORIZ. $K_{MAX}=6.3\times10^{-8}$ cm/s)
(VERT. $K_{MAX}=5.7\times10^{-7}$ cm/s)

B – UPPER TRANSMISSIVE ZONE
(HORIZ. $K_{MAX}=5.23\times10^{-2}$ cm/s)
(VERT. $K_{MAX}=5.23\times10^{-2}$ cm/s)

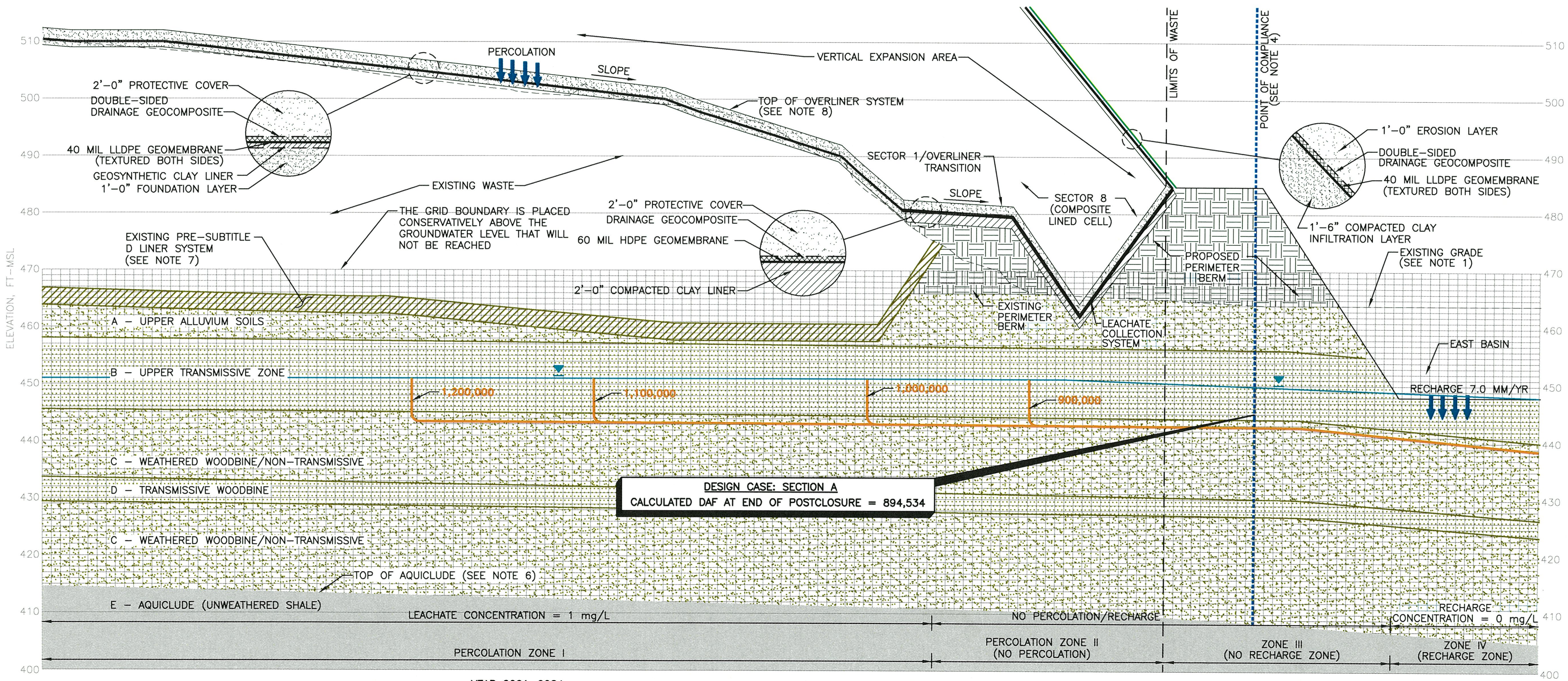
C – WEATHERED WOODBINE/NON-TRANSMISSIVE
(HORIZ. $K_{MAX}=3.2\times10^{-7}$ cm/s)
(VERT. $K_{MAX}=1.7\times10^{-7}$ cm/s)

D – TRANSMISSIVE WOODBINE
(HORIZ. $K_{MAX}=6.2\times10^{-4}$ cm/s)
(VERT. $K_{MAX}=4.7\times10^{-4}$ cm/s)

E – AQUICLUDE (UNWEATHERED SHALE)
(HORIZ. $K_{MAX}=1.5\times10^{-6}$ cm/s)
(VERT. $K_{MAX}=3.5\times10^{-7}$ cm/s)

LEGEND

- PERMIT BOUNDARY (SEE NOTE 2)
- LIMITS OF WASTE (SEE NOTE 2)
- GROUNDWATER SURFACE (SEE NOTE 3)
- EXISTING GRADE (SEE NOTE 1)
- POINT OF COMPLIANCE (SEE NOTE 4)
- PERCOLATION/RECHARGE
- 1×10^{5} DAF CONTOUR AT END OF POSTCLOSURE
- MODFLOW MODEL GRID (SEE NOTE 9)



YEAR 2021–2084
(PROJECTED WASTE FILLING OPERATIONS IN WDA TO END OF POSTCLOSURE)

HORIZONTAL SCALE IN FEET: 0, 50, 100

VERTICAL SCALE IN FEET: 0, 10, 20

NOTES:

1. EXISTING GRADE PROVIDED BY COOPER AERIAL SURVEYS, CO. FROM AERIAL PHOTOGRAPHY FLOWN 11–16–2020.
2. PERMIT BOUNDARY, LIMITS OF WASTE, FINAL COVER GRADES, AND PERIMETER DRAINAGE STRUCTURES PROVIDED BY GOLDER ASSOCIATES, INC.
3. GROUNDWATER POTENTIOMETRIC SURFACE WAS REPRODUCED FROM THE MODFLOW MODEL GROUNDWATER POTENTIOMETRIC SURFACE AT THE END OF POSTCLOSURE. REFER TO APPENDIX IIIH FOR INFORMATION REGARDING MODFLOW MODEL GROUNDWATER INPUT AND HOW THE GROUNDWATER LEVELS CHANGE WITH TIME.
4. GROUNDWATER MONITOR WELL AND POINT OF COMPLIANCE REPRODUCED FROM THE PROPOSED GROUNDWATER MONITORING SYSTEM PLAN POST WASTE REMOVAL INCLUDED IN APPENDIX IIIH.
5. GEOLOGIC CROSS SECTION BASED ON GEOLOGIC CROSS SECTIONS A–A', C–C', F–F', AND G–G' INCLUDED IN APPENDIX IIIG. MAXIMUM HYDRAULIC CONDUCTIVITIES FROM LAB AND SLUG TEST DATA WERE USED IN ALL MODFLOW SIMULATIONS.
6. TOP OF AQUICLUDE REPRODUCED FROM A TOP OF AQUICLUDE MAP INCLUDED IN APPENDIX IIIG.
7. EXISTING BOTTOM OF WASTE IN PRE–SUBTITLE D AREA DEVELOPED FROM AVAILABLE SLERS AND GAS WELL INSTALLATION INFORMATION (SEE SECTION 2.1.3 OF APPENDIX IIIB).
8. OVERLINER DETAILS AND SPECIFICATIONS ARE INCLUDED IN APPENDIX IIIA.
9. THE MODFLOW MODEL GRID IS OVERLAIN ON SECTION A FOR ILLUSTRATION PURPOSES ONLY. THE MODFLOW MODEL GRID DIMENSIONS CONSIST OF 1–FOOT–THICK LAYERS, 8–FOOT–WIDE COLUMNS, AND A SINGLE 5–FOOT–DEEP ROW PERPENDICULAR TO THE SECTION.

LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2021	12/31/2054	PROJECTED WASTE FILLING OPERATIONS IN WDA	PROJECTED FINAL COVER CONSTRUCTION (OVERLINER AREA)	OVERLINER	0.001 MM/YR	COMPOSITE LINED CELL	3.289E–07 MM/YR
12/31/2054	12/31/2084	PROJECTED FINAL COVER CONSTRUCTION	END OF POSTCLOSURE	OVERLINER & FINAL COVER	0.001 MM/YR		

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☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023–404–11
CAD: FIG 6–2 SECTION A.dwg

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F–3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
DESIGN CASE–SECTION A

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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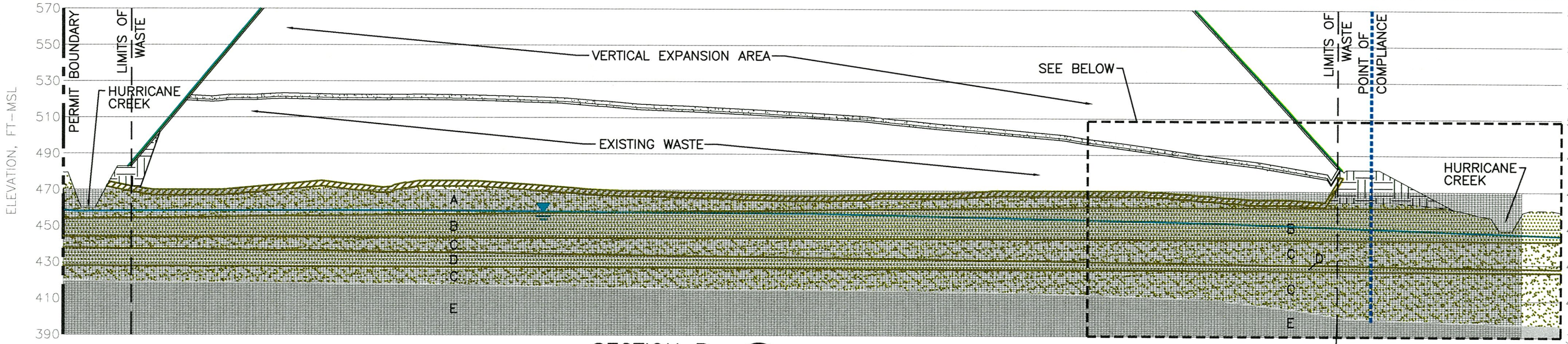
FIGURE 6–2

O:\0023\404\EXPANSION 2021\PART III\IIIB\FIG 6–2 SECTION A–DESIGN CASE.dwg, jwilson, 1:2



SECTION B (B / 6-16-3)

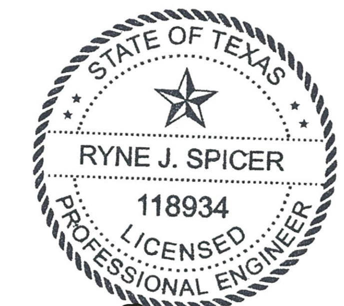
0 200 400 HORIZONTAL SCALE IN FEET
0 40 80 VERTICAL SCALE IN FEET

SUBSURFACE SOILS INFORMATION
(SEE NOTE 5)

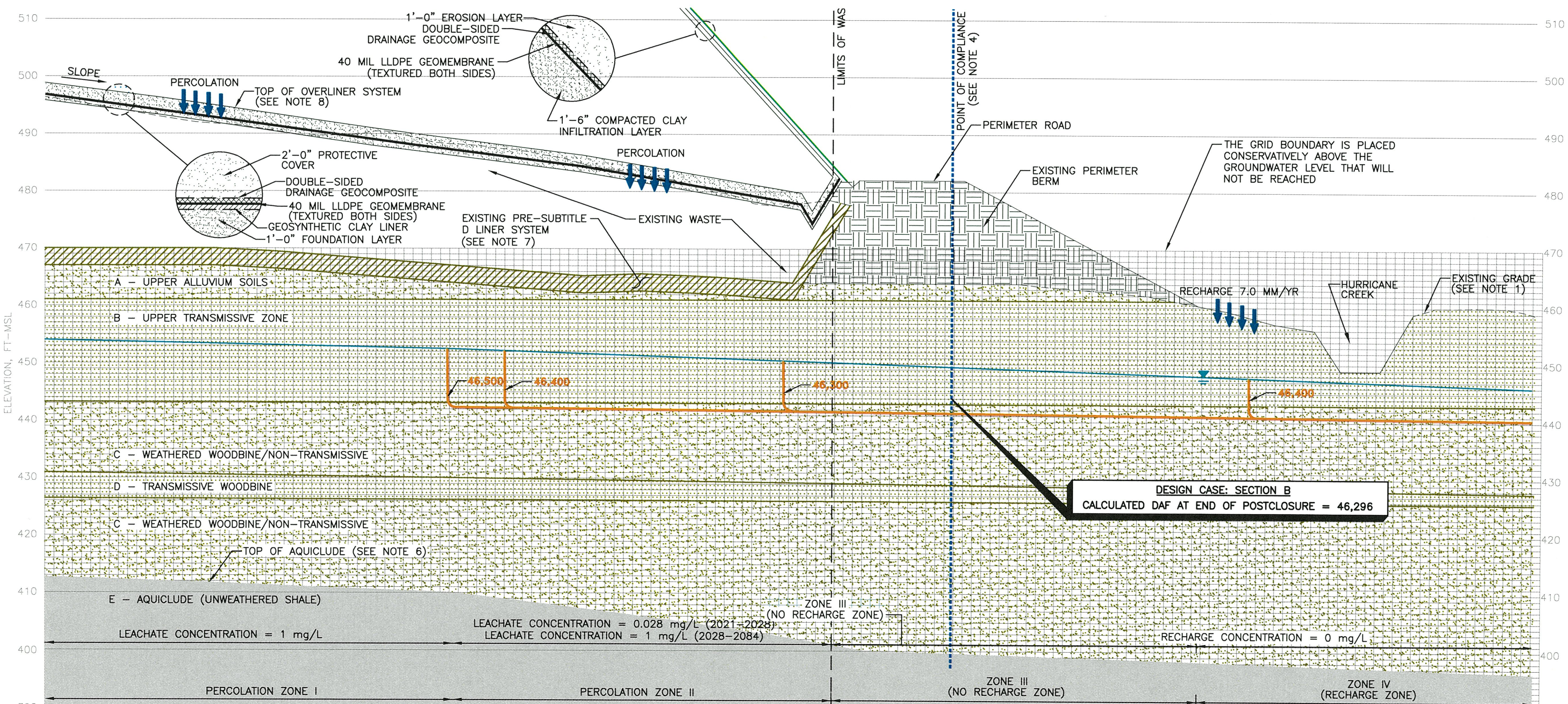
A – UPPER ALLUVIUM SOILS
(HORIZ. $K_{MAX}=6.3x10^{-8}$ cm/s)
(VERT. $K_{MAX}=5.7x10^{-7}$ cm/s)
B – UPPER TRANSMISSIVE ZONE
(HORIZ. $K_{MAX}=5.23x10^{-2}$ cm/s)
(VERT. $K_{MAX}=5.23x10^{-2}$ cm/s)
C – WEATHERED WOODBINE/ NON-TRANSMISSIVE
(HORIZ. $K_{MAX}=3.2x10^{-7}$ cm/s)
(VERT. $K_{MAX}=1.7x10^{-7}$ cm/s)
D – TRANSMISSIVE WOODBINE
(HORIZ. $K_{MAX}=6.2x10^{-4}$ cm/s)
(VERT. $K_{MAX}=4.7x10^{-4}$ cm/s)
E – AQUICLUDE (UNWEATHERED SHALE)
(HORIZ. $K_{MAX}=1.5x10^{-6}$ cm/s)
(VERT. $K_{MAX}=3.5x10^{-7}$ cm/s)

LEGEND

PERMIT BOUNDARY (SEE NOTE 2)
LIMITS OF WASTE (SEE NOTE 2)
GROUNDWATER SURFACE (SEE NOTE 3)
EXISTING GRADE (SEE NOTE 1)
POINT OF COMPLIANCE (SEE NOTE 4)
PERCOLATION/RECHARGE
$1x10^6$ DAF CONTOUR AT END OF POSTCLOSURE
MODFLOW MODEL GRID (SEE NOTE 9)



5-19-2022



YEAR 2021–2084
(PROJECTED WASTE FILLING OPERATIONS IN WDA TO END OF POSTCLOSURE)

0 50 100 HORIZONTAL SCALE IN FEET
0 10 20 VERTICAL SCALE IN FEET

NOTES:

1. EXISTING GRADE PROVIDED BY COOPER AERIAL SURVEYS, CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY, LIMITS OF WASTE, FINAL COVER GRADES, AND PERIMETER DRAINAGE STRUCTURES PROVIDED BY GOLDER ASSOCIATES, INC.
3. GROUNDWATER POTENTIOMETRIC SURFACE WAS REPRODUCED FROM THE MODFLOW MODEL GROUNDWATER POTENTIOMETRIC SURFACE AT THE END OF POSTCLOSURE. REFER TO APPENDIX IIIH FOR INFORMATION REGARDING MODFLOW MODEL GROUNDWATER INPUT AND HOW THE GROUNDWATER LEVELS CHANGE WITH TIME.
4. GROUNDWATER MONITOR WELL AND POINT OF COMPLIANCE REPRODUCED FROM THE PROPOSED GROUNDWATER MONITORING SYSTEM PLAN POST WASTE REMOVAL INCLUDED IN APPENDIX IIIH.
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6. TOP OF AQUICLUDE REPRODUCED FROM A TOP OF AQUICLUDE MAP INCLUDED IN APPENDIX IIIG.
7. EXISTING BOTTOM OF WASTE IN PRE-SUBTITLE D AREA DEVELOPED FROM AVAILABLE SLERS AND GAS WELL INSTALLATION INFORMATION (SEE SECTION 2.1.3 OF APPENDIX IIIB).
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LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2021	12/31/2028	PROJECTED WASTE FILLING OPERATIONS IN WDA	CONTINUED WASTE FILLING OPERATIONS IN WDA	OVERLINER	0.001 MM/YR	PRE-SUBTITLE D FINAL COVER	50.7 MM/YR
12/31/2028	12/31/2054	CONTINUED WASTE FILLING OPERATIONS IN WDA	PROJECTED FINAL COVER CONSTRUCTION	OVERLINER	0.001 MM/YR	OVERLINER	0.001 MM/YR
12/31/2054	12/31/2084	PROJECTED FINAL COVER CONSTRUCTION	END OF POSTCLOSURE	OVERLINER & FINAL COVER	0.001 MM/YR	OVERLINER & FINAL COVER	0.001 MM/YR

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☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: FIG 6-3 SECTION B.dwg

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: RJS

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
DESIGN CASE-SECTION B

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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FIGURE 6-3

7 ADDITIONAL POC DEMONSTRATION

7.1 Purpose

The POC demonstration described in Sections 3 through 6 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 WDA 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, existing pre-Subtitle D final cover system, and Subtitle D final cover system) work together to establish a design 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.

An additional case was developed that artificially modified model parameters of the "design case" demonstration to further show the waste containment system's ability to meet the design criteria listed in §330.331(a)(1).

7.2 Additional Case – Artificially Increased Percolation Rate Through Overliner

For this case, all model assumptions are the same as the information presented in Sections 3 through 6, including the key assumption that percolation through the overliner system percolates directly to groundwater. However, the percolation rate through the overliner system has been intentionally increased by artificially varying several parameters related to the overliner leachate collection system. The changes are summarized below.

- The overliner leachate collection system has been modified to include a slope of 0.001 percent in lieu of the design slope of 1.5 percent and a slope length of 1,600 feet in lieu of the design slope length of 800 feet.
- This case models 20 feet of waste thickness on the overliner for the entire 33-year period that the overliner is proposed to be in the "active" condition

(refer to Appendix IIIB-A.1 for a demonstration that shows this is a conservative assumption).

The assumptions described above resulted in an annual average of 2.75 feet of leachate to accumulate on the overliner at the end of the "active condition." During the "closed condition," the depth of leachate was assumed to be a starting condition for the model (i.e., 2.75 feet).

Other key model assumptions for this case are listed below (these assumptions are also used for the design case discussed in Section 6).

- Leachate was assumed to percolate from the overliner directly to groundwater.
- Leachate quality information is based on historical leachate data suggested by TCEQ, not site specific leachate data which has much lower leachate constituent concentrations.
- The unsaturated portions of Zone A (the low permeability soils of the upper Alluvium) was not included in the analysis.
- To provide for a conservative analysis, the fate and transport modeling did not include chemical and biological decay and adsorption of constituents.

The results of this analysis are shown on Figures 7-1 through 7-2 and summarized in the following table.

Table 7-1
Design Case and Case I Comparison

Model Section	Design Case Calculated DAF	Additional Case – Artificially Increased Percolation Rate Through Overliner Calculated DAF
Section A	894,534	5,599
Section B	46,296	1,350

As shown in Table 7-1, the waste containment system produces DAFs that are well above the required minimum value, and 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 7-2
Summary of Constituent Levels at the POC
(Using Site Specific Leachate Data)

Constituent	C_{BG}, Background Concentration[1] (mg/l)	C_O[2]	/ DAF[3] (mg/l)	=	C_P (mg/l) (Constituent Concentration at the POC due to Estimated Leachate Percolation)	$C_{BG} + C_P = C_T$ at POC (mg/l)	MCL (mg/l) Listed in §330.331(a)(1)	C_T at POC < MCL
Arsenic	0.013	0.148	1,350	=	1.10E-04	0.013	0.05	Yes
Barium	0.082	0.5	1,350	=	3.70E-04	0.08237	1	Yes
Benzene	0.0005	0.0025	1,350	=	1.85E-06	0.0005	0.005	Yes
Cadmium	0.001	0.003	1,350	=	2.22E-06	0.001	0.01	Yes
Carbon tetrachloride	0.0025	0.0025	1,350	=	1.85E-06	0.0025	0.005	Yes
Chromium (hexavalent)	0.01	0.14	1,350	=	1.04E-04	0.01	0.05	Yes
2,4-Dichlorophenoxy acetic acid	--	0.05	1,350	=	3.70E-05	--	0.1	Yes
1,4-Dichlorobenzene	0.001	0.007	1,350	=	5.19E-06	0.001	0.075	Yes
1,2-Dichloroethane	0.0005	0.0025	1,350	=	1.85E-06	0.0005	0.005	Yes
1,1-Dichloroethylene	0.0005	0.0035	1,350	=	2.59E-06	0.0005	0.007	Yes
Endrin	--	0.0001	1,350	=	7.41E-08	--	0.0002	Yes
Fluoride	--	2	1,350	=	1.48E-03	--	4	Yes
Lindane	--	0.002	1,350	=	1.48E-06	--	0.004	Yes
Lead	0.0075	0.014	1,350	=	1.04E-05	0.0075	0.05	Yes
Mercury	--	0.001	1,350	=	7.41E-07	--	0.002	Yes
Methoxychlor	--	0.05	1,350	=	3.70E-05	--	0.1	Yes
Nitrate	--	5	1,350	=	3.70E-03	--	10	Yes
Selenium	0.005	0.016	1,350	=	1.19E-05	0.005	0.01	Yes
Silver	0.005	0.025	1,350	=	1.85E-05	0.005	0.05	Yes
Toxaphene	--	0.0025	1,350	=	1.85E-06	--	0.005	Yes
1,1,1-Trichloroethane	0.0005	0.1	1,350	=	7.41E-05	0.0006	0.2	Yes
Trichloroethylene	0.0025	0.0025	1,350	=	1.85E-06	0.0025	0.005	Yes
2,4,5-Trichlorophenoxy acetic acid	--	0.005	1,350	=	3.70E-06	--	0.01	Yes
Vinyl Chloride	0.001	0.001	1,350	=	7.41E-07	0.001	0.002	Yes

1 Background concentrations have been obtained from Table 1-1.
2 Leachate concentrations (C_O, Site Specific Concentrations) represent levels obtained from the leachate sample analysis results provided in Table 2-2.
3 DAF value for Case II presented on Figure 3 in Appendix IIIB-C.

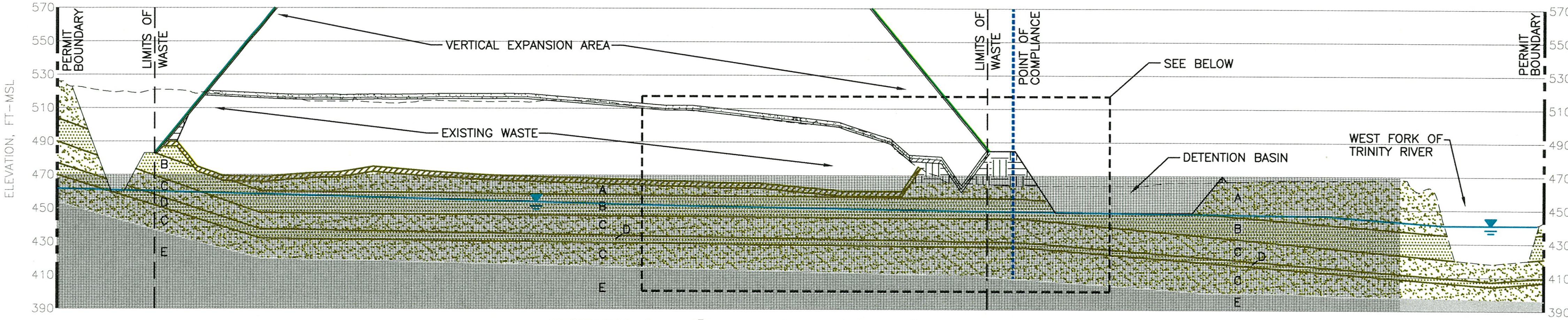
Table 7-3
Summary of Constituent Levels at the POC
(Using Historical Guidance Information)

Constituent	C_{BG}, Background Concentration[1] (mg/l)	C_O[2] / (mg/l)	DAF[3]	=	C_P (mg/l) (Constituent Concentration at the POC due to Estimated Leachate Percolation)	$C_{BG} + C_P = C_T$ at POC (mg/l)	MCL (mg/l) Listed in §330.331(a)(1)	C_T at POC < MCL
Arsenic	0.013	0.05	1,350	=	3.70E-05	0.013	0.05	Yes
Barium	0.082	1	1,350	=	7.41E-04	0.08274	1	Yes
Benzene	0.0005	0.005	1,350	=	3.70E-06	0.0005	0.005	Yes
Cadmium	0.001	0.01	1,350	=	7.41E-06	0.001	0.01	Yes
Carbon tetrachloride	0.0025	0.005	1,350	=	3.70E-06	0.0025	0.005	Yes
Chromium (hexavalent)	0.01	0.05	1,350	=	3.70E-05	0.01	0.05	Yes
2,4-Dichlorophenoxy acetic acid	--	0.1	1,350	=	7.41E-05	--	0.1	Yes
1,4-Dichlorobenzene	0.001	0.075	1,350	=	5.56E-05	0.001	0.075	Yes
1,2-Dichloroethane	0.0005	0.005	1,350	=	3.70E-06	0.0005	0.005	Yes
1,1-Dichloroethylene	0.0005	0.007	1,350	=	5.19E-06	0.0005	0.007	Yes
Endrin	--	0.0002	1,350	=	1.48E-07	--	0.0002	Yes
Fluoride	--	4	1,350	=	2.96E-03	--	4	Yes
Lindane	--	0.004	1,350	=	2.96E-06	--	0.004	Yes
Lead	0.0075	0.05	1,350	=	3.70E-05	0.0075	0.05	Yes
Mercury	--	0.002	1,350	=	1.48E-06	--	0.002	Yes
Methoxychlor	--	0.1	1,350	=	7.41E-05	--	0.1	Yes
Nitrate	--	10	1,350	=	7.41E-03	--	10	Yes
Selenium	0.005	0.01	1,350	=	7.41E-06	0.005	0.01	Yes
Silver	0.005	0.05	1,350	=	3.70E-05	0.005	0.05	Yes
Toxaphene	--	0.005	1,350	=	3.70E-06	--	0.005	Yes
1,1,1-Trichloroethane	0.0005	0.2	1,350	=	1.48E-04	0.0006	0.2	Yes
Trichloroethylene	0.0025	0.005	1,350	=	3.70E-06	0.0025	0.005	Yes
2,4,5-Trichlorophenoxy acetic acid	--	0.01	1,350	=	7.41E-06	--	0.01	Yes
Vinyl Chloride	0.001	0.002	1,350	=	1.48E-06	0.001	0.002	Yes

1 Background concentrations have been obtained from Table 1-1.

2 C_P represents chemical concentrations estimated by the fate and transport model or the POC. Initial concentrations, C_O, has been reproduced from historical standard information utilized by TCEQ as discussed in Section 1.3. Total concentration for each constituent at the POC is the sum of C_P and the background concentration, C_{BG}.

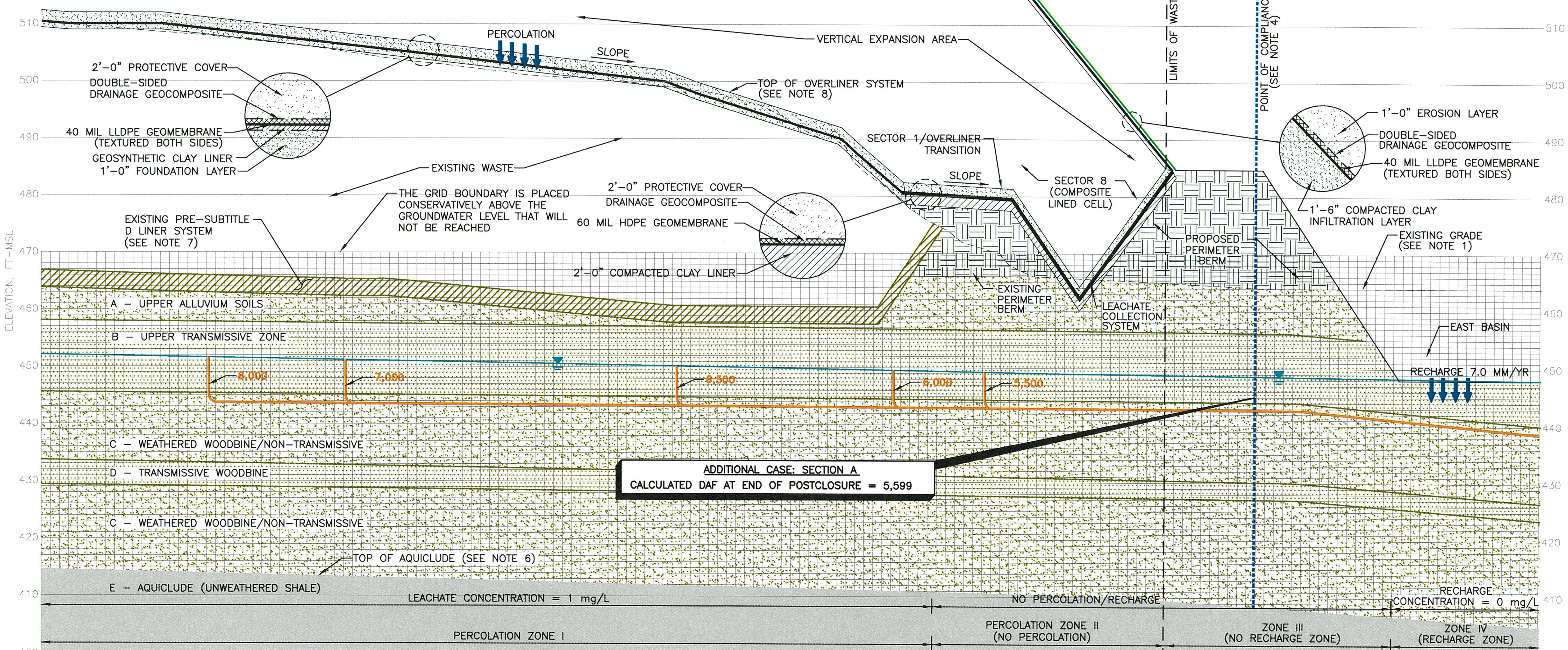
3 DAF value for Case II presented on Figure 3 in Appendix IIIB-C.



SECTION A

0 200 400 HORIZONTAL SCALE IN FEET

0 40 80 VERTICAL SCALE IN FEET



YEAR 2021–2084
(PROJECTED WASTE FILLING OPERATIONS IN WDA TO END OF POSTCLOSURE)

0 50 100 HORIZONTAL SCALE IN FEET

0 10 20 VERTICAL SCALE IN FEET

SUBSURFACE SOILS INFORMATION
(SEE NOTE 5)

- A – UPPER ALLUVIUM SOILS
  (HORIZ. $K_{MAX}=6.3\times10^{-6}$ cm/s)
  (VERT. $K_{MAX}=5.7\times10^{-7}$ cm/s)
- B – UPPER TRANSMISSIVE ZONE
  (HORIZ. $K_{MAX}=5.23\times10^{-2}$ cm/s)
  (VERT. $K_{MAX}=5.23\times10^{-2}$ cm/s)
- C – WEATHERED WOODBINE/ NON-TRANSMISSIVE
  (HORIZ. $K_{MAX}=3.2\times10^{-7}$ cm/s)
  (VERT. $K_{MAX}=1.7\times10^{-7}$ cm/s)
- D – TRANSMISSIVE WOODBINE
  (HORIZ. $K_{MAX}=6.2\times10^{-4}$ cm/s)
  (VERT. $K_{MAX}=4.7\times10^{-4}$ cm/s)
- E – AQUICLUDE (UNWEATHERED SHALE)
  (HORIZ. $K_{MAX}=1.5\times10^{-6}$ cm/s)
  (VERT. $K_{MAX}=3.5\times10^{-7}$ cm/s)

LEGEND

- PERMIT BOUNDARY (SEE NOTE 2)
- LIMITS OF WASTE (SEE NOTE 2)
- GROUNDWATER SURFACE (SEE NOTE 3)
- EXISTING GRADE (SEE NOTE 1)
- POINT OF COMPLIANCE (SEE NOTE 4)
- PERCOLATION/RECHARGE
- 1×10^{5} DAF CONTOUR AT END OF POSTCLOSURE
- MODFLOW MODEL GRID (SEE NOTE 9)

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

NOTES:

1. EXISTING GRADE PROVIDED BY COOPER AERIAL SURVEYS, CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY, LIMITS OF WASTE, FINAL COVER GRADES, AND PERIMETER DRAINAGE STRUCTURES PROVIDED BY GOLDER ASSOCIATES, INC.
3. GROUNDWATER POTENTIOMETRIC SURFACE WAS REPRODUCED FROM THE MODFLOW MODEL GROUNDWATER POTENTIOMETRIC SURFACE AT THE END OF POSTCLOSURE. REFER TO APPENDIX IIIH FOR INFORMATION REGARDING MODFLOW MODEL GROUNDWATER INPUT AND HOW THE GROUNDWATER LEVELS CHANGE WITH TIME.
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5. GEOLOGIC CROSS SECTION BASED ON GEOLOGIC CROSS SECTIONS A-A', C-C', F-F', AND G-G' INCLUDED IN APPENDIX IIIG. MAXIMUM HYDRAULIC CONDUCTIVITIES FROM LAB AND SLUG TEST DATA WERE USED IN ALL MODFLOW SIMULATIONS.
6. TOP OF AQUICLUDE REPRODUCED FROM A TOP OF AQUICLUDE MAP INCLUDED IN APPENDIX IIIG.
7. EXISTING BOTTOM OF WASTE IN PRE-SUBTITLE D AREA DEVELOPED FROM AVAILABLE SLERS AND GAS WELL INSTALLATION INFORMATION (SEE SECTION 2.1.3 OF APPENDIX IIIB).
8. OVERLINER DETAILS AND SPECIFICATIONS ARE INCLUDED IN APPENDIX IIIA.
9. THE MODFLOW MODEL GRID IS OVERLAIN ON SECTION A FOR ILLUSTRATION PURPOSES ONLY. THE MODFLOW MODEL GRID DIMENSIONS CONSIST OF 1-FOOT-THICK LAYERS, 8-FOOT-WIDE COLUMNS, AND A SINGLE 5-FOOT-DEEP ROW PERPENDICULAR TO THE SECTION.

LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2021	12/31/2054	PROJECTED WASTE FILLING OPERATIONS IN WDA	PROJECTED FINAL COVER CONSTRUCTION (OVERLINER AREA)	OVERLINER	0.16 MM/YR	COMPOSITE LINED CELL	3.289E-07 MM/YR
12/31/2054	12/31/2084	PROJECTED FINAL COVER CONSTRUCTION	END OF POSTCLOSURE	OVERLINER & FINAL COVER	0.16 MM/YR		

- [ ] DRAFT
- [x] FOR PERMITTING PURPOSES ONLY
- [ ] ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: FIG 7-1 SECTION A.dwg

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
ADDITIONAL CASE–SECTION A

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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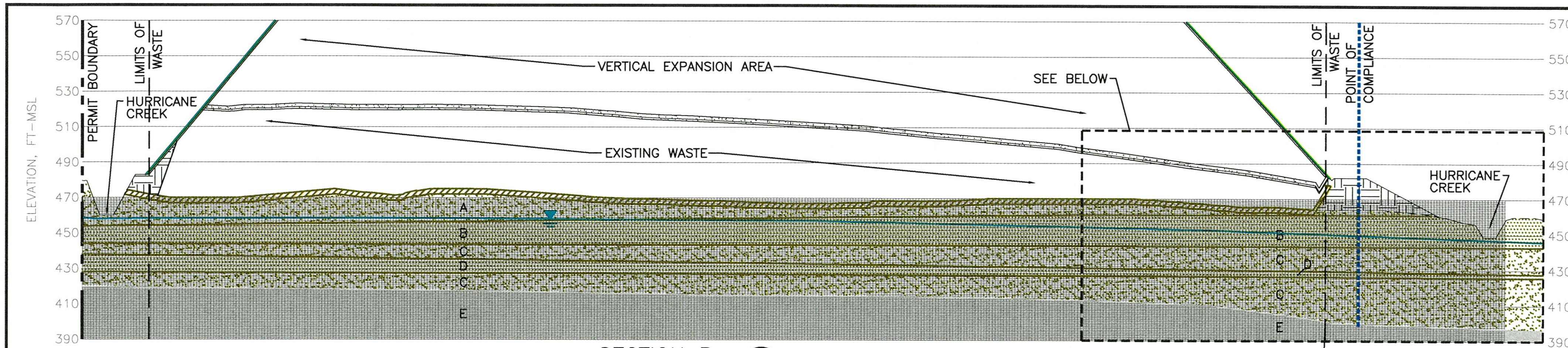
FIGURE 7–1



SECTION B (B / 6-17-2)

0 200 400 HORIZONTAL SCALE IN FEET

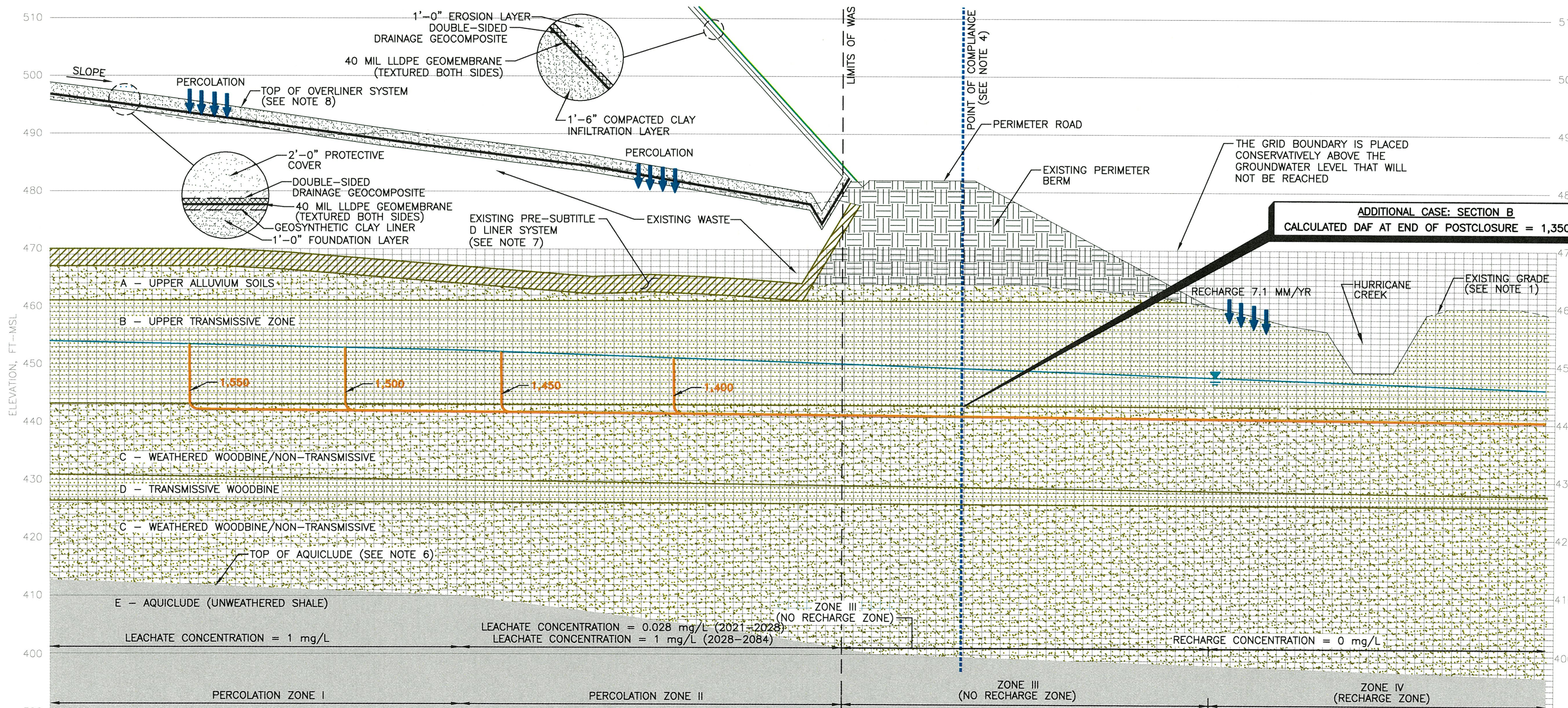
0 40 80 VERTICAL SCALE IN FEET

SUBSURFACE SOILS INFORMATION (SEE NOTE 5)
A – UPPER ALLUVIUM SOILS (HORIZ. $K_{MAX}=6.3\times10^{-8}$ cm/s) (VERT. $K_{MAX}=5.7\times10^{-7}$ cm/s)
B – UPPER TRANSMISSIVE ZONE (HORIZ. $K_{MAX}=5.23\times10^{-2}$ cm/s) (VERT. $K_{MAX}=5.23\times10^{-2}$ cm/s)
C – WEATHERED WOODBINE/ NON-TRANSMISSIVE (HORIZ. $K_{MAX}=3.2\times10^{-7}$ cm/s) (VERT. $K_{MAX}=1.7\times10^{-7}$ cm/s)
D – TRANSMISSIVE WOODBINE (HORIZ. $K_{MAX}=6.2\times10^{-4}$ cm/s) (VERT. $K_{MAX}=4.7\times10^{-4}$ cm/s)
E – AQUICLUDE (UNWEATHERED SHALE) (HORIZ. $K_{MAX}=1.5\times10^{-6}$ cm/s) (VERT. $K_{MAX}=3.5\times10^{-7}$ cm/s)

LEGEND

- PERMIT BOUNDARY (SEE NOTE 2)
- LIMITS OF WASTE (SEE NOTE 2)
- GROUNDWATER SURFACE (SEE NOTE 3)
- EXISTING GRADE (SEE NOTE 1)
- POINT OF COMPLIANCE (SEE NOTE 4)
- PERCOLATION/RECHARGE
- 1×10^{6} DAF CONTOUR AT END OF POSTCLOSURE
- MODFLOW MODEL GRID (SEE NOTE 9)

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER
5-19-2022



YEAR 2021–2084
(PROJECTED WASTE FILLING OPERATIONS IN WDA TO END OF POSTCLOSURE)

0 50 100 HORIZONTAL SCALE IN FEET

0 10 20 VERTICAL SCALE IN FEET

NOTES:

1. EXISTING GRADE PROVIDED BY COOPER AERIAL SURVEYS, CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY, LIMITS OF WASTE, FINAL COVER GRADES, AND PERIMETER DRAINAGE STRUCTURES PROVIDED BY GOLDER ASSOCIATES, INC.
3. GROUNDWATER POTENTIOMETRIC SURFACE WAS REPRODUCED FROM THE MODFLOW MODEL GROUNDWATER POTENTIOMETRIC SURFACE AT THE END OF POSTCLOSURE. REFER TO APPENDIX IIIH FOR INFORMATION REGARDING MODFLOW MODEL GROUNDWATER INPUT AND HOW THE GROUNDWATER LEVELS CHANGE WITH TIME.
4. GROUNDWATER MONITOR WELL AND POINT OF COMPLIANCE REPRODUCED FROM THE PROPOSED GROUNDWATER MONITORING SYSTEM PLAN POST WASTE REMOVAL INCLUDED IN APPENDIX IIIH.
5. GEOLOGIC CROSS SECTION BASED ON GEOLOGIC CROSS SECTIONS A-A', C-C', F-F', AND G-G' INCLUDED IN APPENDIX IIIG. MAXIMUM HYDRAULIC CONDUCTIVITIES FROM LAB AND SLUG TEST DATA WERE USED IN ALL MODFLOW SIMULATIONS.
6. TOP OF AQUICLUDE REPRODUCED FROM A TOP OF AQUICLUDE MAP INCLUDED IN APPENDIX IIIG.
7. EXISTING BOTTOM OF WASTE IN PRE-SUBTITLE D AREA DEVELOPED FROM AVAILABLE SLERS AND GAS WELL INSTALLATION INFORMATION (SEE SECTION 2.1.3 OF APPENDIX IIIB).
8. OVERLINER DETAILS AND SPECIFICATIONS ARE INCLUDED IN APPENDIX IIIA.
9. THE MODFLOW MODEL GRID IS OVERLAIN ON SECTION A FOR ILLUSTRATION PURPOSES ONLY. THE MODFLOW MODEL GRID DIMENSIONS CONSIST OF 1-FOOT-THICK LAYERS, 8-FOOT-WIDE COLUMNS, AND A SINGLE 5-FOOT-DEEP ROW PERPENDICULAR TO THE SECTION.

LEACHATE PERCOLATION VALUES FOR VARIOUS STAGES OF LANDFILL DEVELOPMENT

TIME PERIOD				PERCOLATION ZONE I		PERCOLATION ZONE II	
START DATE	END DATE	START DESCRIPTION	END DESCRIPTION	DESCRIPTION	PERCOLATION	DESCRIPTION	PERCOLATION
01/01/2021	12/31/2028	PROJECTED WASTE FILLING OPERATIONS IN WDA	CONTINUED WASTE FILLING OPERATIONS IN WDA	OVERLINER	0.16 MM/YR	PRE-SUBTITLE D FINAL COVER	50.7 MM/YR
12/31/2028	12/31/2054	CONTINUED WASTE FILLING OPERATIONS IN WDA	PROJECTED FINAL COVER CONSTRUCTION	OVERLINER	0.16 MM/YR	OVERLINER	0.16 MM/YR
12/31/2054	12/31/2084	PROJECTED FINAL COVER CONSTRUCTION	END OF POSTCLOSURE	OVERLINER & FINAL COVER	0.16 MM/YR	OVERLINER & FINAL COVER	0.16 MM/YR

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: FIG 7-2 SECTION B.dwg

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
ADDITIONAL CASE–SECTION B

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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FIGURE 7–2

APPENDIX IIIB-A

HELP MODEL ANALYSIS

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIB-A-1 through IIIB-A-62

HELP MODEL ANALYSIS

The following HELP model simulations were run to obtain percolation rates through the pre-Subtitle D area and the overliner.

Table 1
Landfill Configurations

Case		Description
Design Case	Active, 230 ft waste	The design case models the impact of percolation through the overliner system under expected filling conditions for both active and closed conditions.
	Closed, 280 ft waste	
Additional Case	Active, 20 ft waste	In the additional case, the capacity of the overliner leachate collection system is restricted by flatting the slope to 0.001% to maximize the buildup of leachate on the overliner.
	Closed, 280 ft waste	
Pre-Subtitle D Final Cover	2 ft final cover	The pre-Subtitle D final cover was modeled to simulate the percolation through the pre-Subtitle D areas.
Off-Site Recharge	30 ft alluvial soil	The off-site recharge area between the limits of waste and the point of compliance was modeled.

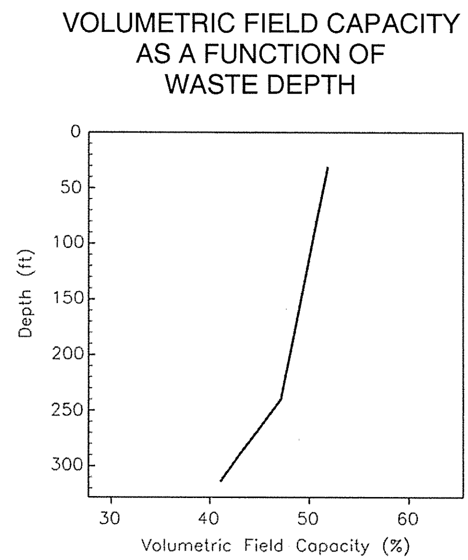
The evaporative zone depth and leaf area index were chosen to be 10 inches and 2.0, respectively, for the active case and 12 inches and 4.5, respectively, for the closed cases. The Soil Conservation Service (SCS) runoff curve numbers were calculated by HELP based on soil data and expected ground cover, surface slope, and slope length. The HELP Model output results can be found starting on page IIIB-A-4.

Climate Data Input

Precipitation data was synthetically generated by the HELP model program using normal mean monthly precipitation and temperature data from the NOAA for the Arlington Municipal Airport weather station. The average annual precipitation over the modeled 30-year period was 35.65 inches. Solar radiation data were synthetically generated by the HELP model using program defaults for Dallas, Texas.

Field Capacity and Moisture Content

The porosity values for each layer other than the waste were provided by HELP. The field capacity and porosity 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, as shown in the following graph.



For a conservative analysis, the initial moisture content was set at field capacity for all profile layers except the waste layer. The initial moisture content for the waste layer was selected to be 25 percent for the 20-foot-thick waste column case. 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.

Landfill Profile Information

The various landfill layers that are included in this demonstration are discussed below.

Overliner System

The overliner consists of a 40-mil LLDPE geomembrane overlying a geosynthetic clay liner (GCL). The geomembrane liner was modeled for good installation quality, five construction defects per acre, and a production pinhole density of twenty holes/acre. Default soil characteristics from the HELP Model were selected for the LLDPE geomembrane hydraulic conductivity.

Overliner Leachate Collection System

The overliner LCS includes a drainage geocomposite collection layer consisting of a 300-mil geonet with a 6 oz/sy geotextile heat-bonded to both sides. The calculations for determining the hydraulic conductivity of the geocomposite are included in Appendix IIIC-A.

Protective Cover

The 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 1.2×10^{-4} cm/s.

Waste

The overliner area cases include waste layers of 20 feet and 280 feet. Default wilting point values were 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 daily and intermediate cover consists of a 6-inch-thick and 12-inch-thick layer of soil placed over the waste. Default soil characteristics from the HELP Version 3.07 table were selected to represent the available on-site soils.

Final Cover System

The final cover consists of a 12-inch erosion layer with the top 6 inches capable of sustaining growth of vegetation, a geocomposite drainage layer, a 40-mil LLDPE geomembrane liner, and an infiltration layer. The geomembrane liner was modeled for good installation quality, one construction defect per acre, and a pinhole density of four holes/acre. The infiltration layer consists of 18-inch-thick compacted soil with a hydraulic conductivity of 1×10^{-5} cm/s.

Help Output

The HELP summaries and output files are presented starting on page IIIB-A-4.

Prep By: BPY
05/2022

CITY OF ARLINGTON LANDFILL
0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
POINT OF COMPLIANCE DEMONSTRATION

Chkd By: RJS
05/2022

			DESIGN CASE		ADDITIONAL CASE		PRE-SUBTITLE D FINAL COVER[2]	OFF SITE RECHARGE[4]
			ACTIVE (280 FT WASTE)	CLOSED (280 FT WASTE)	ACTIVE (280 FT WASTE)	CLOSED (280 FT WASTE)		
GENERAL INFORMATION		Case No.	1	2	2	2	1	1
		No. of Years	33	30	33	30	7	30
		Ground Cover	FAIR	GOOD	FAIR	GOOD	EXCELLENT	EXCELLENT
		SCS Runoff Curve No.	81.9	81.2	81.9	81.2	60.4	95.1
		Model Area (acre)	1	1	1	1	1	1
		Runoff Area (%)	90	100	80	100	100	100
		Maximum Leaf Area Index	2.0	4.5	2.0	4.5	4.5	4.5
		Evaporative Zone Depth (inch)	10	12	10	12	6	6
Final Cover	TOPSOIL LAYER (Texture = 10)	Thickness (in)		12		12	6	6
		Porosity (vol/vol)		0.3980		0.3980	0.4570	0.4200
		Field Capacity (vol/vol)		0.2440		0.2440	0.1310	0.3500
		Wilting Point (vol/vol)		0.1360		0.1360	0.0580	0.3000
		Init. Moisture Content (vol/vol)		0.2440		0.2440	0.3980	0.3000
		Hyd. Conductivity (cm/s)		1.2E-04		1.2E-04	1.0E-03	5.7E-07
	GEOCOMPIOSITE DRAINAGE LAYER (Texture = 0)	Thickness (in)		0.300		0.300		
		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)		12.17		12.17		
		Slope (%)		25		25		
		Slope Length (ft)		500		500		
	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)		5		5		
		Install. Defects (holes/acre)		20		20		
		Placement Quality		GOOD		GOOD		
	INFILTRATION LAYER (Texture = 0)	Thickness (in)		18.00		18.00	18	354
		Porosity (vol/vol)		0.4270		0.4270	0.4270	0.4200
		Field Capacity (vol/vol)		0.4180		0.4180	0.4180	0.3500
		Wilting Point (vol/vol)		0.3670		0.3670	0.3670	0.3000
		Init. Moisture Content (vol/vol)		0.4270		0.4270	0.4270	0.4200
		Hyd. Conductivity (cm/s)		1.0E-05		1.0E-05	2.0E-07	1.0E-07
Intermediate Cover	INTERMEDIATE COVER (Texture = 11) (Active Cases Modeled with 6 inch-thick daily cover)	Thickness (in)	6	12	6	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[1] (Texture = 0)	Thickness (in)	1500	1500	1500	1500		
		Porosity (vol/vol)	0.6174	0.6174	0.6174	0.6174		
		Field Capacity (vol/vol)	0.5127	0.5127	0.5127	0.5127		
		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-03	1.0E-03	1.0E-03	1.0E-03		
	WASTE BOTTOM[1] (Texture = 0)	Thickness (in)	1860	1860	1860	1827		
		Porosity (vol/vol)	0.5017	0.5017	0.5017	0.5029		
		Field Capacity (vol/vol)	0.4798	0.4798	0.4798	0.4801		
		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		
	WASTE BOTTOM-SATURATED[1] (Texture = 0)	Thickness (in)				33		
		Porosity (vol/vol)				0.4389		
		Field Capacity (vol/vol)				0.4388		
		Wilting Point (vol/vol)				0.0770		
		Init. Moisture Content (vol/vol)				0.5180		
		Hyd. Conductivity (cm/s)				1.0E-04		
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	0.3980		
		Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04		
	LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.223	0.222	0.223	0.230		
		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)	4.03	3.49	4.03	6.74		
		Slope[3] (%)	1.5	1.5	0.001	0.001		
		Slope Length (ft)	800	800	1,600	1,600		
	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)	5	5	5	5		
		Install. Defects (holes/acre)	20	20	20	20		
		Placement Quality	GOOD	GOOD	GOOD	GOOD		
	GEOSYNTHETIC CLAY LINER (Texture = 0)	Thickness (in)	0.25	0.25	0.25	0.25		
		Porosity (vol/vol)	0.7500	0.7500	0.7500	0.7500		
		Field Capacity (vol/vol)	0.7470	0.7470	0.7470	0.7470		
		Wilting Point (vol/vol)	0.4000	0.4000	0.4000	0.4000		
		Init. Moisture Content (vol/vol)	0.7470	0.7470	0.7470	0.7470		
		Hyd. Conductivity (cm/s)	5.0E-09	5.0E-09	5.0E-09	5.0E-09		
	COMPACTED SOIL LAYER (Texture = 0)	Thickness (in)	12.00	12.00	12.00	12.00		
		Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270		
		Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180		
		Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670		
		Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270		
		Hyd. Conductivity (cm/s)	1.0E-06	1.0E-06	1.0E-06	1.0E-06		
PRECIPITATION		Average Annual (in)	35.24	35.65	35.24	35.65	38.18	35.65
RUNOFF		Average Annual (in)	1.34	1.63	1.34	1.63	7.59	17.35
EVAPOTRANSPIRATION		Average Annual (in)	24.80	25.75	24.80	25.75	28.57	18.02
HEAD ON OVERLINER		Average Annual (in)	0.053	0.042	15.106	14.716		
LEACHATE GENERATION (OVERLINER)		Average Annual (cf/yr)	30,345.2	20,756.7	2,678.2	30,105.7		
PERCOLATION THROUGH			Overliner	Overliner	Overliner	Overliner	Pre-D Final Cover	Bottom of 30 ft Alluvial Soil
PERCOLATION VALUES		Average Annual (in/yr)	0.00003	0.00004	0.00621	0.00621	2.00339	0.27665
		Average Annual (mm/yr)	0.001	0.001	0.16	0.16	50.9	7.0

Notes: [1] 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.

[2] Pre-Subtitle D Final Cover hydraulic conductivity has been reduced from required values at the time of construction to account for impact of vegetation

[3] Slope of 0.001 is shown as 0.00 in the HELP Model output files due to the fact that the HELP Model prints the slope value with two decimal points (e.g., see slope information for layer 4 on page F-1-26).

[4] Estimated recharge occurs onsite, between the landfill limist of waste and downgradient model boundary where the POC monitoring wells exist.

SUMMARY OF CASES:

DESIGN CASE: The design case has been develop to show the impact of the percolation through the overliner system on the groundwater quality between the landfill unit and the POC. This demonstration incorporates the "design" and active and closed condition for the vertical expansion area above the overliner.

ADD'L CASE: In this case, the capacity of the overliner leachate collection system is restricted by flatting the slope to 0.001% to create a scenario that results in over 2.75 feet of leachate build-up on the overliner. This will artificia through the overliner system.

HELP MODEL OUTPUT FILES

HELP MODEL OUTPUT FOR DESIGN CASE

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\AR\B\DESIGN\AC\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\DESIGN\AC\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\DESIGN\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\DESIGN\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\DESIGN\AC\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\DESIGN\AC\OUTPUT1.OUT


TIME:  16: 8     DATE:   1/27/2022


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

     TITLE:  ARLINGTON LANDFILL - DESIGN CASE - ACTIVE 280 FT

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


     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  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                        =      0.6174 VOL/VOL
   FIELD CAPACITY                  =      0.5127 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                       =   1860.00   INCHES
   POROSITY                        =      0.5017 VOL/VOL
   FIELD CAPACITY                  =      0.4798 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                   =      0.22   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.   =   4.03000021000     CM/SEC
SLOPE                       =      1.50   PERCENT
DRAINAGE LENGTH             =    800.0    FEET


                      LAYER  6
                      --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      5.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     20.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                      LAYER  7
                      --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              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.   =  0.499999986000E-09 CM/SEC


                      LAYER  8
                      --------

             TYPE 3 - BARRIER SOIL LINER
             MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     12.00   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
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  5.%
         AND A SLOPE LENGTH OF  420. FEET.

SCS RUNOFF CURVE NUMBER            =     81.90
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  =      3.380  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      5.254  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      1.430  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =   1289.830  INCHES
TOTAL INITIAL WATER                =   1289.830  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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 33

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.95	2.57	3.09	3.01	3.79	3.59
	2.36	1.67	3.53	4.53	2.36	2.78
STD. DEVIATIONS	1.31	1.44	1.84	1.79	1.80	2.25
	1.80	1.19	2.01	3.85	1.81	2.09
RUNOFF						
TOTALS	0.009	0.052	0.071	0.091	0.120	0.183
	0.067	0.019	0.108	0.490	0.068	0.059
STD. DEVIATIONS	0.025	0.119	0.155	0.218	0.304	0.288
	0.163	0.059	0.169	0.871	0.205	0.128
EVAPOTRANSPIRATION						
TOTALS	1.539	1.755	2.262	2.396	3.106	2.687
	2.126	1.529	2.428	2.063	1.427	1.479
STD. DEVIATIONS	0.546	0.741	0.997	1.117	1.093	1.380
	1.237	1.067	1.089	0.972	0.622	0.584
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.7029	0.6557	0.7157	0.6912	0.7051	0.6839
	0.7130	0.7062	0.6837	0.7027	0.6877	0.7117
STD. DEVIATIONS	0.0837	0.0877	0.0929	0.0861	0.0849	0.0867
	0.0803	0.0935	0.0788	0.0797	0.0710	0.0678
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
PERCOLATION/LEAKAGE THROUGH LAYER 8						
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	0.0001	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	0.0529	0.0542	0.0539	0.0538	0.0531	0.0532
	0.0537	0.0532	0.0532	0.0529	0.0535	0.0536
STD. DEVIATIONS	0.0063	0.0073	0.0070	0.0067	0.0064	0.0067
	0.0060	0.0070	0.0061	0.0060	0.0055	0.0051

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0004	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 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.24 (7.011)	127910.2	100.00
RUNOFF	1.337 (0.9741)	4852.49	3.794
EVAPOTRANSPIRATION	24.796 (3.7968)	90010.30	70.370
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.35957 (0.90370)	30345.227	23.72385
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001 (0.00000)	0.044	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.053 (0.006)		
PERCOLATION/LEAKAGE THROUGH	0.00003 (0.00013)	0.126	0.00010

```
  LAYER  8

 AVERAGE HEAD ON TOP                0.000 (    0.000)
   OF LAYER  8

 CHANGE IN WATER STORAGE            0.744   (  4.2093)       2702.09      2.112

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                PEAK DAILY VALUES FOR YEARS     1 THROUGH   33
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
      PRECIPITATION                                5.27        19130.100

      RUNOFF                                       1.558        5654.0879

      DRAINAGE COLLECTED FROM LAYER  5             0.04161       151.03342

      PERCOLATION/LEAKAGE THROUGH LAYER  6         0.000000        0.00020

      AVERAGE HEAD ON TOP OF LAYER  6              0.097

      MAXIMUM HEAD ON TOP OF LAYER  6              0.193

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)                  4.1 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  8         0.000750        2.72253

      AVERAGE HEAD ON TOP OF LAYER  8              0.063

      SNOW WATER                                   1.37         4974.2432


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4788

      MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1430

       ***  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
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Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 33

LAYER	(INCHES)	(VOL/VOL)
1	1.0870	0.1812
2	642.1511	0.4281
3	659.1862	0.3544
4	6.6040	0.2752
5	0.0547	0.2454
6	0.0000	0.0000
7	0.1868	0.7470
8	5.1240	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:\AR\B\DESIGN\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\DESIGN\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\DESIGN\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\DESIGN\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\DESIGN\CL\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\DESIGN\CL\OUTPUT1.OUT


TIME:  16:11     DATE:   1/27/2022


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

     TITLE:  ARLINGTON LANDFILL - DESIGN CASE - CLOSED 280 FT

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


     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 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.    =   12.1700001000     CM/SEC
   SLOPE                        =     25.00   PERCENT
   DRAINAGE LENGTH              =    500.0    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          =      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                      =      0.6174 VOL/VOL
FIELD CAPACITY                =      0.5127 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                     =   1860.00   INCHES
POROSITY                      =      0.5017 VOL/VOL
FIELD CAPACITY                =      0.4798 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	=	0.22	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.	=	3.49000001000	CM/SEC
SLOPE	=	1.50	PERCENT
DRAINAGE LENGTH	=	800.0	FEET

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

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.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	5.00	HOLES/ACRE

```
FML INSTALLATION DEFECTS     =     20.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                         LAYER 11
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  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.    =  0.499999986000E-09 CM/SEC


                         LAYER 12
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  16
THICKNESS                    =     12.00   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  5.%
         AND A SLOPE LENGTH OF  420. FEET.

SCS RUNOFF CURVE NUMBER               =     81.20
FRACTION OF AREA ALLOWING RUNOFF      =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE    =      1.000   ACRES
EVAPORATIVE ZONE DEPTH                =     12.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE     =      2.928   INCHES
```

UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1302.307	INCHES
TOTAL INITIAL WATER	=	1302.307	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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.016	0.044	0.085	0.105	0.152	0.206
	0.082	0.010	0.137	0.622	0.085	0.087
STD. DEVIATIONS	0.043	0.103	0.195	0.254	0.375	0.313
	0.204	0.027	0.195	1.041	0.229	0.164
EVAPOTRANSPIRATION						
TOTALS	1.596	1.704	2.425	2.583	3.303	2.853
	2.201	1.512	2.658	2.121	1.274	1.523
STD. DEVIATIONS	0.509	0.744	1.019	1.209	1.107	1.500
	1.335	1.138	1.205	0.971	0.517	0.498
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.5632	0.5567	0.6986	0.4304	0.4237	0.7045
	0.2248	0.0318	0.4863	1.8605	0.8772	1.4359
STD. DEVIATIONS	0.7926	0.6695	1.1057	0.6917	0.6501	0.7925
	0.4830	0.0885	0.6070	2.1361	1.2570	1.5514

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

LATERAL DRAINAGE COLLECTED FROM LAYER 9

TOTALS	0.4799	0.4521	0.4929	0.4769	0.4907	0.4708
	0.4881	0.4870	0.4662	0.4784	0.4583	0.4768
STD. DEVIATIONS	0.1818	0.1938	0.2095	0.2019	0.2008	0.1946
	0.1984	0.2047	0.1905	0.1915	0.1836	0.1860

PERCOLATION/LEAKAGE THROUGH LAYER 10

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

PERCOLATION/LEAKAGE THROUGH LAYER 12

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	0.0001	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	0.0006	0.0006	0.0007	0.0004	0.0004	0.0007
	0.0002	0.0000	0.0005	0.0018	0.0009	0.0014
STD. DEVIATIONS	0.0008	0.0007	0.0011	0.0007	0.0006	0.0008
	0.0005	0.0001	0.0006	0.0021	0.0013	0.0015

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0417	0.0432	0.0429	0.0429	0.0427	0.0423

	0.0425	0.0424	0.0419	0.0416	0.0412	0.0415
STD. DEVIATIONS	0.0158	0.0186	0.0182	0.0181	0.0175	0.0175
	0.0173	0.0178	0.0171	0.0167	0.0165	0.0162

DAILY AVERAGE HEAD ON TOP OF LAYER 12

AVERAGES	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.65	(6.690)	129402.2	100.00
RUNOFF	1.632	(1.1003)	5923.41	4.578
EVAPOTRANSPIRATION	25.753	(3.4165)	93482.08	72.241
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.29359	(3.65011)	30105.727	23.26523
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00003	(0.00001)	0.121	0.00009
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	5.71811	(2.30592)	20756.730	16.04047
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00001	(0.00000)	0.039	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.042	(0.017)		
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.00004	(0.00014)	0.130	0.00010

AVERAGE HEAD ON TOP OF LAYER 12	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-5.748 (	2.4092)	-20865.81	-16.125

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.740	6317.0625
DRAINAGE COLLECTED FROM LAYER 2	1.74133	6321.03564
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000005	0.01960
AVERAGE HEAD ON TOP OF LAYER 3	0.054	
MAXIMUM HEAD ON TOP OF LAYER 3	0.187	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.04106	149.03012
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00023
AVERAGE HEAD ON TOP OF LAYER 10	0.111	
MAXIMUM HEAD ON TOP OF LAYER 10	0.220	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	5.6 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.000750	2.72253
AVERAGE HEAD ON TOP OF LAYER 12	0.063	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3522

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	2.0266	0.1689
2	0.0030	0.0100
3	0.0000	0.0000
4	7.6860	0.4270
5	3.7200	0.3100
6	543.5816	0.3624
7	561.2573	0.3018
8	6.2516	0.2605
9	0.0251	0.1130
10	0.0000	0.0000
11	0.1867	0.7470
12	5.1240	0.4270
SNOW WATER	0.000	

HELP MODEL OUTPUT FOR ADDITIONAL CASE

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\AR\B\ADD\AC\DATA4.D4
TEMPERATURE DATA FILE:      C:\AR\B\ADD\AC\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\AR\B\ADD\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\AR\B\ADD\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\AR\B\ADD\AC\DATA10.D10
OUTPUT DATA FILE:           C:\AR\B\ADD\AC\OUTPUT1.OUT


TIME:  17: 4     DATE:   1/27/2022


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

     TITLE:  ARLINGTON LANDFILL - ADD POC ADDITIONAL CASE - ACTIVE 280 FT

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


     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  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                        =       0.6174 VOL/VOL
   FIELD CAPACITY                  =       0.5127 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                       =    1860.00   INCHES
   POROSITY                        =       0.5017 VOL/VOL
   FIELD CAPACITY                  =       0.4798 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                   =      0.22   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.   =   4.03000021000      CM/SEC
SLOPE                       =      0.00   PERCENT
DRAINAGE LENGTH             =   1600.0    FEET


                      LAYER  6
                      --------

           TYPE 4 - FLEXIBLE MEMBRANE LINER
             MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      5.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     20.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                      LAYER  7
                      --------

         TYPE 1 - VERTICAL PERCOLATION LAYER
             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.   =  0.499999986000E-09 CM/SEC


                        LAYER  8
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     12.00   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
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  5.%
          AND A SLOPE LENGTH OF  420. FEET.

SCS RUNOFF CURVE NUMBER            =     81.90
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  =      3.380  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      5.254  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      1.430  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =   1289.830  INCHES
TOTAL INITIAL WATER                =   1289.830  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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 33

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.95	2.57	3.09	3.01	3.79	3.59
	2.36	1.67	3.53	4.53	2.36	2.78
STD. DEVIATIONS	1.31	1.44	1.84	1.79	1.80	2.25
	1.80	1.19	2.01	3.85	1.81	2.09
RUNOFF						
TOTALS	0.009	0.052	0.071	0.091	0.120	0.183
	0.067	0.019	0.108	0.490	0.068	0.059
STD. DEVIATIONS	0.025	0.119	0.155	0.218	0.304	0.288
	0.163	0.059	0.169	0.871	0.205	0.128
EVAPOTRANSPIRATION						
TOTALS	1.539	1.755	2.262	2.396	3.106	2.687
	2.126	1.529	2.428	2.063	1.427	1.479
STD. DEVIATIONS	0.546	0.741	0.997	1.117	1.093	1.380
	1.237	1.067	1.089	0.972	0.622	0.584
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.0610	0.0563	0.0627	0.0608	0.0629	0.0608
	0.0629	0.0630	0.0608	0.0629	0.0609	0.0628
STD. DEVIATIONS	0.0098	0.0045	0.0015	0.0017	0.0020	0.0015
	0.0017	0.0019	0.0019	0.0020	0.0020	0.0015
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0001	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 8						
TOTALS	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
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	14.7239	14.9151	15.1241	15.1435	15.1616	15.1553
	15.1686	15.1986	15.1515	15.1757	15.1784	15.1409
STD. DEVIATIONS	2.3712	1.1730	0.3707	0.4200	0.4776	0.3852
	0.4081	0.4595	0.4722	0.4797	0.5030	0.3548

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
STD. DEVIATIONS	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.24 (7.011)	127910.2	100.00
RUNOFF	1.337 (0.9741)	4852.49	3.794
EVAPOTRANSPIRATION	24.796 (3.7968)	90010.30	70.370
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.73771 (0.02415)	2677.902	2.09358
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00619 (0.00013)	22.460	0.01756
AVERAGE HEAD ON TOP OF LAYER 6	15.103 (0.498)		
PERCOLATION/LEAKAGE THROUGH	0.00621 (0.00001)	22.542	0.01762

LAYER 8

AVERAGE HEAD ON TOP OF LAYER 8	0.001 (	0.000)		
CHANGE IN WATER STORAGE	8.360 (	3.8206)	30346.99	23.725

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 33

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.558	5654.0879
DRAINAGE COLLECTED FROM LAYER 5	0.00228	8.27517
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000017	0.06174
AVERAGE HEAD ON TOP OF LAYER 6	17.060	
MAXIMUM HEAD ON TOP OF LAYER 6	21.442	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1585.9 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000750	2.72253
AVERAGE HEAD ON TOP OF LAYER 8	0.063	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4788
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1430

*** 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 33

LAYER	(INCHES)	(VOL/VOL)
1	1.0870	0.1812
2	767.3539	0.5116
3	783.5726	0.4213
4	8.1975	0.3416
5	0.1895	0.8496
6	0.0000	0.0000
7	0.1868	0.7470
8	5.1240	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:\AR\B\ADD\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\ADD\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\ADD\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\ADD\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\ADD\CL\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\ADD\CL\OUTPUT1.OUT


TIME:  16:17     DATE:   1/27/2022


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     TITLE:  ARLINGTON LANDFILL - ADDITIONAL CASE - CLOSED 280 FT

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     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 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.       =   12.1700001000     CM/SEC
   SLOPE                           =     25.00   PERCENT
   DRAINAGE LENGTH                 =    500.0    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             =      1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS        =      4.00   HOLES/ACRE
   FML PLACEMENT QUALITY           =  3 - GOOD


                         LAYER  4
                         --------

                  TYPE 3 - BARRIER SOIL LINER
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              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                     =      0.6174 VOL/VOL
FIELD CAPACITY               =      0.5127 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                    =   1827.00   INCHES
POROSITY                     =      0.5029 VOL/VOL
FIELD CAPACITY               =      0.4801 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                  =      33.00   INCHES
POROSITY                   =       0.4389 VOL/VOL
FIELD CAPACITY             =       0.4388 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  9
                        --------

            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 10
                        --------

              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.   =    3.49000001000      CM/SEC
SLOPE                      =       0.00   PERCENT
DRAINAGE LENGTH            =    1600.0    FEET
```

LAYER 11

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

```
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      5.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     20.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD
```

LAYER 12

TYPE 1 - VERTICAL PERCOLATION LAYER
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.   =  0.499999986000E-09 CM/SEC
```

LAYER 13

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

```
THICKNESS                   =     12.00   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 5.% AND A SLOPE LENGTH OF 420. FEET.

SCS RUNOFF CURVE NUMBER	=	81.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.928	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1302.307	INCHES
TOTAL INITIAL WATER	=	1302.307	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	=	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

2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.016	0.044	0.085	0.105	0.152	0.206
	0.082	0.010	0.137	0.622	0.085	0.087
STD. DEVIATIONS	0.043	0.103	0.195	0.254	0.375	0.313
	0.204	0.027	0.195	1.041	0.229	0.164

EVAPOTRANSPIRATION

TOTALS	1.596	1.704	2.425	2.583	3.303	2.853
	2.201	1.512	2.658	2.121	1.274	1.523
STD. DEVIATIONS	0.509	0.744	1.019	1.209	1.107	1.500
	1.335	1.138	1.205	0.971	0.517	0.498

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.5632	0.5567	0.6986	0.4304	0.4237	0.7045
	0.2248	0.0318	0.4863	1.8605	0.8772	1.4359
STD. DEVIATIONS	0.7926	0.6695	1.1057	0.6917	0.6501	0.7925
	0.4830	0.0885	0.6070	2.1361	1.2570	1.5514

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

LATERAL DRAINAGE COLLECTED FROM LAYER 10

TOTALS	0.0513	0.0476	0.0528	0.0511	0.0528	0.0511
	0.0526	0.0527	0.0512	0.0528	0.0510	0.0528
STD. DEVIATIONS	0.0080	0.0027	0.0006	0.0005	0.0006	0.0006
	0.0004	0.0005	0.0006	0.0006	0.0004	0.0005

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0001	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 13

TOTALS	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0001	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	0.0006	0.0006	0.0007	0.0004	0.0004	0.0007
	0.0002	0.0000	0.0005	0.0018	0.0009	0.0014
STD. DEVIATIONS	0.0008	0.0007	0.0011	0.0007	0.0006	0.0008
	0.0005	0.0001	0.0006	0.0021	0.0013	0.0015

DAILY AVERAGE HEAD ON TOP OF LAYER 11

AVERAGES	14.3326	14.6289	14.7711	14.7724	14.7769	14.7647
	14.7138	14.7485	14.7880	14.7709	14.7437	14.7783
STD. DEVIATIONS	2.2323	0.7722	0.1562	0.1368	0.1619	0.1638
	0.1237	0.1350	0.1785	0.1680	0.1221	0.1543

DAILY AVERAGE HEAD ON TOP OF LAYER 13

AVERAGES	0.0008	0.0007	0.0007	0.0007	0.0007	0.0007
	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
STD. DEVIATIONS	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.65	(6.690)	129402.2	100.00
RUNOFF	1.632	(1.1003)	5923.41	4.578
EVAPOTRANSPIRATION	25.753	(3.4165)	93482.08	72.241
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.29359	(3.65011)	30105.727	23.26523
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00003	(0.00001)	0.121	0.00009

AVERAGE HEAD ON TOP OF LAYER 3	0.001 (	0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.61995 (	0.01001)	2250.406	1.73908
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00619 (	0.00011)	22.460	0.01736
AVERAGE HEAD ON TOP OF LAYER 11	14.716 (	0.239)		
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.00621 (	0.00003)	22.551	0.01743
AVERAGE HEAD ON TOP OF LAYER 13	0.001 (	0.000)		
CHANGE IN WATER STORAGE	-0.656 (	0.5478)	-2381.89	-1.841

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.740	6317.0625
DRAINAGE COLLECTED FROM LAYER 2	1.74133	6321.03564
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000005	0.01960
AVERAGE HEAD ON TOP OF LAYER 3	0.054	
MAXIMUM HEAD ON TOP OF LAYER 3	0.187	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 10	0.00179	6.49120
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000017	0.06174

```
AVERAGE HEAD ON TOP OF LAYER 11              15.508

MAXIMUM HEAD ON TOP OF LAYER 11              19.482

LOCATION OF MAXIMUM HEAD IN LAYER 10
      (DISTANCE FROM DRAIN)                1584.5 FEET

PERCOLATION/LEAKAGE THROUGH LAYER 13          0.000750         2.72252

AVERAGE HEAD ON TOP OF LAYER 13               0.062

SNOW WATER                                    1.37          4974.2432


MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.3522

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           2.0266          0.1689

                 2           0.0030          0.0100

                 3           0.0000          0.0000

                 4           7.6860          0.4270

                 5           3.7200          0.3100

                 6         570.0010          0.3800
```

7	674.7179	0.3693
8	10.8823	0.3298
9	8.0853	0.3369
10	0.1887	0.8500
11	0.0000	0.0000
12	0.1867	0.7470
13	5.1240	0.4270
SNOW WATER	0.000	

****
****

HELP MODEL OUTPUT FOR PRE-SUBTITLE D FINAL COVER

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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:\AR\B\PRED\DATA4.D4
TEMPERATURE DATA FILE:      C:\AR\B\PRED\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\AR\B\PRED\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\AR\B\PRED\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\AR\B\PRED\DATA10.D10
OUTPUT DATA FILE:           C:\AR\B\PRED\OUTPUT1.OUT


TIME: 104:41     DATE:   1/17/2022


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     TITLE:  ARLINGTON LANDFILL - PRE-D CASE

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


     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   5
          THICKNESS                        =      6.00   INCHES
```

```
     POROSITY                        =      0.4570 VOL/VOL
     FIELD CAPACITY                  =      0.1310 VOL/VOL
     WILTING POINT                   =      0.0580 VOL/VOL
     INITIAL SOIL WATER CONTENT      =      0.3980 VOL/VOL
     EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
   NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
            FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                               LAYER  2
                               --------

                     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.       =  0.200000002000E-06 CM/SEC


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

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
            GOOD STAND OF GRASS, A SURFACE SLOPE OF 25.%
            AND A SLOPE LENGTH OF  200. FEET.

   SCS RUNOFF CURVE NUMBER              =     60.40
   FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
   EVAPORATIVE ZONE DEPTH               =      6.0    INCHES
   INITIAL WATER IN EVAPORATIVE ZONE    =      2.388  INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE   =      2.742  INCHES
   LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.348  INCHES
   INITIAL SNOW WATER                   =      0.000  INCHES
   INITIAL WATER IN LAYER MATERIALS     =     10.074  INCHES
   TOTAL INITIAL WATER                  =     10.074  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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 27

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.13	2.75	2.72	2.66	3.43	4.67
	3.50	1.44	4.82	4.06	2.29	3.73
STD. DEVIATIONS	1.79	1.08	1.07	1.01	2.18	2.47
	2.53	1.01	1.51	4.01	1.58	1.92
RUNOFF						
TOTALS	0.583	0.683	0.289	0.319	0.312	0.880
	0.147	0.000	0.493	1.791	0.608	1.485
STD. DEVIATIONS	0.640	0.806	0.502	0.684	0.599	0.849
	0.388	0.000	0.597	3.607	1.041	1.501
EVAPOTRANSPIRATION						
TOTALS	1.537	1.897	2.050	2.738	3.726	3.595
	3.265	1.694	3.356	1.964	1.085	1.666
STD. DEVIATIONS	0.362	0.381	0.501	0.911	1.361	1.912
	1.679	1.205	1.274	1.198	0.594	0.516
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.2533	0.2333	0.2522	0.2393	0.1452	0.0846
	0.0473	0.0206	0.1244	0.1715	0.1965	0.2352
STD. DEVIATIONS	0.0124	0.0075	0.0062	0.0087	0.0462	0.0561
	0.0396	0.0282	0.0709	0.1135	0.0915	0.0549

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	3.9072	3.9373	3.5216	3.1052	1.2569	0.9176

	0.4418	0.1371	1.2895	2.4258	2.5441	3.7327
STD. DEVIATIONS	0.6860	0.6670	0.5275	0.7664	0.7163	0.8018
	0.5581	0.2384	0.9859	2.2276	2.0026	1.9733

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 27

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.18	(4.813)	138588.2	100.00
RUNOFF	7.590	(4.1444)	27552.74	19.881
EVAPOTRANSPIRATION	28.572	(4.1727)	103717.98	74.839
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.00339	(0.21690)	7272.323	5.24743
AVERAGE HEAD ON TOP OF LAYER 2	2.268	(0.459)		
CHANGE IN WATER STORAGE	0.012	(1.0426)	45.19	0.033

****

****

PEAK DAILY VALUES FOR YEARS 21 THROUGH 27

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	4.465	16206.3359
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.009071	32.92681
AVERAGE HEAD ON TOP OF LAYER 2	6.000	
SNOW WATER	0.81	2941.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)   0.4570

MINIMUM VEG. SOIL WATER (VOL/VOL)   0.0580

****

****

FINAL WATER STORAGE AT END OF YEAR 27

LAYER	(INCHES)	(VOL/VOL)
1	2.4751	0.4125
2	7.6860	0.4270
SNOW WATER	0.000	

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****

HELP MODEL OUTPUT FOR OFF-SITE AREAS (RECHARGE)

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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:\AR\B\OFFSITE\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\OFFSITE\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\OFFSITE\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\OFFSITE\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\OFFSITE\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\OFFSITE\OUTPUT1.OUT


TIME:  16:44     DATE:   1/17/2022


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

     TITLE:  ARLINGTON LANDFILL - OFF SITE RECHRAGE

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


     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                     =      6.00   INCHES
```

POROSITY	=	0.4200 VOL/VOL
FIELD CAPACITY	=	0.3500 VOL/VOL
WILTING POINT	=	0.3000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.569999997000E-06 CM/SEC

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	354.00 INCHES
POROSITY	=	0.4200 VOL/VOL
FIELD CAPACITY	=	0.3500 VOL/VOL
WILTING POINT	=	0.3000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4200 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	95.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.800	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.520	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.800	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	150.480	INCHES
TOTAL INITIAL WATER	=	150.480	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 = 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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.666	1.116	1.507	1.269	1.716	1.884
	1.004	0.437	1.737	3.093	1.236	1.688
STD. DEVIATIONS	0.797	0.889	1.399	1.279	1.341	1.483
	1.169	0.519	1.328	3.334	1.411	1.646
EVAPOTRANSPIRATION						
TOTALS	1.177	1.314	1.568	1.768	2.119	1.744
	1.436	1.129	1.833	1.638	1.031	1.260
STD. DEVIATIONS	0.573	0.671	0.704	0.922	0.738	0.970
	0.828	0.774	0.740	0.835	0.543	0.548
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0433	0.0401	0.0300	0.0152	0.0097	0.0085
	0.0038	0.0018	0.0066	0.0277	0.0345	0.0553
STD. DEVIATIONS	0.0315	0.0272	0.0192	0.0162	0.0099	0.0082
	0.0059	0.0042	0.0085	0.0223	0.0304	0.0354

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.5484	0.5963	0.4408	0.2054	0.1596	0.1297
	0.0482	0.0211	0.1167	0.5011	0.5881	1.0781
STD. DEVIATIONS	0.5486	0.5676	0.4236	0.2712	0.1775	0.1549
	0.0933	0.0546	0.1579	0.4505	0.7156	0.9853

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.65	(6.690)	129402.2	100.00
RUNOFF	17.353	(4.5908)	62993.19	48.680
EVAPOTRANSPIRATION	18.016	(2.6950)	65399.52	50.540
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.27665	(0.08333)	1004.230	0.77605
AVERAGE HEAD ON TOP OF LAYER 2	0.369	(0.130)		
CHANGE IN WATER STORAGE	0.001	(0.2528)	5.29	0.004

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	4.480	16263.7900
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.003459	12.55680
AVERAGE HEAD ON TOP OF LAYER 2	6.000	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4200
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.3000

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.8437	0.3073
2	148.6800	0.4200
SNOW WATER	0.000	

****
****

APPENDIX IIIB-A.1

ADDITIONAL HELP INFORMATION

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIB-A.1-1 through IIIB-A.1-22

ADDITIONAL HELP INFORMATION

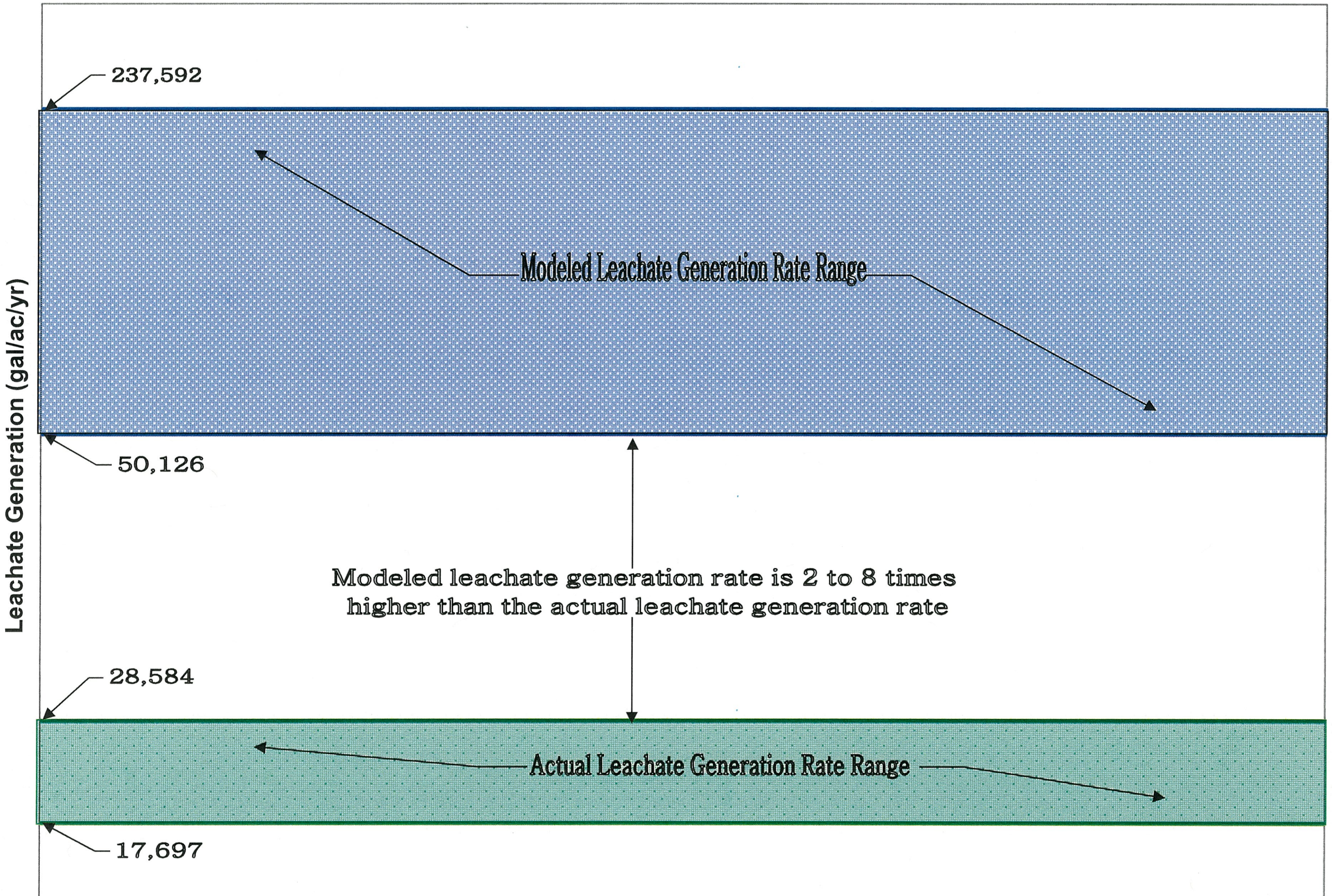
The purpose of this appendix is to demonstrate that the waste column thicknesses selected in Appendix IIIB-A provide conservative (i.e., higher) percolation rates, leachate generation values, and head on liner values for use in MODFLOW. To demonstrate this, additional HELP runs were performed to provide each case (Design Case and Additional Case) with an active case run using a 20-foot waste column thickness and a 280-foot waste column thickness. The HELP model summary table and output are provided beginning on page IIIB-A.1-3. The results are summarized in the table below.

Table 1
Additional HELP Modeling Results

Item	Design Case		Additional Case	
Waste Column Thickness (Location of HELP Output)	280 ft (Appendix IIIB-A)	20 ft (Appendix IIIB-A.1)	280 ft (Appendix IIIB-A)	20 ft (Appendix IIIB-A.1)
Leachate Generation (cf/yr)	30,345.2	28,322.1	25,060.6	2,678.2
Average Head on Overliner (in)	0.053	0.016	32.976	15.186
Percolation through Overliner (mm/yr)	0.001	0.001	0.14	0.16

As shown in the table, the percolation rates, leachate generation values, and head on liner values from the Appendix IIIB-A HELP runs are higher than the HELP runs included in this appendix. Therefore, the scenarios presented in Appendix IIIB-A provide a conservative input for MODFLOW because the highest percolation rates were used in the MODFLOW model. However, any waste column thickness modeled would provide a conservative analysis because the modeled leachate generation values are much higher than the actual site leachate generation values as shown on Figure 1. As shown on Figure 1, modeled leachate generation rates are 2 to 8 times higher than the actual leachate generation rates. Therefore, the POC demonstration is based on a HELP analysis that provides the highest percolation rate through the overliner to provide a conservative analysis.

Figure 1
Leachate Generation Comparison



CITY OF ARLINGTON LANDFILL
0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
POC - ADDITIONAL HELP DEMONSTRATIONS

			DESIGN CASE		ADDITIONAL CASE	
			ACTIVE (20 FT WASTE)	ACTIVE (280 FT WASTE)	ACTIVE (20 FT WASTE)	ACTIVE (280 FT WASTE)
GENERAL INFORMATION		Case No.	1	2	1	2
		No. of Years	33	33	33	33
		Ground Cover	FAIR	FAIR	FAIR	FAIR
		SCS Runoff Curve No.	81.9	81.9	81.9	81.9
		Model Area (acre)	1	1	1	1
		Runoff Area (%)	80	90	80	80
		Maximum Leaf Area Index	2.0	2.0	2.0	2.0
		Evaporative Zone Depth (inch)	10	10	10	10
Final Cover	TOPSOIL LAYER (Texture = 10)	Thickness (in)				
		Porosity (vol/vol)				
		Field Capacity (vol/vol)				
		Wilting Point (vol/vol)				
		Init. Moisture Content (vol/vol)				
		Hyd. Conductivity (cm/s)				
	GEOCOMPIOSITE DRAINAGE LAYER (Texture = 0)	Thickness (in)				
		Porosity (vol/vol)				
		Field Capacity (vol/vol)				
		Wilting Point (vol/vol)				
		Init. Moisture Content (vol/vol)				
		Hyd. Conductivity (cm/s)				
		Slope (%)				
		Slope Length (ft)				
	FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)				
		Hyd. Conductivity (cm/s)				
		Pinhole Density (holes/acre)				
		Install. Defects (holes/acre)				
		Placement Quality				
	INFILTRATION LAYER (Texture = 0)	Thickness (in)				
		Porosity (vol/vol)				
		Field Capacity (vol/vol)				
		Wilting Point (vol/vol)				
		Init. Moisture Content (vol/vol)				
		Hyd. Conductivity (cm/s)				
Intermediate Cover	INTERMEDIATE COVER (Texture = 11) (Active Cases Modeled with 6 inch-thick daily cover)	Thickness (in)	6	6	6	6
		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[1] (Texture = 0)	Thickness (in)	240	1500	240	1500
		Porosity (vol/vol)	0.6607	0.6174	0.6607	0.6174
		Field Capacity (vol/vol)	0.5250	0.5127	0.5250	0.5127
		Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770
		Init. Moisture Content (vol/vol)	0.2500	0.3800	0.2500	0.3800
		Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03
	WASTE BOTTOM[1] (Texture = 0)	Thickness (in)		1860		1860
		Porosity (vol/vol)		0.5017		0.5017
		Field Capacity (vol/vol)		0.4798		0.4798
		Wilting Point (vol/vol)		0.0770		0.0770
		Init. Moisture Content (vol/vol)		0.3800		0.3800
		Hyd. Conductivity (cm/s)		1.0E-04		1.0E-04
	WASTE BOTTOM-SATURATED[1] (Texture = 0)	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)	0.300	0.223	0.300	0.223
		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)	12.78	4.03	12.78	4.03
		Slope[2] (%)	1.5	1.5	0.001	0.001
		Slope Length (ft)	800	800	1,600	1,600
	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)	5	5	5	5
		Install. Defects (holes/acre)	20	20	20	20
		Placement Quality	GOOD	GOOD	GOOD	GOOD
	GEOSYNTHETIC CLAY LINER (Texture = 0)	Thickness (in)	0.25	0.25	0.25	0.25
		Porosity (vol/vol)	0.7500	0.7500	0.7500	0.7500
		Field Capacity (vol/vol)	0.7470	0.7470	0.7470	0.7470
		Wilting Point (vol/vol)	0.4000	0.4000	0.4000	0.4000
		Init. Moisture Content (vol/vol)	0.7470	0.7470	0.7470	0.7470
		Hyd. Conductivity (cm/s)	5.0E-09	5.0E-09	5.0E-09	5.0E-09
	COMPACTED SOIL LAYER (Texture = 0)	Thickness (in)	12.00	12.00	12.00	12.00
		Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270
		Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180
		Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670
		Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270
		Hyd. Conductivity (cm/s)	1.0E-06	1.0E-06	1.0E-06	1.0E-06
PRECIPITATION		Average Annual (in)	35.24	35.24	35.24	35.24
RUNOFF		Average Annual (in)	1.19	1.34	1.19	1.34
EVAPOTRANSPIRATION		Average Annual (in)	25.10	24.80	25.10	24.80
HEAD ON OVERLINER		Average Annual (in)	0.016	0.053	32.976	15.106
LEACHATE GENERATION (OVERLINER)		Average Annual (cf/yr)	28,322.1	30,345.2	25,060.6	2,678.2
PERCOLATION THROUGH			Overliner	Overliner	Overliner	Overliner
PERCOLATION VALUES		Average Annual (in/yr)	0.00003	0.00003	0.00555	0.00621
		Average Annual (mm/yr)	0.001	0.001	0.14	0.16

Notes: [1] 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.

[2] Slope of 0.001 is shown as 0.00 in the HELP Model output files due to the fact that the HELP Model prints the slope value with two decimal points (e.g., see slope information for layer

HELP MODEL OUTPUT FILES

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\AR\B\A1\DESIGN\AC20\DATA4.D4
TEMPERATURE DATA FILE:        C:\AR\B\A1\DESIGN\AC20\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\AR\B\A1\DESIGN\AC20\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\AR\B\A1\DESIGN\AC20\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\AR\B\A1\DESIGN\AC20\DATA10.D10
OUTPUT DATA FILE:             C:\AR\B\A1\DESIGN\AC20\OUTPUT1.OUT


TIME:  16:36     DATE:   1/27/2022


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

     TITLE:  ARLINGTON LANDFILL - ADD POC - DESIGN CASE - ACTIVE 20 FT

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


     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  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                           LAYER  2
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =    240.00   INCHES
   POROSITY                        =       0.6607 VOL/VOL
   FIELD CAPACITY                  =       0.5250 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.   =   12.7799997000     CM/SEC
SLOPE                       =      1.50   PERCENT
DRAINAGE LENGTH             =    800.0    FEET


                       LAYER  5
                       --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
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.   = 0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      5.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     20.00   HOLES/ACRE
FML PLACEMENT QUALITY       = 3 - GOOD


                       LAYER  6
                       --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               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.   = 0.499999986000E-09 CM/SEC


                       LAYER  7
                       --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     12.00   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
       GOOD STAND OF GRASS, A SURFACE SLOPE OF  5.%
       AND A SLOPE LENGTH OF  420. FEET.

SCS RUNOFF CURVE NUMBER             =     81.90
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   =      2.860  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      5.427  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.430  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     73.031  INCHES
TOTAL INITIAL WATER                 =     73.031  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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 33

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.95	2.57	3.09	3.01	3.79	3.59
	2.36	1.67	3.53	4.53	2.36	2.78
STD. DEVIATIONS	1.31	1.44	1.84	1.79	1.80	2.25
	1.80	1.19	2.01	3.85	1.81	2.09
RUNOFF						
TOTALS	0.009	0.047	0.063	0.081	0.107	0.164

	0.059	0.017	0.096	0.437	0.062	0.053
STD. DEVIATIONS	0.023	0.107	0.138	0.194	0.272	0.257
	0.145	0.053	0.151	0.776	0.187	0.114

EVAPOTRANSPIRATION

TOTALS	1.563	1.769	2.309	2.407	3.167	2.718
	2.159	1.540	2.459	2.082	1.439	1.492
STD. DEVIATIONS	0.543	0.742	1.008	1.134	1.088	1.388
	1.260	1.087	1.115	0.973	0.624	0.587

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.7119	0.6436	0.6542	0.6318	0.6419	0.6599
	0.6594	0.6277	0.5811	0.6722	0.6311	0.6875
STD. DEVIATIONS	0.3583	0.2991	0.2891	0.2785	0.2703	0.2964
	0.2640	0.2468	0.2410	0.2862	0.2528	0.2714

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

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	0.0001	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	0.0169	0.0168	0.0155	0.0155	0.0152	0.0162
	0.0157	0.0149	0.0143	0.0160	0.0155	0.0163
STD. DEVIATIONS	0.0085	0.0078	0.0069	0.0068	0.0064	0.0073
	0.0063	0.0059	0.0059	0.0068	0.0062	0.0064

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.24 (7.011)	127910.2	100.00
RUNOFF	1.193 (0.8688)	4331.10	3.386
EVAPOTRANSPIRATION	25.103 (3.8482)	91124.25	71.241
LATERAL DRAINAGE COLLECTED FROM LAYER 4	7.80222 (3.17571)	28322.072	22.14215
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00001 (0.00000)	0.025	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.016 (0.006)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00003 (0.00013)	0.107	0.00008
AVERAGE HEAD ON TOP OF LAYER 7	0.000 (0.000)		
CHANGE IN WATER STORAGE	1.138 (4.6620)	4132.68	3.231

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 33

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.386	5030.8579
DRAINAGE COLLECTED FROM LAYER 4	0.08411	305.33243
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00013
AVERAGE HEAD ON TOP OF LAYER 5	0.062	
MAXIMUM HEAD ON TOP OF LAYER 5	0.123	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	3.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000750	2.72255
AVERAGE HEAD ON TOP OF LAYER 7	0.063	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5014
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1430

*** 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 33

LAYER	(INCHES)	(VOL/VOL)

1	1.0869	0.1812
2	97.6188	0.4067
3	6.5715	0.2738
4	0.0123	0.0409
5	0.0000	0.0000
6	0.1867	0.7470
7	5.1240	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:\AR\B\A1\ADD\AC20\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\A1\ADD\AC20\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\A1\ADD\AC20\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\A1\ADD\AC20\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\A1\ADD\AC20\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\A1\ADD\AC20\OUTPUT1.OUT


TIME:  17: 2     DATE:   1/27/2022


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

     TITLE:  ARLINGTON LANDFILL - ADDITIONAL CASE - ACTIVE 20 FT

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


     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  3.00
          FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER  2
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   0
     THICKNESS                     =    240.00   INCHES
     POROSITY                      =      0.6607 VOL/VOL
     FIELD CAPACITY                =      0.5250 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.   =   12.7799997000     CM/SEC
SLOPE                       =      0.00   PERCENT
DRAINAGE LENGTH             =   1600.0    FEET


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      5.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     20.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              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.   =  0.499999986000E-09 CM/SEC


                        LAYER  7
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     12.00   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
       GOOD STAND OF GRASS, A SURFACE SLOPE OF  5.%
       AND A SLOPE LENGTH OF  420. FEET.

SCS RUNOFF CURVE NUMBER              =     81.90
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    =      2.860  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      5.427  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.430  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =     73.031  INCHES
TOTAL INITIAL WATER                  =     73.031  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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 33

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.95	2.57	3.09	3.01	3.79	3.59
	2.36	1.67	3.53	4.53	2.36	2.78
STD. DEVIATIONS	1.31	1.44	1.84	1.79	1.80	2.25
	1.80	1.19	2.01	3.85	1.81	2.09
RUNOFF						
TOTALS	0.009	0.047	0.063	0.081	0.107	0.164

	0.059	0.017	0.096	0.437	0.062	0.053
STD. DEVIATIONS	0.023	0.107	0.138	0.194	0.272	0.257
	0.145	0.053	0.151	0.776	0.187	0.114

EVAPOTRANSPIRATION

TOTALS	1.563	1.769	2.309	2.407	3.167	2.718
	2.159	1.540	2.459	2.082	1.439	1.492
STD. DEVIATIONS	0.543	0.742	1.008	1.134	1.088	1.388
	1.260	1.087	1.115	0.973	0.624	0.587

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.6509	0.5789	0.6194	0.5748	0.5864	0.5671
	0.5703	0.5146	0.4765	0.5786	0.5821	0.6303
STD. DEVIATIONS	0.4422	0.3771	0.3907	0.3549	0.3482	0.3287
	0.3313	0.2896	0.2625	0.3193	0.3439	0.3865

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0005	0.0004	0.0005	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002
	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0005	0.0004	0.0005	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002
	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	36.5478	35.6984	34.8096	33.4198	33.0028	32.9775
	32.1171	29.0215	27.7772	32.5659	33.8324	35.4215
STD. DEVIATIONS	24.6532	23.1402	21.8241	20.4980	19.4722	19.0034
	18.5441	16.2399	15.2257	17.8797	19.8788	21.5847

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006
	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
STD. DEVIATIONS	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002
	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.24 (7.011)	127910.2	100.00
RUNOFF	1.193 (0.8688)	4331.10	3.386
EVAPOTRANSPIRATION	25.103 (3.8482)	91124.25	71.241
LATERAL DRAINAGE COLLECTED FROM LAYER 4	6.92999 (3.86612)	25155.881	19.66683
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00553 (0.00183)	20.079	0.01570
AVERAGE HEAD ON TOP OF LAYER 5	33.099 (18.383)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00555 (0.00176)	20.162	0.01576
AVERAGE HEAD ON TOP OF LAYER 7	0.001 (0.000)		
CHANGE IN WATER STORAGE	2.005 (5.0996)	7278.81	5.691

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 33

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.386	5030.8579
DRAINAGE COLLECTED FROM LAYER 4	0.05045	183.12828
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000017	0.06174
AVERAGE HEAD ON TOP OF LAYER 5	87.055	
MAXIMUM HEAD ON TOP OF LAYER 5	110.286	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	1597.2 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000750	2.72255
AVERAGE HEAD ON TOP OF LAYER 7	0.063	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5014
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1430

*** 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 33

LAYER	(INCHES)	(VOL/VOL)

1	1.0869	0.1812
2	124.3095	0.5180
3	8.2393	0.3433
4	0.2550	0.8500
5	0.0000	0.0000
6	0.1867	0.7470
7	5.1240	0.4270
SNOW WATER	0.000	

****
****

APPENDIX IIIB-B

ASSESSMENT OF GROUNDWATER LEVELS

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIB-B-1 through IIIB-B-3

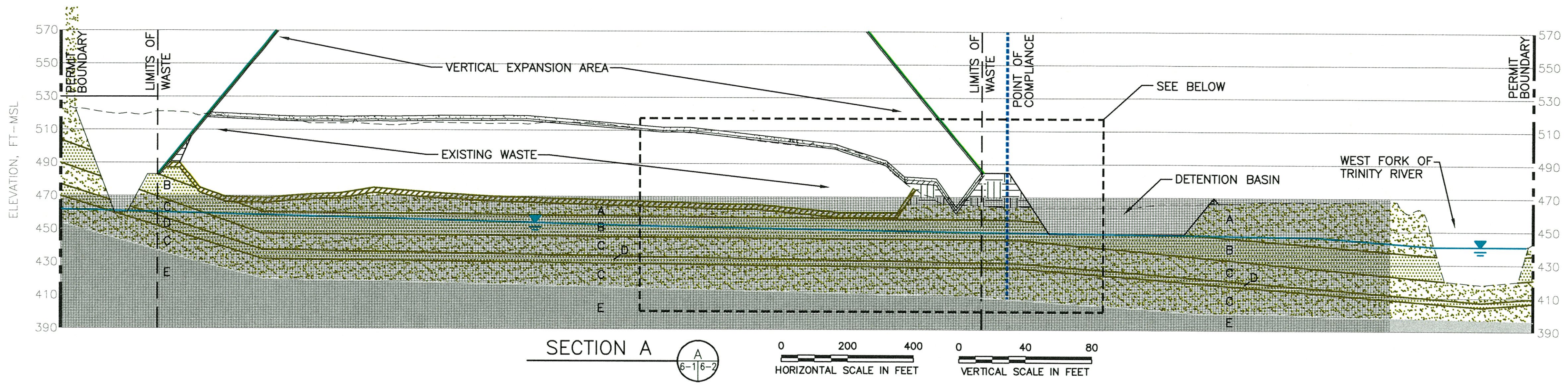
ASSESSMENT OF GROUNDWATER LEVELS

The purpose of this appendix is to provide a summary of groundwater levels between the landfill and the POC during the active life and postclosure period. The figures in Section 6 and Section 7 of Appendix IIIB only show the groundwater surface at the end of the postclosure period. This appendix will summarize how the groundwater potentiometric surface varies during the modeling period. The design case discussed in Section 6 is used for this assessment.

As discussed in Section 4.3 of Appendix IIIB, the modeling period covers a 63-year timeframe (33 years active life and 30 years with final cover). Groundwater level information throughout the 63-year modeling period is shown on Figures A and B. As noted on each of the figures, the initial groundwater potentiometric surface used for the POC demonstration was obtained from a September 2021 event. The other groundwater level information was obtained from the MODFLOW model output for selected years.

As shown on Figures A and B, after year 10 there is very little change in the potentiometric surface. For both sections, the groundwater levels decrease due to the very low percolation rate through the overliner system (i.e., 0.001 mm/yr for the active and closed conditions).

Given the change to the site condition during the modeling period due to the continued development of the WDA overliner system, the modeled groundwater elevations are within the expected range.



SUBSURFACE SOILS INFORMATION

(SEE NOTE 5)

A – UPPER ALLUVIUM SOILS
(HORIZ. $K_{MAX}=6.3\times10^{-8}$ cm/s)
(VERT. $K_{MAX}=5.7\times10^{-7}$ cm/s)

B – UPPER TRANSMISSIVE ZONE
(HORIZ. $K_{MAX}=5.23\times10^{-2}$ cm/s)
(VERT. $K_{MAX}=5.23\times10^{-2}$ cm/s)

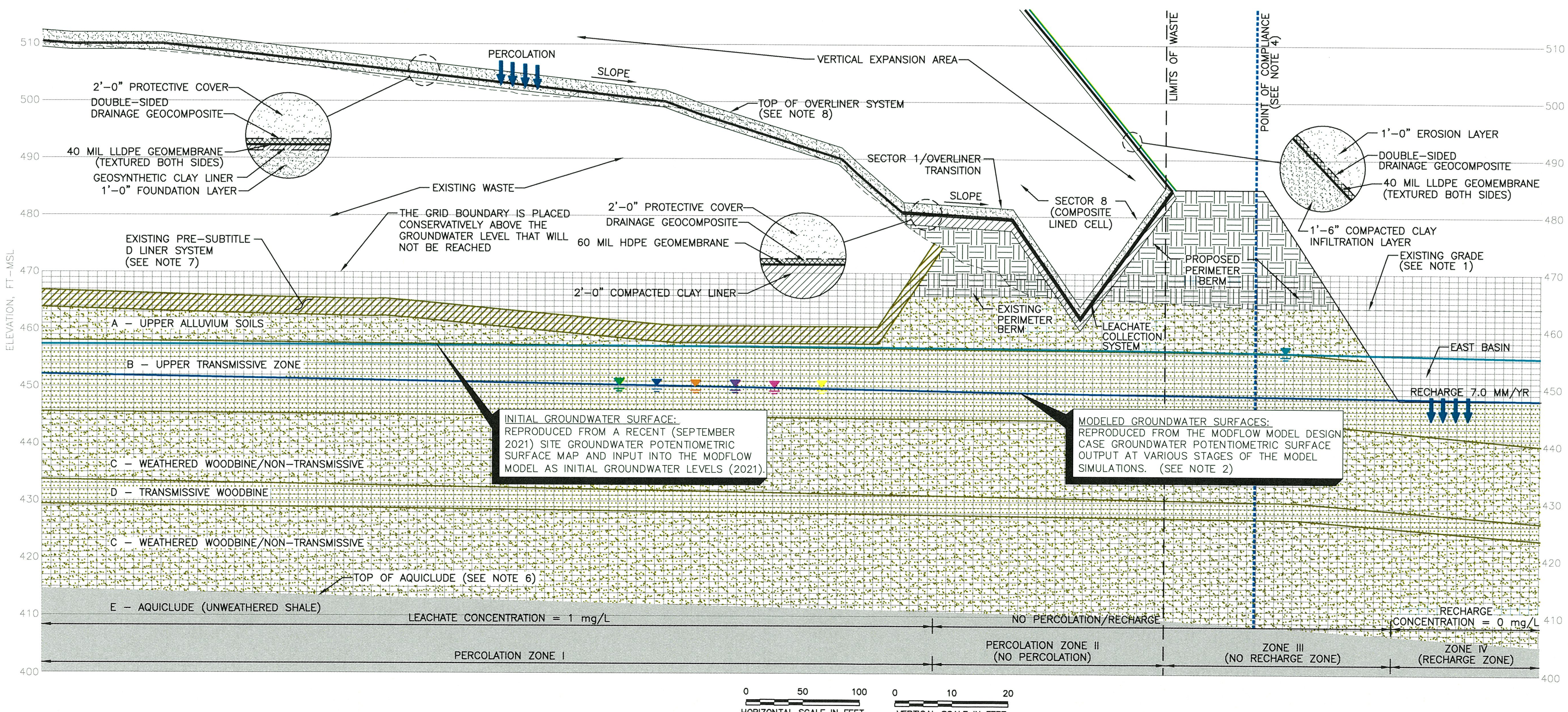
C – WEATHERED WOODBINE/ NON-TRANSMISSIVE
(HORIZ. $K_{MAX}=3.2\times10^{-7}$ cm/s)
(VERT. $K_{MAX}=1.7\times10^{-7}$ cm/s)

D – TRANSMISSIVE WOODBINE
(HORIZ. $K_{MAX}=6.2\times10^{-4}$ cm/s)
(VERT. $K_{MAX}=4.7\times10^{-4}$ cm/s)

E – AQUICLUDE (UNWEATHERED SHALE)
(HORIZ. $K_{MAX}=1.5\times10^{-6}$ cm/s)
(VERT. $K_{MAX}=3.5\times10^{-7}$ cm/s)

LEGEND

- GROUNDWATER SURFACE
- GROUNDWATER SURFACE (10 YEARS)
- GROUNDWATER SURFACE (20 YEARS)
- GROUNDWATER SURFACE (30 YEARS)
- GROUNDWATER SURFACE (40 YEARS)
- GROUNDWATER SURFACE (50 YEARS)
- GROUNDWATER SURFACE (63 YEARS)



NOTES:

1. REFER TO FIGURE 6-1 OF APPENDIX IIIB FOR SECTION LOCATION.
2. THE GROUNDWATER SURFACE SHOWN REPRESENTS THE GROUNDWATER POTENTIOMETRIC SURFACE AT YEARS 10, 20, 30, 40, 50 AND 63. REFER TO PAGE IIIB-6 FOR A DISCUSSION OF GROUNDWATER LEVELS.

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED PROFESSIONAL ENGINEER

5-19-2022

O:\0023\404\EXPANSION 2021\PART III\IIIB\FIG A - SECTION A.dwg, jwilson, 1:2

SHEET IIIB-B-2

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: FIG A SECTION A.dwg

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

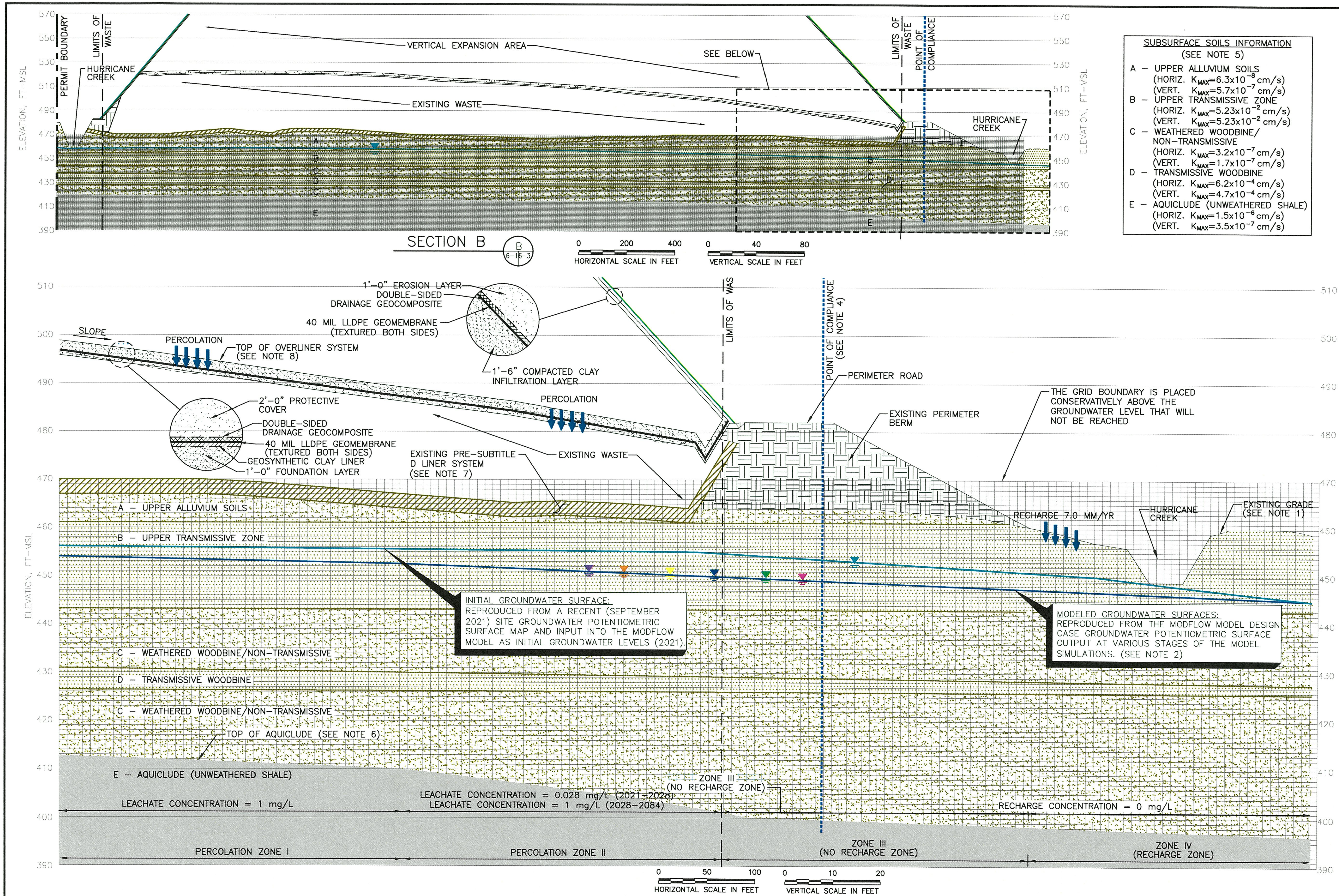
REVISIONS		
NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
SECTION A GROUNDWATER POTENTIOMETRIC SURFACE

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE A



SUBSURFACE SOILS INFORMATION
(SEE NOTE 5)

A – UPPER ALLUVIUM SOILS
(HORIZ. $K_{MAX}=6.3\times10^{-8}$ cm/s)
(VERT. $K_{MAX}=5.7\times10^{-7}$ cm/s)

B – UPPER TRANSMISSIVE ZONE
(HORIZ. $K_{MAX}=5.23\times10^{-2}$ cm/s)
(VERT. $K_{MAX}=5.23\times10^{-2}$ cm/s)

C – WEATHERED WOODBINE/NON-TRANSMISSIVE
(HORIZ. $K_{MAX}=3.2\times10^{-7}$ cm/s)
(VERT. $K_{MAX}=1.7\times10^{-7}$ cm/s)

D – TRANSMISSIVE WOODBINE
(HORIZ. $K_{MAX}=6.2\times10^{-4}$ cm/s)
(VERT. $K_{MAX}=4.7\times10^{-4}$ cm/s)

E – AQUICLUDE (UNWEATHERED SHALE)
(HORIZ. $K_{MAX}=1.5\times10^{-6}$ cm/s)
(VERT. $K_{MAX}=3.5\times10^{-7}$ cm/s)

LEGEND

GROUNDWATER SURFACE
GROUNDWATER SURFACE (10 YEARS)
GROUNDWATER SURFACE (20 YEARS)
GROUNDWATER SURFACE (30 YEARS)
GROUNDWATER SURFACE (40 YEARS)
GROUNDWATER SURFACE (50 YEARS)
GROUNDWATER SURFACE (63 YEARS)

NOTES:

1. REFER TO FIGURE 6-1 OF APPENDIX IIIB FOR SECTION LOCATION.
2. THE GROUNDWATER SURFACE SHOWN REPRESENTS THE GROUNDWATER POTENTIOMETRIC SURFACE AT YEARS 10, 20, 30, 40, 50 AND 63. REFER TO PAGE IIIB-6 FOR A DISCUSSION OF GROUNDWATER LEVELS.

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

☐ DRAFT	
☒ FOR PERMITTING PURPOSES ONLY	
☐ ISSUED FOR CONSTRUCTION	
DATE: 05/2022	DRAWN BY: JDW
FILE: 0023-404-11	DESIGN BY: BPY
CAD: FIG B SECTION B.dwg	REVIEWED BY: RJS

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
SECTION B GROUNDWATER POTENTIOMETRIC SURFACE

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE B

SHEET IIIB-B-3

O:\0023\404\EXPANSION 2021\PART III\IIIB\FIG B - SECTION B.dwg, jwilson, 1:2

APPENDIX IIIB-C

ALTERNATIVE LINER EQUIVALENCY DEMONSTRATION

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIB-C-1 through IIIB-C-136

ALTERNATIVE LINER EQUIVALENCY DEMONSTRATION

1.0 PURPOSE AND SCOPE

The purpose of this appendix is to demonstrate that the proposed alternative liner for the undeveloped, Subtitle D portion of the landfill is equivalent to the composite liner specified in Title 30 Texas Administrative Code (TAC) §330.331(a)(2). The following sections provide a description of the proposed alternative liner, the methods used in the analysis, and the results of the demonstration.

2.0 PROPOSED ALTERNATIVE LINER

The proposed alternative liner system for future sectors will consist of a 60-mil HDPE geomembrane placed over a geosynthetic clay liner (GCL). A geocomposite leachate collection layer consisting of a 250-mil-thick geonet with a 6 oz/sy non-woven geotextile heat-bonded to both sides for sideslopes and a geotextile heat-bonded to one side for the floor grades will be placed above the geomembrane and will be covered with a 2-foot-thick layer of protective cover soil.

Details for the alternative liner system are provided in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. Liner slope stability calculations are presented in Appendix IIIE – Geotechnical Report.

3.0 EQUIVALENCY DEMONSTRATION METHODS

This alternative liner equivalency demonstration has been developed using the HELP model. The HELP model was used to estimate and compare the leachate percolation through the alternative liner (GCL/geomembrane/leachate collection layer) and the composite liner specified in Title 30 TAC §330.331(a)(2) (compacted clay liner/geomembrane/leachate collection layer). The HELP model analysis, including assumptions, landfill profiles analyzed, and model outputs, is presented in Appendix IIIB-A. The results of the HELP model analysis are discussed in Section 4.

4.0 EQUIVALENCY DEMONSTRATION RESULTS

The results of the HELP model analysis are presented graphically on Figure 1 on Page IIIB-C-5. As shown, the percolation rates for the alternative liner that includes a GCL component is less than the standard liner that includes a compacted clay liner component. Therefore, the alternative composite liner incorporating GCL is equivalent or more protective than the composite liner specified in Title 30 TAC §330.331(a)(2).

Additionally, the percolation values modeled in this appendix were used to demonstrate the proposed containment system design meets the point of compliance (POC) requirements set forth in Title 30 TAC §330.331(a) 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 of the POC. This demonstration uses the higher percolation values for the standard composite liner system (i.e., compacted clay components) to represent the Subtitle D area in the POC demonstration in Appendix IIIB, which provides for a conservative analysis.

CITY OF ARLINGTON LANDFILL
0023-404 -11-104
HELP VERSION 3.07 SUMMARY SHEET
GEOSYNTHETIC CLAY LINER

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (310 FT WASTE)	CLOSED (310 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4	5	6	7
	No. of Years	1	10	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	86.1	86.7	86.7	86.7	86.7	81.2
	Model Area (acre)	1	1	1	1	1	1	1
	Runoff Area (%)	0	70	80	80	80	90	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	10	12
TOPSOIL LAYER (Texture = 10)	Thickness (in)							12
	Porosity (vol/vol)							0.3980
	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
GEOCOMPIOSITE DRAINAGE LAYER (Texture = 0)	Thickness (in)							0.300
	Porosity (vol/vol)							0.8500
	Field Capacity (vol/vol)							0.0100
	Wilting Point (vol/vol)							0.0050
	Init. Moisture Content (vol/vol)							0.0100
	Hyd. Conductivity (cm/s)							12.17
	Slope (%)							25.0
	Slope Length (ft)							420
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)							0.04
	Hyd. Conductivity (cm/s)							4.0E-13
	Pinhole Density (holes/acre)							1
	Install. Defects (holes/acre)							4
	Placement Quality							GOOD
COMPACTED CLAY LINER (Texture = 0)	Thickness (in)							18.00
	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-05
INTERMEDIATE COVER (Texture = 11)	Thickness (in)		12	12	12	12	12	12
	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
	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] (Texture = 0)	Thickness (in)	120	600	1200	1500	1500	1500	1500
	Porosity (vol/vol)	0.6376	0.6376	0.6277	0.6174	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5185	0.5156	0.5127	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	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	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)				900	2100	2220	2220
	Porosity (vol/vol)				0.5348	0.4935	0.4893	0.4893
	Field Capacity (vol/vol)				0.4892	0.4775	0.7463	0.4863
	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 COVER (Texture = 10)	Thickness (in)	24	24	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	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	0.1360
	Init. Moisture Content (vol/vol)	0.2440	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	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.248	0.235	0.214	0.164	0.144	0.143	0.143
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	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	0.0100
	Hyd. Conductivity (cm/s)	26.13	14.31	8.05	4.13	2.68	2.59	2.26
	Slope (%)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Slope Length (ft)	165	165	165	165	165	165	165
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
	Pinhole Density (holes/acre)	1	1	1	1	1	1	1
	Install. Defects (holes/acre)	1	1	1	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	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	0.3670
	Init. Moisture Content (vol/vol)	0.4270	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	1.0E-07
PRECIPITATION	Average Annual (in)	47.30	38.39	38.39	38.39	38.39	38.39	35.65
RUNOFF	Average Annual (in)	0.00	2.06	2.43	2.37	2.37	2.63	1.45
EVAPOTRANSPIRATION	Average Annual (in)	34.10	27.86	27.68	27.37	27.37	27.31	25.55
HEAD ON LINER	Average Annual (in)	0.000	0.000	0.003	0.006	0.014	0.016	0.012
LEACHATE GENERATION	Average Annual (cf/yr)	1,112.3	5,187.1	22,664.7	23,512.7	34,817.1	36,618.4	23,704.4
PERCOLATION THROUGH		Sub-D Liner	Sub-D Liner	Sub-D Liner	Sub-D Liner	Sub-D Liner	Sub-D Liner	Sub-D Liner
PERCOLATION VALUES	Average Annual (in/yr)	0.003	0.010	0.025	0.031	0.045	0.047	0.040
	Average Annual (mm/yr)	2.099E-08	6.997E-08	1.749E-07	2.169E-07	3.149E-07	3.289E-07	2.799E-07

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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.

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0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
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GENERAL INFORMATION	Case No.	1	2	3	4	5	6	7
	No. of Years	1	10	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	86.1	86.7	86.7	86.7	86.7	81.2
	Model Area (acre)	1	1	1	1	1	1	1
	Runoff Area (%)	0	70	80	80	80	90	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	10	12
TOPSOIL LAYER (Texture = 10)	Thickness (in)							12
	Porosity (vol/vol)							0.3980
	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
GEOCOMPIOSITE DRAINAGE LAYER (Texture = 0)	Thickness (in)							0.300
	Porosity (vol/vol)							0.8500
	Field Capacity (vol/vol)							0.0100
	Wilting Point (vol/vol)							0.0050
	Init. Moisture Content (vol/vol)							0.0100
	Hyd. Conductivity (cm/s)							12.17
	Slope (%)							25.0
	Slope Length (ft)							420
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)							0.04
	Hyd. Conductivity (cm/s)							4.0E-13
	Pinhole Density (holes/acre)							1
	Install. Defects (holes/acre)							4
	Placement Quality							GOOD
COMPACTED CLAY LINER (Texture = 0)	Thickness (in)							18.00
	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-05
INTERMEDIATE COVER (Texture = 11)	Thickness (in)		12	12	12	12	12	12
	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
	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] (Texture = 0)	Thickness (in)	120	600	1200	1500	1500	1500	1500
	Porosity (vol/vol)	0.6376	0.6376	0.6277	0.6174	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5185	0.5156	0.5127	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	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	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)				900	2100	2220	2220
	Porosity (vol/vol)				0.5348	0.4935	0.4893	0.4893
	Field Capacity (vol/vol)				0.4892	0.4775	0.7463	0.4863
	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 COVER (Texture = 10)	Thickness (in)	24	24	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	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	0.1360
	Init. Moisture Content (vol/vol)	0.2440	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	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.248	0.235	0.214	0.164	0.144	0.143	0.143
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	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	0.0100
	Hyd. Conductivity (cm/s)	26.13	14.31	8.05	4.13	2.68	2.59	2.26
	Slope (%)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Slope Length (ft)	165	165	165	165	165	165	165
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
	Pinhole Density (holes/acre)	1	1	1	1	1	1	1
	Install. Defects (holes/acre)	1	1	1	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
GEOSYNTHETIC CLAY LINER (Texture = 0)	Thickness (in)	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Porosity (vol/vol)	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500
	Field Capacity (vol/vol)	0.7470	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	0.4000
	Init. Moisture Content (vol/vol)	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	47.30	38.39	38.39	38.39	38.39	38.39	35.65
RUNOFF	Average Annual (in)	0.00	2.06	2.43	2.37	2.37	2.63	1.45
EVAPOTRANSPIRATION	Average Annual (in)	34.10	27.86	27.68	27.37	27.37	27.31	25.55
HEAD ON LINER	Average Annual (in)	0.000	0.000	0.003	0.006	0.014	0.016	0.012
LEACHATE GENERATION	Average Annual (cf/yr)	1,112.3	5,198.4	22,839.7	23,518.3	34,810.6	36,570.9	23,693.2
PERCOLATION THROUGH		Sub-D Liner	Sub-D Liner	Sub-D Liner	Sub-D Liner	Sub-D Liner	Sub-D Liner	Sub-D Liner
PERCOLATION VALUES	Average Annual (in/yr)	0.003	0.009	0.019	0.019	0.021	0.021	0.020
	Average Annual (mm/yr)	2.099E-08	6.298E-08	1.329E-07	1.329E-07	1.469E-07	1.469E-07	1.399E-07

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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.

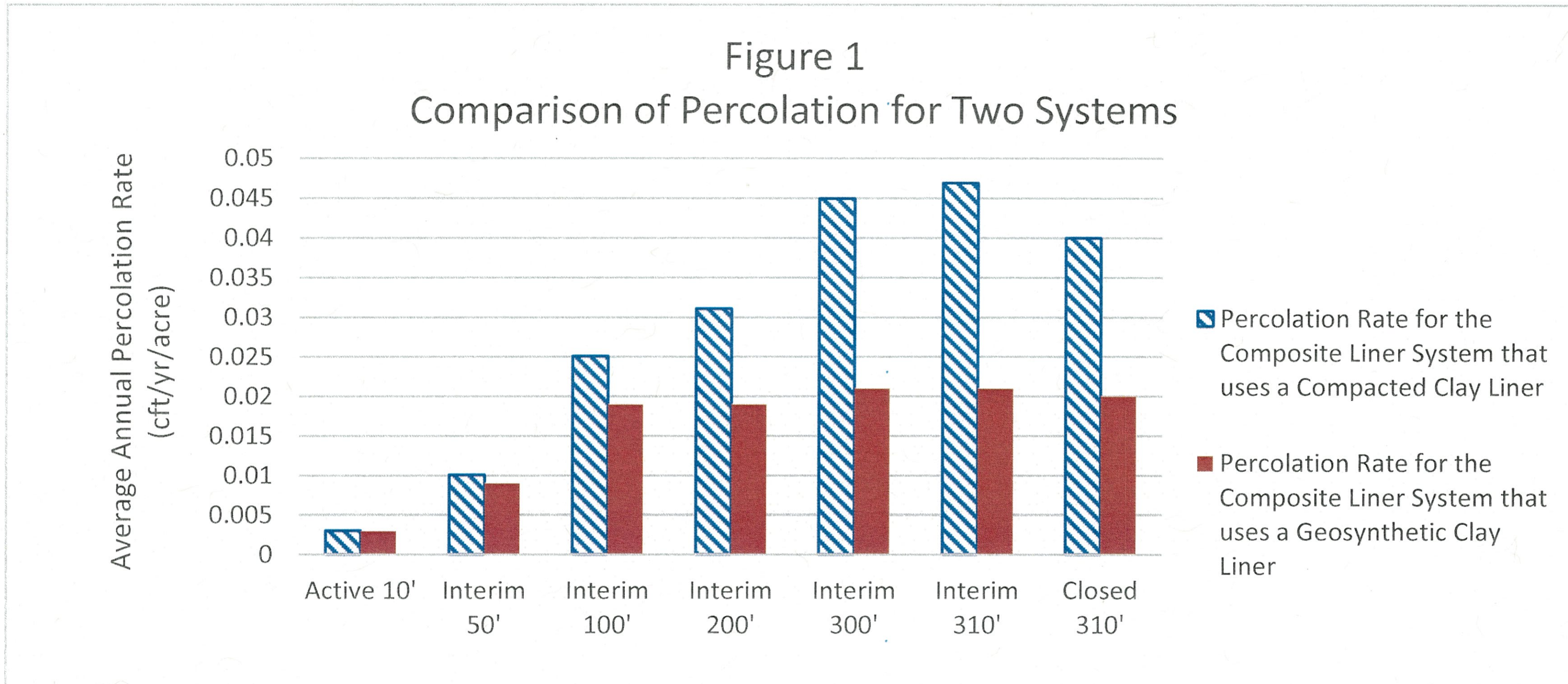
Figure 1
Comparison of Percolation for Two Systems
Average Annual Percolation Rate (cft/yr/acre)
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Active 10'
Interim 50'
Interim 100'
Interim 200'
Interim 300'
Interim 310'
Closed 310'
Percolation Rate for the Composite Liner System that uses a Compacted Clay Liner
Percolation Rate for the Composite Liner System that uses a Geosynthetic Clay Liner

HELP MODEL OUTPUT FILES

HELP MODEL OUTPUT FOR COMPACTED CLAY LINER

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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:\AR\B\C\CCL\AC\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\CCL\AC\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\CCL\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\CCL\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\CCL\AC\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\CCL\AC\OUTPUT1.OUT


TIME:  13:19     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - ACTIVE (10 FT) CCL

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


     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                    =      0.25   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.    =   26.1299992000     CM/SEC
SLOPE                        =      2.00   PERCENT
DRAINAGE LENGTH              =    165.0    FEET


                     LAYER  4
                     --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
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.   = 0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 9 THROUGH 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.58	3.36	4.22	4.24	6.45	2.75
	4.65	0.00	5.51	2.75	8.07	3.72
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	2.870	3.067	3.988	2.169	4.219	4.226
	2.804	0.000	3.522	2.177	3.114	1.941
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
	0.0000	0.0000	0.0000	0.0094	0.0784	0.2187
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
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004
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	47.30	(0.000)	171699.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	34.097	(0.0000)	123773.06	72.087
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.30641	(0.00000)	1112.271	0.64780
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.003	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
CHANGE IN WATER STORAGE	12.896	(0.0000)	46813.77	27.265

PEAK DAILY VALUES FOR YEARS 9 THROUGH 9

	(INCHES)	(CU. FT.)
PRECIPITATION	3.04	11035.200

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.00863	31.33748
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 4	0.000	
MAXIMUM HEAD ON TOP OF LAYER 4	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4012
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.

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FINAL WATER STORAGE AT END OF YEAR 9

LAYER	(INCHES)	(VOL/VOL)
1	42.5603	0.3547
2	6.1917	0.2580
3	0.0027	0.0109
4	0.0000	0.0000

5	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:\AR\B\C\CCL\I50\DATA4.D4
TEMPERATURE DATA FILE:        C:\AR\B\C\CCL\I50\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\AR\B\C\CCL\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\AR\B\C\CCL\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\AR\B\C\CCL\I50\DATA10.D10
OUTPUT DATA FILE:             C:\AR\B\C\CCL\I50\OUTPUT1.OUT


TIME:  13:20     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 50 FT CCL

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


     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                       =       0.23   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.         =   14.3100004000     CM/SEC
  SLOPE                             =      2.00   PERCENT
  DRAINAGE LENGTH                   =    165.0    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  36
  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.         =  0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY               =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS          =      1.00   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 800. FEET.

SCS RUNOFF CURVE NUMBER	=	86.10	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.060	0.102	0.057	0.052	0.134	0.349
	0.158	0.043	0.313	0.534	0.060	0.198
STD. DEVIATIONS	0.065	0.183	0.071	0.074	0.143	0.386
	0.245	0.079	0.286	1.163	0.112	0.236
EVAPOTRANSPIRATION						
TOTALS	1.929	1.948	2.397	2.956	3.051	2.568
	2.824	1.581	3.098	2.332	1.345	1.832
STD. DEVIATIONS	0.352	0.751	0.662	1.248	1.123	1.637

	1.461	1.122	1.217	1.346	0.678	0.559

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0111	0.0108	0.0116	0.0112	0.0122	0.0116
	0.0124	0.0119	0.0117	0.0125	0.0132	0.0126
STD. DEVIATIONS	0.0126	0.0122	0.0131	0.0126	0.0137	0.0131
	0.0140	0.0135	0.0132	0.0137	0.0130	0.0130

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.0996	0.0968	0.1048	0.1011	0.1101	0.1044
	0.1116	0.1067	0.1057	0.1129	0.1184	0.1138
STD. DEVIATIONS	0.1132	0.1097	0.1178	0.1135	0.1233	0.1177
	0.1259	0.1214	0.1187	0.1232	0.1173	0.1174

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0111	0.0108	0.0116	0.0112	0.0122	0.0116
	0.0124	0.0119	0.0117	0.0125	0.0132	0.0126
STD. DEVIATIONS	0.0126	0.0122	0.0131	0.0126	0.0137	0.0131
	0.0140	0.0135	0.0132	0.0137	0.0130	0.0130

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	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
STD. DEVIATIONS	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.060	(1.0080)	7478.83	5.367
EVAPOTRANSPIRATION	27.861	(2.8144)	101136.98	72.577
DRAINAGE RECIRCULATED INTO LAYER 2	0.14289	(0.15705)	518.707	0.37223
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.28605	(1.41343)	4668.364	3.35005
DRAINAGE RECIRCULATED FROM LAYER 4	0.14289	(0.15705)	518.707	0.37223
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.010	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.000	(0.000)		
CHANGE IN WATER STORAGE	7.181	(3.4622)	26067.54	18.706

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.026	7354.2529
DRAINAGE RECIRCULATED INTO LAYER 2	0.00154	5.60780
DRAINAGE COLLECTED FROM LAYER 4	0.01390	50.47016

DRAINAGE RECIRCULATED FROM LAYER 4	0.00154	5.60780
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 5	0.002	
MAXIMUM HEAD ON TOP OF LAYER 5	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4521	
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	2.6572	0.2214
2	222.4541	0.3708
3	6.2751	0.2615
4	0.0032	0.0137
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             **
**                                                                         **
**                                                                         **
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PRECIPITATION DATA FILE:     C:\AR\B\C\CCL\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\CCL\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\CCL\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\CCL\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\CCL\I100\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\CCL\I100\OUTPUT1.OUT


TIME:  13:21     DATE:   2/ 1/2022


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 100 FT CCL

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     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                       =      0.6277 VOL/VOL
   FIELD CAPACITY                 =      0.5156 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                      =      0.21   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.   =   8.05000019000      CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    165.0    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  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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 4.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	86.70	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.071	0.126	0.075	0.069	0.164	0.380
	0.196	0.049	0.378	0.608	0.069	0.242
STD. DEVIATIONS	0.073	0.222	0.091	0.093	0.168	0.425
	0.305	0.088	0.339	1.271	0.131	0.287
EVAPOTRANSPIRATION						
TOTALS	1.928	1.933	2.373	2.951	3.003	2.573
	2.793	1.565	3.062	2.320	1.338	1.836
STD. DEVIATIONS	0.348	0.758	0.644	1.226	1.105	1.634

	1.439	1.128	1.174	1.334	0.698	0.557

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0508	0.0471	0.0546	0.0511	0.0521	0.0529
	0.0546	0.0529	0.0511	0.0524	0.0515	0.0533
STD. DEVIATIONS	0.0138	0.0059	0.0067	0.0076	0.0057	0.0081
	0.0079	0.0079	0.0077	0.0065	0.0072	0.0074

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.4569	0.4236	0.4914	0.4595	0.4689	0.4765
	0.4911	0.4763	0.4602	0.4718	0.4632	0.4797
STD. DEVIATIONS	0.1245	0.0533	0.0605	0.0683	0.0510	0.0725
	0.0711	0.0715	0.0691	0.0586	0.0651	0.0662

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0508	0.0471	0.0546	0.0511	0.0521	0.0529
	0.0546	0.0529	0.0511	0.0524	0.0515	0.0533
STD. DEVIATIONS	0.0138	0.0059	0.0067	0.0076	0.0057	0.0081
	0.0079	0.0079	0.0077	0.0065	0.0072	0.0074

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	0.0030	0.0030	0.0032	0.0031	0.0030	0.0032
	0.0032	0.0031	0.0031	0.0031	0.0031	0.0031
STD. DEVIATIONS	0.0008	0.0004	0.0004	0.0005	0.0003	0.0005
	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.429 (1.1471)	8816.72	6.327
EVAPOTRANSPIRATION	27.676 (2.7427)	100465.27	72.095
DRAINAGE RECIRCULATED INTO LAYER 2	0.62437 (0.08439)	2266.469	1.62643
LATERAL DRAINAGE COLLECTED FROM LAYER 4	5.61935 (0.75950)	20398.232	14.63791
DRAINAGE RECIRCULATED FROM LAYER 4	0.62437 (0.08439)	2266.469	1.62643
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001 (0.00000)	0.025	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.003 (0.000)		
CHANGE IN WATER STORAGE	2.664 (3.0779)	9671.62	6.940

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.220	8060.1060
DRAINAGE RECIRCULATED INTO LAYER 2	0.00349	12.65112
DRAINAGE COLLECTED FROM LAYER 4	0.03137	113.86010

DRAINAGE RECIRCULATED FROM LAYER 4	0.00349	12.65112
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00008
AVERAGE HEAD ON TOP OF LAYER 5	0.006	
MAXIMUM HEAD ON TOP OF LAYER 5	0.013	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4529
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	2.5930	0.2161
2	483.1090	0.4026
3	6.5150	0.2715
4	0.0047	0.0218
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:\AR\B\C\CCL\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\CCL\I200\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\CCL\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\CCL\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\CCL\I200\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\CCL\I200\OUTPUT1.OUT


TIME:  13:22     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 200 FT CCL

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


     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                         =      0.6174 VOL/VOL
  FIELD CAPACITY                   =      0.5127 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                         =      0.5348 VOL/VOL
  FIELD CAPACITY                   =      0.4892 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.     =   4.13000011000     CM/SEC
SLOPE                         =      2.00   PERCENT
DRAINAGE LENGTH               =    165.0    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  36
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.     =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY           =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =      1.00   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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278

EVAPOTRANSPIRATION

TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639
	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0519	0.0506	0.0564	0.0546	0.0559	0.0529
	0.0554	0.0550	0.0531	0.0552	0.0524	0.0543
STD. DEVIATIONS	0.0089	0.0069	0.0082	0.0071	0.0074	0.0059
	0.0063	0.0059	0.0060	0.0064	0.0053	0.0051

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.4675	0.4553	0.5076	0.4917	0.5034	0.4757
	0.4984	0.4951	0.4778	0.4965	0.4720	0.4886
STD. DEVIATIONS	0.0800	0.0622	0.0739	0.0636	0.0664	0.0534
	0.0567	0.0530	0.0540	0.0575	0.0481	0.0458

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0519	0.0506	0.0564	0.0546	0.0559	0.0529
	0.0554	0.0550	0.0531	0.0552	0.0524	0.0543
STD. DEVIATIONS	0.0089	0.0069	0.0082	0.0071	0.0074	0.0059
	0.0063	0.0059	0.0060	0.0064	0.0053	0.0051

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	0.0059	0.0063	0.0064	0.0064	0.0064	0.0062
	0.0063	0.0063	0.0062	0.0063	0.0062	0.0062
STD. DEVIATIONS	0.0010	0.0009	0.0009	0.0008	0.0008	0.0007
	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.368	(1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374	(2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.64773	(0.06511)	2351.265	1.68728
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.82958	(0.58602)	21161.387	15.18555
DRAINAGE RECIRCULATED FROM LAYER 5	0.64773	(0.06511)	2351.265	1.68728
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.031	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.006	(0.001)		
CHANGE IN WATER STORAGE	2.818	(3.0495)	10227.94	7.340

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00373	13.55322
DRAINAGE COLLECTED FROM LAYER 5	0.03360	121.97903
DRAINAGE RECIRCULATED FROM LAYER 5	0.00373	13.55322
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00012
AVERAGE HEAD ON TOP OF LAYER 6	0.013	
MAXIMUM HEAD ON TOP OF LAYER 6	0.027	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436
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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	616.1625	0.4108
3	324.4710	0.3605
4	6.5169	0.2715
5	0.0053	0.0324
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              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\AR\B\C\CCL\I300\DATA4.D4
TEMPERATURE DATA FILE:      C:\AR\B\C\CCL\I300\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\AR\B\C\CCL\I300\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\AR\B\C\CCL\I300\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\AR\B\C\CCL\I300\DATA10.D10
OUTPUT DATA FILE:           C:\AR\B\C\CCL\I300\OUTPUT1.OUT


TIME:  13:23     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 300 FT CCL

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


     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                      =     0.6174 VOL/VOL
  FIELD CAPACITY                =     0.5127 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                     =   2100.00   INCHES
  POROSITY                      =     0.4935 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  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                  =      0.14   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.  =   2.68000007000     CM/SEC
SLOPE                      =      2.00   PERCENT
DRAINAGE LENGTH            =    165.0    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  36
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.  = 0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY        =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =      1.00   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	=	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	=	1387.825	INCHES
TOTAL INITIAL WATER	=	1387.825	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278

EVAPOTRANSPIRATION

TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639
	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0790	0.0768	0.0828	0.0799	0.0814	0.0797
	0.0824	0.0810	0.0780	0.0805	0.0776	0.0801
STD. DEVIATIONS	0.0147	0.0153	0.0191	0.0159	0.0147	0.0144
	0.0153	0.0152	0.0160	0.0148	0.0151	0.0155

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.7111	0.6914	0.7453	0.7192	0.7325	0.7175
	0.7416	0.7287	0.7018	0.7242	0.6982	0.7209
STD. DEVIATIONS	0.1320	0.1374	0.1715	0.1432	0.1319	0.1293
	0.1379	0.1364	0.1440	0.1328	0.1359	0.1398

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0790	0.0768	0.0828	0.0799	0.0814	0.0797
	0.0824	0.0810	0.0780	0.0805	0.0776	0.0801
STD. DEVIATIONS	0.0147	0.0153	0.0191	0.0159	0.0147	0.0144
	0.0153	0.0152	0.0160	0.0148	0.0151	0.0155

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	0.0138	0.0148	0.0145	0.0145	0.0143	0.0144
	0.0144	0.0142	0.0141	0.0141	0.0140	0.0140
STD. DEVIATIONS	0.0026	0.0030	0.0033	0.0029	0.0026	0.0026
	0.0027	0.0027	0.0029	0.0026	0.0027	0.0027

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.368 (1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374 (2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.95915 (0.17622)	3481.712	2.49850
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.63235 (1.58597)	31335.412	22.48651
DRAINAGE RECIRCULATED FROM LAYER 5	0.95915 (0.17622)	3481.712	2.49850
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.045	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.014 (0.003)		
CHANGE IN WATER STORAGE	0.015 (3.5225)	54.33	0.039

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00568	20.60622
DRAINAGE COLLECTED FROM LAYER 5	0.05109	185.45595
DRAINAGE RECIRCULATED FROM LAYER 5	0.00568	20.60622
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00020
AVERAGE HEAD ON TOP OF LAYER 6	0.031	
MAXIMUM HEAD ON TOP OF LAYER 6	0.061	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.3 FEET	
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	639.6804	0.4265
3	728.8403	0.3471
4	6.5939	0.2747
5	0.0147	0.1021
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:\AR\B\C\CCL\I310\DATA4.D4
TEMPERATURE DATA FILE:      C:\AR\B\C\CCL\I310\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\AR\B\C\CCL\I310\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\AR\B\C\CCL\I310\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\AR\B\C\CCL\I310\DATA10.D10
OUTPUT DATA FILE:           C:\AR\B\C\CCL\I310\OUTPUT1.OUT


TIME:  13:23     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 310 FT CCL

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


     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                        =       0.6174 VOL/VOL
  FIELD CAPACITY                  =       0.5127 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                       =    2220.00   INCHES
  POROSITY                        =       0.4893 VOL/VOL
  FIELD CAPACITY                  =       0.4763 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                    =      0.14   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.    =   2.58999991000     CM/SEC
SLOPE                        =      2.00   PERCENT
DRAINAGE LENGTH              =    165.0    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  36
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.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      1.00   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	=	1433.425	INCHES
TOTAL INITIAL WATER	=	1433.425	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.071	0.139	0.083	0.073	0.188	0.406
	0.215	0.057	0.401	0.698	0.062	0.241
STD. DEVIATIONS	0.078	0.246	0.103	0.099	0.200	0.448
	0.345	0.101	0.361	1.452	0.118	0.310

EVAPOTRANSPIRATION

TOTALS	1.929	1.887	2.343	2.924	2.989	2.511
	2.754	1.537	3.008	2.267	1.322	1.843
STD. DEVIATIONS	0.343	0.741	0.616	1.207	1.073	1.630
	1.407	1.091	1.159	1.322	0.698	0.584

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0844	0.0798	0.0882	0.0841	0.0852	0.0832
	0.0871	0.0860	0.0816	0.0846	0.0815	0.0831
STD. DEVIATIONS	0.0155	0.0171	0.0202	0.0165	0.0185	0.0159
	0.0170	0.0169	0.0168	0.0177	0.0151	0.0140

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.7595	0.7182	0.7938	0.7570	0.7666	0.7492
	0.7838	0.7739	0.7343	0.7615	0.7336	0.7476
STD. DEVIATIONS	0.1398	0.1535	0.1815	0.1485	0.1666	0.1428
	0.1526	0.1522	0.1514	0.1589	0.1356	0.1259

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0844	0.0798	0.0882	0.0841	0.0852	0.0832
	0.0871	0.0860	0.0816	0.0846	0.0815	0.0831
STD. DEVIATIONS	0.0155	0.0171	0.0202	0.0165	0.0185	0.0159
	0.0170	0.0169	0.0168	0.0177	0.0151	0.0140

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	0.0153	0.0159	0.0160	0.0158	0.0154	0.0156
	0.0158	0.0156	0.0153	0.0153	0.0153	0.0151
STD. DEVIATIONS	0.0028	0.0035	0.0037	0.0031	0.0034	0.0030
	0.0031	0.0031	0.0032	0.0032	0.0028	0.0025

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.633	(1.3086)	9558.92	6.860
EVAPOTRANSPIRATION	27.314	(2.8436)	99150.34	71.151
DRAINAGE RECIRCULATED INTO LAYER 2	1.00877	(0.19125)	3661.841	2.62776
LATERAL DRAINAGE COLLECTED FROM LAYER 5	9.07895	(1.72129)	32956.570	23.64986
DRAINAGE RECIRCULATED FROM LAYER 5	1.00877	(0.19125)	3661.841	2.62776
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.047	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.016	(0.003)		
CHANGE IN WATER STORAGE	-0.637	(3.5523)	-2313.06	-1.660

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.549	9252.6611
DRAINAGE RECIRCULATED INTO LAYER 2	0.00568	20.60222
DRAINAGE COLLECTED FROM LAYER 5	0.05108	185.41997
DRAINAGE RECIRCULATED FROM LAYER 5	0.00568	20.60222
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00020
AVERAGE HEAD ON TOP OF LAYER 6	0.032	
MAXIMUM HEAD ON TOP OF LAYER 6	0.063	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.5 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4609

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	2.6013	0.2168
2	641.3478	0.4276
3	766.2641	0.3452
4	6.5808	0.2742
5	0.0111	0.0776
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:\AR\B\C\CCL\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\CCL\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\CCL\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\CCL\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\CCL\CL\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\CCL\CL\OUTPUT1.OUT


TIME:  13:25     DATE:   2/ 1/2022


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - CLOSED 310 FT CCL

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     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 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.        =   12.1700001000     CM/SEC
    SLOPE                            =       5.00   PERCENT
    DRAINAGE LENGTH                  =     420.0    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              =       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                     =       0.6174 VOL/VOL
FIELD CAPACITY               =       0.5127 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                    =   2220.00   INCHES
POROSITY                     =       0.4893 VOL/VOL
FIELD CAPACITY               =       0.4763 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	=	0.14 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.	=	2.25999999000 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	165.0 FEET

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 36

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.	=	0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE

```
FML INSTALLATION DEFECTS     =      1.00   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  5.%
         AND A SLOPE LENGTH OF  420. FEET.

SCS RUNOFF CURVE NUMBER             =     81.20
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     12.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      2.928  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      4.776  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.632  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =   1444.042  INCHES
TOTAL INITIAL WATER                 =   1444.042  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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.012	0.042	0.075	0.098	0.130	0.181
	0.069	0.009	0.116	0.569	0.075	0.078
STD. DEVIATIONS	0.031	0.097	0.180	0.236	0.329	0.296
	0.173	0.025	0.180	0.975	0.196	0.158
EVAPOTRANSPIRATION						
TOTALS	1.587	1.709	2.416	2.539	3.267	2.805
	2.180	1.506	2.632	2.117	1.278	1.517
STD. DEVIATIONS	0.508	0.746	1.005	1.215	1.093	1.474
	1.313	1.129	1.188	0.981	0.525	0.505
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.5671	0.5634	0.7341	0.4721	0.4747	0.7643
	0.2584	0.0386	0.5604	1.9533	0.8554	1.4312
STD. DEVIATIONS	0.8075	0.6725	1.1259	0.7378	0.7158	0.8498
	0.5485	0.1067	0.6609	2.2284	1.2560	1.5243
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.5539	0.5185	0.5661	0.5446	0.5560	0.5381
	0.5561	0.5536	0.5328	0.5459	0.5284	0.5361
STD. DEVIATIONS	0.2293	0.2274	0.2580	0.2358	0.2408	0.2298

```
                    0.2432   0.2406   0.2279   0.2378   0.2225   0.2201

 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         0.0041   0.0054   0.0069   0.0051   0.0070   0.0095
                    0.0029   0.0002   0.0053   0.0423   0.0086   0.0130

   STD. DEVIATIONS  0.0067   0.0089   0.0123   0.0102   0.0177   0.0148
                    0.0069   0.0004   0.0075   0.0703   0.0165   0.0182

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   AVERAGES         0.0115   0.0118   0.0118   0.0117   0.0116   0.0116
                    0.0116   0.0115   0.0114   0.0113   0.0113   0.0111

   STD. DEVIATIONS  0.0048   0.0052   0.0054   0.0051   0.0050   0.0049
                    0.0051   0.0050   0.0049   0.0049   0.0048   0.0046

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    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                     INCHES           CU. FEET      PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                  35.65    (   6.690)    129402.2     100.00

 RUNOFF                          1.453   (  1.0545)      5273.29      4.075

 EVAPOTRANSPIRATION             25.553   (  3.3734)     92758.78     71.683

 LATERAL DRAINAGE COLLECTED      8.67288 (  3.73985)    31482.549    24.32921
   FROM LAYER  2
```

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00028 (	0.00017)	1.020	0.00079
AVERAGE HEAD ON TOP OF LAYER 3	0.009 (	0.006)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	6.53013 (	2.78868)	23704.385	18.31837
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00001 (	0.00000)	0.040	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.012 (	0.005)		
CHANGE IN WATER STORAGE	-6.561 (	2.8780)	-23816.79	-18.405

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.715	6227.1909
DRAINAGE COLLECTED FROM LAYER 2	2.18862	7944.69092
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000221	0.80383
AVERAGE HEAD ON TOP OF LAYER 3	3.221	
MAXIMUM HEAD ON TOP OF LAYER 3	5.363	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	26.5 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.05553	201.57152
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00022
AVERAGE HEAD ON TOP OF LAYER 10	0.036	

```
MAXIMUM HEAD ON TOP OF LAYER 10              0.071

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)                  1.8 FEET

SNOW WATER                                   1.37          4974.2432


MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.3656

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	1.9909	0.1659
2	0.0030	0.0100
3	0.0000	0.0000
4	7.6860	0.4270
5	3.7200	0.3100
6	552.2114	0.3681
7	665.0493	0.2996
8	6.2913	0.2621
9	0.0095	0.0662

10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

****
****

HELP MODEL OUTPUT FOR GEOSYNTHETIC CLAY LINER

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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:\AR\B\C\GCL\AC\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\GCL\AC\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\GCL\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\GCL\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\GCL\AC\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\GCL\AC\OUTPUT1.OUT


TIME:  14:41     DATE:   2/ 1/2022


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - ACTIVE (10 FT) GCL

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     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                      =      0.25   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.      =   26.1299992000      CM/SEC
SLOPE                          =      2.00   PERCENT
DRAINAGE LENGTH                =    165.0    FEET


                      LAYER  4
                      --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 9 THROUGH 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.58	3.36	4.22	4.24	6.45	2.75
	4.65	0.00	5.51	2.75	8.07	3.72
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	2.870	3.067	3.988	2.169	4.219	4.226
	2.804	0.000	3.522	2.177	3.114	1.941
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
	0.0000	0.0000	0.0000	0.0094	0.0784	0.2187
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
                             0.0000   0.0000   0.0000   0.0000   0.0001   0.0004

    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                    47.30    (   0.000)     171699.0     100.00

 RUNOFF                            0.000   (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION               34.097   (  0.0000)     123773.06     72.087

 LATERAL DRAINAGE COLLECTED        0.30641 (  0.00000)      1112.271    0.64780
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH       0.00000 (  0.00000)         0.003    0.00000
   LAYER  5

 AVERAGE HEAD ON TOP               0.000 (     0.000)
   OF LAYER  4

 CHANGE IN WATER STORAGE          12.896   (  0.0000)      46813.77     27.265

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


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

                PEAK DAILY VALUES FOR YEARS    9 THROUGH    9
   ------------------------------------------------------------------------
                                                     (INCHES)      (CU. FT.)
                                                    ----------   -------------
      PRECIPITATION                                    3.04        11035.200
```

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.00863	31.33748
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 4	0.000	
MAXIMUM HEAD ON TOP OF LAYER 4	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4012
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.

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FINAL WATER STORAGE AT END OF YEAR 9

LAYER	(INCHES)	(VOL/VOL)
1	42.5603	0.3547
2	6.1917	0.2580
3	0.0027	0.0109
4	0.0000	0.0000

5	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:     C:\AR\B\C\GCL\I50\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\GCL\I50\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\GCL\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\GCL\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\GCL\I50\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\GCL\I50\OUTPUT1.OUT


TIME:  14:43     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 50 FT GCL

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


     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                         =       0.23   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.       =   14.3100004000      CM/SEC
  SLOPE                           =      2.00   PERCENT
  DRAINAGE LENGTH                 =    165.0    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  36
  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.       =  0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY             =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS        =      1.00   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 800. FEET.

SCS RUNOFF CURVE NUMBER	=	86.10	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.060	0.102	0.057	0.052	0.134	0.349
	0.158	0.043	0.313	0.534	0.060	0.198
STD. DEVIATIONS	0.065	0.183	0.071	0.074	0.143	0.386
	0.245	0.079	0.286	1.163	0.112	0.236
EVAPOTRANSPIRATION						
TOTALS	1.929	1.948	2.397	2.956	3.051	2.568
	2.824	1.581	3.098	2.332	1.345	1.832
STD. DEVIATIONS	0.352	0.751	0.662	1.248	1.123	1.637

	1.461	1.122	1.217	1.346	0.678	0.559

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0110	0.0107	0.0120	0.0114	0.0120	0.0113
	0.0120	0.0120	0.0116	0.0127	0.0131	0.0133
STD. DEVIATIONS	0.0128	0.0121	0.0138	0.0128	0.0135	0.0127
	0.0135	0.0135	0.0134	0.0138	0.0130	0.0139

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.0989	0.0965	0.1083	0.1024	0.1084	0.1019
	0.1078	0.1083	0.1047	0.1144	0.1180	0.1194
STD. DEVIATIONS	0.1148	0.1085	0.1239	0.1150	0.1213	0.1143
	0.1215	0.1217	0.1205	0.1241	0.1172	0.1247

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0110	0.0107	0.0120	0.0114	0.0120	0.0113
	0.0120	0.0120	0.0116	0.0127	0.0131	0.0133
STD. DEVIATIONS	0.0128	0.0121	0.0138	0.0128	0.0135	0.0127
	0.0135	0.0135	0.0134	0.0138	0.0130	0.0139

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	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
STD. DEVIATIONS	0.0004	0.0004	0.0005	0.0004	0.0004	0.0004
	0.0004	0.0004	0.0005	0.0005	0.0004	0.0005

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.060	(1.0080)	7478.83	5.367
EVAPOTRANSPIRATION	27.861	(2.8144)	101136.98	72.577
DRAINAGE RECIRCULATED INTO LAYER 2	0.14321	(0.15788)	519.838	0.37304
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.28885	(1.42088)	4678.540	3.35735
DRAINAGE RECIRCULATED FROM LAYER 4	0.14321	(0.15788)	519.838	0.37304
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.000	(0.000)		
CHANGE IN WATER STORAGE	7.178	(3.4707)	26057.31	18.699

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.026	7354.2529
DRAINAGE RECIRCULATED INTO LAYER 2	0.00161	5.85968
DRAINAGE COLLECTED FROM LAYER 4	0.01453	52.73710

DRAINAGE RECIRCULATED FROM LAYER 4	0.00161	5.85968
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 5	0.002	
MAXIMUM HEAD ON TOP OF LAYER 5	0.003	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4521
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	2.6572	0.2214
2	222.4312	0.3707
3	6.2700	0.2613
4	0.0031	0.0130
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:     C:\AR\B\C\GCL\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\GCL\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\GCL\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\GCL\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\GCL\I100\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\GCL\I100\OUTPUT1.OUT


TIME:  14:57     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 100 FT GCL

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     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                        =       0.6277 VOL/VOL
  FIELD CAPACITY                  =       0.5156 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                       =       0.21   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.  =   8.05000019000     CM/SEC
     SLOPE                      =      2.00   PERCENT
     DRAINAGE LENGTH            =    165.0    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  36
     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.  = 0.399999993000E-12 CM/SEC
     FML PINHOLE DENSITY        =      1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS   =      1.00   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 4.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	86.70	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.071	0.126	0.075	0.069	0.164	0.380
	0.196	0.049	0.378	0.608	0.069	0.242
STD. DEVIATIONS	0.073	0.222	0.091	0.093	0.168	0.425
	0.305	0.088	0.339	1.271	0.131	0.287
EVAPOTRANSPIRATION						
TOTALS	1.928	1.933	2.373	2.951	3.003	2.573
	2.793	1.565	3.062	2.320	1.338	1.836
STD. DEVIATIONS	0.348	0.758	0.644	1.226	1.105	1.634

	1.439	1.128	1.174	1.334	0.698	0.557

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0516	0.0483	0.0530	0.0511	0.0533	0.0516
	0.0533	0.0543	0.0504	0.0547	0.0523	0.0553
STD. DEVIATIONS	0.0140	0.0091	0.0085	0.0075	0.0088	0.0076
	0.0070	0.0089	0.0064	0.0091	0.0057	0.0050

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.4647	0.4344	0.4767	0.4595	0.4796	0.4647
	0.4801	0.4887	0.4539	0.4923	0.4703	0.4977
STD. DEVIATIONS	0.1263	0.0819	0.0769	0.0673	0.0796	0.0683
	0.0629	0.0800	0.0578	0.0815	0.0514	0.0447

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0516	0.0483	0.0530	0.0511	0.0533	0.0516
	0.0533	0.0543	0.0504	0.0547	0.0523	0.0553
STD. DEVIATIONS	0.0140	0.0091	0.0085	0.0075	0.0088	0.0076
	0.0070	0.0089	0.0064	0.0091	0.0057	0.0050

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	0.0030	0.0031	0.0031	0.0031	0.0031	0.0031
	0.0031	0.0032	0.0030	0.0032	0.0031	0.0032
STD. DEVIATIONS	0.0008	0.0006	0.0005	0.0005	0.0005	0.0005
	0.0004	0.0005	0.0004	0.0005	0.0003	0.0003

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.429	(1.1471)	8816.72	6.327
EVAPOTRANSPIRATION	27.676	(2.7427)	100465.27	72.095
DRAINAGE RECIRCULATED INTO LAYER 2	0.62919	(0.08815)	2283.969	1.63899
LATERAL DRAINAGE COLLECTED FROM LAYER 4	5.66273	(0.79334)	20555.721	14.75093
DRAINAGE RECIRCULATED FROM LAYER 4	0.62919	(0.08815)	2283.969	1.63899
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001	(0.00000)	0.019	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.003	(0.000)		
CHANGE IN WATER STORAGE	2.621	(3.1641)	9514.04	6.827

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.220	8060.1060
DRAINAGE RECIRCULATED INTO LAYER 2	0.00369	13.40759
DRAINAGE COLLECTED FROM LAYER 4	0.03324	120.66829

DRAINAGE RECIRCULATED FROM LAYER 4	0.00369	13.40759
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00005
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)	0.0 FEET	
SNOW WATER	1.20	4357.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4529
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	2.5930	0.2161
2	482.6446	0.4022
3	6.5445	0.2727
4	0.0055	0.0255
5	0.0000	0.0000
6	0.1875	0.7500

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:\AR\B\C\GCL\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\GCL\I200\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\GCL\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\GCL\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\GCL\I200\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\GCL\I200\OUTPUT1.OUT


TIME:  14:55     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 200 FT

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


     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                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5127 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                        =      0.5348 VOL/VOL
  FIELD CAPACITY                  =      0.4892 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.   =   4.13000011000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    165.0    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  36
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.   = 0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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    =     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    =    921.765   INCHES
TOTAL INITIAL WATER                 =    921.765   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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

```
RUNOFF
------
  TOTALS                 0.063    0.124    0.074    0.065    0.168    0.364
                         0.192    0.051    0.358    0.640    0.055    0.215

  STD. DEVIATIONS        0.070    0.219    0.092    0.088    0.180    0.408
                         0.308    0.090    0.326    1.337    0.105    0.278

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.932    1.915    2.318    2.932    2.989    2.523
                         2.754    1.561    3.011    2.263    1.323    1.851

  STD. DEVIATIONS        0.346    0.735    0.610    1.218    1.087    1.639
                         1.401    1.088    1.151    1.321    0.700    0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                 0.0517   0.0508   0.0571   0.0540   0.0562   0.0540
                         0.0548   0.0547   0.0526   0.0549   0.0524   0.0548

  STD. DEVIATIONS        0.0089   0.0069   0.0075   0.0076   0.0071   0.0053
                         0.0066   0.0065   0.0062   0.0067   0.0052   0.0050

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.4652   0.4571   0.5142   0.4857   0.5056   0.4856
                         0.4932   0.4922   0.4731   0.4937   0.4719   0.4936

  STD. DEVIATIONS        0.0797   0.0624   0.0674   0.0682   0.0636   0.0477
                         0.0593   0.0581   0.0559   0.0601   0.0465   0.0450

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                 0.0517   0.0508   0.0571   0.0540   0.0562   0.0540
                         0.0548   0.0547   0.0526   0.0549   0.0524   0.0548

  STD. DEVIATIONS        0.0089   0.0069   0.0075   0.0076   0.0071   0.0053
                         0.0066   0.0065   0.0062   0.0067   0.0052   0.0050

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	0.0059	0.0064	0.0065	0.0063	0.0064	0.0063
	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
STD. DEVIATIONS	0.0010	0.0009	0.0009	0.0009	0.0008	0.0006
	0.0007	0.0007	0.0007	0.0008	0.0006	0.0006

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.368 (1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374 (2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.64789 (0.06395)	2351.828	1.68769
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.83098 (0.57552)	21166.453	15.18919
DRAINAGE RECIRCULATED FROM LAYER 5	0.64789 (0.06395)	2351.828	1.68769
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.019	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.006 (0.001)		
CHANGE IN WATER STORAGE	2.816 (3.0729)	10223.11	7.336

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00373	13.55323
DRAINAGE COLLECTED FROM LAYER 5	0.03360	121.97907
DRAINAGE RECIRCULATED FROM LAYER 5	0.00373	13.55323
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 6	0.013	
MAXIMUM HEAD ON TOP OF LAYER 6	0.027	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	616.2164	0.4108
3	324.4123	0.3605
4	6.5028	0.2710
5	0.0109	0.0667
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             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\AR\B\C\GCL\I300\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\GCL\I300\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\GCL\I300\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\GCL\I300\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\GCL\I300\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\GCL\I300\OUTPUT1.OUT


TIME:  14:58     DATE:   2/ 1/2022


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 300 FT GCL

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


     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                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5127 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                       =   2100.00   INCHES
  POROSITY                        =      0.4935 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  10
  THICKNESS                       =     24.00   INCHES
  POROSITY                        =      0.3980 VOL/VOL
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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                   =      0.14   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.   =   2.68000007000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    165.0    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  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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	=	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	=	1377.765	INCHES
TOTAL INITIAL WATER	=	1377.765	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278

EVAPOTRANSPIRATION

TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639
	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0790	0.0771	0.0841	0.0799	0.0813	0.0790
	0.0820	0.0806	0.0789	0.0805	0.0766	0.0799
STD. DEVIATIONS	0.0148	0.0147	0.0178	0.0159	0.0147	0.0150
	0.0157	0.0155	0.0151	0.0147	0.0159	0.0156

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.7107	0.6942	0.7567	0.7191	0.7316	0.7108
	0.7378	0.7257	0.7103	0.7249	0.6897	0.7191
STD. DEVIATIONS	0.1328	0.1326	0.1606	0.1432	0.1327	0.1352
	0.1415	0.1398	0.1356	0.1324	0.1432	0.1402

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0790	0.0771	0.0841	0.0799	0.0813	0.0790
	0.0820	0.0806	0.0789	0.0805	0.0766	0.0799
STD. DEVIATIONS	0.0148	0.0147	0.0178	0.0159	0.0147	0.0150
	0.0157	0.0155	0.0151	0.0147	0.0159	0.0156

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	0.0138	0.0149	0.0147	0.0145	0.0142	0.0143
	0.0144	0.0141	0.0143	0.0141	0.0139	0.0140
STD. DEVIATIONS	0.0026	0.0029	0.0031	0.0029	0.0026	0.0027
	0.0028	0.0027	0.0027	0.0026	0.0029	0.0027

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.368 (1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374 (2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.95897 (0.17644)	3481.063	2.49803
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.63074 (1.58793)	31329.570	22.48231
DRAINAGE RECIRCULATED FROM LAYER 5	0.95897 (0.17644)	3481.063	2.49803
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.021	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.014 (0.003)		
CHANGE IN WATER STORAGE	0.017 (3.5312)	60.35	0.043

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00568	20.60623
DRAINAGE COLLECTED FROM LAYER 5	0.05109	185.45604
DRAINAGE RECIRCULATED FROM LAYER 5	0.00568	20.60623
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00007
AVERAGE HEAD ON TOP OF LAYER 6	0.031	
MAXIMUM HEAD ON TOP OF LAYER 6	0.061	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.4 FEET	
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	639.7103	0.4265
3	728.8331	0.3471
4	6.5861	0.2744
5	0.0162	0.1128
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              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\AR\B\C\GCL\I310\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\GCL\I310\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\GCL\I310\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\GCL\I310\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\GCL\I310\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\GCL\I310\OUTPUT1.OUT


TIME:  14:59     DATE:   2/ 1/2022


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 310 FT GCL

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


     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                        =      0.6174 VOL/VOL
   FIELD CAPACITY                  =      0.5127 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                       =   2220.00   INCHES
   POROSITY                        =      0.4893 VOL/VOL
   FIELD CAPACITY                  =      0.4763 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                   =      0.14   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.   =   2.58999991000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    165.0    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  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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	=	1423.365	INCHES
TOTAL INITIAL WATER	=	1423.365	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.071	0.139	0.083	0.073	0.188	0.406
	0.215	0.057	0.401	0.698	0.062	0.241
STD. DEVIATIONS	0.078	0.246	0.103	0.099	0.200	0.448
	0.345	0.101	0.361	1.452	0.118	0.310

EVAPOTRANSPIRATION

TOTALS	1.929	1.887	2.343	2.924	2.989	2.511
	2.754	1.537	3.008	2.267	1.322	1.843
STD. DEVIATIONS	0.343	0.741	0.616	1.207	1.073	1.630
	1.407	1.091	1.159	1.322	0.698	0.584

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0843	0.0792	0.0884	0.0839	0.0852	0.0832
	0.0868	0.0858	0.0817	0.0849	0.0810	0.0833
STD. DEVIATIONS	0.0156	0.0177	0.0200	0.0167	0.0184	0.0159
	0.0173	0.0170	0.0167	0.0174	0.0156	0.0138

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.7583	0.7128	0.7952	0.7552	0.7665	0.7487
	0.7809	0.7725	0.7351	0.7637	0.7287	0.7497
STD. DEVIATIONS	0.1405	0.1593	0.1802	0.1500	0.1655	0.1431
	0.1554	0.1529	0.1502	0.1565	0.1400	0.1245

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0843	0.0792	0.0884	0.0839	0.0852	0.0832
	0.0868	0.0858	0.0817	0.0849	0.0810	0.0833
STD. DEVIATIONS	0.0156	0.0177	0.0200	0.0167	0.0184	0.0159
	0.0173	0.0170	0.0167	0.0174	0.0156	0.0138

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	0.0153	0.0158	0.0160	0.0157	0.0154	0.0156
	0.0157	0.0156	0.0153	0.0154	0.0152	0.0151
STD. DEVIATIONS	0.0028	0.0036	0.0036	0.0031	0.0033	0.0030
	0.0031	0.0031	0.0031	0.0032	0.0029	0.0025

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.633	(1.3086)	9558.92	6.860
EVAPOTRANSPIRATION	27.314	(2.8436)	99150.34	71.151
DRAINAGE RECIRCULATED INTO LAYER 2	1.00746	(0.19240)	3657.088	2.62435
LATERAL DRAINAGE COLLECTED FROM LAYER 5	9.06716	(1.73155)	32913.801	23.61917
DRAINAGE RECIRCULATED FROM LAYER 5	1.00746	(0.19240)	3657.088	2.62435
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.021	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.016	(0.003)		
CHANGE IN WATER STORAGE	-0.625	(3.5233)	-2270.12	-1.629

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.549	9252.6611
DRAINAGE RECIRCULATED INTO LAYER 2	0.00568	20.60223
DRAINAGE COLLECTED FROM LAYER 5	0.05108	185.42007
DRAINAGE RECIRCULATED FROM LAYER 5	0.00568	20.60223
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00007
AVERAGE HEAD ON TOP OF LAYER 6	0.032	
MAXIMUM HEAD ON TOP OF LAYER 6	0.063	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.5 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4609
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	2.6013	0.2168
2	641.3654	0.4276
3	766.3364	0.3452
4	6.6108	0.2754
5	0.0096	0.0669
6	0.0000	0.0000
7	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:     C:\AR\B\C\GCL\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\B\C\GCL\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\B\C\GCL\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\B\C\GCL\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\B\C\GCL\CL\DATA10.D10
OUTPUT DATA FILE:            C:\AR\B\C\GCL\CL\OUTPUT1.OUT


TIME:  15:10     DATE:   2/ 1/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - CLOSED 310 FT GCL

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


     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 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.    =   12.1700001000     CM/SEC
   SLOPE                        =      5.00   PERCENT
   DRAINAGE LENGTH              =    420.0    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          =      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                       =      0.6174 VOL/VOL
FIELD CAPACITY                 =      0.5127 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                      =   2220.00   INCHES
POROSITY                       =      0.4893 VOL/VOL
FIELD CAPACITY                 =      0.4763 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                   =       0.14   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.   =   2.25999999000      CM/SEC
SLOPE                       =       2.00   PERCENT
DRAINAGE LENGTH             =    165.0     FEET


                        LAYER 10
                        --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =       1.00   HOLES/ACRE
```

```
FML INSTALLATION DEFECTS     =      1.00   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  5.%
         AND A SLOPE LENGTH OF  420. FEET.

SCS RUNOFF CURVE NUMBER              =     80.40
FRACTION OF AREA ALLOWING RUNOFF     =    100.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000   ACRES
EVAPORATIVE ZONE DEPTH               =     12.0     INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      2.928   INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.776   INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.632   INCHES
INITIAL SNOW WATER                   =      0.000   INCHES
INITIAL WATER IN LAYER MATERIALS     =   1433.982   INCHES
TOTAL INITIAL WATER                  =   1433.982   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                     =  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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.009	0.036	0.066	0.088	0.115	0.160
	0.060	0.007	0.099	0.522	0.066	0.067
STD. DEVIATIONS	0.026	0.088	0.163	0.217	0.308	0.272
	0.156	0.020	0.162	0.911	0.178	0.142
EVAPOTRANSPIRATION						
TOTALS	1.587	1.709	2.414	2.540	3.270	2.814
	2.181	1.504	2.632	2.123	1.279	1.518
STD. DEVIATIONS	0.507	0.746	1.003	1.218	1.092	1.476
	1.316	1.124	1.186	0.983	0.525	0.505
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.5692	0.5672	0.7430	0.4842	0.4782	0.7835
	0.2653	0.0442	0.5749	1.9946	0.8745	1.4317
STD. DEVIATIONS	0.8120	0.6782	1.1405	0.7566	0.7213	0.8683
	0.5617	0.1127	0.6729	2.2906	1.2762	1.5271
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.5540	0.5177	0.5658	0.5424	0.5548	0.5378
	0.5568	0.5532	0.5336	0.5475	0.5281	0.5353
STD. DEVIATIONS	0.2292	0.2281	0.2583	0.2378	0.2417	0.2298

```
                        0.2426    0.2410    0.2270    0.2365    0.2227    0.2205

 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             0.0044    0.0054    0.0069    0.0054    0.0076    0.0102
                        0.0032    0.0002    0.0059    0.0494    0.0087    0.0139

   STD. DEVIATIONS      0.0071    0.0095    0.0118    0.0109    0.0203    0.0157
                        0.0078    0.0004    0.0081    0.0848    0.0159    0.0195

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   AVERAGES             0.0115    0.0118    0.0118    0.0116    0.0115    0.0115
                        0.0116    0.0115    0.0115    0.0114    0.0113    0.0111

   STD. DEVIATIONS      0.0048    0.0052    0.0054    0.0051    0.0050    0.0049
                        0.0050    0.0050    0.0049    0.0049    0.0048    0.0046

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


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

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                  35.65    (   6.690)     129402.2     100.00

 RUNOFF                          1.298   (  0.9837)       4710.08      3.640

 EVAPOTRANSPIRATION             25.571   (  3.3797)      92822.50     71.732

 LATERAL DRAINAGE COLLECTED      8.81046 (  3.78178)     31981.957   24.71515
   FROM LAYER  2
```

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00030 (	0.00019)	1.106	0.00085
AVERAGE HEAD ON TOP OF LAYER 3	0.010 (	0.007)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	6.52706 (	2.79091)	23693.215	18.30974
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00001 (	0.00000)	0.020	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.012 (	0.005)		
CHANGE IN WATER STORAGE	-6.558 (	2.8807)	-23805.54	-18.397

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.621	5885.4028
DRAINAGE COLLECTED FROM LAYER 2	2.21705	8047.90381
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000226	0.81871
AVERAGE HEAD ON TOP OF LAYER 3	3.270	
MAXIMUM HEAD ON TOP OF LAYER 3	5.509	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	27.1 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.05553	201.57166
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00007
AVERAGE HEAD ON TOP OF LAYER 10	0.036	

MAXIMUM HEAD ON TOP OF LAYER 10	0.071	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	1.8 FEET	
SNOW WATER	1.37	4974.2432
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.3731
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	1.9908	0.1659
2	0.0030	0.0100
3	0.0000	0.0000
4	7.6860	0.4270
5	3.7200	0.3100
6	552.2505	0.3682
7	665.1124	0.2996
8	6.2827	0.2618
9	0.0091	0.0634

10	0.0000	0.0000
11	0.1875	0.7500
SNOW WATER	0.000	

****
****

CITY OF CITY OF ARLINGTON LANDFILL
TARRANT COUNTY
TCEQ PERMIT NO. MSW-358C

MAJOR PERMIT AMENDMENT APPLICATION

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

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER
5-19-2022

Prepared for

Republic Waste Services of Texas, Ltd

May 2022

Prepared by

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

WCG Project No. 0023-404-11-104

This document is intended for permitting purposes only.

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER
5-19-2022

CONTENTS

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER
5-19-2022

CONTENTS (Continued)

TABLES

Tables **Page No.**

1 PURPOSE AND SCOPE

This appendix addresses §§330.305(g), 330.177, 330.207 and 330.333.

This Leachate and Contaminated Water Management Plan for the City of Arlington Landfill was prepared consistent with Title 30 Texas Administrative Code (TAC) §§330.305(g), 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 landfill completion 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.

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 City of Arlington 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 are used for the leachate collection system design which is conservative compared to using site-specific leachate generation information.

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 City of Arlington 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. Uncontaminated 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.10 – 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 Sections 4 and 5 of this appendix, respectively.

The final cover has been designed to minimize infiltration and promote runoff. Uncontaminated 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. Uncontaminated 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 to collect leachate generated from the waste placed over the pre-Subtitle D area. The plan for the LCS piping and grading is shown on Figure 3-1 and in Part III, Appendix IIIA-A, Drawing A.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 sector, 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 Title 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 Title 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 Subtitle D areas is designed to manage leachate that may be recirculated at the working face. Section 5.2 includes a leachate recirculation plan. Also, Appendix IIIC-A (page IIIC-A-4 and IIIC-A-5) 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. Subtitle D Sector 2 through 5 have been constructed to date. For the Subtitle D sectors, the leachate collection layer includes a 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 final conditions (i.e., after landfill foundation settlement – refer to Appendix IIIE). Leachate collection layer slopes and slope lengths have been estimated for the proposed closed landfill conditions. Table 3-1 provides a design summary for the developed Subtitle D Sectors. 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 sectors (Sector 6 through 12), the leachate collection layer will also be placed directly over the liner system. The undeveloped sectors have been designed for the estimated overburden pressure that will be created by the proposed site reconfiguration. Material specifications are included in the following

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

Sector[3]	Location	Initial Slope	Post-Settlement Slope/Slope Used for Design[4]	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
Developed Areas Sector 2 through 5	Slope between cell ridgeline and leachate collection pipe	2%	2%	0.083 inches	0.0038 inches	Yes
	Slope of leachate collection pipe	0.6%	0.6%	Peak flow less than the capacity of the collection pipe[2]	Peak flow less than the capacity of the collection pipe[2]	
Undeveloped Areas Sectors 6 and 7	Slope between cell ridgeline and leachate collection pipe	2.2%	2.0%	0.071 inches	0.0030 inches	Yes
	Slope of leachate collection pipe	0.7%	0.6%	Peak flow less than the capacity of the collection pipe[2]	Peak flow less than the capacity of the collection pipe[2]	
Undeveloped Areas Sectors 8 through 12	Slope between cell ridgeline and leachate collection pipe	2.2%	2.0%	0.102 inches	0.0057 inches	Yes
	Slope of leachate collection pipe	1.0%	0.6%	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.
2 The leachate collection pipe is a 6-inch-diameter pipe.
3 The leachate collection layer for the developed areas is as follows: Developed Sectors 2 through 5 – 200-mil-thick single-sided geocomposite; Undeveloped Sectors 6 through 12 – 250-mil-thick single-sided geocomposite.
4 Foundation settlement is discussed in Appendix IIIE.

subsections for these sectors. Table 3-1 shows that the maximum leachate depth for these sectors is also less than 12 inches and the flow depth is less than the thickness of the drainage geocomposite. Table 3-1 presents a summary of the initial and post-settlement/design slope for each Subtitle D sector 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 will be installed over the west pre-Subtitle D area. The leachate will drain to collection pipes and be conveyed to sumps located in both Sectors 6 and 7.

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. The settlement analysis for the overliner is discussed in detail in Appendix IIIE-B. To provide for a conservative analysis, a slope of 1.5 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.

3.2 Leachate Collection Layer

3.2.1 Subtitle D Areas

The leachate collection layer for the undeveloped sectors 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 (minimum) 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 sectors will comply with the specifications listed in Table 3-3.

An analysis of the existing Subtitle D areas is also included in Appendix IIIC-A. Sectors 2 through 4 were constructed with a 200-mil-thick geocomposite and Sector 5 was constructed with a 300-mil-thick geocomposite. A 200-mil-thick geocomposite was modeled for all of the developed areas (Sectors 2 through 5) and is sufficient to maintain less than 12 inches of head above the bottom liner with the additional overburden pressure resulting from the site reconfiguration.

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

Sector	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 Sectors 01 through 05	Slope of overliner	1.9% – 25%	1.5%	0.220 inches	0.0109 inches	Yes
	Slope of leachate collection pipe	0.1% (minimum)	0.01%	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 is a 6-inch-diameter HDPE pipe.

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 to collect and transfer leachate to the leachate collection system drainage pipes and sumps.

The leachate collection layer placed in 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 the specifications for the geocomposite are listed in Liner Quality Control Plan in Appendix IIID. The demonstration that the overliner design meets the requirements presented in Title 30 TAC §330.331(a)(1) is included in Appendix IIIB.

3.2.3 Chimney Drains

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.5, Detail L3, and Drawing A.12, Details OL2 and OL4, 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 demonstrating the adequacy of the chimney drain design 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 11 HDPE smooth wall pipe (refer to Appendix IIIC-B for LCS pipe designs for the Subtitle D area). The existing leachate collection pipes are perforated 6-inch SDR 11 HDPE smooth wall pipes. As shown in Table 3-1, the LCS pipes are designed for after settlement slopes.

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 Overliner Area

The overliner leachate collection layer is designed with the same parameters as the Subtitle D areas. 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 design standard listed in Title 30 TAC §330.331(a)(2). The leachate collection sumps and pumps have been designed to maintain less than 30 cm (12 inches) depth of leachate over the liner. The leachate sump operating plan is included in Table 3-3.

Each leachate sump will be sized based on the amount of leachate generation taking into consideration the contributing area from both the Subtitle D sector and any overliner sector draining to the Subtitle D sectors. As shown on Figure 3-1, the undeveloped Sector 6 will receive leachate from the constructed Sector 5, and overliner Sector O4. The undeveloped Sector 7 will receive leachate from the constructed Sectors 2 through 4, and overliner Sectors O1, O2, O3, and O5. The size and capacity of the sumps for all the undeveloped sectors 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 between the lip of the sump and pump intake. 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 (see Table 3-3 for additional information).

The leachate depth monitoring procedure and leachate removal will be the same for all disposal areas. 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.

The specified pump for each sector as specified in Table 4-1 will have the capacity to remove leachate to maintain less than 12 inches of head on the liner. The maximum estimated flow to be pumped from the largest undeveloped sector (Sector 7 with a contributing area of 159.2 acres) is approximately 119,460 gpd (refer to Appendix IIIC-B). 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).

Table 3-3
Leachate Sump Operating Plan

Leachate Level Description	Condition	Action Required
Leachate level between lip of sump and pump intake at the bottom of the sump.	System is functioning as designed. The leachate sump controls will be set to turn on once the leachate level reaches the lip of the sump. The drainage geocomposite leachate collection layer installed on the floor of the landfill 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 §330.331(a)(2).	The depth of leachate in the sump is monitored by a pressure transducer which is 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 near the sump riser, 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. Leachate flow to the sump required, sump pump capacity, and range of pump operating times are listed in Appendix IIIC, Table 4-1. The sump design is discussed in Appendix IIIC, Section 3.4 and detailed sump design calculations are provided in Appendix IIIC-B.
Leachate level between the lip of the sump and 30 cm (or 12 inches) above the lip of the sump.	The pump is not able to maintain the leachate levels at or below the lip of the sump. However, the 12-inch design standard listed in §330.331(a)(2) has not been exceeded.	For these two conditions, the sump operation will be monitored daily to determine if this leachate level is the result of a short-term situation (e.g., significant storm event during initial waste filling operations of a sector, temporary loss of power at the site, etc.) or if there is a maintenance issue with the pump or pump controls. For both conditions, the leachate levels in the sump will be recorded daily (as discussed in Part IV – SOP, Section 4.23). If the leachate sump pumps are not able to maintain the leachate level below the lip of the sump at reasonable cycle times, then a pump with more capacity will be used to maintain the leachate level below the lip of the sump. As listed on Table 4-1, the typical sump operating time should typically be less than 2 hours per day (based on expected flow rates in Table 4-1). If the pump has to operate close to 24 hours per day for a significant period of time, then it is approaching the pump capacity limits and a larger pump will need to be installed. As noted in the EPA Technical Manual *Solid Waste Disposal Facility Criteria,* EPA530-R-93-017, "The 30-cm head allowance is a design standard and the [EPA] recognizes that this design standard may be exceeded for relatively short periods of time during the active life of the unit." To address this requirement, adequately sized sump pumps will be set to initiate pumping when leachate levels reach the lip of the sump. After the sump pump has been evaluated and found to be operating inadequately, the issue will be noted in the site operating record and the pump will be repaired or replaced within 5 business days from the discovery of the leachate/level pumping issues when practicable.
Leachate level over 12 inches above the lip of the sump.	System not functioning as designed and the design standard listed in §330.331(a)(2) has been exceeded.	

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:

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

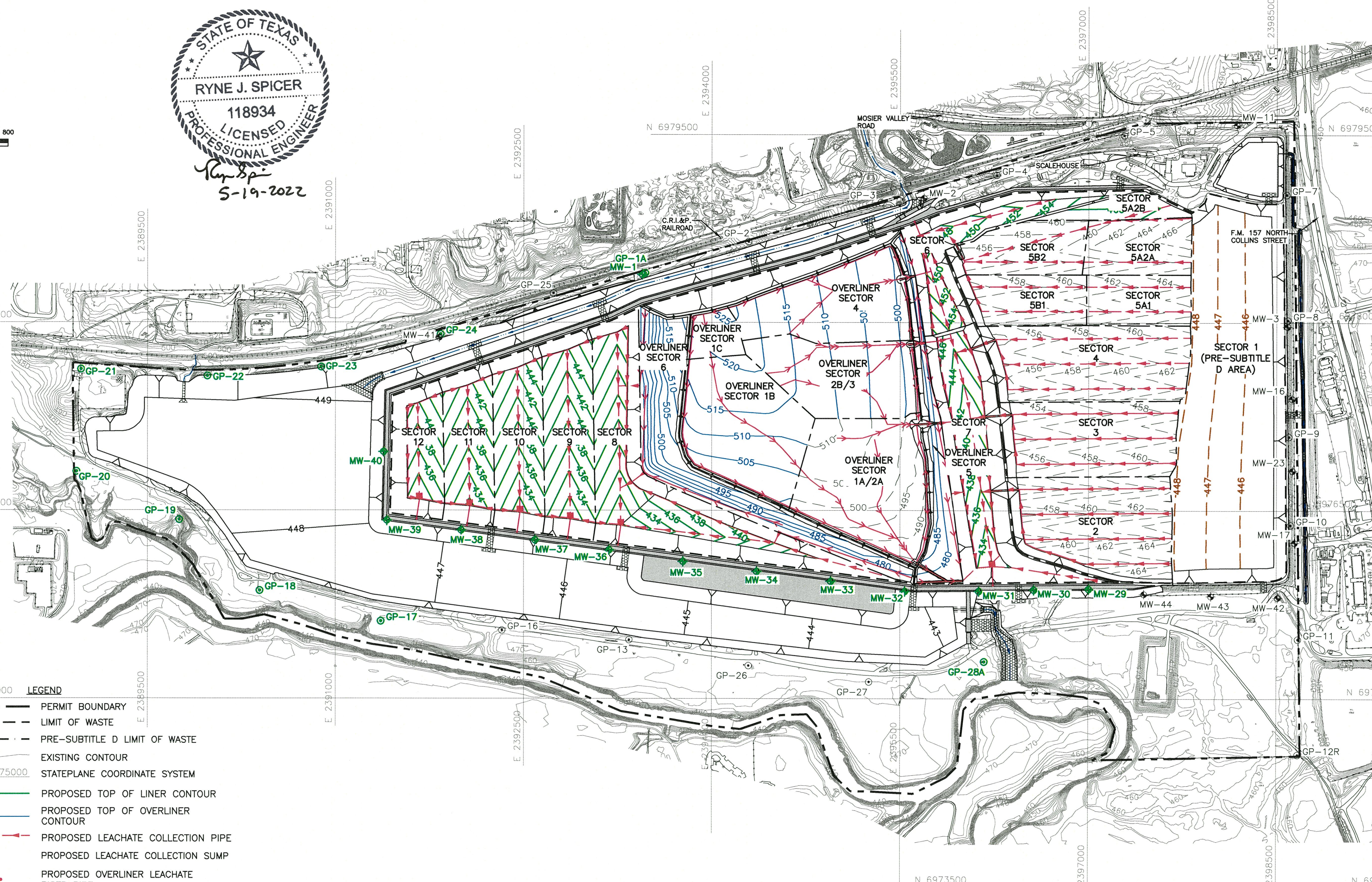
For slots:

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

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.

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED PROFESSIONAL ENGINEER
5-19-2022

0 400 800
SCALE IN FEET



LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- PRE-SUBTITLE D LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 430 PROPOSED TOP OF LINER CONTOUR
- 520 PROPOSED TOP OF OVERLINER CONTOUR
- PROPOSED LEACHATE COLLECTION PIPE
- PROPOSED LEACHATE COLLECTION SUMP
- PROPOSED OVERLINER LEACHATE RISER PIPE
- PROPOSED OVERLINER LEACHATE DRAINAGE PIPE
- PROPOSED OVERLINER LEACHATE DRAINAGE PIPE (MULTIPLE PIPES IN TRENCH)
- MW-8 EXISTING GROUNDWATER MONITORING WELL
- MW-40 PROPOSED GROUNDWATER MONITORING WELL
- GP-2 EXISTING LANDFILL GAS MONITORING PROBE
- GP-17 PROPOSED LANDFILL GAS MONITORING PROBE

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY LANDES & ASSOCIATES, INC. DATED MARCH 2011.
3. ELEVATION OF DEEPEST EXCAVATION AT THE LCS SUMP IS 424.5 FT-MSL.

SHEET IIIC-13A

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: 3-1 LEACHATE COLLECTION PLAN.DWG
DRAWN BY: BPY
DESIGN BY: BPY
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE COLLECTION SYSTEM PLAN

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE 3-1

O:\0023\404\EXPANSION 2021\PART III\IIIC\3-1 LEACHATE COLLECTION SYSTEM PLAN.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. Leachate generated in the developed areas and overliner area will drain to the sumps in Sectors 6 and 7. Leachate generated in the undeveloped Sectors 8 through 12 will drain to sumps in their respective sectors. Additional storage will be provided in the onsite above-ground storage tank 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 two representative sectors/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 site-specific leachate generation is much less than what is predicted by the HELP model. Therefore, the use of the average annual leachate generation rate produced by HELP to design the leachate collection sumps provides for a conservative analysis. Table 4-1 also includes the expected leachate generation and pump operating times 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 as required by the Leachate Sump Operating Plan presented in Table 3-3. Disposal of leachate is discussed in Section 5. Leachate will be pumped to the leachate storage tank through the forcemain or recirculated at the working face. The design and operation of the onsite storage tank is discussed in Section 4.3. The location of the leachate storage tank area after the site is completely developed is shown on Figure 4-1. The storage tank calculations are presented in Appendix IIIC-D.

The forcemain that connects the sumps to the leachate storage tank will consist 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 sector as landfill development progresses. The location of the leachate forcemain and the storage tank is shown on Figure 4-1. Details of the connection between the 18-inch riser and forcemain are presented on Figure 4-2, and the forcemain capacity calculations are presented in Appendix IIIC-D.

Table 4-1
Sump Flow and Pump Operating Times

Condition	Sump Storage Summary														
	Sector 6[1]					Sector 7[1]					Sectors 8 through 12[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[1]	Expected[3]	Average[2]	Expected[3]		Average[2]	Expected[3]	Average[2]	Expected[3]		Average[2]	Expected[3]	Average[2]	Expected[3]	
Active	34,400	4,492	9.6	1.2	60	79,466	10,043	8.9	1.7	100	20,153	3,060	8.4	1.3	40
Interim	53,430	4,492	14.8	1.2	60	119,468	10,043	19.9	1.7	100	29,254	3,060	12.2	1.3	40
Closed	43,209	449	12.0	0.1	60	96,613	1,005	12.2	0.4	100	17,459	306	7.3	0.1	40

1 Sumps for the largest drainage areas are shown. Refer to Appendix IIIC-B, Sheet IIIC-B-57 – Sump Drainage Areas for sector layout and sump drainage areas.
2 Refer to Appendix IIIC-B, pages IIIC-B-52 through IIIC-B-56 for sump calculations for the developed and undeveloped areas.
3 The expected flow values are based on actual site-specific leachate generation listed in Table 6-1. The average value listed in Table 6-1 was used (i.e., 23,026 gal/ac/yr).

4.2 Contaminated Water Management

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 transported via tanker trucks to a properly permitted privately owned offsite wastewater treatment facility or publicly owned treatment works (POTW), as discussed in Section 5.

4.3 Onsite Storage Tank(s)

The location of the existing and future leachate storage tank(s) and pre-treatment systems are shown on Figure 4-1 and described in Table 4-2 (including tank composition, secondary containment, level controls, etc.). City of Arlington Landfill will relocate existing tanks (e.g., due to landfill development) and install additional storage tanks as necessary to maintain the minimum capacity required for continued operation of the facility and to facilitate liquids management.

As presented in Appendix IIIC-D, approximately 200,000 gallons of leachate storage provides storage for the maximum daily leachate generation rate from the HELP model of 150,710 gallons, with an additional 49,000 gallons available for emergency or surge storage. Note that this estimate of leachate generation is considered conservative, as actual site leachate generation information (as presented in Appendix IIIC-E) demonstrates that actual leachate generation at the City of Arlington Landfill is significantly less than as estimated by the HELP model. Additionally, the need for leachate storage from the currently (2022) available volume of 100,000 gallons to the proposed future 200,000 gallons will occur over time, as the landfill expands beyond the current waste footprint. Therefore, leachate storage capacity (beyond the current 100,000 gallons) will be added to the site as new sector construction and actual leachate generation and collection rates dictate.

The storage tank(s) consists of a double-walled leachate tank made of steel that contains an inner tank ("storage vessel") consisting of a geomembrane liner. The tank will be placed 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 in Appendix IIIC-D, 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. Alternative leachate tank designs that incorporate secondary containment and leak detection may be substituted for the tank design described above.

Leachate levels within the tanks will be controlled by discharging leachate to the existing City of Arlington sanitary sewer connection which discharges to the City of Arlington POTW. Alternatively, leachate will be transferred from the storage tanks to a tanker truck and transported to a properly permitted off-site treatment facility.

4.3.1 Leachate and Gas Condensate Pre-Treatment System

The leachate and gas condensate pre-treatment system will consist of a diffusion aeration system that will remove volatile and semi-volatile compounds from the leachate and gas condensate. The leachate and condensate will first be combined in a mixing tank located adjacent to the different aeration tanks. Anti-sealing and anti-fouling agents will also be introduced into this tank to limit the formation of scale and organic material in the other treatment components. The combined fluid will then be treated in the diffused aeration basin to bring the wastewater into compliance with the existing discharge permit. The treated effluent will be pumped directly to the sewer discharge and exhaust gasses will be collected and treated via an odor control system. The odor control system includes a liquid knockout tank, a drum scrubber, and a final absorbent media odor removal unit.

Table 4-2
Existing Tanks and Treatment Systems

Designation (see Figure 4-1)	Tank Storage Capacity[1] (Total, gal)	Tank Freeboard[2] (ft)	Overfill Protection	Tank Construction	Tank Dimensions	Secondary Containment Description	Leak Detection	Secondary Containment Capacity (gallons)	Tank Discharge
L1	100,000 (total) 89,600 (working)	1	Yes, high level sensor within tank with actuated shutoff valve and visual alarm. Alarm set at or below freeboard height.	Steel panel bolted shell with reinforced membrane liners (dual liner system). Steel-reinforced concrete ring foundation with sand liner bedding layer and leak detection. Open top.	42-ft dia. 10-ft height	Dual membrane liners within steel tank with interstitial leak detection and leak monitoring	Yes, leak indicator (riser) located on exterior of tank	100,000 (provides containment for working volume plus 1-ft freeboard) (Note 3)	Discharge by forcemain to sanitary sewer.
L2-L5	4 Frac Tanks 21,000 (each)	1	N/A	Single walled welded/bolted steel. Closed top.	45-ft length 8.5-ft width 11-ft height	Earthen berm (70 ft x 50ft x 3.5 ft) which includes 1-ft freeboard	Visual leak detection in bermed containment area	38,053 (Provides containment for largest tank and 25-year 24 hour storm event plus 1-ft freeboard)	Discharge by forcemain to sanitary sewer.
Leachate and Gas Condensate Pre-Treatment System	N/A	N/A	N/A	N/A	N/A	Concrete pad (27 ft x 29 ft x 1 ft curb)	Visual leak detection in concrete containment area	5,857 (Provides containment for largest tank (2,000 gal) and 25-year 24 hour storm event)	Discharge by forcemain to sanitary sewer.

1 Tank total storage capacity in table includes storage and freeboard volumes combined. Working storage capacity does not include freeboard storage.
2 In all instances freeboard depth exceeds 25-year, 24-hour storm event depth of 7.16 inches (reference: Appendix IIIC-C, Page IIIC-C-2).
3 Bolted steel tanks with dual geomembrane liners have installed controls and valves to keep water level at depth of 1' below top of tank at all times, providing a minimum 1' of freeboard to contain the 24-hour 25-year storm event.

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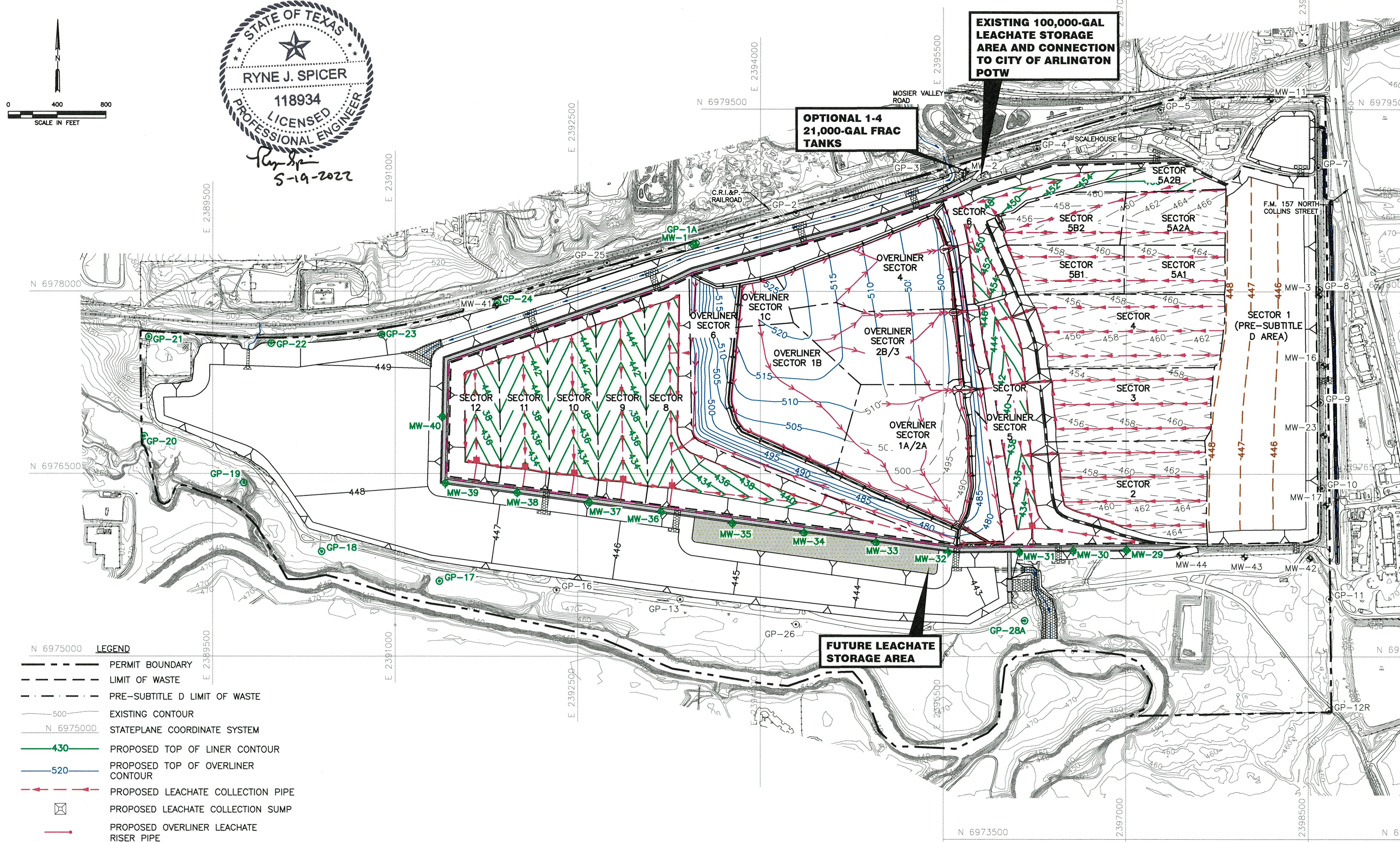

LEGEND

PERMIT BOUNDARY
LIMIT OF WASTE
PRE-SUBTITLE D LIMIT OF WASTE
500 EXISTING CONTOUR
N 6975000 STATEPLANE COORDINATE SYSTEM
430 PROPOSED TOP OF LINER CONTOUR
520 PROPOSED TOP OF OVERLINER CONTOUR
PROPOSED LEACHATE COLLECTION PIPE
PROPOSED LEACHATE COLLECTION SUMP
PROPOSED OVERLINER LEACHATE RISER PIPE
PROPOSED OVERLINER LEACHATE DRAINAGE PIPE
PROPOSED OVERLINER LEACHATE DRAINAGE PIPE (MULTIPLE PIPES IN TRENCH)
MW-8 EXISTING GROUNDWATER MONITORING WELL
MW-40 PROPOSED GROUNDWATER MONITORING WELL
GP-2 EXISTING LANDFILL GAS MONITORING PROBE
GP-17 PROPOSED LANDFILL GAS MONITORING PROBE

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY LANDES & ASSOCIATES, INC. DATED MARCH 2011.
3. ELEVATION OF DEEPEST EXCAVATION AT THE LCS SUMP IS 424.5 FT-MSL.

SHEET IIIC-19A

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022 DRAWN BY: BPY
FILE: 0023-404-11 DESIGN BY: BPY
CAD: 4-1 FORCEMAIN AND STORAGE PLAN.DWG REVIEWED BY: RJS

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
FORCEMAIN AND STORAGE TANK PLAN

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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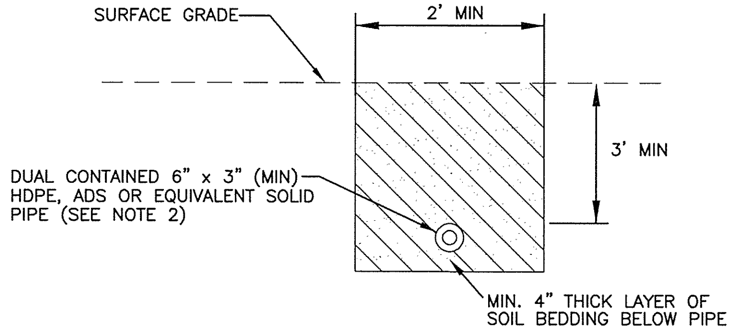
FIGURE 4-1

O:\0023\404\EXPANSION 2021\PART III\IIIC\4-1 LEACHATE STORAGE TANK AND FORCEMAIN PLAN.dwg, jwilson, 1:2



LEACHATE FORCEMAIN (DUAL CONTAINED) LCS1 4-2 4-2

N.T.S.

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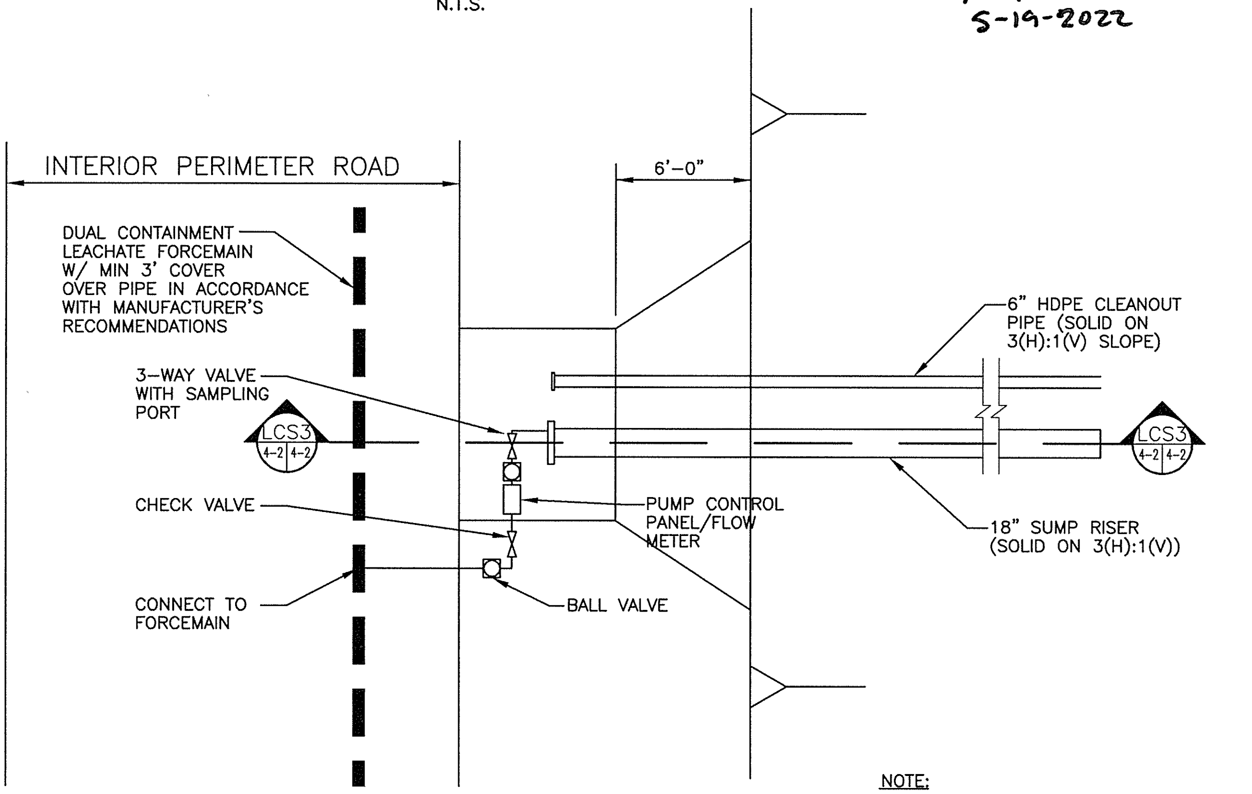
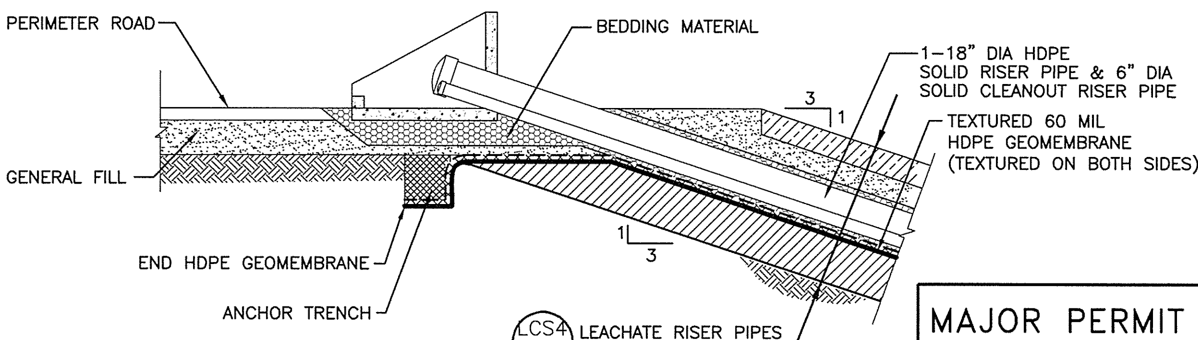


FORCEMAIN CONNECTION LCS2 4-1 4-2

N.T.S.

NOTE:

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



LEACHATE RISER/CLEANOUT LCS3 4-2 4-2

0 4 8
SCALE IN FEET

MAJOR PERMIT AMENDMENT

LEACHATE FORCEMAIN DETAILS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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TBPE REGISTRATION NO. F-3727

DRAWN BY: BPY	DATE: 05/2022	FILE: 0023-406-11
REVIEWED BY: BPY	CAD: 4-2 FORCEMAIN DTLS.DWG	FIGURE 4-2

SHEET IIIC-19B

O:\0023\404\EXPANSION 2021\PART III\IIIC\4-2 FORCEMAIN DETAILS.dwg, jwilson, 1:1

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 4.23, the leachate levels for each sump will be recorded in the Site Operating Record once per week at a minimum. Leachate will be pumped from the leachate sumps and transferred to the leachate storage tank via the forcemain (see Figure 4-1 for location).

The storage tank capacity calculations are presented in Appendix IIIC-D. As noted in Appendix IIIC-D, the leachate levels in the storage tank(s) will be maintained so that a minimum of 40,000 gallons of emergency backup leachate storage capacity will be provided.

The collected leachate will be transported by forcemain to the leachate storage tank(s) and then discharged to the existing City of Arlington sanitary sewer connection which discharges to the City of Arlington POTW or recirculated back into the landfill (refer top Section 5.2). For leachate that is discharged to the sanitary sewer, sampling and analysis will be limited to the disposal facility's requirements. The results of leachate monitoring required by the direct discharge permit will be kept in the Site Operating Record.

Leachate levels in the storage tank 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 areas underlain by a Subtitle D liner system (no recirculation will occur over the pre-Subtitle D areas). 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).

The average site-specific leachate generation rate is about 23,026 gal/acre/year. The leachate collection system is conservatively designed to handle a leachate generation rate over 273,925 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, 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 sector.

- 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.

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 tank. When contaminated water is stored in the leachate storage tank, 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.

5.4 Landfill Gas Condensate

Consistent with Title 30 TAC §330.177 and §330.207(e), landfill gas condensate will be pumped to the onsite leachate storage tank(s). It will then be handled and disposed of consistent with Section 5.1 or recirculated consistent with Section 5.2.

6 LEACHATE GENERATION SUMMARY

6.1 Purpose

The purpose of this section is to summarize the leachate generation rates developed in Appendix IIIC-A using the HELP model and compare them to leachate generation rates developed from actual leachate generation information obtained at the City of Arlington 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 Generation Information

Table 6-1 summarizes the leachate generation information that has been obtained for the existing site in 2016 through 2020. 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 23,026 gal/acre/year and the maximum leachate generation has been 28,584 gal/acre/year. No leachate was recirculated during this time period.

Table 6-1
Existing Site Leachate Generation Summary

Year	Annual Rainfall[1] (in)	Total Leachate Generated Per Year (gallons)	Total Subtitle D Lined Area (acres)	Leachate Generated Per Acre (gallons/ac/year)
2016	35.4	1,415,744	80.0	17,697
2017	32.1	1,783,975	88.7	20,112
2018	37.4	2,029,477	88.7	22,880
2019	30.2	2,533,947	98.0	25,857
2020	38.0	2,801,221	98.0	28,584
Average	34.6	2,112,873	90.7	23,026

[1] The rainfall data was provided by Republic 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 from the HELP model predict higher amounts of leachate generation than the actual leachate generation rates.

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 sectors, overliner sectors, and developed sectors 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 sectors, 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 Arlington Landfill for the 2016-2020 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. Koerner 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.

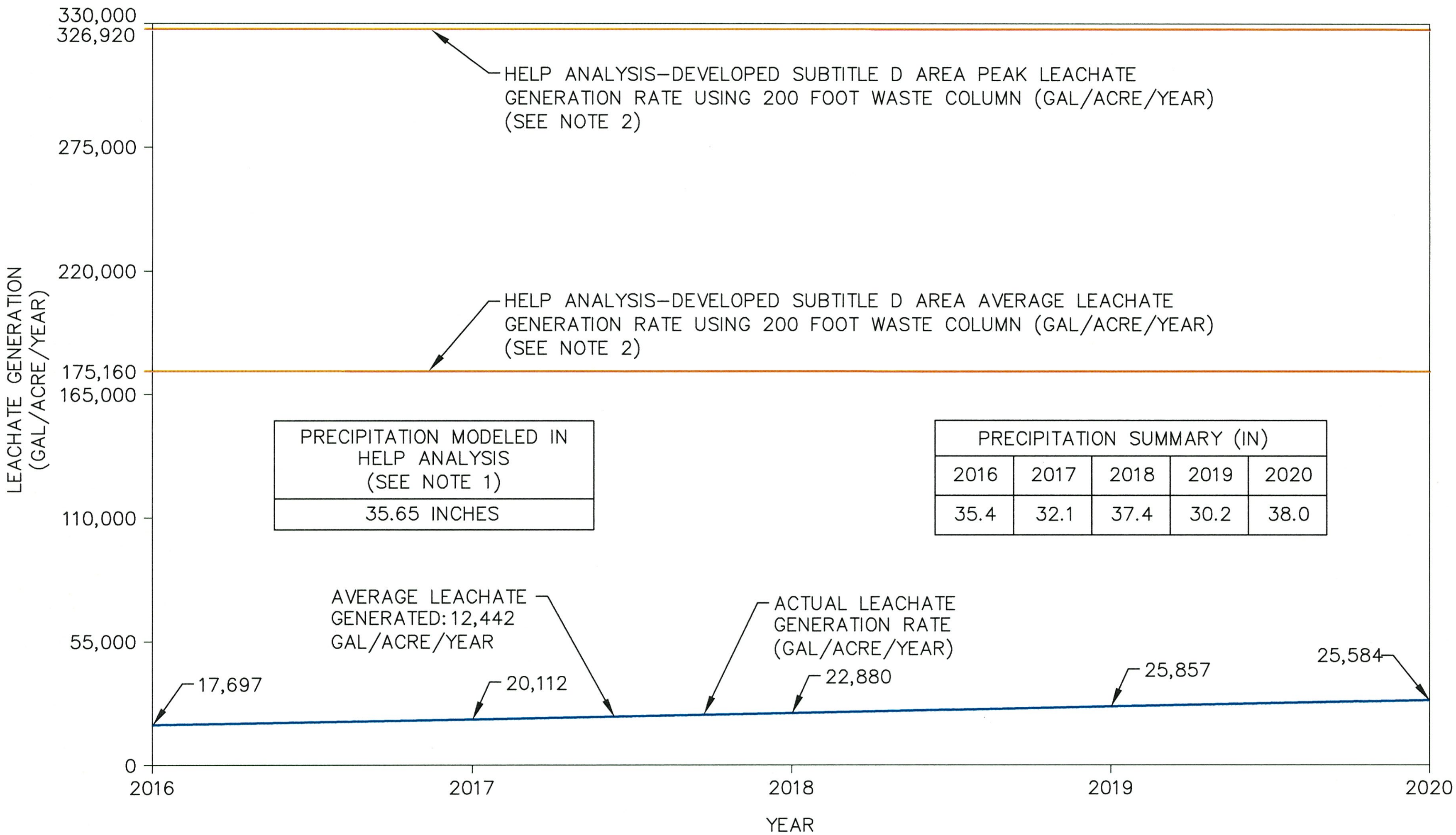
As shown on Figure 6-2, the leachate generation rate over the life of the site that was determined from actual leachate generation information is less than both the average and the peak values estimated by the HELP model for most of the life of the site and during the post-closure period.

6.4 Comparison of Leachate Thickness on Liner System

Figures 6-3 through 6-6 provide leachate depth information for the Subtitle D area and the overliner area. The leachate depths for each area are also compared to the compressed thickness of the geocomposite. 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 virtually zero. Additionally, in each case the peak head on the liner using the flow rates produced by HELP is contained within the thickness of the geocomposite.

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 predicted 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 that those predicted by HELP and result in a smaller volume of leachate of the life of site as shown on Figure 6-2.



PRECIPITATION MODELED IN HELP ANALYSIS (SEE NOTE 1)
35.65 INCHES

PRECIPITATION SUMMARY (IN)				
2016	2017	2018	2019	2020
35.4	32.1	37.4	30.2	38.0

NOTES:

1. THE AVERAGE ANNUAL PRECIPITATION MODELED IN HELP OVER 30 YEARS IS 35.65 INCHES.
2. REPRESENTATIVE VALUES WERE SELECTED FROM THE AVERAGE LEACHATE GENERATION RATES FOR THE DEVELOPED AREA HELP RUN CASES. REFER TO APPENDIX IIIC–A FOR HELP RUN OUTPUT.

LEACHATE GENERATION RATE COMPARISON

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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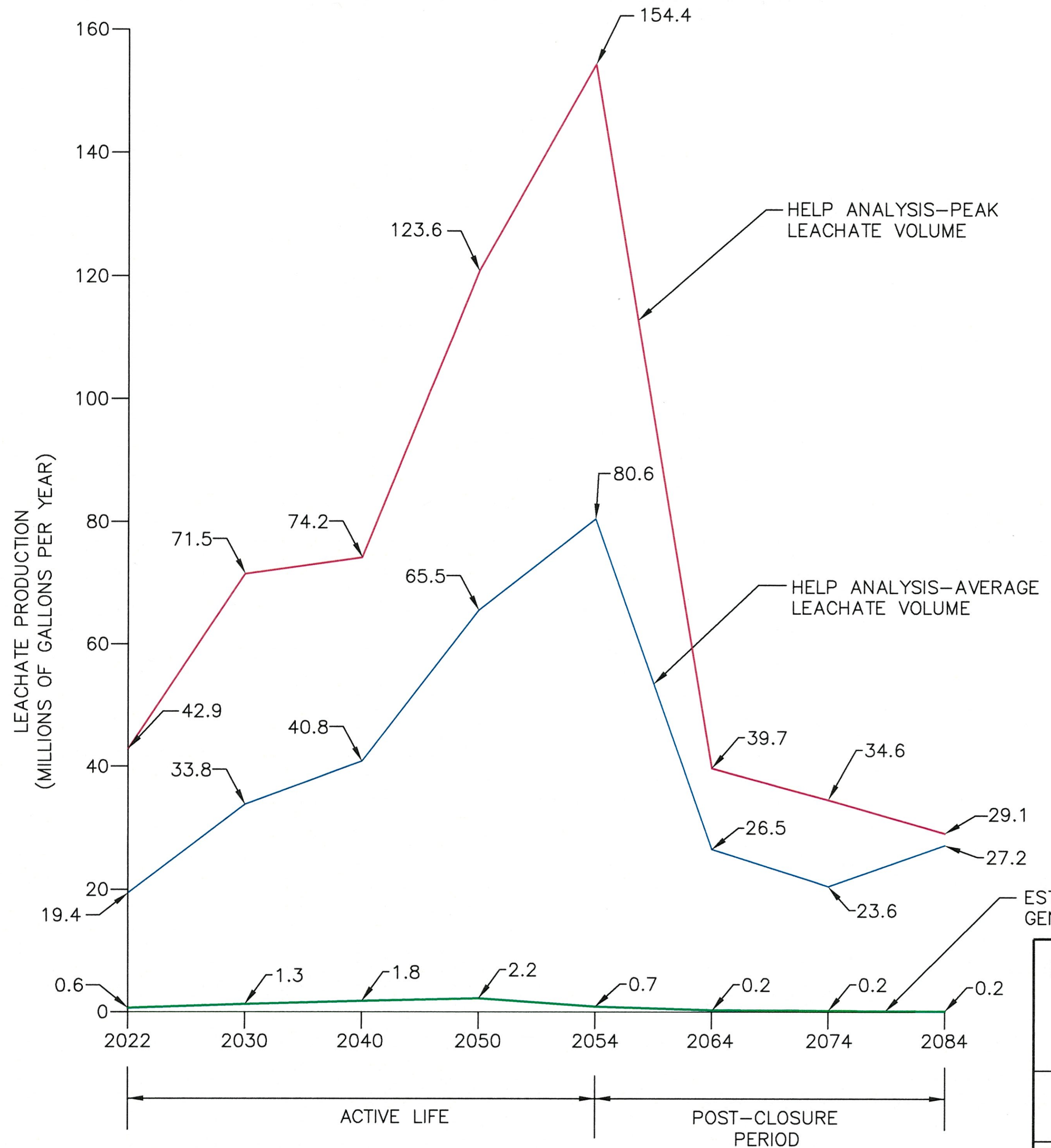
DRAWN BY: RAA	DATE: 03/2022	FILE: 0023–404–11
REVIEWED BY: BPY	CAD: FIG 6–1.DWG	FIGURE 6–1

O:\0023\404\EXPANSION 2021\PART III\IIIC\FIGURE 6–1.dwg, rarrington, 1:1



NOTE:

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

LEACHATE GENERATION VOLUME ESTIMATION

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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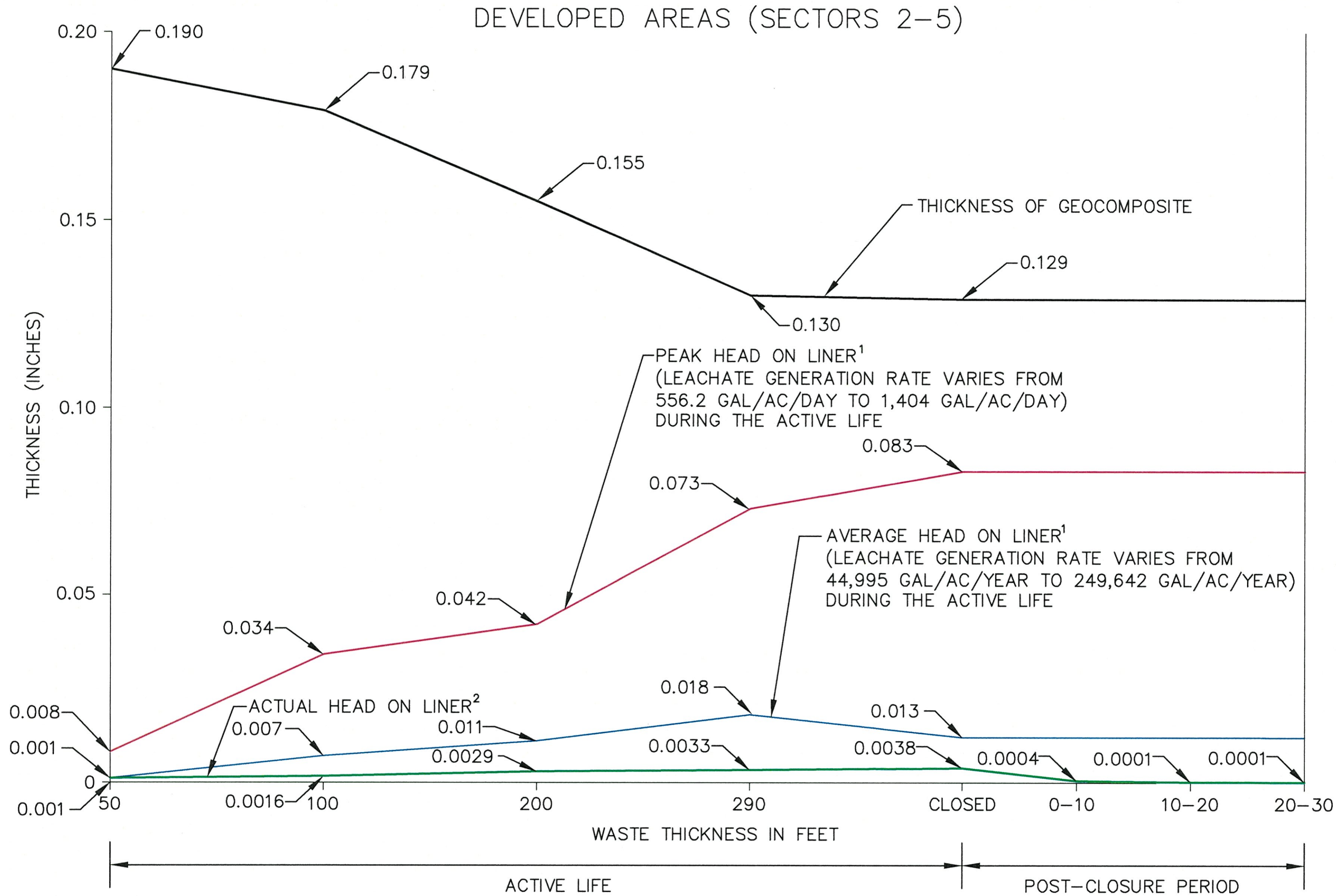
O:\0023\404\EXPANSION 2021\PART III\IIIC\FIGURE 6–2.dwg, rarrington, 1:1



[1] PEAK AND AVERAGE HEAD ON LINER VALUES CALCULATED BY THE HELP MODEL. THE RESULTS OF THE HELP MODEL CAN BE FOUND IN APPENDIX IIIC–A.

[2] ACTUAL HEAD ON LINER DERIVED FROM MEASURED LEACHATE COLLECTION RATES AT LANDFILL. SEE APPENDIX IIIC–E FOR MORE INFORMATION.

ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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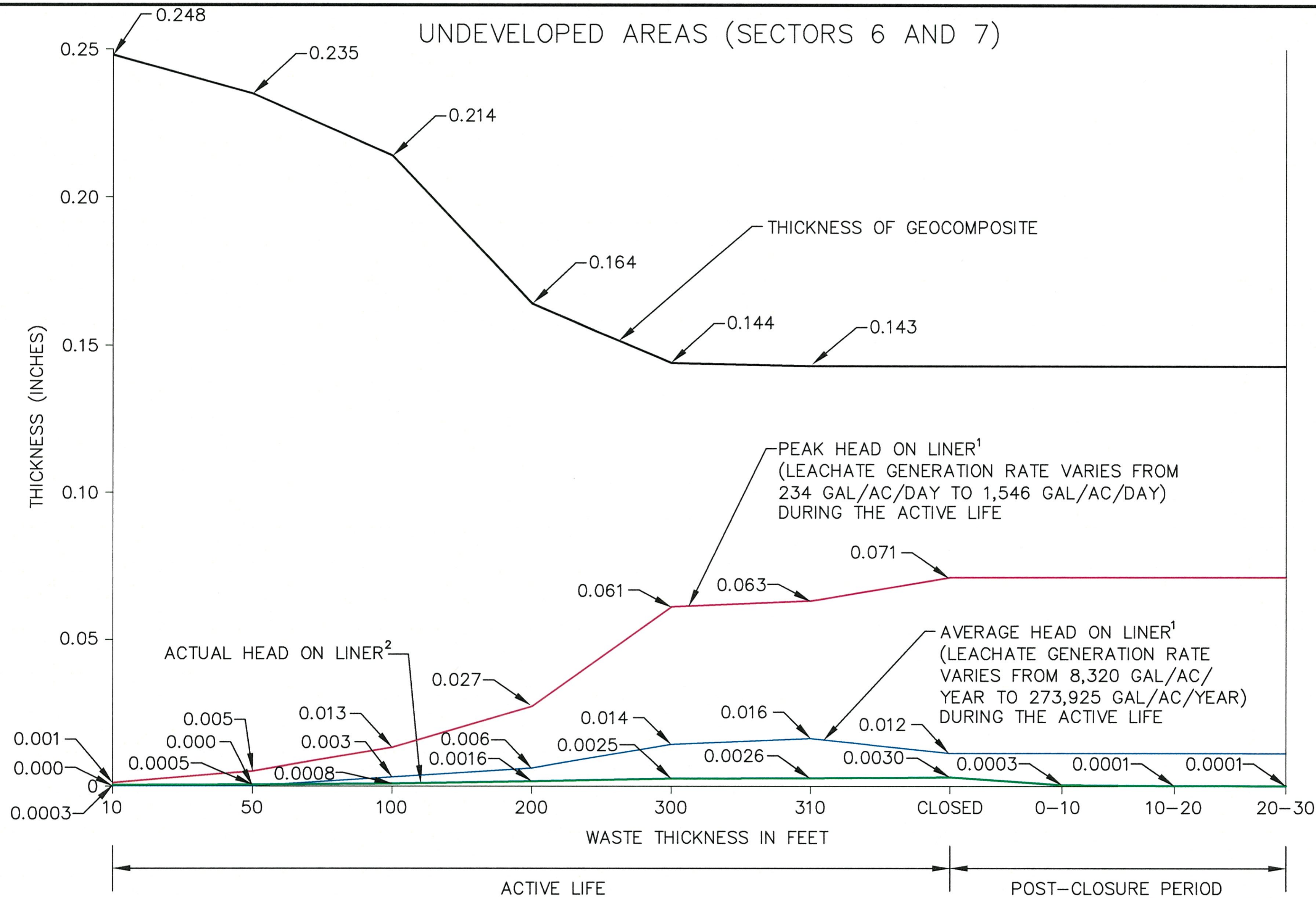
REVIEWED BY: BPY	CAD: FIG 6–3.DWG	FIGURE 6–3

O:\0023\404\EXPANSION 2021\PART III\IIIC\FIGURE 6-3.dwg, rarrington, 1:1



[1] PEAK AND AVERAGE HEAD ON LINER VALUES CALCULATED BY THE HELP MODEL. THE RESULTS OF THE HELP MODEL CAN BE FOUND IN APPENDIX IIIC–A.

[2] ACTUAL HEAD ON LINER DERIVED FROM MEASURED LEACHATE COLLECTION RATES AT LANDFILL. SEE APPENDIX IIIC–E FOR MORE INFORMATION.

ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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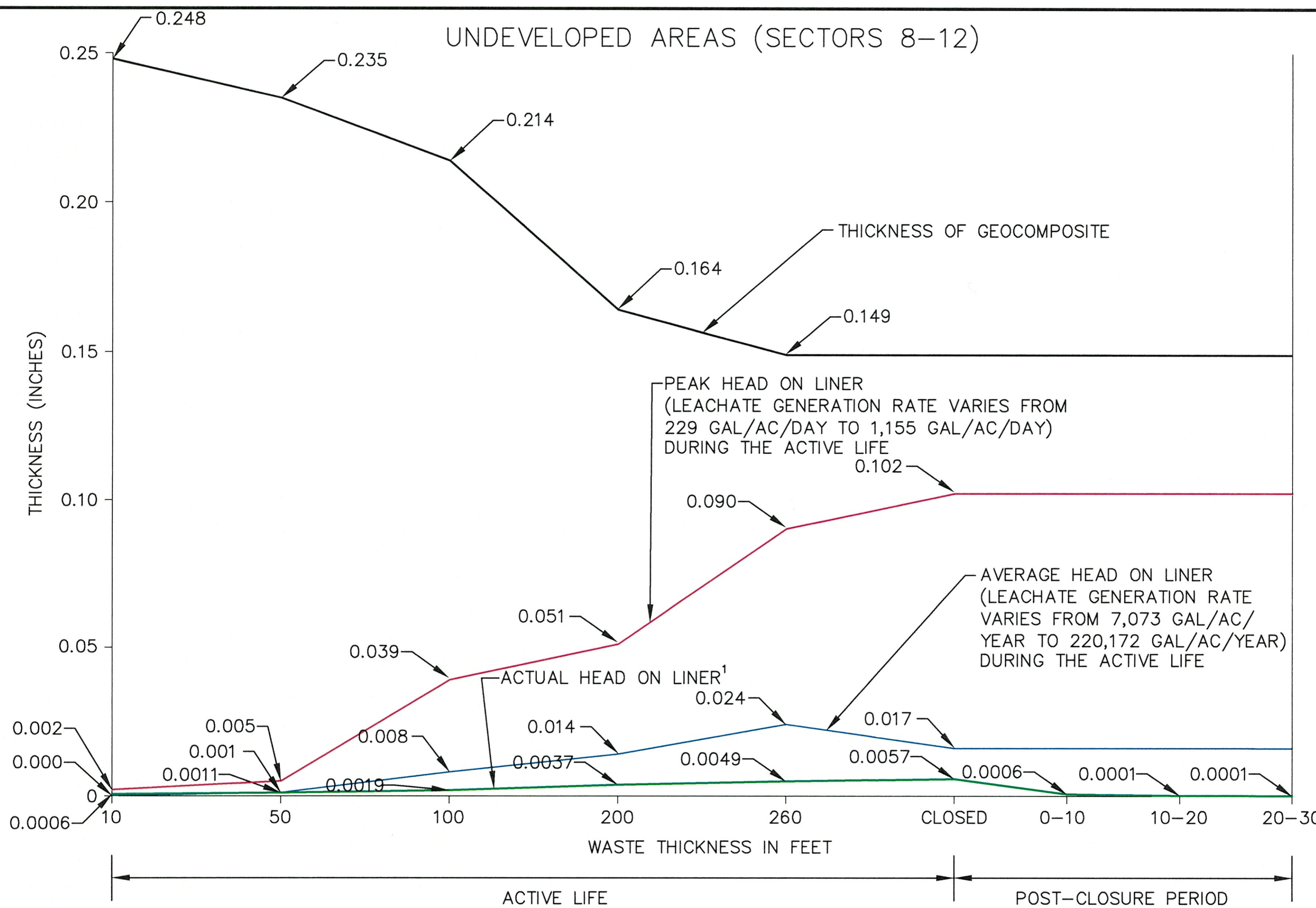
DRAWN BY: RAA	DATE: 03/2022	FILE: 0023–404–11
REVIEWED BY: BPY	CAD: FIG 6–4.DWG	FIGURE 6–4

O:\0023\404\EXPANSION 2021\PART III\IIIC\FIGURE 6-4.dwg, rarrington, 1:1



¹ PEAK AND AVERAGE HEAD ON LINER VALUES CALCULATED BY THE HELP MODEL. THE RESULTS OF THE HELP MODEL CAN BE FOUND IN APPENDIX IIIC–A.

ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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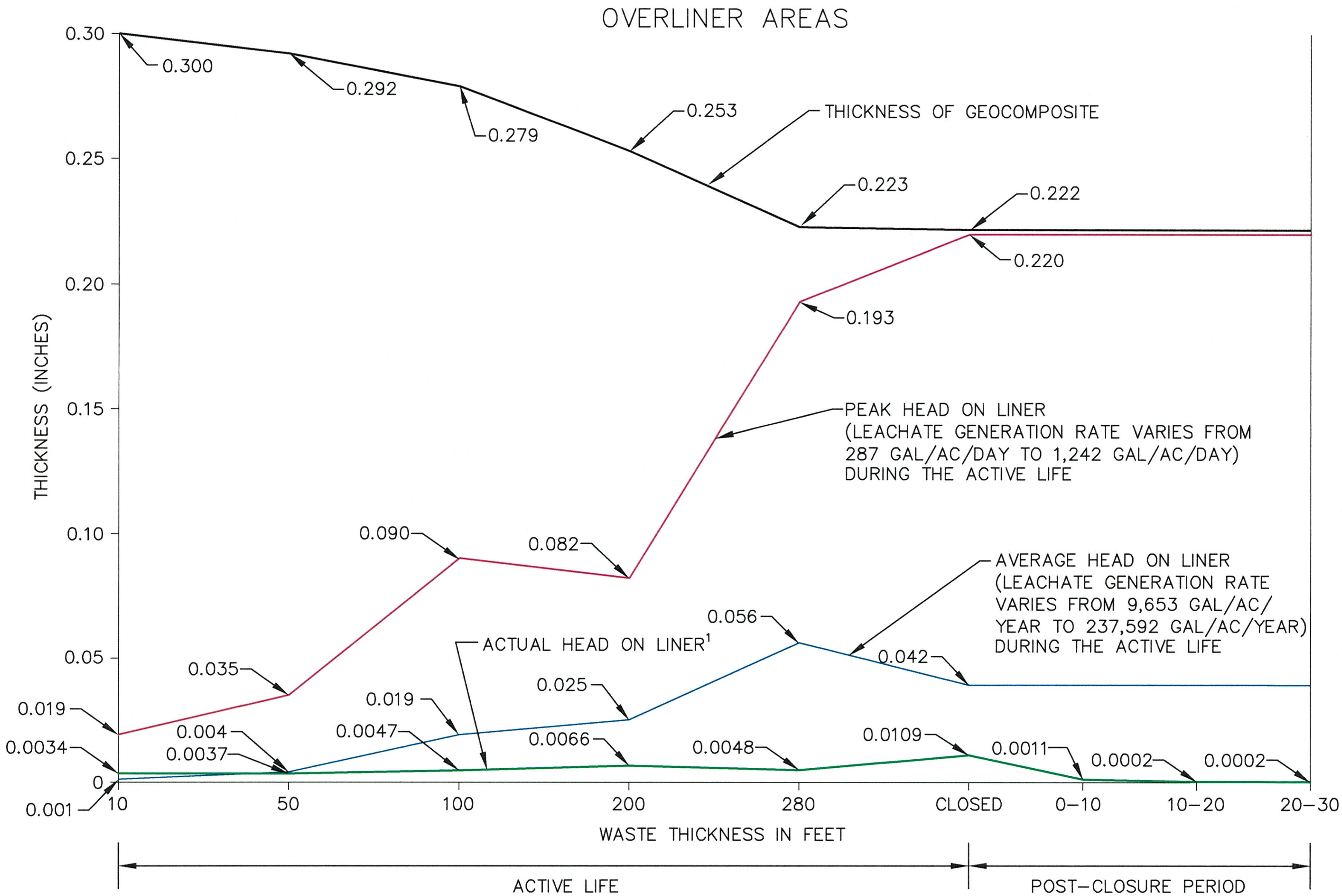
DRAWN BY: RAA	DATE: 03/2022	FILE: 0023-404-11
REVIEWED BY: BPY	CAD: FIG 6-5.DWG	FIGURE 6-5

O:\0023\404\EXPANSION 2021\PART III\IIIC\FIGURE 6-5.dwg, rarrington, 1:1



[1] PEAK AND AVERAGE HEAD ON LINER VALUES CALCULATED BY THE HELP MODEL. THE RESULTS OF THE HELP MODEL CAN BE FOUND IN APPENDIX IIIC–A.

ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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REVIEWED BY: BPY	CAD: FIG 6–6.DWG	FIGURE 6–6

O:\0023\404\EXPANSION 2021\PART III\IIIC\FIGURE 6-6.dwg, rarrington, 1:1

APPENDIX IIIC-A

LEACHATE GENERATION MODEL

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5-19-2022

Includes pages IIIC-A-1 through IIIC-A-253

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 City of Arlington 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 developed areas (Sector 2 through 5):

- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 200 feet of waste with intermediate cover
- 290 feet of waste with intermediate cover
- 290 feet of waste with final cover

The site was modeled as a 1-acre unit area for the following stages of landfill development in undeveloped areas (Sector 6 and 7):

- 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
- 300 feet of waste with intermediate cover
- 310 feet of waste with intermediate cover
- 310 feet of waste with final cover

The site was modeled as a 1-acre unit area for the following stages of landfill development in the undeveloped areas (Sectors 8 through 12):

- 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
- 290 feet of waste with intermediate cover
- 290 feet of waste with final cover

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

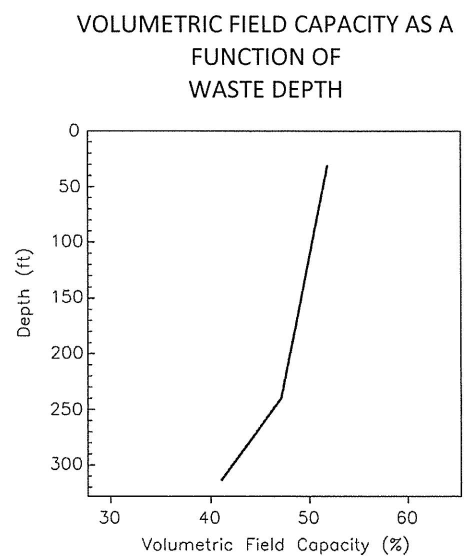
- Working face with 10 feet of waste
- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 200 feet of waste with intermediate cover
- 280 feet of waste with intermediate cover
- 280 feet of waste with final cover

The active stage was modeled for one year with no intermediate or daily cover. 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 12 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 86.1 and 86.7 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 81.2 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 following graph.



CLIMATE DATA INPUT

Precipitation and temperature data was synthetically generated by the HELP model program using normal mean monthly precipitation data and temperature date from the NOAA for the Arlington Municipal Airport weather station. The average annual precipitation over the modeled 30-year period was 35.65 inches. 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 $1x10^{-7}$ cm/s. The geomembrane liner was modeled for good installation quality, with 1 installation defect and 1 pinhole per acre. 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 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 1 installation defect 1 pinhole per acre. 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 $5x10^{-9}$ cm/s.

Leachate Collection System

Developed areas Sectors 2 through 5 were modeled with an LCS that includes a 200-mil thick single-sided geocomposite (floor grades). Undeveloped areas Sectors 6 through 12 will be constructed with an LCS that includes a 250-mil-thick single-sided geocomposite (floor grades). The calculations for determining the hydraulic conductivity of the geocomposite are shown on pages IIIC-A-6 through IIIC-A-17. The double-sided geocomposite used on sideslopes is analyzed in Appendix IIIC-A.2.

In HELP model demonstrations 10 percent recirculation is used for the developed and undeveloped 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. 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 does not recirculate any leachate that is produced). In addition to the above, a second demonstration is included in Appendix IIIC-A.1 that shows the additional leachate generation that would result from leachate being recirculated at a working face that is "parked" over a 1-acre area for 50 percent of the site's life. This analysis is included to show that the leachate collection system will meet the regulatory requirements, even with this extreme leachate loading scenario. 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 IIIC-A-17 through IIIC-A-21.

Waste Layers

Various waste thicknesses were modeled to represent the various stages of landfill development in the Subtitle D and pre-subtitle D areas. 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 $1x10^{-3}$ cm/s. A lower hydraulic conductivity of $1x10^{-4}$ 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 with a hydraulic conductivity of $6.4x10^{-5}$ cm/s.

Final Cover

The composite final cover over the Subtitle D and overliner areas consists of a 12-inch erosion layer with the top 6 inches capable of sustaining growth of vegetation, a geocomposite drainage layer, 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 $1x10^{-5}$ cm/s.

HELP MODEL OUTPUT

The HELP summary tables and output files for the various stages of the landfill development are presented beginning on page IIIC-A-29.

CITY OF ARLINGTON LANDFILL
0023-404-11-104
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
DEVELOPED AREAS - SECTORS 2-5

Required: Estimate the properties of the geocomposite leachate collection layer for the developed Subtitle D sectors.

Note: Sectors 2 through 5 were constructed with a 200-mil-thick geocomposite and Sector 5 was constructed with a 300-mil-thick geocomposite. The entire developed area (Sectors 2 through 5) were conservatively modeled with a 200-mil-thick geocomposite.

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 required transmissivity for the 200-mil-thick single-sided geocomposite collection layer.
4. Compute the design transmissivity of the 200-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, Second Edition, June 2007.
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. Determine the 200-mil geocomposite leachate collection layer thickness under the expected loading conditions.

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of 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 for Subtitle D Areas

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	51	2,895	0.190	0.005
Interim - 100'	100	3	57	6,045	0.179	0.005
Interim - 200'	200	3	71	14,545	0.155	0.004
Interim - 290'	290	3	79	23,255	0.130	0.003
Closed - 290'	290	4	79	23,370	0.129	0.003

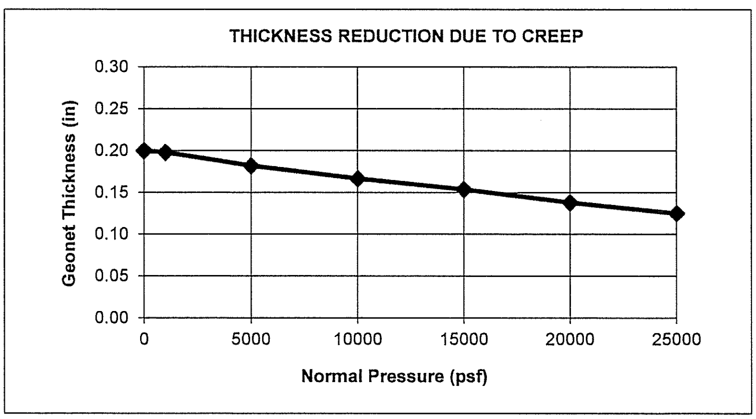
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, 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.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (290' Waste)	Closed
		Fill Condition					
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. Identify the minimum required transmissivity for the 200-mil-thick double-sided geocomposite collection layer.

The required minimum transmissivity for the 200-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown on Sheet IIIC-A-22. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the design transmissivity of the 200-mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3 - Required Transmissivity for Subtitle D Areas

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (m)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	2,895	0.005	1.28E-03	3.15	4.06E-04	8.40
Interim - 100'	100	6,045	0.005	9.78E-04	3.96	2.47E-04	5.45
Interim - 200'	200	14,545	0.004	5.62E-04	4.75	1.18E-04	3.00
Interim - 290'	290	23,255	0.003	4.42E-04	5.02	8.82E-05	2.68
Closed - 290'	290	23,370	0.003	4.41E-04	5.72	7.71E-05	2.35

[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.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A-22.

[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:

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

CITY OF ARLINGTON LANDFILL
0023-404-11-104
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
UNDEVELOPED AREA - SECTORS 6-7

Required: Determine the minimum requirements of the 250-mil geocomposite leachate collection layer for Sectors 6 & 7

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, Second Edition, June 2007.
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. Determine the 250-mil geocomposite leachate collection layer thickness under the expected loading conditions.

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of 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 for Subtitle D 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	51	740	0.248	0.006
Interim - 50'	50	3	51	2,895	0.235	0.006
Interim - 100'	100	3	57	6,045	0.214	0.005
Interim - 200'	200	3	71	14,545	0.164	0.004
Interim - 300'	300	3	79	24,045	0.144	0.004
Interim - 310'	310	3	79	24,835	0.143	0.004
Closed - 310'	310	4	79	24,950	0.143	0.004

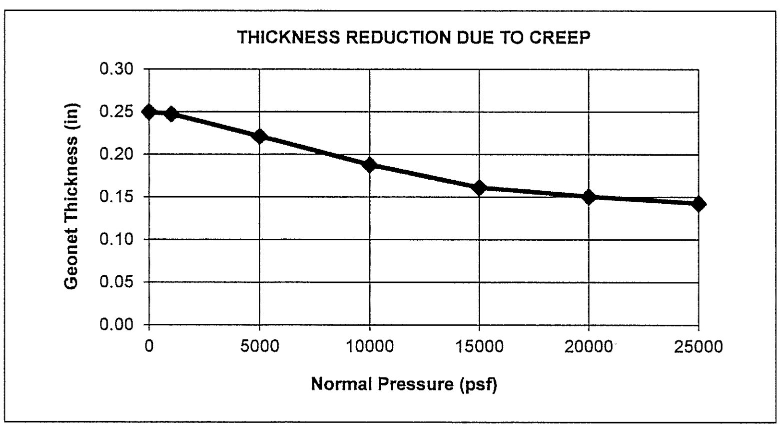
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[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.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition						
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (300' Waste)	Interim (308' Waste)	Closed
RF_{IN}	Delayed Intrusion	1.1	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	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.38	2.51	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	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	5.02	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. Identify the minimum required transmissivity for the 250-mil-thick double-sided geocomposite collection layer.

The required minimum transmissivity for the 250-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown on Sheet IIIC-A-23. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

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.

Table 3 - Required Transmissivity for Subtitle D Areas

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (m)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	740	0.006	3.62E-03	2.20	1.65E-03	26.13
Interim - 50'	50	2,895	0.006	2.69E-03	3.15	8.55E-04	14.31
Interim - 100'	100	6,045	0.005	1.73E-03	3.96	4.38E-04	8.05
Interim - 200'	200	14,545	0.004	8.16E-04	4.75	1.72E-04	4.13
Interim - 300'	300	24,045	0.004	4.92E-04	5.02	9.81E-05	2.68
Interim - 310'	310	24,835	0.004	4.72E-04	5.02	9.41E-05	2.59
Closed - 310'	310	24,950	0.004	4.69E-04	5.72	8.20E-05	2.26

[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.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer 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:

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

5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the graph shown on Sheet IIIC-A-23 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 0.02 under normal pressures of 1,000, 15,000 and 24,950 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seat 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 maximum normal stress (i.e., 24,950 psf) with all the same assumptions as the first three tests. The minimum transmissivity will be 4.69×10^{-4} m^2/s.

Note:
Reference to "geocomposite thickness" within these calculations refers to thickness of geonet, not the overall thickness of geocomposite. Actual manufacturer's specified thickness for a geocomposite incorporating the specified geonet thickness may be greater. The transmissivity values used for these calculations may or may not be representative of actual transmissivity values for every manufacturer, and may require a prospective material supplier provide a geocomposite that varies in thickness or composition from the geocomposite assumed for these calculations in order to meet minimum transmissivity criteria set forth in the Appendix IIID - Liner Quality Control Plan.

CITY OF ARLINGTON LANDFILL
0023-404-11-104
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
UNDEVELOPED AREA - SECTORS 8-12

Required: Determine the minimum requirements of the 250-mil geocomposite leachate collection layer for Sectors 8 through 12

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, Second Edition, June 2007.
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. Determine the 250-mil geocomposite leachate collection layer thickness under the expected loading conditions.

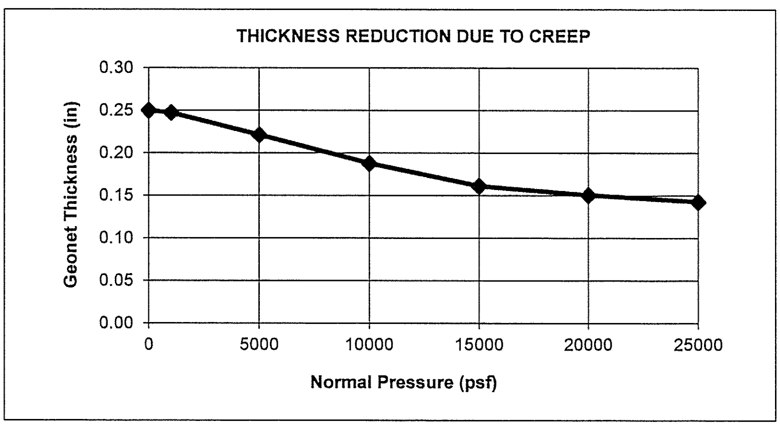
Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of intermediate cover, protective cover, or final cover) and waste.

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

Table 1 - Geocomposite Thickness for Subtitle D 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	51	740	0.248	0.006
Interim - 50'	50	3	51	2,895	0.235	0.006
Interim - 100'	100	3	57	6,045	0.214	0.005
Interim - 200'	200	3	71	14,545	0.164	0.004
Interim - 260'	260	3	79	20,885	0.149	0.004
Closed - 260'	260	4	79	21,000	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.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition						
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (300' Waste)	Interim (308' Waste)	Closed
RF_{IN}	Delayed Intrusion	1.1	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	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.38	2.51	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	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	5.02	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. Identify the minimum required transmissivity for the 250-mil-thick double-sided geocomposite collection layer.

The required minimum transmissivity for the 250-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown on Sheet IIIC-A-23. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

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.

Table 3 - Required Transmissivity for Subtitle D Areas

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (m)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	740	0.006	3.62E-03	2.20	1.65E-03	26.13
Interim - 50'	50	2,895	0.006	2.69E-03	3.15	8.55E-04	14.31
Interim - 100'	100	6,045	0.005	1.73E-03	3.96	4.38E-04	8.05
Interim - 200'	200	14,545	0.004	8.16E-04	4.75	1.72E-04	4.13
Interim - 260'	260	20,885	0.004	5.83E-04	5.02	1.16E-04	3.07
Closed - 260'	260	21,000	0.004	5.80E-04	5.72	1.01E-04	2.68

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.

4 T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer 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:

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

5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the graph shown on Sheet IIIC-A-23 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 0.02 under normal pressures of 1,000, 15,000 and 21,000 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seat 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 maximum normal stress (i.e., 21,000 psf) with all the same assumptions as the first three tests. The minimum transmissivity will be 5.80×10^{-4} m^2/s.

Note:
Reference to "geocomposite thickness" within these calculations refers to thickness of geonet, not the overall thickness of geocomposite. Actual manufacturer's specified thickness for a geocomposite incorporating the specified geonet thickness may be greater. The transmissivity values used for these calculations may or may not be representative of actual transmissivity values for every manufacturer, and may require a prospective material supplier provide a geocomposite that varies in thickness or composition from the geocomposite assumed for these calculations in order to meet minimum transmissivity criteria set forth in the Appendix IIID - Liner Quality Control Plan.

CITY OF ARLINGTON LANDFILL
0023-404-11-104
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
OVERLINER AREA

Required: Determine the minimum requirements of the 300-mil geocomposite leachate collection layer for the overliner.

Method:

1. Determine the 300-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 300-mil-thick double-sided geocomposite collection layer.
4. Compute the design transmissivity of the 300-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, Second Edition, June 2007.
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. Determine the 300-mil geocomposite leachate collection layer thickness under the expected loading conditions.

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of 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 - Geocomposite Thickness for Subtitle D 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	51	740	0.300	0.008
Interim - 50'	50	3	51	2,895	0.292	0.007
Interim - 100'	100	3	57	6,045	0.279	0.007
Interim - 200'	200	3	71	14,545	0.253	0.006
Interim - 280'	280	3	79	22,465	0.223	0.006
Closed - 280'	280	4	79	22,580	0.222	0.006

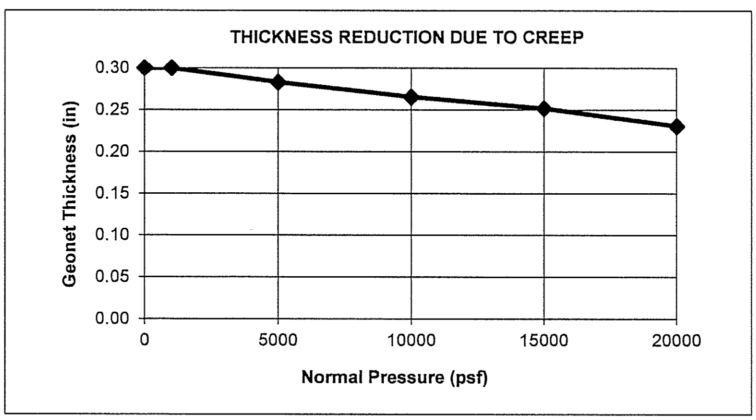
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[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.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition: Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (290' Waste)	Closed
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. Identify the minimum required transmissivity for the 300-mil-thick double-sided geocomposite collection layer.

The required minimum transmissivity for the 300-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown on Sheet IIIC-A-24. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the design transmissivity of the 300-mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3 - Required Transmissivity for Subtitle D Areas

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (m)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	740	0.008	2.14E-03	2.20	9.74E-04	12.78
Interim - 50'	50	2,895	0.007	2.73E-03	3.15	8.69E-04	11.72
Interim - 100'	100	6,045	0.007	2.63E-03	3.96	6.64E-04	9.35
Interim - 200'	200	14,545	0.006	2.01E-03	4.75	4.23E-04	6.58
Interim - 280'	280	22,465	0.006	1.14E-03	5.02	2.28E-04	4.03
Closed - 280'	280	22,580	0.006	1.13E-03	5.72	1.97E-04	3.49

[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.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer 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:

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

5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

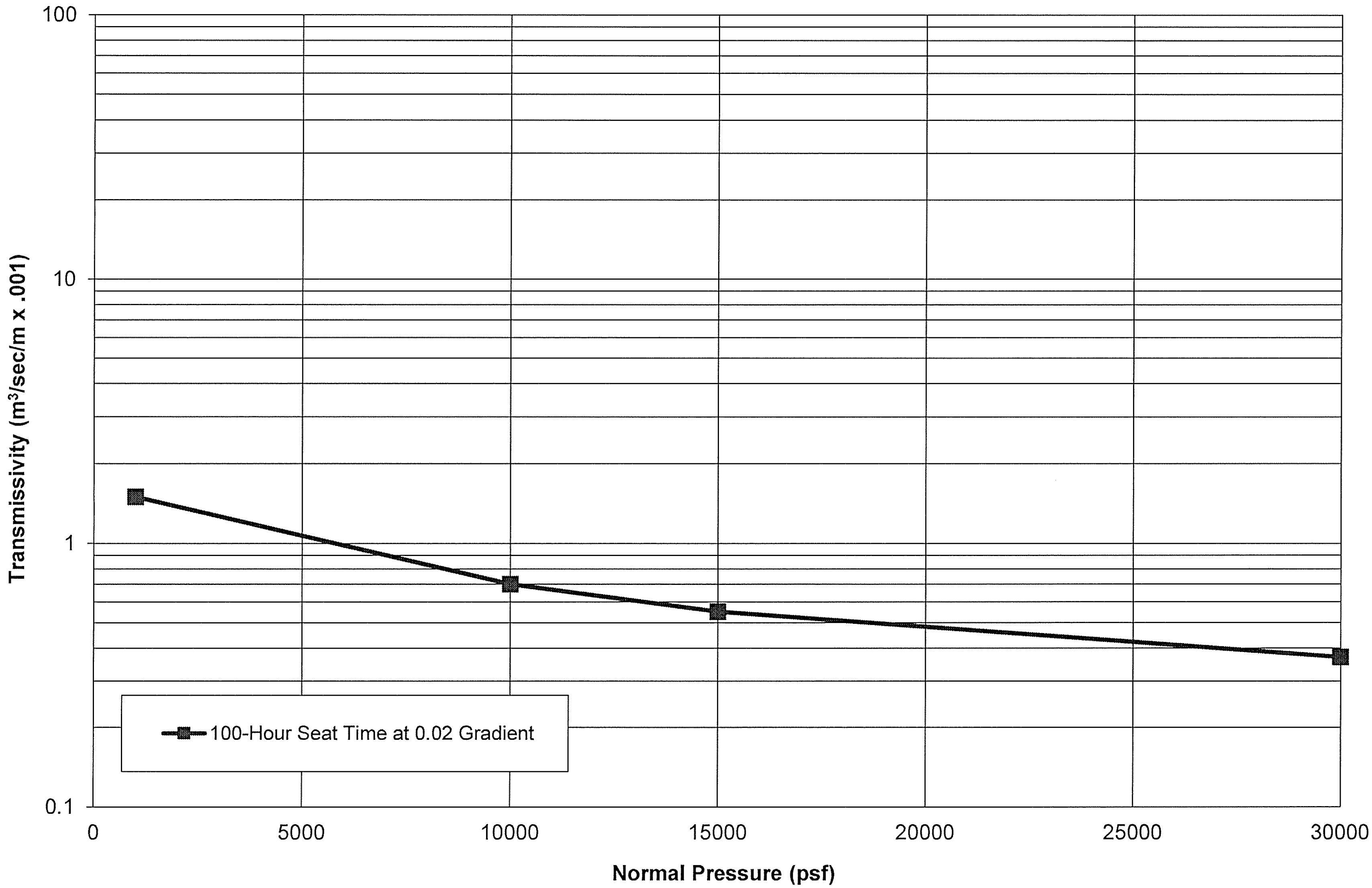
As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the graph shown on Sheet IIIC-A-24 will provide a drainage layer that will maintain less than twelve inches of head on the liner system.

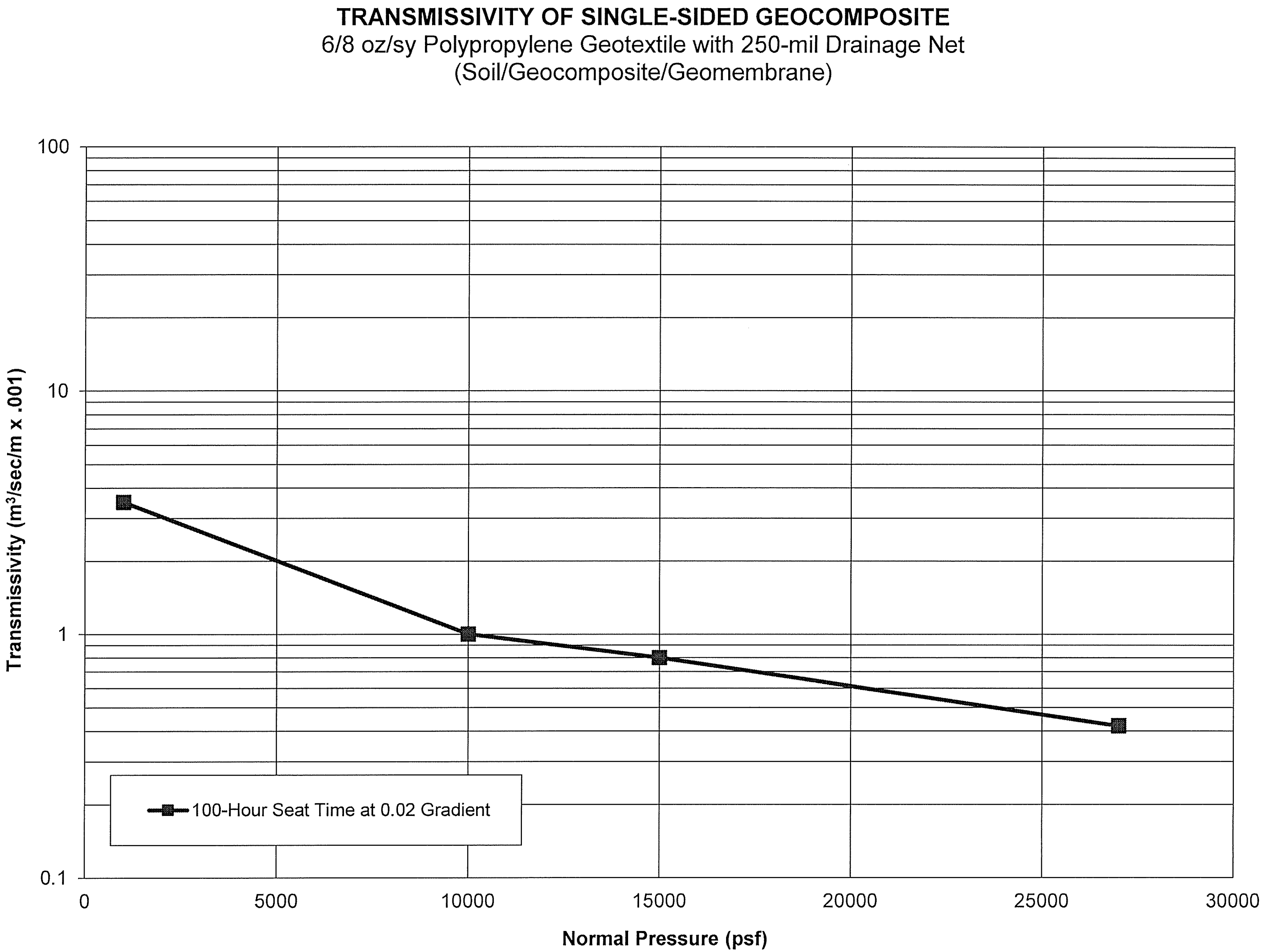
The drainage geocomposite required transmissivity values will be measured at a gradient of 0.015 under normal pressures of 1,000, 15,000 and 22,580 psf (or higher), boundary conditions consisting of soil/geocomposite/ geomembrane with minimum seat time of 100 hours and will be run for the first 100,000 square feet of liner construction. For each additional 100,000 square feet of double-sided geocomposite placement area, one additional transmissivity test will be run under the maximum normal stress (i.e., 22,580 psf) with all the same assumptions as the first three tests. The minimum transmissivity will be 1.13×10^{-3} m^2/s.

Note:
Reference to "geocomposite thickness" within these calculations refers to thickness of geonet, not the overall thickness of geocomposite. Actual manufacturer's specified thickness for a geocomposite incorporating the specified geonet thickness may be greater. The transmissivity values used for these calculations may or may not be representative of actual transmissivity values for every manufacturer, and may require a prospective material supplier provide a geocomposite that varies in thickness or composition from the geocomposite assumed for these calculations in order to meet minimum transmissivity criteria set forth in the Appendix IIID - Liner Quality Control Plan.

TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE

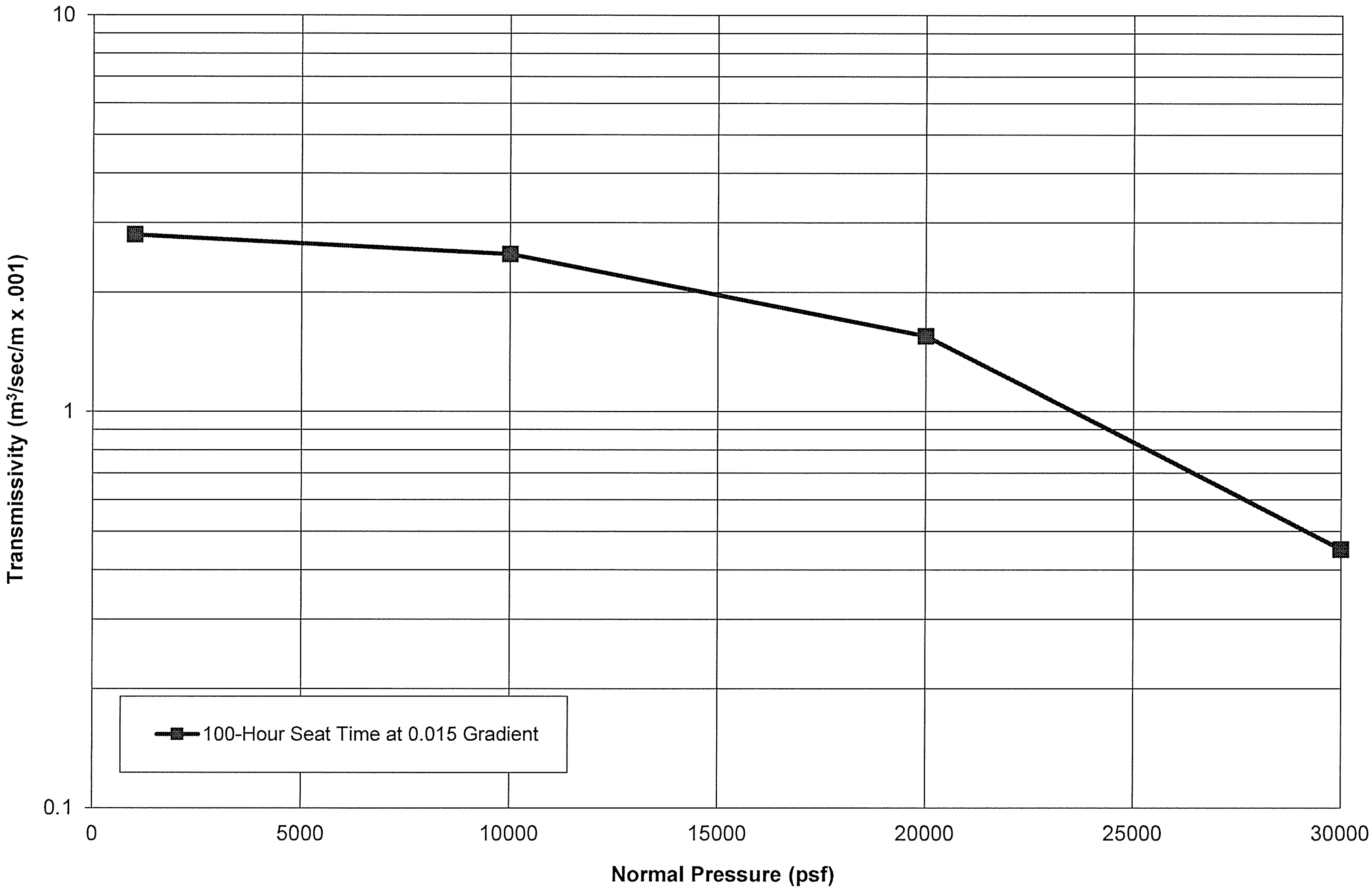
6/8 oz/sy Polypropylene Geotextile with 200-mil Drainage Net
(Soil/Geocomposite/Geomembrane)




TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE
6/8 oz/sy Polypropylene Geotextile with 250-mil Drainage Net
(Soil/Geocomposite/Geomembrane)
100
10
1
0.1
Transmissivity (m3/sec/m x .001)
0
5000
10000
15000
20000
25000
30000
Normal Pressure (psf)
100-Hour Seat Time at 0.02 Gradient

TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE

6/8 oz/sy Polypropylene Geotextile with 300-mil Drainage Net
(Soil/Geocomposite/Geomembrane)



		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (290 FT WASTE)	CLOSED (290 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4	5
	No. of Years	10	10	10	10	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	86.1	86.7	86.7	86.7	79.5
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	70	80	80	90	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	12
TOPSOIL LAYER (Texture = 10)	Thickness (in)					12
	Porosity (vol/vol)					0.3980
	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
GEOCOMPIOSITE DRAINAGE LAYER (Texture = 0)	Thickness (in)					0.300
	Porosity (vol/vol)					0.8500
	Field Capacity (vol/vol)					0.0100
	Wilting Point (vol/vol)					0.0050
	Init. Moisture Content (vol/vol)					0.0100
	Hyd. Conductivity (cm/s)					12.17
	Slope (%)					5.0
	Slope Length (ft)					1000
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)					0.04
	Hyd. Conductivity (cm/s)					4.0E-13
	Pinhole Density (holes/acre)					1
	Install. Defects (holes/acre)					4
	Placement Quality					GOOD
COMPACTED CLAY LINER (Texture = 0)	Thickness (in)					18.00
	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-05
INTERMEDIATE COVER (Texture = 11)	Thickness (in)	12	12	12	12	12
	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640
	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] (Texture = 0)	Thickness (in)	600	1200	1500	1500	1500
	Porosity (vol/vol)	0.6376	0.6277	0.6174	0.6174	0.6148
	Field Capacity (vol/vol)	0.5185	0.5156	0.5127	0.5127	0.5114
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)			900	1980	1980
	Porosity (vol/vol)			0.5348	0.4976	0.4976
	Field Capacity (vol/vol)			0.4892	0.4786	0.4786
	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 COVER (Texture = 10)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.190	0.179	0.155	0.130	0.129
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	8.40	5.45	3.00	2.68	2.35
	Slope (%)	2.0	2.0	2.0	2.0	2.0
	Slope Length (ft)	215	215	215	215	215
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
	Pinhole Density (holes/acre)	1	1	1	1	1
	Install. Defects (holes/acre)	1	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	38.39	38.39	38.39	38.39	35.65
RUNOFF	Average Annual (in)	1.94	2.37	2.37	2.63	1.22
EVAPOTRANSPIRATION	Average Annual (in)	27.58	27.37	27.37	27.31	25.50
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	6,014.9	26,856.3	23,415.4	33,372.2	21,669.3
	Peak Daily (cf/day)	74.4	178.9	119.7	187.8	187.7
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)	601.5	2,685.6	2,341.5	3,337.2	
	Peak Daily (cf/day)	7.4	17.9	12.0	18.8	
HEAD ON LINER	Average Annual (in)	0.001	0.007	0.011	0.018	0.013
	Peak Daily (in)	0.008	0.034	0.042	0.073	0.083

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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.

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (310 FT WASTE)	CLOSED (310 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6	7
INFORMATION	No. of Years	1	10	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	86.1	86.7	86.7	86.7	86.7	81.2
	Model Area (acre)	1	1	1	1	1	1	1
	Runoff Area (%)	0	70	80	80	80	90	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	10	12
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
GEOCOMPIOSITE	Thickness (in)							0.300
DRAINAGE	Porosity (vol/vol)							0.8500
LAYER	Field Capacity (vol/vol)							0.0100
(Texture = 0)	Wilting Point (vol/vol)							0.0050
	Init. Moisture Content (vol/vol)							0.0100
	Hyd. Conductivity (cm/s)							12.17
	Slope (%)							25.0
	Slope Length (ft)							420
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
COMPACTED	Thickness (in)							18.00
CLAY LINER	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)	120	600	1200	1500	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6376	0.6277	0.6174	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5185	0.5156	0.5127	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	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	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)				900	2100	2220	2220
(Texture = 0)	Porosity (vol/vol)				0.5348	0.4935	0.4893	0.4893
	Field Capacity (vol/vol)				0.4892	0.4775	0.7463	0.4863
	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	24
COVER	Porosity (vol/vol)	0.3980	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	0.2440
	Wilting Point (vol/vol)	0.1360	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	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.248	0.235	0.214	0.164	0.144	0.143	0.143
COLLECTION	Porosity (vol/vol)	0.8500	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	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	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	0.0100
	Hyd. Conductivity (cm/s)	26.13	14.31	8.05	4.13	2.68	2.59	2.26
	Slope (%)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Slope Length (ft)	165	165	165	165	165	165	165
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1	1	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	1	1	1	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	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	0.4180
	Wilting Point (vol/vol)	0.3670	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	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	47.30	38.39	38.39	38.39	38.39	38.39	35.65
RUNOFF	Average Annual (in)	0.00	2.06	2.43	2.37	2.37	2.63	1.45
EVAPOTRANSPIRATION	Average Annual (in)	34.10	27.86	27.68	27.37	27.37	27.31	25.55
LATERAL	Average Annual (cf/year)	1,112.3	5,187.1	22,664.7	23,512.7	34,817.1	36,618.4	23,704.4
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	31.3	56.1	126.5	135.5	206.1	206.0	201.6
LATERAL	Average Annual (cf/year)		518.7	2,266.5	2,351.3	3,481.7	3,661.8	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)		5.6	12.7	13.6	20.6	20.6	
HEAD ON LINER	Average Annual (in)	0.000	0.000	0.003	0.006	0.014	0.016	0.012
	Peak Daily (in)	0.001	0.005	0.013	0.027	0.061	0.063	0.071

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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.

CITY OF ARLINGTON LANDFILL
0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
UNDEVELOPED SECTORS 8-12

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (260 FT WASTE)	CLOSED (260 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	1	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	86.1	86.7	86.7	86.7	85.7
	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	12
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
GEOCOMPIOSITE	Thickness (in)						0.300
DRAINAGE	Porosity (vol/vol)						0.8500
LAYER	Field Capacity (vol/vol)						0.0100
(Texture = 0)	Wilting Point (vol/vol)						0.0050
	Init. Moisture Content (vol/vol)						0.0100
	Hyd. Conductivity (cm/s)						12.17
	Slope (%)						25.0
	Slope Length (ft)						300
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
COMPACTED	Thickness (in)						18.00
CLAY LINER	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	0.6277	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5185	0.5156	0.5127	0.5127	0.5127
	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	1620	2220
(Texture = 0)	Porosity (vol/vol)				0.5348	0.5100	0.4893
	Field Capacity (vol/vol)				0.4892	0.4822	0.4863
	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)	0.248	0.235	0.214	0.164	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)	26.13	14.31	8.05	4.13	3.07	2.68
	Slope (%)	2.0	2.0	2.0	2.0	2.0	2.0
	Slope Length (ft)	370	370	370	370	370	370
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
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)	1	1	1	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	1	1	1	1	1	1
	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)	47.30	38.39	38.39	38.39	38.39	35.65
RUNOFF	Average Annual (in)	0.00	1.93	2.37	2.37	2.63	2.96
EVAPOTRANSPIRATION	Average Annual (in)	34.50	27.58	27.37	27.37	27.31	25.67
LATERAL	Average Annual (cf/year)	945.5	6,096.4	26,854.2	23,488.4	29,432.8	17,566.0
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	30.5	81.9	176.8	114.5	154.3	153.3
LATERAL	Average Annual (cf/year)		609.6	2,685.4	2,348.8	2,943.3	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)		8.2	17.7	11.4	15.4	
HEAD ON LINER	Average Annual (in)	0.000	0.001	0.008	0.014	0.024	0.017
	Peak Daily (in)	0.002	0.005	0.039	0.051	0.090	0.102

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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.

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (280 FT WASTE)	CLOSED (280 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	1	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	86.1	86.7	86.7	86.7	81.2
	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	12
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
GEOCOMPIOSITE	Thickness (in)						0.300
DRAINAGE	Porosity (vol/vol)						0.8500
LAYER	Field Capacity (vol/vol)						0.0100
(Texture = 0)	Wilting Point (vol/vol)						0.0050
	Init. Moisture Content (vol/vol)						0.0100
	Hyd. Conductivity (cm/s)						12.17
	Slope (%)						25.0
	Slope Length (ft)						500
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
COMPACTED	Thickness (in)						18.00
CLAY LINER	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[1]	Thickness (in)	120	600	1200	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6376	0.6277	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5185	0.5156	0.5127	0.5127	0.5127
	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[1]	Thickness (in)				900	1860	2610
(Texture = 0)	Porosity (vol/vol)				0.5348	0.5017	0.4893
	Field Capacity (vol/vol)				0.4892	0.4798	0.4863
	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	0.292	0.279	0.253	0.223	0.222
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)	12.78	11.72	9.35	6.58	4.03	3.49
	Slope[2] (%)	1.5	1.5	1.5	1.5	1.5	1.5
	Slope Length (ft)	800	800	800	800	800	800
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
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)	1	1	1	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	1	1	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
GEOSYNTHETIC	Thickness (in)	0.25	0.25	0.25	0.25	0.25	0.25
SOIL LAYER	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
COMPACTED	Thickness (in)	12	12	12	12	12	12
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)	47.30	38.39	38.39	38.39	38.39	35.65
RUNOFF	Average Annual (in)	0.00	1.94	2.37	2.37	2.63	1.63
EVAPOTRANSPIRATION	Average Annual (in)	34.24	27.34	27.37	27.37	27.31	25.75
LATERAL	Average Annual (cf/year)	1,290.4	6,700.9	25,605.0	23,121.4	31,761.4	20,756.7
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	38.4	88.9	166.0	105.9	151.0	149.0
HEAD ON LINER	Average Annual (in)	0.001	0.004	0.019	0.025	0.056	0.042
	Peak Daily (in)	0.019	0.035	0.090	0.082	0.193	0.220

[1] 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.

[2] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the overliner.

HELP MODEL OUTPUT FOR DEVELOPED AREAS (SECTORS 2 THROUGH 5)

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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:\AR\C\DEV\I50\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\DEV\I50\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\DEV\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\DEV\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\DEV\I50\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\DEV\I50\OUTPUT1.OUT


TIME:  81:34     DATE:  12/14/2021


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     TITLE:  ARLINGTON LANDFILL - DEVELOPED AREAS (2-5) - INTERIM 50 FT

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     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
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```
  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                     =      0.19   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.   =   8.39999962000     CM/SEC
     SLOPE                       =      2.00   PERCENT
     DRAINAGE LENGTH             =    215.0    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  36
     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.   =  0.399999993000E-12 CM/SEC
     FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS    =      1.00   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 800. FEET.

SCS RUNOFF CURVE NUMBER	=	86.10	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.053	0.101	0.053	0.050	0.124	0.298
	0.151	0.039	0.300	0.529	0.048	0.189
STD. DEVIATIONS	0.057	0.181	0.065	0.072	0.130	0.345
	0.247	0.070	0.280	1.119	0.096	0.237
EVAPOTRANSPIRATION						
TOTALS	1.938	1.934	2.357	2.942	2.984	2.513
	2.812	1.567	3.050	2.318	1.321	1.842
STD. DEVIATIONS	0.348	0.751	0.626	1.222	1.068	1.643

1.449	1.127	1.167	1.327	0.679	0.560

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0123	0.0117	0.0133	0.0132	0.0133	0.0132
	0.0154	0.0133	0.0141	0.0148	0.0154	0.0158
STD. DEVIATIONS	0.0139	0.0135	0.0155	0.0153	0.0154	0.0148
	0.0159	0.0156	0.0151	0.0149	0.0155	0.0152

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1104	0.1056	0.1197	0.1189	0.1198	0.1186
	0.1385	0.1194	0.1265	0.1331	0.1384	0.1423
STD. DEVIATIONS	0.1253	0.1215	0.1393	0.1375	0.1386	0.1333
	0.1430	0.1404	0.1358	0.1342	0.1393	0.1366

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0123	0.0117	0.0133	0.0132	0.0133	0.0132
	0.0154	0.0133	0.0141	0.0148	0.0154	0.0158
STD. DEVIATIONS	0.0139	0.0135	0.0155	0.0153	0.0154	0.0148
	0.0159	0.0156	0.0151	0.0149	0.0155	0.0152

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	0.0009	0.0009	0.0010	0.0010	0.0010	0.0010
	0.0011	0.0010	0.0011	0.0011	0.0012	0.0012
STD. DEVIATIONS	0.0010	0.0011	0.0011	0.0012	0.0011	0.0011
	0.0012	0.0011	0.0011	0.0011	0.0012	0.0011

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	1.934 (1.0157)	7021.98	5.039
EVAPOTRANSPIRATION	27.578 (2.7771)	100109.87	71.840
DRAINAGE RECIRCULATED INTO LAYER 2	0.16570 (0.17844)	601.490	0.43163
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.49130 (1.60596)	5413.408	3.88470
DRAINAGE RECIRCULATED FROM LAYER 4	0.16570 (0.17844)	601.490	0.43163
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.012	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.001 (0.001)		
CHANGE IN WATER STORAGE	7.385 (3.6117)	26806.39	19.236

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.057	7467.6079
DRAINAGE RECIRCULATED INTO LAYER 2	0.00205	7.43564
DRAINAGE COLLECTED FROM LAYER 4	0.01844	66.92074

DRAINAGE RECIRCULATED FROM LAYER 4	0.00205	7.43564
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00008
AVERAGE HEAD ON TOP OF LAYER 5	0.005	
MAXIMUM HEAD ON TOP OF LAYER 5	0.008	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	31.0 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4488
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	2.6021	0.2168
2	224.5172	0.3742
3	6.2996	0.2625
4	0.0056	0.0297
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              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\AR\C\DEV\I100\DATA4.D4
TEMPERATURE DATA FILE:      C:\AR\C\DEV\I100\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\AR\C\DEV\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\AR\C\DEV\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\AR\C\DEV\I100\DATA10.D10
OUTPUT DATA FILE:           C:\AR\C\DEV\I100\OUTPUT1.OUT


TIME:  81:36     DATE:  12/14/2021


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

     TITLE:  ARLINGTON LANDFILL - DEVELOPED AREAS (2-5) - INTERIM 100 FT

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


     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                          =       0.6277 VOL/VOL
    FIELD CAPACITY                    =       0.5156 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                         =       0.18   INCHES
    POROSITY                          =       0.8500 VOL/VOL
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  FIELD CAPACITY                    =      0.0100 VOL/VOL
  WILTING POINT                     =      0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =   5.44999981000     CM/SEC
  SLOPE                             =      2.00   PERCENT
  DRAINAGE LENGTH                   =    215.0    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  36
  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.         =  0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY               =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS          =      1.00   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 4.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	86.70	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278
EVAPOTRANSPIRATION						
TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639

	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0623	0.0559	0.0627	0.0628	0.0614	0.0619
	0.0611	0.0602	0.0590	0.0683	0.0615	0.0629
STD. DEVIATIONS	0.0157	0.0065	0.0105	0.0060	0.0066	0.0067
	0.0078	0.0113	0.0063	0.0157	0.0107	0.0056

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.5603	0.5027	0.5644	0.5651	0.5528	0.5570
	0.5496	0.5416	0.5307	0.6147	0.5538	0.5660
STD. DEVIATIONS	0.1413	0.0582	0.0943	0.0538	0.0592	0.0602
	0.0704	0.1020	0.0563	0.1414	0.0967	0.0501

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0623	0.0559	0.0627	0.0628	0.0614	0.0619
	0.0611	0.0602	0.0590	0.0683	0.0615	0.0629
STD. DEVIATIONS	0.0157	0.0065	0.0105	0.0060	0.0066	0.0067
	0.0078	0.0113	0.0063	0.0157	0.0107	0.0056

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	0.0070	0.0069	0.0070	0.0073	0.0069	0.0072
	0.0069	0.0068	0.0068	0.0077	0.0071	0.0071
STD. DEVIATIONS	0.0018	0.0008	0.0012	0.0007	0.0007	0.0008
	0.0009	0.0013	0.0007	0.0018	0.0012	0.0006

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.368	(1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374	(2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.73984	(0.07640)	2685.628	1.92722
LATERAL DRAINAGE COLLECTED FROM LAYER 4	6.65858	(0.68759)	24170.654	17.34502
DRAINAGE RECIRCULATED FROM LAYER 4	0.73984	(0.07640)	2685.628	1.92722
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001	(0.00000)	0.032	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.007	(0.001)		
CHANGE IN WATER STORAGE	1.988	(2.9689)	7217.96	5.180

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00493	17.89005
DRAINAGE COLLECTED FROM LAYER 4	0.04436	161.01044

DRAINAGE RECIRCULATED FROM LAYER 4	0.00493	17.89005
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00014
AVERAGE HEAD ON TOP OF LAYER 5	0.017	
MAXIMUM HEAD ON TOP OF LAYER 5	0.034	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	476.2912	0.3969
3	6.5609	0.2734
4	0.0120	0.0671
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           **
**                                                                        **
**                                                                        **
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PRECIPITATION DATA FILE:     C:\AR\C\DEV\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\DEV\I200\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\DEV\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\DEV\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\DEV\I200\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\DEV\I200\OUTPUT1.OUT


TIME:  81:52     DATE:  12/14/2021


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     TITLE:  ARLINGTON LANDFILL - DEVELOPED AREAS (2-5) - INTERIM 200 FT

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     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                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5127 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                        =      0.5348 VOL/VOL
  FIELD CAPACITY                  =      0.4892 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.      =   3.00000000000     CM/SEC
SLOPE                          =      2.00   PERCENT
DRAINAGE LENGTH                =    215.0    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  36
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.      =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY            =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS       =      1.00   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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278

EVAPOTRANSPIRATION

TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639
	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0514	0.0508	0.0558	0.0544	0.0559	0.0524
	0.0553	0.0550	0.0527	0.0542	0.0527	0.0545
STD. DEVIATIONS	0.0090	0.0068	0.0083	0.0072	0.0076	0.0062
	0.0062	0.0060	0.0061	0.0067	0.0053	0.0053

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.4622	0.4572	0.5019	0.4896	0.5034	0.4712
	0.4974	0.4951	0.4743	0.4879	0.4746	0.4906
STD. DEVIATIONS	0.0814	0.0614	0.0750	0.0649	0.0688	0.0556
	0.0557	0.0539	0.0550	0.0601	0.0475	0.0481

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0514	0.0508	0.0558	0.0544	0.0559	0.0524
	0.0553	0.0550	0.0527	0.0542	0.0527	0.0545
STD. DEVIATIONS	0.0090	0.0068	0.0083	0.0072	0.0076	0.0062
	0.0062	0.0060	0.0061	0.0067	0.0053	0.0053

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	0.0105	0.0114	0.0114	0.0115	0.0114	0.0110
	0.0113	0.0112	0.0111	0.0111	0.0111	0.0111
STD. DEVIATIONS	0.0018	0.0016	0.0017	0.0015	0.0016	0.0013
	0.0013	0.0012	0.0013	0.0014	0.0011	0.0011

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.368	(1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374	(2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.64505	(0.06600)	2341.542	1.68031
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.80548	(0.59401)	21073.877	15.12276
DRAINAGE RECIRCULATED FROM LAYER 5	0.64505	(0.06600)	2341.542	1.68031
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.039	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.011	(0.001)		
CHANGE IN WATER STORAGE	2.842	(3.0767)	10315.68	7.403

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00330	11.97338
DRAINAGE COLLECTED FROM LAYER 5	0.02969	107.76039
DRAINAGE RECIRCULATED FROM LAYER 5	0.00330	11.97338
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00015
AVERAGE HEAD ON TOP OF LAYER 6	0.021	
MAXIMUM HEAD ON TOP OF LAYER 6	0.042	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	616.3557	0.4109
3	324.5271	0.3606
4	6.5009	0.2709
5	0.0138	0.0889
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:\AR\C\DEV\I290\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\DEV\I290\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\DEV\I290\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\DEV\I290\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\DEV\I290\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\DEV\I290\OUTPUT1.OUT


TIME:  14:18     DATE:  12/20/2021


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     TITLE:  ARLINGTON LANDFILL - DEVELOPED AREAS (2-5) - INTERIM 290 FT

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     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                        =      0.6174 VOL/VOL
    FIELD CAPACITY                  =      0.5127 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                       =   1980.00   INCHES
    POROSITY                        =      0.4976 VOL/VOL
    FIELD CAPACITY                  =      0.4786 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                   =      0.13   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.   =   2.34999990000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    215.0    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  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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	=	1342.225	INCHES
TOTAL INITIAL WATER	=	1342.225	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.071	0.139	0.083	0.073	0.188	0.406
	0.215	0.057	0.401	0.698	0.062	0.241
STD. DEVIATIONS	0.078	0.246	0.103	0.099	0.200	0.448
	0.345	0.101	0.361	1.452	0.118	0.310

EVAPOTRANSPIRATION

TOTALS	1.929	1.887	2.343	2.924	2.989	2.511
	2.754	1.537	3.008	2.267	1.322	1.843
STD. DEVIATIONS	0.343	0.741	0.616	1.207	1.073	1.630
	1.407	1.091	1.159	1.322	0.698	0.584

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0754	0.0730	0.0805	0.0782	0.0797	0.0758
	0.0779	0.0782	0.0749	0.0784	0.0736	0.0765
STD. DEVIATIONS	0.0132	0.0129	0.0176	0.0155	0.0154	0.0156
	0.0152	0.0145	0.0141	0.0150	0.0139	0.0124

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.6783	0.6571	0.7247	0.7039	0.7177	0.6826
	0.7007	0.7041	0.6738	0.7060	0.6626	0.6886
STD. DEVIATIONS	0.1189	0.1162	0.1580	0.1396	0.1390	0.1407
	0.1370	0.1309	0.1267	0.1351	0.1252	0.1116

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0754	0.0730	0.0805	0.0782	0.0797	0.0758
	0.0779	0.0782	0.0749	0.0784	0.0736	0.0765
STD. DEVIATIONS	0.0132	0.0129	0.0176	0.0155	0.0154	0.0156
	0.0152	0.0145	0.0141	0.0150	0.0139	0.0124

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	0.0196	0.0209	0.0210	0.0210	0.0208	0.0204
	0.0203	0.0204	0.0201	0.0204	0.0198	0.0199
STD. DEVIATIONS	0.0034	0.0037	0.0046	0.0042	0.0040	0.0042
	0.0040	0.0038	0.0038	0.0039	0.0037	0.0032

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.633 (1.3086)	9558.92	6.860
EVAPOTRANSPIRATION	27.314 (2.8436)	99150.34	71.151
DRAINAGE RECIRCULATED INTO LAYER 2	0.92225 (0.16591)	3347.782	2.40239
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.30029 (1.49317)	30130.035	21.62152
DRAINAGE RECIRCULATED FROM LAYER 5	0.92225 (0.16591)	3347.782	2.40239
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00002 (0.00000)	0.055	0.00004
AVERAGE HEAD ON TOP OF LAYER 6	0.020 (0.004)		
CHANGE IN WATER STORAGE	0.141 (3.4390)	513.13	0.368

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.549	9252.6611
DRAINAGE RECIRCULATED INTO LAYER 2	0.00517	18.77381
DRAINAGE COLLECTED FROM LAYER 5	0.04655	168.96429
DRAINAGE RECIRCULATED FROM LAYER 5	0.00517	18.77381
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00024
AVERAGE HEAD ON TOP OF LAYER 6	0.042	
MAXIMUM HEAD ON TOP OF LAYER 6	0.083	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.1 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4609

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	2.6013	0.2168
2	635.8170	0.4239
3	688.4046	0.3477
4	6.5501	0.2729
5	0.0177	0.1359
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:\AR\C\DEV\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\DEV\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\DEV\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\DEV\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\DEV\CL\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\DEV\CL\OUTPUT1.OUT


TIME:  10:16     DATE:   1/17/2022


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

     TITLE:  ARLINGTON LANDFILL - DEVELOPED AREAS (2-5) - CLOSED 290 FT

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


     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 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.    =   12.1700001000     CM/SEC
SLOPE                        =      5.00   PERCENT
DRAINAGE LENGTH              =   1000.0    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          =      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                      =      0.6174 VOL/VOL
FIELD CAPACITY                =      0.5127 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                     =   1980.00   INCHES
POROSITY                      =      0.4976 VOL/VOL
FIELD CAPACITY                =      0.4786 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                   =      0.13   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.   =   2.34999990000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    215.0    FEET


                        LAYER 10
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
```

```
FML INSTALLATION DEFECTS     =       1.00   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  5.%
         AND A SLOPE LENGTH OF 1000. FEET.

SCS RUNOFF CURVE NUMBER              =     79.50
FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     12.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      2.928  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.776  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.632  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =   1352.842  INCHES
TOTAL INITIAL WATER                  =   1352.842  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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.006	0.029	0.049	0.076	0.100	0.135
	0.052	0.004	0.080	0.565	0.064	0.055
STD. DEVIATIONS	0.021	0.076	0.130	0.192	0.285	0.246
	0.139	0.013	0.139	1.033	0.192	0.125
EVAPOTRANSPIRATION						
TOTALS	1.586	1.708	2.391	2.540	3.254	2.792
	2.173	1.495	2.634	2.128	1.282	1.517
STD. DEVIATIONS	0.509	0.746	0.991	1.219	1.077	1.465
	1.314	1.117	1.172	0.982	0.522	0.507
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.5650	0.5985	0.7666	0.4856	0.5213	0.8264
	0.2761	0.0513	0.5728	1.9568	0.8858	1.4580
STD. DEVIATIONS	0.8120	0.6895	1.1744	0.7491	0.7322	0.9027
	0.5804	0.1239	0.6821	2.1790	1.2725	1.5683
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
	0.0000	0.0000	0.0000	0.0005	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002
	0.0001	0.0000	0.0001	0.0008	0.0003	0.0002
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.4964	0.4700	0.5196	0.4988	0.5139	0.4945
	0.5044	0.5062	0.4827	0.5055	0.4829	0.4947
STD. DEVIATIONS	0.1921	0.1987	0.2291	0.2165	0.2192	0.2095

	0.2129	0.2108	0.2013	0.2101	0.1967	0.1972

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	0.0119	0.0197	0.0348	0.0319	0.0326	0.0482
	0.0165	0.0007	0.0165	0.2304	0.0540	0.0612
STD. DEVIATIONS	0.0213	0.0336	0.0737	0.0801	0.0782	0.0867
	0.0498	0.0019	0.0266	0.3761	0.1484	0.1075

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0129	0.0134	0.0135	0.0134	0.0134	0.0133
	0.0131	0.0132	0.0130	0.0132	0.0130	0.0129
STD. DEVIATIONS	0.0050	0.0057	0.0060	0.0058	0.0057	0.0056
	0.0055	0.0055	0.0054	0.0055	0.0053	0.0051

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.65	(6.690)	129402.2	100.00
RUNOFF	1.217	(1.0719)	4419.38	3.415
EVAPOTRANSPIRATION	25.501	(3.4051)	92569.52	71.536
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.96420	(3.77995)	32540.047	25.14643

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00126 (	0.00093)	4.579	0.00354
AVERAGE HEAD ON TOP OF LAYER 3	0.047 (	0.037)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	5.96950 (	2.47228)	21669.293	16.74569
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00001 (	0.00000)	0.043	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.013 (	0.005)		
CHANGE IN WATER STORAGE	-6.004 (	2.5662)	-21796.06	-16.844

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.169	7874.2632
DRAINAGE COLLECTED FROM LAYER 2	1.03254	3748.12476
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000695	2.52404
AVERAGE HEAD ON TOP OF LAYER 3	10.398	
MAXIMUM HEAD ON TOP OF LAYER 3	18.993	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	84.5 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.05172	187.73811
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00024
AVERAGE HEAD ON TOP OF LAYER 10	0.042	

MAXIMUM HEAD ON TOP OF LAYER 10	0.083	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	2.1 FEET	
SNOW WATER	1.37	4974.2432
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	1.8431	0.1536
2	0.0030	0.0100
3	0.0000	0.0000
4	7.6860	0.4270
5	3.7200	0.3100
6	546.6268	0.3644
7	596.3240	0.3012
8	6.2505	0.2604
9	0.0083	0.0646

10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

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****

HELP MODEL OUTPUT FOR UNDEVELOPED AREAS
(SECTORS 6 AND 7)

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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:\AR\C\UNDEVM\AC\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVM\AC\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVM\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVM\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVM\AC\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVM\AC\OUTPUT1.OUT


TIME:  15:16     DATE:  12/20/2021


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - ACTIVE (10 FT)

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


     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                     =      0.25   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.     =   26.1299992000     CM/SEC
SLOPE                         =      2.00   PERCENT
DRAINAGE LENGTH               =    165.0    FEET


                           LAYER  4
                           --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 9 THROUGH 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.58	3.36	4.22	4.24	6.45	2.75
	4.65	0.00	5.51	2.75	8.07	3.72
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	2.870	3.067	3.988	2.169	4.219	4.226
	2.804	0.000	3.522	2.177	3.114	1.941
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
	0.0000	0.0000	0.0000	0.0094	0.0784	0.2187
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
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004
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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 9 THROUGH 9

	INCHES		CU. FEET	PERCENT
PRECIPITATION	47.30	(0.000)	171699.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	34.097	(0.0000)	123773.06	72.087
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.30641	(0.00000)	1112.271	0.64780
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.003	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
CHANGE IN WATER STORAGE	12.896	(0.0000)	46813.77	27.265

****

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PEAK DAILY VALUES FOR YEARS 9 THROUGH 9

	(INCHES)	(CU. FT.)
PRECIPITATION	3.04	11035.200

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.00863	31.33748
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 4	0.000	
MAXIMUM HEAD ON TOP OF LAYER 4	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4012
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.

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FINAL WATER STORAGE AT END OF YEAR 9

LAYER	(INCHES)	(VOL/VOL)
1	42.5603	0.3547
2	6.1917	0.2580
3	0.0027	0.0109
4	0.0000	0.0000

5	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:\AR\C\UNDEVM\I50\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVM\I50\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVM\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVM\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVM\I50\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVM\I50\OUTPUT1.OUT


TIME:  15:18     DATE:  12/20/2021


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 50 FT

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


     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                       =      0.23   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.     =    14.3100004000     CM/SEC
  SLOPE                         =       2.00    PERCENT
  DRAINAGE LENGTH               =     165.0     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  36
  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.     =   0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY           =       1.00    HOLES/ACRE
  FML INSTALLATION DEFECTS      =       1.00    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 800. FEET.

SCS RUNOFF CURVE NUMBER	=	86.10	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.060	0.102	0.057	0.052	0.134	0.349
	0.158	0.043	0.313	0.534	0.060	0.198
STD. DEVIATIONS	0.065	0.183	0.071	0.074	0.143	0.386
	0.245	0.079	0.286	1.163	0.112	0.236
EVAPOTRANSPIRATION						
TOTALS	1.929	1.948	2.397	2.956	3.051	2.568
	2.824	1.581	3.098	2.332	1.345	1.832
STD. DEVIATIONS	0.352	0.751	0.662	1.248	1.123	1.637

```
                              1.461     1.122     1.217     1.346     0.678     0.559

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                      0.0111    0.0108    0.0116    0.0112    0.0122    0.0116
                              0.0124    0.0119    0.0117    0.0125    0.0132    0.0126

  STD. DEVIATIONS             0.0126    0.0122    0.0131    0.0126    0.0137    0.0131
                              0.0140    0.0135    0.0132    0.0137    0.0130    0.0130

LATERAL DRAINAGE COLLECTED FROM LAYER  4
----------------------------------------
  TOTALS                      0.0996    0.0968    0.1048    0.1011    0.1101    0.1044
                              0.1116    0.1067    0.1057    0.1129    0.1184    0.1138

  STD. DEVIATIONS             0.1132    0.1097    0.1178    0.1135    0.1233    0.1177
                              0.1259    0.1214    0.1187    0.1232    0.1173    0.1174

LATERAL DRAINAGE RECIRCULATED FROM LAYER  4
-------------------------------------------
  TOTALS                      0.0111    0.0108    0.0116    0.0112    0.0122    0.0116
                              0.0124    0.0119    0.0117    0.0125    0.0132    0.0126

  STD. DEVIATIONS             0.0126    0.0122    0.0131    0.0126    0.0137    0.0131
                              0.0140    0.0135    0.0132    0.0137    0.0130    0.0130

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                    0.0004    0.0004    0.0004    0.0004    0.0004    0.0004
                              0.0004    0.0004    0.0004    0.0004    0.0004    0.0004

  STD. DEVIATIONS             0.0004    0.0004    0.0004    0.0004    0.0004    0.0004
                              0.0005    0.0004    0.0004    0.0004    0.0004    0.0004

*******************************************************************************
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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.060 (1.0080)	7478.83	5.367
EVAPOTRANSPIRATION	27.861 (2.8144)	101136.98	72.577
DRAINAGE RECIRCULATED INTO LAYER 2	0.14289 (0.15705)	518.707	0.37223
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.28605 (1.41343)	4668.364	3.35005
DRAINAGE RECIRCULATED FROM LAYER 4	0.14289 (0.15705)	518.707	0.37223
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.010	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.000 (0.000)		
CHANGE IN WATER STORAGE	7.181 (3.4622)	26067.54	18.706

****

****

PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.026	7354.2529
DRAINAGE RECIRCULATED INTO LAYER 2	0.00154	5.60780
DRAINAGE COLLECTED FROM LAYER 4	0.01390	50.47016

DRAINAGE RECIRCULATED FROM LAYER 4	0.00154	5.60780
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 5	0.002	
MAXIMUM HEAD ON TOP OF LAYER 5	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4521
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	2.6572	0.2214
2	222.4541	0.3708
3	6.2751	0.2615
4	0.0032	0.0137
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            **
**                                                                        **
**                                                                        **
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PRECIPITATION DATA FILE:     C:\AR\C\UNDEVM\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVM\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVM\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVM\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVM\I100\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVM\I100\OUTPUT1.OUT


TIME:  15:20     DATE:  12/20/2021


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 100 FT

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     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                           =      0.6277 VOL/VOL
    FIELD CAPACITY                     =      0.5156 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                          =      0.21   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.   =   8.05000019000     CM/SEC
    SLOPE                       =      2.00   PERCENT
    DRAINAGE LENGTH             =    165.0    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  36
    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.   =  0.399999993000E-12 CM/SEC
    FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
    FML INSTALLATION DEFECTS    =      1.00   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 4.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	86.70	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.071	0.126	0.075	0.069	0.164	0.380
	0.196	0.049	0.378	0.608	0.069	0.242
STD. DEVIATIONS	0.073	0.222	0.091	0.093	0.168	0.425
	0.305	0.088	0.339	1.271	0.131	0.287
EVAPOTRANSPIRATION						
TOTALS	1.928	1.933	2.373	2.951	3.003	2.573
	2.793	1.565	3.062	2.320	1.338	1.836
STD. DEVIATIONS	0.348	0.758	0.644	1.226	1.105	1.634

```
                             1.439     1.128     1.174     1.334     0.698     0.557

  LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
  -------------------------------------------
    TOTALS                   0.0508    0.0471    0.0546    0.0511    0.0521    0.0529
                             0.0546    0.0529    0.0511    0.0524    0.0515    0.0533

    STD. DEVIATIONS          0.0138    0.0059    0.0067    0.0076    0.0057    0.0081
                             0.0079    0.0079    0.0077    0.0065    0.0072    0.0074

  LATERAL DRAINAGE COLLECTED FROM LAYER  4
  ----------------------------------------
    TOTALS                   0.4569    0.4236    0.4914    0.4595    0.4689    0.4765
                             0.4911    0.4763    0.4602    0.4718    0.4632    0.4797

    STD. DEVIATIONS          0.1245    0.0533    0.0605    0.0683    0.0510    0.0725
                             0.0711    0.0715    0.0691    0.0586    0.0651    0.0662

  LATERAL DRAINAGE RECIRCULATED FROM LAYER  4
  -------------------------------------------
    TOTALS                   0.0508    0.0471    0.0546    0.0511    0.0521    0.0529
                             0.0546    0.0529    0.0511    0.0524    0.0515    0.0533

    STD. DEVIATIONS          0.0138    0.0059    0.0067    0.0076    0.0057    0.0081
                             0.0079    0.0079    0.0077    0.0065    0.0072    0.0074

  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                 0.0030    0.0030    0.0032    0.0031    0.0030    0.0032
                             0.0032    0.0031    0.0031    0.0031    0.0031    0.0031

    STD. DEVIATIONS          0.0008    0.0004    0.0004    0.0005    0.0003    0.0005
                             0.0005    0.0005    0.0005    0.0004    0.0004    0.0004

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.429	(1.1471)	8816.72	6.327
EVAPOTRANSPIRATION	27.676	(2.7427)	100465.27	72.095
DRAINAGE RECIRCULATED INTO LAYER 2	0.62437	(0.08439)	2266.469	1.62643
LATERAL DRAINAGE COLLECTED FROM LAYER 4	5.61935	(0.75950)	20398.232	14.63791
DRAINAGE RECIRCULATED FROM LAYER 4	0.62437	(0.08439)	2266.469	1.62643
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001	(0.00000)	0.025	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.003	(0.000)		
CHANGE IN WATER STORAGE	2.664	(3.0779)	9671.62	6.940

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.220	8060.1060
DRAINAGE RECIRCULATED INTO LAYER 2	0.00349	12.65112
DRAINAGE COLLECTED FROM LAYER 4	0.03137	113.86010

DRAINAGE RECIRCULATED FROM LAYER 4	0.00349	12.65112
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00008
AVERAGE HEAD ON TOP OF LAYER 5	0.006	
MAXIMUM HEAD ON TOP OF LAYER 5	0.013	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4529	
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	2.5930	0.2161
2	483.1090	0.4026
3	6.5150	0.2715
4	0.0047	0.0218
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              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\AR\C\UNDEVM\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVM\I200\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVM\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVM\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVM\I200\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVM\I200\OUTPUT1.OUT


TIME:  15:22     DATE:  12/20/2021


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 200 FT

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


     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                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5127 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                        =      0.5348 VOL/VOL
  FIELD CAPACITY                  =      0.4892 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.	=	4.13000011000 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	165.0 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 36

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.	=	0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00 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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278

EVAPOTRANSPIRATION

TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639
	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0519	0.0506	0.0564	0.0546	0.0559	0.0529
	0.0554	0.0550	0.0531	0.0552	0.0524	0.0543
STD. DEVIATIONS	0.0089	0.0069	0.0082	0.0071	0.0074	0.0059
	0.0063	0.0059	0.0060	0.0064	0.0053	0.0051

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.4675	0.4553	0.5076	0.4917	0.5034	0.4757
	0.4984	0.4951	0.4778	0.4965	0.4720	0.4886
STD. DEVIATIONS	0.0800	0.0622	0.0739	0.0636	0.0664	0.0534
	0.0567	0.0530	0.0540	0.0575	0.0481	0.0458

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0519	0.0506	0.0564	0.0546	0.0559	0.0529
	0.0554	0.0550	0.0531	0.0552	0.0524	0.0543
STD. DEVIATIONS	0.0089	0.0069	0.0082	0.0071	0.0074	0.0059
	0.0063	0.0059	0.0060	0.0064	0.0053	0.0051

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	0.0059	0.0063	0.0064	0.0064	0.0064	0.0062
	0.0063	0.0063	0.0062	0.0063	0.0062	0.0062
STD. DEVIATIONS	0.0010	0.0009	0.0009	0.0008	0.0008	0.0007
	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.368 (1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374 (2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.64773 (0.06511)	2351.265	1.68728
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.82958 (0.58602)	21161.387	15.18555
DRAINAGE RECIRCULATED FROM LAYER 5	0.64773 (0.06511)	2351.265	1.68728
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.031	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.006 (0.001)		
CHANGE IN WATER STORAGE	2.818 (3.0495)	10227.94	7.340

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00373	13.55322
DRAINAGE COLLECTED FROM LAYER 5	0.03360	121.97903
DRAINAGE RECIRCULATED FROM LAYER 5	0.00373	13.55322
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00012
AVERAGE HEAD ON TOP OF LAYER 6	0.013	
MAXIMUM HEAD ON TOP OF LAYER 6	0.027	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	616.1625	0.4108
3	324.4710	0.3605
4	6.5169	0.2715
5	0.0053	0.0324
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:\AR\C\UNDEVM\I300\DATA4.D4
TEMPERATURE DATA FILE:      C:\AR\C\UNDEVM\I300\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\AR\C\UNDEVM\I300\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\AR\C\UNDEVM\I300\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\AR\C\UNDEVM\I300\DATA10.D10
OUTPUT DATA FILE:           C:\AR\C\UNDEVM\I300\OUTPUT1.OUT


TIME:  15:23     DATE:  12/20/2021


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 300 FT

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


     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                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5127 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                       =   2100.00   INCHES
  POROSITY                        =      0.4935 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  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                   =      0.14   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.   =   2.68000007000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    165.0    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  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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	=	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	=	1387.825	INCHES
TOTAL INITIAL WATER	=	1387.825	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

```
RUNOFF
------
  TOTALS                    0.063    0.124    0.074    0.065    0.168    0.364
                            0.192    0.051    0.358    0.640    0.055    0.215

  STD. DEVIATIONS           0.070    0.219    0.092    0.088    0.180    0.408
                            0.308    0.090    0.326    1.337    0.105    0.278

EVAPOTRANSPIRATION
------------------
  TOTALS                    1.932    1.915    2.318    2.932    2.989    2.523
                            2.754    1.561    3.011    2.263    1.323    1.851

  STD. DEVIATIONS           0.346    0.735    0.610    1.218    1.087    1.639
                            1.401    1.088    1.151    1.321    0.700    0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                    0.0790   0.0768   0.0828   0.0799   0.0814   0.0797
                            0.0824   0.0810   0.0780   0.0805   0.0776   0.0801

  STD. DEVIATIONS           0.0147   0.0153   0.0191   0.0159   0.0147   0.0144
                            0.0153   0.0152   0.0160   0.0148   0.0151   0.0155

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                    0.7111   0.6914   0.7453   0.7192   0.7325   0.7175
                            0.7416   0.7287   0.7018   0.7242   0.6982   0.7209

  STD. DEVIATIONS           0.1320   0.1374   0.1715   0.1432   0.1319   0.1293
                            0.1379   0.1364   0.1440   0.1328   0.1359   0.1398

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                    0.0790   0.0768   0.0828   0.0799   0.0814   0.0797
                            0.0824   0.0810   0.0780   0.0805   0.0776   0.0801

  STD. DEVIATIONS           0.0147   0.0153   0.0191   0.0159   0.0147   0.0144
                            0.0153   0.0152   0.0160   0.0148   0.0151   0.0155

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	0.0138	0.0148	0.0145	0.0145	0.0143	0.0144
	0.0144	0.0142	0.0141	0.0141	0.0140	0.0140
STD. DEVIATIONS	0.0026	0.0030	0.0033	0.0029	0.0026	0.0026
	0.0027	0.0027	0.0029	0.0026	0.0027	0.0027

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.368 (1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374 (2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.95915 (0.17622)	3481.712	2.49850
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.63235 (1.58597)	31335.412	22.48651
DRAINAGE RECIRCULATED FROM LAYER 5	0.95915 (0.17622)	3481.712	2.49850
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.045	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.014 (0.003)		
CHANGE IN WATER STORAGE	0.015 (3.5225)	54.33	0.039

****

PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00568	20.60622
DRAINAGE COLLECTED FROM LAYER 5	0.05109	185.45595
DRAINAGE RECIRCULATED FROM LAYER 5	0.00568	20.60622
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00020
AVERAGE HEAD ON TOP OF LAYER 6	0.031	
MAXIMUM HEAD ON TOP OF LAYER 6	0.061	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.3 FEET	
SNOW WATER	1.20	4357.1436

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.

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	639.6804	0.4265
3	728.8403	0.3471
4	6.5939	0.2747
5	0.0147	0.1021
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:     C:\AR\C\UNDEVM\I310\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVM\I310\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVM\I310\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVM\I310\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVM\I310\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVM\I310\OUTPUT1.OUT


TIME:  15:24     DATE:  12/20/2021


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - INTERIM 310 FT

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


     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                         =      0.6174 VOL/VOL
   FIELD CAPACITY                   =      0.5127 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                        =   2220.00   INCHES
   POROSITY                         =      0.4893 VOL/VOL
   FIELD CAPACITY                   =      0.4763 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                  =      0.14   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.  =   2.58999991000     CM/SEC
SLOPE                      =      2.00   PERCENT
DRAINAGE LENGTH            =    165.0    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  36
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.  = 0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY        =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =      1.00   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	=	1433.425	INCHES
TOTAL INITIAL WATER	=	1433.425	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

```
RUNOFF
------
  TOTALS                   0.071    0.139    0.083    0.073    0.188    0.406
                           0.215    0.057    0.401    0.698    0.062    0.241

  STD. DEVIATIONS          0.078    0.246    0.103    0.099    0.200    0.448
                           0.345    0.101    0.361    1.452    0.118    0.310

EVAPOTRANSPIRATION
------------------
  TOTALS                   1.929    1.887    2.343    2.924    2.989    2.511
                           2.754    1.537    3.008    2.267    1.322    1.843

  STD. DEVIATIONS          0.343    0.741    0.616    1.207    1.073    1.630
                           1.407    1.091    1.159    1.322    0.698    0.584

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                   0.0844   0.0798   0.0882   0.0841   0.0852   0.0832
                           0.0871   0.0860   0.0816   0.0846   0.0815   0.0831

  STD. DEVIATIONS          0.0155   0.0171   0.0202   0.0165   0.0185   0.0159
                           0.0170   0.0169   0.0168   0.0177   0.0151   0.0140

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                   0.7595   0.7182   0.7938   0.7570   0.7666   0.7492
                           0.7838   0.7739   0.7343   0.7615   0.7336   0.7476

  STD. DEVIATIONS          0.1398   0.1535   0.1815   0.1485   0.1666   0.1428
                           0.1526   0.1522   0.1514   0.1589   0.1356   0.1259

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                   0.0844   0.0798   0.0882   0.0841   0.0852   0.0832
                           0.0871   0.0860   0.0816   0.0846   0.0815   0.0831

  STD. DEVIATIONS          0.0155   0.0171   0.0202   0.0165   0.0185   0.0159
                           0.0170   0.0169   0.0168   0.0177   0.0151   0.0140

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	0.0153	0.0159	0.0160	0.0158	0.0154	0.0156
	0.0158	0.0156	0.0153	0.0153	0.0153	0.0151
STD. DEVIATIONS	0.0028	0.0035	0.0037	0.0031	0.0034	0.0030
	0.0031	0.0031	0.0032	0.0032	0.0028	0.0025

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.633	(1.3086)	9558.92	6.860
EVAPOTRANSPIRATION	27.314	(2.8436)	99150.34	71.151
DRAINAGE RECIRCULATED INTO LAYER 2	1.00877	(0.19125)	3661.841	2.62776
LATERAL DRAINAGE COLLECTED FROM LAYER 5	9.07895	(1.72129)	32956.570	23.64986
DRAINAGE RECIRCULATED FROM LAYER 5	1.00877	(0.19125)	3661.841	2.62776
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.047	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.016	(0.003)		
CHANGE IN WATER STORAGE	-0.637	(3.5523)	-2313.06	-1.660

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.549	9252.6611
DRAINAGE RECIRCULATED INTO LAYER 2	0.00568	20.60222
DRAINAGE COLLECTED FROM LAYER 5	0.05108	185.41997
DRAINAGE RECIRCULATED FROM LAYER 5	0.00568	20.60222
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00020
AVERAGE HEAD ON TOP OF LAYER 6	0.032	
MAXIMUM HEAD ON TOP OF LAYER 6	0.063	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.5 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4609
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	2.6013	0.2168
2	641.3478	0.4276
3	766.2641	0.3452
4	6.5808	0.2742
5	0.0111	0.0776
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:\AR\C\UNDEVM\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVM\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVM\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVM\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVM\CL\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVM\CL\OUTPUT1.OUT


TIME:  10:19     DATE:   1/17/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (6-7) - CLOSED 310 FT

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


     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 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.   =   12.1700001000     CM/SEC
SLOPE                       =      5.00   PERCENT
DRAINAGE LENGTH             =    420.0    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         =      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                     =      0.6174 VOL/VOL
FIELD CAPACITY               =      0.5127 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                    =   2220.00   INCHES
POROSITY                     =      0.4893 VOL/VOL
FIELD CAPACITY               =      0.4763 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                   =      0.14   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.   =   2.25999999000      CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    165.0    FEET


                         LAYER 10
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
```

```
FML INSTALLATION DEFECTS     =      1.00   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  5.%
         AND A SLOPE LENGTH OF  420. FEET.

SCS RUNOFF CURVE NUMBER              =    81.20
FRACTION OF AREA ALLOWING RUNOFF     =   100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =     1.000  ACRES
EVAPORATIVE ZONE DEPTH               =    12.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =     2.928  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =     4.776  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =     1.632  INCHES
INITIAL SNOW WATER                   =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =  1444.042  INCHES
TOTAL INITIAL WATER                  =  1444.042  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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.012	0.042	0.075	0.098	0.130	0.181
	0.069	0.009	0.116	0.569	0.075	0.078
STD. DEVIATIONS	0.031	0.097	0.180	0.236	0.329	0.296
	0.173	0.025	0.180	0.975	0.196	0.158
EVAPOTRANSPIRATION						
TOTALS	1.587	1.709	2.416	2.539	3.267	2.805
	2.180	1.506	2.632	2.117	1.278	1.517
STD. DEVIATIONS	0.508	0.746	1.005	1.215	1.093	1.474
	1.313	1.129	1.188	0.981	0.525	0.505
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.5671	0.5634	0.7341	0.4721	0.4747	0.7643
	0.2584	0.0386	0.5604	1.9533	0.8554	1.4312
STD. DEVIATIONS	0.8075	0.6725	1.1259	0.7378	0.7158	0.8498
	0.5485	0.1067	0.6609	2.2284	1.2560	1.5243
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.5539	0.5185	0.5661	0.5446	0.5560	0.5381
	0.5561	0.5536	0.5328	0.5459	0.5284	0.5361
STD. DEVIATIONS	0.2293	0.2274	0.2580	0.2358	0.2408	0.2298

	0.2432	0.2406	0.2279	0.2378	0.2225	0.2201

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	0.0041	0.0054	0.0069	0.0051	0.0070	0.0095
	0.0029	0.0002	0.0053	0.0423	0.0086	0.0130
STD. DEVIATIONS	0.0067	0.0089	0.0123	0.0102	0.0177	0.0148
	0.0069	0.0004	0.0075	0.0703	0.0165	0.0182

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0115	0.0118	0.0118	0.0117	0.0116	0.0116
	0.0116	0.0115	0.0114	0.0113	0.0113	0.0111
STD. DEVIATIONS	0.0048	0.0052	0.0054	0.0051	0.0050	0.0049
	0.0051	0.0050	0.0049	0.0049	0.0048	0.0046

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.65 (6.690)	129402.2	100.00
RUNOFF	1.453 (1.0545)	5273.29	4.075
EVAPOTRANSPIRATION	25.553 (3.3734)	92758.78	71.683
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.67288 (3.73985)	31482.549	24.32921

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00028 (	0.00017)	1.020	0.00079
AVERAGE HEAD ON TOP OF LAYER 3	0.009 (	0.006)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	6.53013 (	2.78868)	23704.385	18.31837
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00001 (	0.00000)	0.040	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.012 (	0.005)		
CHANGE IN WATER STORAGE	-6.561 (	2.8780)	-23816.79	-18.405

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.715	6227.1909
DRAINAGE COLLECTED FROM LAYER 2	2.18862	7944.69092
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000221	0.80383
AVERAGE HEAD ON TOP OF LAYER 3	3.221	
MAXIMUM HEAD ON TOP OF LAYER 3	5.363	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	26.5 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.05553	201.57152
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00022
AVERAGE HEAD ON TOP OF LAYER 10	0.036	

MAXIMUM HEAD ON TOP OF LAYER 10	0.071	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	1.8 FEET	
SNOW WATER	1.37	4974.2432
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3656	
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	1.9909	0.1659
2	0.0030	0.0100
3	0.0000	0.0000
4	7.6860	0.4270
5	3.7200	0.3100
6	552.2114	0.3681
7	665.0493	0.2996
8	6.2913	0.2621
9	0.0095	0.0662

10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

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HELP MODEL OUTPUT FOR UNDEVELOPED AREAS (SECTORS 8 THROUGH 12)

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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:\AR\C\UNDEVW\AC\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVW\AC\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVW\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVW\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVW\AC\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVW\AC\OUTPUT1.OUT


TIME:  31:53     DATE:  12/20/2021


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (8-12) - ACTIVE (10 FT)

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     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                   =       0.25   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.   =   26.1299992000     CM/SEC
SLOPE                       =       2.00   PERCENT
DRAINAGE LENGTH             =     370.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 9 THROUGH 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.58	3.36	4.22	4.24	6.45	2.75
	4.65	0.00	5.51	2.75	8.07	3.72
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	2.875	3.057	3.959	2.196	4.275	4.269
	2.869	0.138	3.632	2.165	3.096	1.971
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
	0.0000	0.0000	0.0000	0.0000	0.0624	0.1981
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
	0.0000	0.0000	0.0000	0.0000	0.0003	0.0008
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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 9 THROUGH 9

	INCHES		CU. FEET	PERCENT
PRECIPITATION	47.30	(0.000)	171699.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	34.501	(0.0000)	125240.20	72.942
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.26048	(0.00000)	945.546	0.55070
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.003	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
CHANGE IN WATER STORAGE	12.538	(0.0000)	45513.31	26.508

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PEAK DAILY VALUES FOR YEARS 9 THROUGH 9

	(INCHES)	(CU. FT.)
PRECIPITATION	3.04	11035.200

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.00841	30.54360
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 4	0.001	
MAXIMUM HEAD ON TOP OF LAYER 4	0.002	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3999
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.

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FINAL WATER STORAGE AT END OF YEAR 9

LAYER	(INCHES)	(VOL/VOL)
1	42.2201	0.3518
2	6.1735	0.2572
3	0.0029	0.0119
4	0.0000	0.0000

5	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:\AR\C\UNDEVW\I50\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVW\I50\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVW\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVW\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVW\I50\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVW\I50\OUTPUT1.OUT


TIME:  31:54     DATE:  12/20/2021


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (8-12) - INTERIM 50 FT

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


     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                       =      0.23   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.        =   14.3100004000     CM/SEC
 SLOPE                            =      2.00   PERCENT
 DRAINAGE LENGTH                  =    370.0    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  36
 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.        =  0.399999993000E-12 CM/SEC
 FML PINHOLE DENSITY              =      1.00   HOLES/ACRE
 FML INSTALLATION DEFECTS         =      1.00   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 800. FEET.

SCS RUNOFF CURVE NUMBER	=	86.10	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.053	0.101	0.053	0.050	0.124	0.298
	0.151	0.039	0.300	0.529	0.048	0.189
STD. DEVIATIONS	0.057	0.181	0.065	0.072	0.130	0.345
	0.247	0.070	0.280	1.119	0.096	0.237
EVAPOTRANSPIRATION						
TOTALS	1.938	1.934	2.357	2.942	2.984	2.513
	2.812	1.567	3.050	2.318	1.321	1.842
STD. DEVIATIONS	0.348	0.751	0.626	1.222	1.068	1.643

	1.449	1.127	1.167	1.327	0.679	0.560

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0130	0.0117	0.0128	0.0128	0.0145	0.0131
	0.0150	0.0147	0.0141	0.0148	0.0150	0.0164
STD. DEVIATIONS	0.0151	0.0132	0.0150	0.0147	0.0174	0.0144
	0.0153	0.0178	0.0153	0.0150	0.0154	0.0158

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1168	0.1057	0.1151	0.1153	0.1307	0.1176
	0.1353	0.1323	0.1272	0.1330	0.1354	0.1472
STD. DEVIATIONS	0.1356	0.1186	0.1349	0.1325	0.1565	0.1297
	0.1374	0.1601	0.1379	0.1348	0.1383	0.1426

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0130	0.0117	0.0128	0.0128	0.0145	0.0131
	0.0150	0.0147	0.0141	0.0148	0.0150	0.0164
STD. DEVIATIONS	0.0151	0.0132	0.0150	0.0147	0.0174	0.0144
	0.0153	0.0178	0.0153	0.0150	0.0154	0.0158

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	0.0010	0.0009	0.0009	0.0010	0.0011	0.0010
	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012
STD. DEVIATIONS	0.0011	0.0011	0.0011	0.0011	0.0013	0.0011
	0.0011	0.0013	0.0012	0.0011	0.0012	0.0012

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	1.934	(1.0157)	7021.98	5.039
EVAPOTRANSPIRATION	27.578	(2.7771)	100109.87	71.840
DRAINAGE RECIRCULATED INTO LAYER 2	0.16795	(0.18210)	609.644	0.43748
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.51151	(1.63893)	5486.799	3.93736
DRAINAGE RECIRCULATED FROM LAYER 4	0.16795	(0.18210)	609.644	0.43748
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.012	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.001)		
CHANGE IN WATER STORAGE	7.364	(3.6492)	26732.69	19.184

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.057	7467.6079
DRAINAGE RECIRCULATED INTO LAYER 2	0.00226	8.19437
DRAINAGE COLLECTED FROM LAYER 4	0.02032	73.74934

DRAINAGE RECIRCULATED FROM LAYER 4	0.00226	8.19437
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00008
AVERAGE HEAD ON TOP OF LAYER 5	0.005	
MAXIMUM HEAD ON TOP OF LAYER 5	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	183.0 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4488
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	2.6021	0.2168
2	224.2827	0.3738
3	6.3320	0.2638
4	0.0052	0.0222
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              **
**                                                                          **
**                                                                          **
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******************************************************************************


PRECIPITATION DATA FILE:     C:\AR\C\UNDEVW\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVW\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVW\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVW\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVW\I100\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVW\I100\OUTPUT1.OUT


TIME:  31:57     DATE:  12/20/2021


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (8-12) - INTERIM 100 FT

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     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                        =       0.6277 VOL/VOL
  FIELD CAPACITY                  =       0.5156 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                       =       0.21   INCHES
  POROSITY                        =       0.8500 VOL/VOL
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```
  FIELD CAPACITY               =     0.0100 VOL/VOL
  WILTING POINT                =     0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT   =     0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =   8.05000019000     CM/SEC
  SLOPE                        =     2.00   PERCENT
  DRAINAGE LENGTH              =   370.0    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  36
  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.    = 0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY          =     1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS     =     1.00   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 4.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	86.70	
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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278
EVAPOTRANSPIRATION						
TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639

	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0605	0.0587	0.0635	0.0607	0.0625	0.0616
	0.0585	0.0601	0.0603	0.0651	0.0630	0.0653
STD. DEVIATIONS	0.0124	0.0059	0.0100	0.0120	0.0092	0.0119
	0.0064	0.0086	0.0093	0.0061	0.0112	0.0087

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.5448	0.5282	0.5716	0.5461	0.5623	0.5542
	0.5269	0.5410	0.5424	0.5856	0.5670	0.5880
STD. DEVIATIONS	0.1112	0.0529	0.0902	0.1080	0.0826	0.1069
	0.0578	0.0772	0.0840	0.0552	0.1010	0.0786

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0605	0.0587	0.0635	0.0607	0.0625	0.0616
	0.0585	0.0601	0.0603	0.0651	0.0630	0.0653
STD. DEVIATIONS	0.0124	0.0059	0.0100	0.0120	0.0092	0.0119
	0.0064	0.0086	0.0093	0.0061	0.0112	0.0087

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	0.0079	0.0084	0.0083	0.0082	0.0082	0.0083
	0.0077	0.0079	0.0081	0.0085	0.0085	0.0085
STD. DEVIATIONS	0.0016	0.0008	0.0013	0.0016	0.0012	0.0016
	0.0008	0.0011	0.0013	0.0008	0.0015	0.0011

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.368	(1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374	(2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.73979	(0.08096)	2685.423	1.92708
LATERAL DRAINAGE COLLECTED FROM LAYER 4	6.65807	(0.72869)	24168.803	17.34370
DRAINAGE RECIRCULATED FROM LAYER 4	0.73979	(0.08096)	2685.423	1.92708
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001	(0.00000)	0.034	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.008	(0.001)		
CHANGE IN WATER STORAGE	1.989	(3.0590)	7220.35	5.181

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00487	17.67822
DRAINAGE COLLECTED FROM LAYER 4	0.04383	159.10400

DRAINAGE RECIRCULATED FROM LAYER 4	0.00487	17.67822
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00015
AVERAGE HEAD ON TOP OF LAYER 5	0.020	
MAXIMUM HEAD ON TOP OF LAYER 5	0.039	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	2.9 FEET	
SNOW WATER	1.20	4357.1436
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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	476.3146	0.3969
3	6.5417	0.2726
4	0.0147	0.0686
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            **
**                                                                        **
**                                                                        **
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PRECIPITATION DATA FILE:     C:\AR\C\UNDEVW\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVW\I200\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVW\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVW\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVW\I200\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVW\I200\OUTPUT1.OUT


TIME:  31:58     DATE:  12/20/2021


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (8-12) - INTERIM 200 FT

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     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                        =       0.6174 VOL/VOL
  FIELD CAPACITY                  =       0.5127 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                        =       0.5348 VOL/VOL
  FIELD CAPACITY                  =       0.4892 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
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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.   =   4.13000011000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    370.0    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  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278

EVAPOTRANSPIRATION

TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639
	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0513	0.0510	0.0561	0.0549	0.0552	0.0534
	0.0549	0.0549	0.0535	0.0546	0.0529	0.0543
STD. DEVIATIONS	0.0090	0.0070	0.0082	0.0071	0.0076	0.0056
	0.0065	0.0059	0.0058	0.0068	0.0052	0.0054

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.4618	0.4593	0.5053	0.4937	0.4969	0.4808
	0.4945	0.4938	0.4818	0.4910	0.4762	0.4884
STD. DEVIATIONS	0.0811	0.0634	0.0740	0.0636	0.0681	0.0504
	0.0581	0.0529	0.0523	0.0614	0.0465	0.0487

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0513	0.0510	0.0561	0.0549	0.0552	0.0534
	0.0549	0.0549	0.0535	0.0546	0.0529	0.0543
STD. DEVIATIONS	0.0090	0.0070	0.0082	0.0071	0.0076	0.0056
	0.0065	0.0059	0.0058	0.0068	0.0052	0.0054

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	0.0131	0.0143	0.0143	0.0145	0.0141	0.0141
	0.0140	0.0140	0.0141	0.0139	0.0139	0.0138
STD. DEVIATIONS	0.0023	0.0020	0.0021	0.0019	0.0019	0.0015
	0.0016	0.0015	0.0015	0.0017	0.0014	0.0014

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.368	(1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374	(2.8403)	99367.41	71.307
DRAINAGE RECIRCULATED INTO LAYER 2	0.64706	(0.06538)	2348.841	1.68554
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.82357	(0.58843)	21139.570	15.16990
DRAINAGE RECIRCULATED FROM LAYER 5	0.64706	(0.06538)	2348.841	1.68554
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.044	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.014	(0.001)		
CHANGE IN WATER STORAGE	2.824	(3.0700)	10250.12	7.356

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE RECIRCULATED INTO LAYER 2	0.00315	11.44722
DRAINAGE COLLECTED FROM LAYER 5	0.02838	103.02498
DRAINAGE RECIRCULATED FROM LAYER 5	0.00315	11.44722
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00017
AVERAGE HEAD ON TOP OF LAYER 6	0.025	
MAXIMUM HEAD ON TOP OF LAYER 6	0.051	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	616.1356	0.4108
3	324.5466	0.3606
4	6.5254	0.2719
5	0.0093	0.0567
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:\AR\C\UNDEVW\I260\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVW\I260\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVW\I260\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVW\I260\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVW\I260\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVW\I260\OUTPUT1.OUT


TIME:  31:59     DATE:  12/20/2021


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     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (8-12) - INTERIM 260 FT

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     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                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5127 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                       =   1620.00   INCHES
  POROSITY                        =      0.5100 VOL/VOL
  FIELD CAPACITY                  =      0.4822 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.   =   3.06999993000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    370.0    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  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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	=	1205.425	INCHES
TOTAL INITIAL WATER	=	1205.425	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99

RUNOFF

TOTALS	0.071	0.139	0.083	0.073	0.188	0.406
	0.215	0.057	0.401	0.698	0.062	0.241
STD. DEVIATIONS	0.078	0.246	0.103	0.099	0.200	0.448
	0.345	0.101	0.361	1.452	0.118	0.310

EVAPOTRANSPIRATION

TOTALS	1.929	1.887	2.343	2.924	2.989	2.511
	2.754	1.537	3.008	2.267	1.322	1.843
STD. DEVIATIONS	0.343	0.741	0.616	1.207	1.073	1.630
	1.407	1.091	1.159	1.322	0.698	0.584

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0659	0.0651	0.0707	0.0670	0.0699	0.0680
	0.0686	0.0671	0.0670	0.0678	0.0652	0.0685
STD. DEVIATIONS	0.0114	0.0127	0.0122	0.0125	0.0135	0.0112
	0.0128	0.0122	0.0114	0.0107	0.0091	0.0103

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.5934	0.5856	0.6360	0.6034	0.6290	0.6117
	0.6178	0.6038	0.6033	0.6099	0.5871	0.6165
STD. DEVIATIONS	0.1030	0.1145	0.1101	0.1122	0.1219	0.1012
	0.1156	0.1097	0.1026	0.0965	0.0815	0.0924

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0659	0.0651	0.0707	0.0670	0.0699	0.0680
	0.0686	0.0671	0.0670	0.0678	0.0652	0.0685
STD. DEVIATIONS	0.0114	0.0127	0.0122	0.0125	0.0135	0.0112
	0.0128	0.0122	0.0114	0.0107	0.0091	0.0103

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	0.0226	0.0245	0.0242	0.0238	0.0240	0.0241
	0.0235	0.0230	0.0238	0.0232	0.0231	0.0235
STD. DEVIATIONS	0.0039	0.0049	0.0042	0.0044	0.0046	0.0040
	0.0044	0.0042	0.0040	0.0037	0.0032	0.0035

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.633 (1.3086)	9558.92	6.860
EVAPOTRANSPIRATION	27.314 (2.8436)	99150.34	71.151
DRAINAGE RECIRCULATED INTO LAYER 2	0.81082 (0.12896)	2943.277	2.11212
LATERAL DRAINAGE COLLECTED FROM LAYER 5	7.29738 (1.16068)	26489.480	19.00903
DRAINAGE RECIRCULATED FROM LAYER 5	0.81082 (0.12896)	2943.277	2.11212
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00002 (0.00000)	0.060	0.00004
AVERAGE HEAD ON TOP OF LAYER 6	0.024 (0.004)		
CHANGE IN WATER STORAGE	1.144 (3.2133)	4153.67	2.981

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.549	9252.6611
DRAINAGE RECIRCULATED INTO LAYER 2	0.00425	15.43430
DRAINAGE COLLECTED FROM LAYER 5	0.03827	138.90868
DRAINAGE RECIRCULATED FROM LAYER 5	0.00425	15.43430
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00026
AVERAGE HEAD ON TOP OF LAYER 6	0.045	
MAXIMUM HEAD ON TOP OF LAYER 6	0.090	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.4 FEET	
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4609

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	2.6013	0.2168
2	628.0471	0.4187
3	569.3880	0.3515
4	6.5591	0.2733
5	0.0244	0.1636
6	0.0000	0.0000
7	10.2480	0.4270
SNOW WATER	0.000	

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****

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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:\AR\C\UNDEVW\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\UNDEVW\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\UNDEVW\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\UNDEVW\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\UNDEVW\CL\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\UNDEVW\CL\OUTPUT1.OUT


TIME:  10:19     DATE:   1/17/2022


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

     TITLE:  ARLINGTON LANDFILL - UNDEVELOPED (8-12) - CLOSED 260 FT

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


     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 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.       =   12.1700001000     CM/SEC
   SLOPE                           =     25.00   PERCENT
   DRAINAGE LENGTH                 =    300.0    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             =      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                      =      0.6174 VOL/VOL
FIELD CAPACITY                =      0.5127 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                     =   1620.00   INCHES
POROSITY                      =      0.5100 VOL/VOL
FIELD CAPACITY                =      0.4822 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.   =   2.68000007000      CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    370.0    FEET
```

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

```
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
```

```
FML INSTALLATION DEFECTS    =      1.00   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 25.%
          AND A SLOPE LENGTH OF    3. FEET.

SCS RUNOFF CURVE NUMBER              =     85.70
FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     12.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      2.928  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.776  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.632  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =   1216.042  INCHES
TOTAL INITIAL WATER                  =   1216.042  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 = 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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.043	0.100	0.179	0.197	0.283	0.377
	0.163	0.033	0.283	0.955	0.162	0.189
STD. DEVIATIONS	0.091	0.178	0.336	0.392	0.523	0.484
	0.334	0.070	0.338	1.458	0.376	0.288
EVAPOTRANSPIRATION						
TOTALS	1.598	1.697	2.425	2.584	3.285	2.841
	2.180	1.511	2.645	2.116	1.275	1.512
STD. DEVIATIONS	0.506	0.743	1.020	1.210	1.099	1.499
	1.322	1.132	1.202	0.973	0.517	0.497
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.5350	0.5046	0.6100	0.3386	0.3235	0.5342
	0.1608	0.0161	0.3543	1.5362	0.7929	1.3386
STD. DEVIATIONS	0.7502	0.6181	0.9706	0.5587	0.5191	0.6370
	0.3579	0.0562	0.4929	1.7368	1.1265	1.4392
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
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.4399	0.4151	0.4530	0.4338	0.4528	0.4314
	0.4466	0.4430	0.4259	0.4380	0.4200	0.4349
STD. DEVIATIONS	0.1610	0.1744	0.1849	0.1752	0.1829	0.1745

	0.1800	0.1738	0.1720	0.1697	0.1596	0.1669

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	0.0003	0.0003	0.0004	0.0002	0.0002	0.0003
	0.0001	0.0000	0.0002	0.0009	0.0005	0.0008
STD. DEVIATIONS	0.0004	0.0004	0.0006	0.0003	0.0003	0.0004
	0.0002	0.0000	0.0003	0.0010	0.0007	0.0009

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0173	0.0179	0.0178	0.0176	0.0178	0.0175
	0.0176	0.0174	0.0173	0.0172	0.0171	0.0171
STD. DEVIATIONS	0.0063	0.0076	0.0073	0.0071	0.0072	0.0071
	0.0071	0.0068	0.0070	0.0067	0.0065	0.0066

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	35.65	(6.690)	129402.2	100.00
RUNOFF	2.962	(1.5803)	10753.74	8.310
EVAPOTRANSPIRATION	25.670	(3.4134)	93183.65	72.011
LATERAL DRAINAGE COLLECTED FROM LAYER 2	7.04491	(3.19410)	25573.029	19.76243

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00002 (	0.00001)	0.068	0.00005
AVERAGE HEAD ON TOP OF LAYER 3	0.000 (	0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	5.23457 (	2.05012)	19001.504	14.68406
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00001 (	0.00000)	0.050	0.00004
AVERAGE HEAD ON TOP OF LAYER 10	0.017 (	0.007)		
CHANGE IN WATER STORAGE	-5.264 (	2.1623)	-19109.74	-14.768

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.335	8476.0068
DRAINAGE COLLECTED FROM LAYER 2	1.16656	4234.59766
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000002	0.00851
AVERAGE HEAD ON TOP OF LAYER 3	0.022	
MAXIMUM HEAD ON TOP OF LAYER 3	0.114	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.04222	153.27319
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00028
AVERAGE HEAD ON TOP OF LAYER 10	0.051	

```
MAXIMUM HEAD ON TOP OF LAYER 10              0.102

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)                  3.2 FEET

SNOW WATER                                   1.37          4974.2432


MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.3565

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	2.0334	0.1694
2	0.0030	0.0100
3	0.0000	0.0000
4	7.6860	0.4270
5	3.7200	0.3100
6	537.4851	0.3583
7	490.7059	0.3029
8	6.2195	0.2591
9	0.0098	0.0659

10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

****
****

HELP MODEL OUTPUT FOR OVERLINER AREA

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\AR\C\OVERL\AC\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\OVERL\AC\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\OVERL\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\OVERL\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\OVERL\AC\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\OVERL\AC\OUTPUT1.OUT


TIME:  12:43     DATE:  12/27/2021


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

     TITLE:  ARLINGTON LANDFILL - OVERLINER - ACTIVE (10 FT)

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


     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.     =   12.7799997000     CM/SEC
SLOPE                         =      1.50   PERCENT
DRAINAGE LENGTH               =    800.0    FEET


                        LAYER  4
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     12.00   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	=	41.170	INCHES
TOTAL INITIAL WATER	=	41.170	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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

47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 9 THROUGH 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.58	3.36	4.22	4.24	6.45	2.75
	4.65	0.00	5.51	2.75	8.07	3.72
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	2.898	3.082	4.043	2.144	4.224	4.022
	2.884	0.009	3.615	2.213	3.111	2.001
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
	0.0000	0.0000	0.0000	0.0077	0.0980	0.2498

```
  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

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  TOTALS                   0.1054   0.0026   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0088   0.0390   0.0270

  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
                           0.0000   0.0000   0.0000   0.0002   0.0024   0.0059

  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                47.30     (   0.000)     171699.0     100.00

RUNOFF                        0.000    (  0.0000)         0.00       0.000

EVAPOTRANSPIRATION           34.246    (  0.0000)     124311.80     72.401
```

LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.35549 (	0.00000)	1290.412	0.75155
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (	0.00000)	0.003	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.001 (	0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.18283 (	0.00000)	663.667	0.38653
CHANGE IN WATER STORAGE	12.516 (	0.0000)	45433.17	26.461

****

****

PEAK DAILY VALUES FOR YEARS 9 THROUGH 9

	(INCHES)	(CU. FT.)
PRECIPITATION	3.04	11035.200
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.01058	38.40635
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 4	0.008	
MAXIMUM HEAD ON TOP OF LAYER 4	0.019	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.006573	23.86118
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4178

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.

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               FINAL WATER STORAGE AT END OF YEAR    9
   ----------------------------------------------------------------------
                LAYER         (INCHES)        (VOL/VOL)
                -----         --------        ---------
                  1           42.3451           0.3529

                  2            6.2054           0.2586

                  3            0.0074           0.0246

                  4            0.0000           0.0000

                  5            0.1875           0.7500

                  6            4.9412           0.4118

               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:\AR\C\OVERL\I50\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\OVERL\I50\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\OVERL\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\OVERL\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\OVERL\I50\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\OVERL\I50\OUTPUT1.OUT


TIME:  12:44     DATE:  12/27/2021


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

     TITLE:  ARLINGTON LANDFILL - OVERLINER - INTERIM 50 FT

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


     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.   =   11.7200003000     CM/SEC
SLOPE                       =      1.50   PERCENT
DRAINAGE LENGTH             =    800.0    FEET


                       LAYER  5
                       --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                       LAYER  6
                       --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  17
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.   =  0.300000003000E-08 CM/SEC


                       LAYER  7
                       --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     12.00   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  800. FEET.

SCS RUNOFF CURVE NUMBER              =     86.10
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     =    164.890  INCHES
TOTAL INITIAL WATER                  =    164.890  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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.048	0.098	0.054	0.049	0.130	0.305

	0.151	0.039	0.296	0.560	0.040	0.170
STD. DEVIATIONS	0.055	0.176	0.068	0.068	0.144	0.356
	0.246	0.071	0.298	1.204	0.082	0.225

EVAPOTRANSPIRATION

TOTALS	1.932	1.875	2.361	2.923	3.015	2.488
	2.764	1.556	3.013	2.252	1.314	1.844
STD. DEVIATIONS	0.345	0.749	0.624	1.204	1.054	1.692
	1.406	1.081	1.143	1.312	0.707	0.583

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1511	0.1260	0.1453	0.1392	0.1540	0.1359
	0.1700	0.1523	0.1697	0.1645	0.1664	0.1716
STD. DEVIATIONS	0.1676	0.1411	0.1726	0.1639	0.1766	0.1515
	0.1815	0.1481	0.1731	0.1627	0.1705	0.1693

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

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0141	0.0019	0.0017	0.0015	0.0015	0.0028
	0.0045	0.0035	0.0029	0.0026	0.0023	0.0023
STD. DEVIATIONS	0.0325	0.0024	0.0024	0.0022	0.0021	0.0046
	0.0096	0.0069	0.0052	0.0044	0.0036	0.0032

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0039	0.0036	0.0038	0.0037	0.0040	0.0036
	0.0044	0.0039	0.0045	0.0043	0.0045	0.0044
STD. DEVIATIONS	0.0043	0.0040	0.0045	0.0044	0.0046	0.0041
	0.0047	0.0038	0.0046	0.0042	0.0046	0.0044

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	1.939	(1.0918)	7039.54	5.052
EVAPOTRANSPIRATION	27.337	(2.7958)	99234.20	71.211
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.84598	(1.94372)	6700.902	4.80861
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.011	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.004	(0.004)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.04156	(0.04884)	150.880	0.10827
CHANGE IN WATER STORAGE	7.225	(3.6508)	26226.56	18.820

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.237	8120.0547
DRAINAGE COLLECTED FROM LAYER 4	0.02448	88.87569
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00006

AVERAGE HEAD ON TOP OF LAYER 5	0.020	
MAXIMUM HEAD ON TOP OF LAYER 5	0.035	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	78.3 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.006573	23.86118
SNOW WATER	1.20	4357.1436
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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5970	0.2164
2	223.3488	0.3722
3	6.2867	0.2619
4	0.0115	0.0394
5	0.0000	0.0000
6	0.1875	0.7500
7	4.7084	0.3924

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:\AR\C\OVERL\I100\DATA4.D4
TEMPERATURE DATA FILE:      C:\AR\C\OVERL\I100\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\AR\C\OVERL\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\AR\C\OVERL\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\AR\C\OVERL\I100\DATA10.D10
OUTPUT DATA FILE:           C:\AR\C\OVERL\I100\OUTPUT1.OUT


TIME:  12:48     DATE:  12/27/2021


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     TITLE:  ARLINGTON LANDFILL - OVERLINER - INTERIM 100 FT

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     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                        =      0.6277 VOL/VOL
   FIELD CAPACITY                  =      0.5156 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.   =   9.35000038000     CM/SEC
SLOPE                       =      1.50   PERCENT
DRAINAGE LENGTH             =    800.0    FEET


                         LAYER  5
                         --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   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


                         LAYER  7
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     12.00   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     =     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     =    470.890  INCHES
TOTAL INITIAL WATER                  =    470.890  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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.063	0.124	0.074	0.065	0.168	0.364

	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278

EVAPOTRANSPIRATION

TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639
	1.401	1.088	1.151	1.321	0.700	0.565

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.5808	0.5275	0.6357	0.5925	0.6098	0.6159
	0.5672	0.6081	0.5655	0.5793	0.5812	0.5903
STD. DEVIATIONS	0.1232	0.0732	0.1419	0.0614	0.0716	0.0886
	0.0778	0.1152	0.0672	0.0601	0.0569	0.0842

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

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0123	0.0057	0.0046	0.0037	0.0033	0.0028
	0.0027	0.0025	0.0022	0.0022	0.0020	0.0020
STD. DEVIATIONS	0.0327	0.0126	0.0089	0.0062	0.0050	0.0040
	0.0035	0.0030	0.0025	0.0023	0.0020	0.0019

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0189	0.0188	0.0206	0.0199	0.0198	0.0207
	0.0184	0.0197	0.0190	0.0188	0.0195	0.0192
STD. DEVIATIONS	0.0040	0.0026	0.0046	0.0021	0.0023	0.0030
	0.0025	0.0037	0.0023	0.0020	0.0019	0.0027

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.368 (1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374 (2.8403)	99367.41	71.307
LATERAL DRAINAGE COLLECTED FROM LAYER 4	7.05371 (0.70562)	25604.971	18.37430
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001 (0.00000)	0.022	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.019 (0.002)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.04591 (0.08410)	166.636	0.11958
CHANGE IN WATER STORAGE	1.548 (3.0117)	5617.75	4.031

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE COLLECTED FROM LAYER 4	0.04573	165.98407
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00007

AVERAGE HEAD ON TOP OF LAYER 5	0.046	
MAXIMUM HEAD ON TOP OF LAYER 5	0.090	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	15.4 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.006573	23.86120
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	472.1903	0.3935
3	6.7010	0.2792
4	0.0245	0.0877
5	0.0000	0.0000
6	0.1875	0.7500
7	4.6650	0.3888

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:\AR\C\OVERL\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\OVERL\I200\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\OVERL\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\OVERL\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\OVERL\I200\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\OVERL\I200\OUTPUT1.OUT


TIME:  12:49     DATE:  12/27/2021


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

     TITLE:  ARLINGTON LANDFILL - OVERLINER - INTERIM 200 FT

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     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                         =      0.6174 VOL/VOL
   FIELD CAPACITY                   =      0.5127 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                         =      0.5348 VOL/VOL
   FIELD CAPACITY                   =      0.4892 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
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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.   =   6.57999992000      CM/SEC
SLOPE                       =       1.50   PERCENT
DRAINAGE LENGTH             =     800.0    FEET


                        LAYER  6
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =       1.00   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

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00 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	=	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	=	926.890	INCHES
TOTAL INITIAL WATER	=	926.890	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.063	0.124	0.074	0.065	0.168	0.364
	0.192	0.051	0.358	0.640	0.055	0.215
STD. DEVIATIONS	0.070	0.219	0.092	0.088	0.180	0.408
	0.308	0.090	0.326	1.337	0.105	0.278
EVAPOTRANSPIRATION						
TOTALS	1.932	1.915	2.318	2.932	2.989	2.523
	2.754	1.561	3.011	2.263	1.323	1.851
STD. DEVIATIONS	0.346	0.735	0.610	1.218	1.087	1.639
	1.401	1.088	1.151	1.321	0.700	0.565
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.5079	0.4995	0.5619	0.5313	0.5516	0.5282
	0.5452	0.5384	0.5189	0.5334	0.5193	0.5340
STD. DEVIATIONS	0.0923	0.0714	0.0812	0.0776	0.0767	0.0583
	0.0677	0.0654	0.0638	0.0684	0.0539	0.0573
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
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0123	0.0057	0.0046	0.0037	0.0033	0.0028
	0.0027	0.0025	0.0022	0.0022	0.0020	0.0020
STD. DEVIATIONS	0.0327	0.0126	0.0089	0.0062	0.0050	0.0040

0.0035	0.0030	0.0025	0.0023	0.0020	0.0019

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0234	0.0253	0.0259	0.0253	0.0254	0.0252
	0.0252	0.0248	0.0247	0.0246	0.0248	0.0246
STD. DEVIATIONS	0.0043	0.0037	0.0037	0.0037	0.0035	0.0028
	0.0031	0.0030	0.0030	0.0032	0.0026	0.0026

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.39	(4.393)	139352.1	100.00
RUNOFF	2.368	(1.2073)	8595.30	6.168
EVAPOTRANSPIRATION	27.374	(2.8403)	99367.41	71.307
LATERAL DRAINAGE COLLECTED FROM LAYER 5	6.36955	(0.68002)	23121.449	16.59211
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.023	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.025	(0.003)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.04591	(0.08410)	166.637	0.11958
CHANGE IN WATER STORAGE	2.232	(3.1064)	8101.28	5.814

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.414	8763.6221
DRAINAGE COLLECTED FROM LAYER 5	0.02917	105.87412
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00007
AVERAGE HEAD ON TOP OF LAYER 6	0.042	
MAXIMUM HEAD ON TOP OF LAYER 6	0.082	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	8.9 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.006573	23.86119
SNOW WATER	1.20	4357.1436

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 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5978	0.2165
2	612.5300	0.4084
3	322.6958	0.3586
4	6.5057	0.2711
5	0.0257	0.1016
6	0.0000	0.0000
7	0.1875	0.7500
8	4.6650	0.3888
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:\AR\C\OVERL\I280\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\OVERL\I280\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\OVERL\I280\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\OVERL\I280\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\OVERL\I280\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\OVERL\I280\OUTPUT1.OUT


TIME:  12:51     DATE:  12/27/2021


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

     TITLE:  ARLINGTON LANDFILL - OVERLINER - INTERIM 280 FT

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     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                         =      0.6174 VOL/VOL
  FIELD CAPACITY                   =      0.5127 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                        =   1860.00   INCHES
  POROSITY                         =      0.5017 VOL/VOL
  FIELD CAPACITY                   =      0.4798 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
```

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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                   =       0.22   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.   =   4.03000021000     CM/SEC
SLOPE                       =       1.50   PERCENT
DRAINAGE LENGTH             =     800.0    FEET


                         LAYER  6
                         --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =       1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =       1.00   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
```

LAYER 8

```
              TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     12.00   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    =   1291.690  INCHES
TOTAL INITIAL WATER                 =   1291.690  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
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EVAPOTRANSPIRATION AND WEATHER DATA

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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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.38	2.38	3.00	3.10	3.60	3.84
	3.23	1.59	4.86	3.82	2.69	3.91
STD. DEVIATIONS	1.58	1.12	1.26	1.15	2.00	2.52
	2.51	1.16	2.00	3.57	1.76	1.99
RUNOFF						
TOTALS	0.071	0.139	0.083	0.073	0.188	0.406
	0.215	0.057	0.401	0.698	0.062	0.241
STD. DEVIATIONS	0.078	0.246	0.103	0.099	0.200	0.448
	0.345	0.101	0.361	1.452	0.118	0.310
EVAPOTRANSPIRATION						
TOTALS	1.929	1.887	2.343	2.924	2.989	2.511
	2.754	1.537	3.008	2.267	1.322	1.843
STD. DEVIATIONS	0.343	0.741	0.616	1.207	1.073	1.630
	1.407	1.091	1.159	1.322	0.698	0.584
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.7086	0.7017	0.7583	0.7327	0.7527	0.7251
	0.7488	0.7511	0.7104	0.7321	0.7063	0.7219
STD. DEVIATIONS	0.1505	0.1406	0.1614	0.1463	0.1372	0.1447
	0.1378	0.1599	0.1393	0.1341	0.1207	0.1231
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
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0123	0.0057	0.0046	0.0037	0.0033	0.0028
	0.0027	0.0025	0.0022	0.0022	0.0020	0.0020
STD. DEVIATIONS	0.0327	0.0126	0.0089	0.0062	0.0050	0.0040

0.0035	0.0030	0.0025	0.0023	0.0020	0.0019

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0534	0.0581	0.0571	0.0570	0.0567	0.0564
	0.0564	0.0566	0.0553	0.0551	0.0550	0.0544
STD. DEVIATIONS	0.0113	0.0118	0.0122	0.0114	0.0103	0.0113
	0.0104	0.0120	0.0108	0.0101	0.0094	0.0093

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.39 (4.393)	139352.1	100.00
RUNOFF	2.633 (1.3086)	9558.92	6.860
EVAPOTRANSPIRATION	27.314 (2.8436)	99150.34	71.151
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.74969 (1.56591)	31761.385	22.79218
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.029	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.056 (0.010)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.04591 (0.08410)	166.638	0.11958
CHANGE IN WATER STORAGE	-0.354 (3.4860)	-1285.26	-0.922

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	2.549	9252.6611
DRAINAGE COLLECTED FROM LAYER 5	0.04161	151.03348
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00013
AVERAGE HEAD ON TOP OF LAYER 6	0.097	
MAXIMUM HEAD ON TOP OF LAYER 6	0.193	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	4.2 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.006573	23.86119
SNOW WATER	1.20	4357.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4609
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	2.6013	0.2168
2	629.0787	0.4194
3	645.0174	0.3468
4	6.5611	0.2734
5	0.0381	0.1708
6	0.0000	0.0000
7	0.1875	0.7500
8	4.6650	0.3888
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:\AR\C\OVERL\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\AR\C\OVERL\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\AR\C\OVERL\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\AR\C\OVERL\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\AR\C\OVERL\CL\DATA10.D10
OUTPUT DATA FILE:            C:\AR\C\OVERL\CL\OUTPUT1.OUT


TIME:  10:20     DATE:   1/17/2022


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

     TITLE:  ARLINGTON LANDFILL - OVERLINER - CLOSED 280 FT

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     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 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.       =    12.1700001000     CM/SEC
   SLOPE                           =      25.00   PERCENT
   DRAINAGE LENGTH                 =     500.0    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             =       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                      =      0.6174 VOL/VOL
FIELD CAPACITY                =      0.5127 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                     =   1860.00   INCHES
POROSITY                      =      0.5017 VOL/VOL
FIELD CAPACITY                =      0.4798 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                   =      0.22    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.   =   3.49000001000      CM/SEC
SLOPE                       =      1.50    PERCENT
DRAINAGE LENGTH             =    800.0     FEET


                      LAYER 10
                      --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00    HOLES/ACRE
```

FML INSTALLATION DEFECTS	=	1.00	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.	=	0.499999986000E-09	CM/SEC

LAYER 12

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	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 5.% AND A SLOPE LENGTH OF 420. FEET.

SCS RUNOFF CURVE NUMBER	=	81.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.928	INCHES

UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1302.307	INCHES
TOTAL INITIAL WATER	=	1302.307	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	=	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
2.34	2.63	3.37	3.13	4.33	3.54
1.70	1.68	3.32	4.72	2.62	2.81

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
47.30	51.10	58.80	65.90	74.00	81.90
85.40	85.50	78.50	67.80	56.80	48.80

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 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.83	2.44	3.09	3.01	3.88	3.57
	2.37	1.59	3.71	4.77	2.42	2.96
STD. DEVIATIONS	1.25	1.41	1.84	1.85	1.82	2.32
	1.86	1.19	2.03	3.96	1.86	2.11
RUNOFF						
TOTALS	0.016	0.044	0.085	0.105	0.152	0.206
	0.082	0.010	0.137	0.622	0.085	0.087
STD. DEVIATIONS	0.043	0.103	0.195	0.254	0.375	0.313
	0.204	0.027	0.195	1.041	0.229	0.164
EVAPOTRANSPIRATION						
TOTALS	1.596	1.704	2.425	2.583	3.303	2.853
	2.201	1.512	2.658	2.121	1.274	1.523
STD. DEVIATIONS	0.509	0.744	1.019	1.209	1.107	1.500
	1.335	1.138	1.205	0.971	0.517	0.498
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.5632	0.5567	0.6986	0.4304	0.4237	0.7045
	0.2248	0.0318	0.4863	1.8605	0.8772	1.4359
STD. DEVIATIONS	0.7926	0.6695	1.1057	0.6917	0.6501	0.7925
	0.4830	0.0885	0.6070	2.1361	1.2570	1.5514

```
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

LATERAL DRAINAGE COLLECTED FROM LAYER  9
----------------------------------------
  TOTALS                  0.4799   0.4521   0.4929   0.4769   0.4907   0.4708
                          0.4881   0.4870   0.4662   0.4784   0.4583   0.4768

  STD. DEVIATIONS         0.1818   0.1938   0.2095   0.2019   0.2008   0.1946
                          0.1984   0.2047   0.1905   0.1915   0.1836   0.1860

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

PERCOLATION/LEAKAGE THROUGH LAYER 12
------------------------------------
  TOTALS                  0.0044   0.0021   0.0018   0.0014   0.0013   0.0012
                          0.0011   0.0011   0.0010   0.0010   0.0009   0.0009

  STD. DEVIATIONS         0.0191   0.0075   0.0054   0.0038   0.0031   0.0025
                          0.0022   0.0020   0.0017   0.0016   0.0014   0.0013


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


DAILY AVERAGE HEAD ON TOP OF LAYER  3
-------------------------------------
  AVERAGES                0.0006   0.0006   0.0007   0.0004   0.0004   0.0007
                          0.0002   0.0000   0.0005   0.0018   0.0009   0.0014

  STD. DEVIATIONS         0.0008   0.0007   0.0011   0.0007   0.0006   0.0008
                          0.0005   0.0001   0.0006   0.0021   0.0013   0.0015

DAILY AVERAGE HEAD ON TOP OF LAYER 10
-------------------------------------
  AVERAGES                0.0417   0.0432   0.0429   0.0429   0.0427   0.0423
```

	0.0425	0.0424	0.0419	0.0416	0.0412	0.0415
STD. DEVIATIONS	0.0158	0.0186	0.0182	0.0181	0.0175	0.0175
	0.0173	0.0178	0.0171	0.0167	0.0165	0.0162

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.65 (6.690)	129402.2	100.00
RUNOFF	1.632 (1.1003)	5923.41	4.578
EVAPOTRANSPIRATION	25.753 (3.4165)	93482.08	72.241
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.29359 (3.65011)	30105.727	23.26523
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00003 (0.00001)	0.121	0.00009
AVERAGE HEAD ON TOP OF LAYER 3	0.001 (0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	5.71811 (2.30593)	20756.744	16.04048
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00001 (0.00000)	0.020	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.042 (0.017)		
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.01804 (0.05097)	65.501	0.05062
CHANGE IN WATER STORAGE	-5.766 (2.4422)	-20931.20	-16.175

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.27	19130.100
RUNOFF	1.740	6317.0625
DRAINAGE COLLECTED FROM LAYER 2	1.74133	6321.03564
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000005	0.01960
AVERAGE HEAD ON TOP OF LAYER 3	0.054	
MAXIMUM HEAD ON TOP OF LAYER 3	0.187	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.04106	149.03024
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00010
AVERAGE HEAD ON TOP OF LAYER 10	0.111	
MAXIMUM HEAD ON TOP OF LAYER 10	0.220	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	5.8 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.006573	23.86119
SNOW WATER	1.37	4974.2432

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3522

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	2.0266	0.1689
2	0.0030	0.0100
3	0.0000	0.0000
4	7.6860	0.4270
5	3.7200	0.3100
6	543.5816	0.3624
7	561.2573	0.3018
8	6.2516	0.2605
9	0.0251	0.1130
10	0.0000	0.0000
11	0.1875	0.7500
12	4.5828	0.3819
SNOW WATER	0.000	

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APPENDIX IIIC-A.1

SUMMARY OF LEACHATE GENERATION MODEL WITH 50 PERCENT RECIRCULATION

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIC-A.1-1 through IIIC-A.1-4

This appendix includes the summary sheets for the HELP model analyses performed assuming that the working face is "parked" over a 1-acre area for 50 percent of the site's life. The table below compares the leachate generation results from the HELP model runs included in Appendix IIIC-A (which assume that the time that the working face is "parked" over a 1-acre area is 10 percent) with the leachate generation results for the case that assumes that the working face is "parked" over a 1-acre area for 30 percent of the site's life.

As shown in the table below, the increase in leachate recirculation amounts did not significantly affect the leachate generation rates and peak head on the liner values.

Item	Developed Area (Sector 2 through 5)	Undeveloped Area (Sectors 6 and 7)	Undeveloped Area (Sector 8 through 12)
Time (in percent) that Recirculation Occurs over Any Given Area - 10%			
Summary Sheet Location	IIIC-A-25	IIIC-A-26	IIIC-A-27
Waste Column Thickness	Average for 50 ft to 290 ft of waste	Average for 50 ft to 310 ft of waste	Average for 50 ft to 260 ft of waste
Average Leachate Generation Rate (cf/yr/ac)	22,415	24,560	21,468
Average Leachate Recirculation Rate (cf/yr/ac)	2,241	2,456	2,147
Average of Peak Head on Liner (in)	0.008 - 0.073	0.005 - 0.063	0.005 - 0.090
Time (in percent) that Recirculation Occurs over Any Given Area - 50%			
Summary Sheet Location	IIIC-A.1-2	IIIC-A.2-3	IIIC-A.2-4
Waste Column Thickness	Average for 50 ft to 290 ft of waste	Average for 50 ft to 310 ft of waste	Average for 50 ft to 260 ft of waste
Average Leachate Generation Rate (cf/yr/ac)	24,622	26,217	23,645
Average Leachate Recirculation Rate (cf/yr/ac)	12,311	13,108	11,823
Average of Peak Head on Liner (in)	0.010 - 0.073	0.004 - 0.063	0.005 - 0.090

CITY OF ARLINGTON LANDFILL
0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
DEVELOPED AREAS - SECTORS 2-5 - 50% RECIRCULATION

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (290 FT WASTE)
GENERAL	Case No.	1	2	3	4
INFORMATION	No. of Years	10	10	10	10
	Ground Cover	FAIR	FAIR	FAIR	FAIR
	SCS Runoff Curve No.	86.1	86.7	86.7	86.7
	Model Area (acre)	1	1	1	1
	Runoff Area (%)	70	80	80	90
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0
	Evaporative Zone Depth (inch)	10	10	10	10
TOPSOIL	Thickness (in)				
LAYER	Porosity (vol/vol)				
(Texture = 10)	Field Capacity (vol/vol)				
	Wilting Point (vol/vol)				
	Init. Moisture Content (vol/vol)				
	Hyd. Conductivity (cm/s)				
GEOCOMPIOSITE	Thickness (in)				
DRAINAGE	Porosity (vol/vol)				
LAYER	Field Capacity (vol/vol)				
(Texture = 0)	Wilting Point (vol/vol)				
	Init. Moisture Content (vol/vol)				
	Hyd. Conductivity (cm/s)				
	Slope (%)				
	Slope Length (ft)				
FLEXIBLE	Thickness (in)				
MEMBRANE	Hyd. Conductivity (cm/s)				
LINER	Pinhole Density (holes/acre)				
(Texture = 36)	Install. Defects (holes/acre)				
	Placement Quality				
GEOSYNTHETIC	Thickness (in)				
CLAY	Porosity (vol/vol)				
LAYER	Field Capacity (vol/vol)				
(Texture = 17)	Wilting Point (vol/vol)				
	Init. Moisture Content (vol/vol)				
	Hyd. Conductivity (cm/s)				
INTERMEDIATE	Thickness (in)	12	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	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 TOP[2]	Thickness (in)	600	1200	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5156	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			900	1980
(Texture = 0)	Porosity (vol/vol)			0.5348	0.4976
	Field Capacity (vol/vol)			0.4892	0.4786
	Wilting Point (vol/vol)			0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	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	Thickness (in)	0.190	0.179	0.155	0.130
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	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)	8.40	5.45	3.00	2.68
	Slope (%)	2.0	2.0	2.0	2.0
	Slope Length (ft)	215	215	215	215
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	38.39	38.39	38.39	38.39
RUNOFF	Average Annual (in)	1.94	2.37	2.37	2.63
EVAPOTRANSPIRATION	Average Annual (in)	27.34	27.37	27.37	27.31
LATERAL	Average Annual (cf/year)	6,648.5	32,048.8	24,992.0	34,799.4
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	89.3	302.6	119.7	187.8
LATERAL	Average Annual (cf/year)	3,324.2	16,024.4	12,496.0	17,399.7
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	44.7	151.3	59.9	93.9
HEAD ON LINER	Average Annual (in)	0.001	0.008	0.012	0.019
	Peak Daily (in)	0.010	0.058	0.042	0.073

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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.

CITY OF ARLINGTON LANDFILL
0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
UNDEVELOPED AREA - SECTORS 6-7 - 50% RECIRCULATION

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (310 FT WASTE)
GENERAL INFORMATION	Case No.	2	3	4	5	6
	No. of Years	10	10	10	10	10
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR
	SCS Runoff Curve No.	86.1	86.7	86.7	86.7	86.7
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	70	80	80	80	90
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0
	Evaporative Zone Depth (inch)	10	10	10	10	10
TOPSOIL LAYER (Texture = 10)	Thickness (in)					
	Porosity (vol/vol)					
	Field Capacity (vol/vol)					
	Wilting Point (vol/vol)					
	Init. Moisture Content (vol/vol)					
	Hyd. Conductivity (cm/s)					
GEOCOMPIOSITE DRAINAGE LAYER (Texture = 0)	Thickness (in)					
	Porosity (vol/vol)					
	Field Capacity (vol/vol)					
	Wilting Point (vol/vol)					
	Init. Moisture Content (vol/vol)					
	Hyd. Conductivity (cm/s)					
	Slope (%)					
	Slope Length (ft)					
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)					
	Hyd. Conductivity (cm/s)					
	Pinhole Density (holes/acre)					
	Install. Defects (holes/acre)					
	Placement Quality					
GEOSYNTHETIC CLAY LAYER (Texture = 17)	Thickness (in)					
	Porosity (vol/vol)					
	Field Capacity (vol/vol)					
	Wilting Point (vol/vol)					
	Init. Moisture Content (vol/vol)					
	Hyd. Conductivity (cm/s)					
INTERMEDIATE COVER (Texture = 11)	Thickness (in)	12	12	12	12	12
	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640
	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] (Texture = 0)	Thickness (in)	600	1200	1500	1500	1500
	Porosity (vol/vol)	0.6376	0.6277	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5156	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)			900	2100	2220
	Porosity (vol/vol)			0.5348	0.4935	0.4893
	Field Capacity (vol/vol)			0.4892	0.4775	0.7463
	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 COVER (Texture = 10)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.235	0.214	0.164	0.144	0.143
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	14.31	8.05	4.13	2.68	2.59
	Slope (%)	2.0	2.0	2.0	2.0	2.0
	Slope Length (ft)	165	165	165	165	165
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
	Pinhole Density (holes/acre)	1	1	1	1	1
	Install. Defects (holes/acre)	1	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	38.39	38.39	38.39	38.39	38.39
RUNOFF	Average Annual (in)	2.06	2.43	2.37	2.37	2.63
EVAPOTRANSPIRATION	Average Annual (in)	27.86	27.68	27.37	27.37	27.31
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	5,598.5	26,205.8	25,011.9	36,315.2	37,953.6
	Peak Daily (cf/day)	68.4	176.1	135.5	206.1	206.0
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)	2,799.3	13,102.9	12,505.9	18,157.6	18,976.8
	Peak Daily (cf/day)	34.2	88.0	67.8	103.0	103.0
HEAD ON LINER	Average Annual (in)	0.000	0.004	0.007	0.015	0.016
	Peak Daily (in)	0.004	0.017	0.027	0.061	0.063

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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: BPY
Date: 5/20/2022

CITY OF ARLINGTON LANDFILL
0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
UNDEVELOPED SECTORS 8-12 - 50% RECIRCULATION

Chkd By: NT/DEP
Date: 5/20/2022

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (260 FT WASTE)
GENERAL	Case No.	2	3	4	5
INFORMATION	No. of Years	10	10	10	10
	Ground Cover	FAIR	FAIR	FAIR	FAIR
	SCS Runoff Curve No.	86.1	86.7	86.7	86.7
	Model Area (acre)	1	1	1	1
	Runoff Area (%)	70	80	80	90
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0
	Evaporative Zone Depth (inch)	10	10	10	10
TOPSOIL	Thickness (in)				
LAYER	Porosity (vol/vol)				
(Texture = 10)	Field Capacity (vol/vol)				
	Wilting Point (vol/vol)				
	Init. Moisture Content (vol/vol)				
	Hyd. Conductivity (cm/s)				
GEOCOMPIOSITE	Thickness (in)				
DRAINAGE	Porosity (vol/vol)				
LAYER	Field Capacity (vol/vol)				
(Texture = 0)	Wilting Point (vol/vol)				
	Init. Moisture Content (vol/vol)				
	Hyd. Conductivity (cm/s)				
	Slope (%)				
	Slope Length (ft)				
FLEXIBLE	Thickness (in)				
MEMBRANE	Hyd. Conductivity (cm/s)				
LINER	Pinhole Density (holes/acre)				
(Texture = 36)	Install. Defects (holes/acre)				
	Placement Quality				
GEOSYNTHETIC	Thickness (in)				
CLAY	Porosity (vol/vol)				
LAYER	Field Capacity (vol/vol)				
(Texture = 17)	Wilting Point (vol/vol)				
	Init. Moisture Content (vol/vol)				
	Hyd. Conductivity (cm/s)				
INTERMEDIATE	Thickness (in)	12	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	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 TOP[2]	Thickness (in)	600	1200	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5156	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			900	1620
(Texture = 0)	Porosity (vol/vol)			0.5348	0.5100
	Field Capacity (vol/vol)			0.4892	0.4822
	Wilting Point (vol/vol)			0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	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	Thickness (in)	0.235	0.214	0.164	0.149
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	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)	14.31	8.05	4.13	3.07
	Slope (%)	2.0	2.0	2.0	2.0
	Slope Length (ft)	370	370	370	370
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	38.39	38.39	38.39	38.39
RUNOFF	Average Annual (in)	1.94	2.37	2.37	2.63
EVAPOTRANSPIRATION	Average Annual (in)	27.58	27.37	27.37	27.31
LATERAL	Average Annual (cf/year)	6,626.1	31,969.9	25,050.0	30,934.2
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	92.4	304.4	114.5	154.3
LATERAL	Average Annual (cf/year)	3,313.1	15,985.0	12,525.0	15,467.1
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	46.2	152.2	57.2	77.2
HEAD ON LINER	Average Annual (in)	0.001	0.010	0.015	0.025
	Peak Daily (in)	0.005	0.067	0.051	0.090

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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.

APPENDIX IIIC-A.2

SUMMARY OF LEACHATE GENERATION MODEL FOR SIDESLOPES

STATE OF TEXAS
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5-19-2022

Includes pages IIIC-A.2-1 through IIIC-A.2-13

INTRODUCTION

This appendix contains the analysis of the sideslope geocomposite for both the undeveloped and developed Subtitle D areas. This appendix includes the following:

- Sheets IIIC-A.2-2 through IIIC-A.2-9. Geocomposite calculations using transmissivity values for the sideslope.
- Sheets IIIC-A.2-10 and IIIC-A.2-11. Required properties for the double-sided geocomposite to be placed on the sideslopes of undeveloped areas.
- Sheets IIIC-A.2-12 and IIIC-A.2-13. HELP summary sheets for sideslope geocomposite HELP analysis.

As shown in the following HELP model summary sheets, the geocomposite incorporated into the LCS design is adequate (i.e., the calculated head on the liner is within the compressed thickness of the LCS geocomposite).

CITY OF ARLINGTON LANDFILL
0023-404-11-104
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
DEVELOPED AREAS - SECTORS 2-5 - SIDESLOPES

Required: Estimate the properties of the geocomposite leachate collection layer for the developed Subtitle D sectors sideslopes.

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 required transmissivity for the 200-mil-thick double-sided geocomposite collection layer.
4. Compute the design transmissivity of the 200-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, Second Edition, June 2007.
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. Determine the 200-mil geocomposite leachate collection layer thickness under the expected loading conditions.

   Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of 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 for Subtitle D Areas

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	51	2,895	0.190	0.005
Interim - 100'	100	3	57	6,045	0.179	0.005
Interim - 200'	200	3	71	14,545	0.155	0.004
Interim - 290'	290	3	79	23,255	0.130	0.003
Closed - 290'	290	4	79	23,370	0.129	0.003

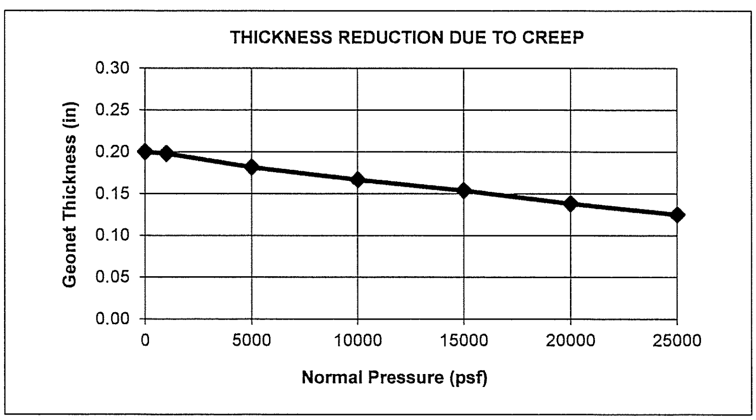
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, 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.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (290' Waste)	Closed
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. Identify the minimum required transmissivity for the 200-mil-thick double-sided geocomposite collection layer.

The required minimum transmissivity for the 200-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown on Sheet IIIC-A.2-10. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the design transmissivity of the 200-mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3 - Required Transmissivity for Subtitle D Areas

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (m)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	2,895	0.005	1.11E-04	3.15	3.54E-05	0.73
Interim - 100'	100	6,045	0.005	7.25E-05	3.96	1.83E-05	0.40
Interim - 200'	200	14,545	0.004	3.44E-05	4.75	7.25E-06	0.18
Interim - 290'	290	23,255	0.003	1.81E-05	5.02	3.60E-06	0.11
Closed - 290'	290	23,370	0.003	1.67E-05	5.72	2.92E-06	0.09

[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.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A-22.

[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:

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

CITY OF ARLINGTON LANDFILL
0023-404-11-104
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
UNDEVELOPED AREA - SECTORS 6-12 - SIDESLOPE

Required: Determine the minimum requirements of the 250-mil geocomposite leachate collection layer for Sectors 6 through 12 sideslope.

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 double-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, Second Edition, June 2007.
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. Determine the 250-mil geocomposite leachate collection layer thickness under the expected loading conditions.

   Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of 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 for Subtitle D 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	51	740	0.248	0.006
Interim - 50'	50	3	51	2,895	0.235	0.006
Interim - 100'	100	3	57	6,045	0.214	0.005
Interim - 200'	200	3	71	14,545	0.164	0.004
Interim - 300'	300	3	79	24,045	0.144	0.004
Interim - 310'	310	3	79	24,835	0.143	0.004
Closed - 310'	310	4	79	24,950	0.143	0.004

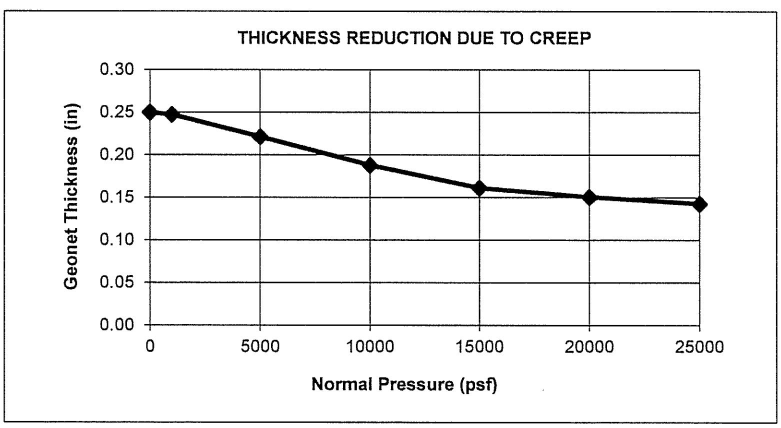
1 d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

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.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition						
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (300' Waste)	Interim (308' Waste)	Closed
RF_{IN}	Delayed Intrusion	1.1	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	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.38	2.51	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	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	5.02	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. Identify the minimum required transmissivity for the 250-mil-thick double-sided geocomposite collection layer.

The required minimum transmissivity for the 250-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown on Sheet IIIC-A.2-11. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

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.

Table 3 - Required Transmissivity for Subtitle D Areas

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (m)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	740	0.006	5.46E-04	2.20	2.48E-04	3.94
Interim - 50'	50	2,895	0.006	3.93E-04	3.15	1.25E-04	2.09
Interim - 100'	100	6,045	0.005	2.64E-04	3.96	6.67E-05	1.22
Interim - 200'	200	14,545	0.004	7.55E-05	4.75	1.59E-05	0.38
Interim - 300'	300	24,045	0.004	2.79E-05	5.02	5.56E-06	0.15
Interim - 310'	310	24,835	0.004	2.67E-05	5.02	5.32E-06	0.15
Closed - 310'	310	24,950	0.004	2.65E-05	5.72	4.64E-06	0.13

[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.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A.2-11.

[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 the Leachate Collection Layer

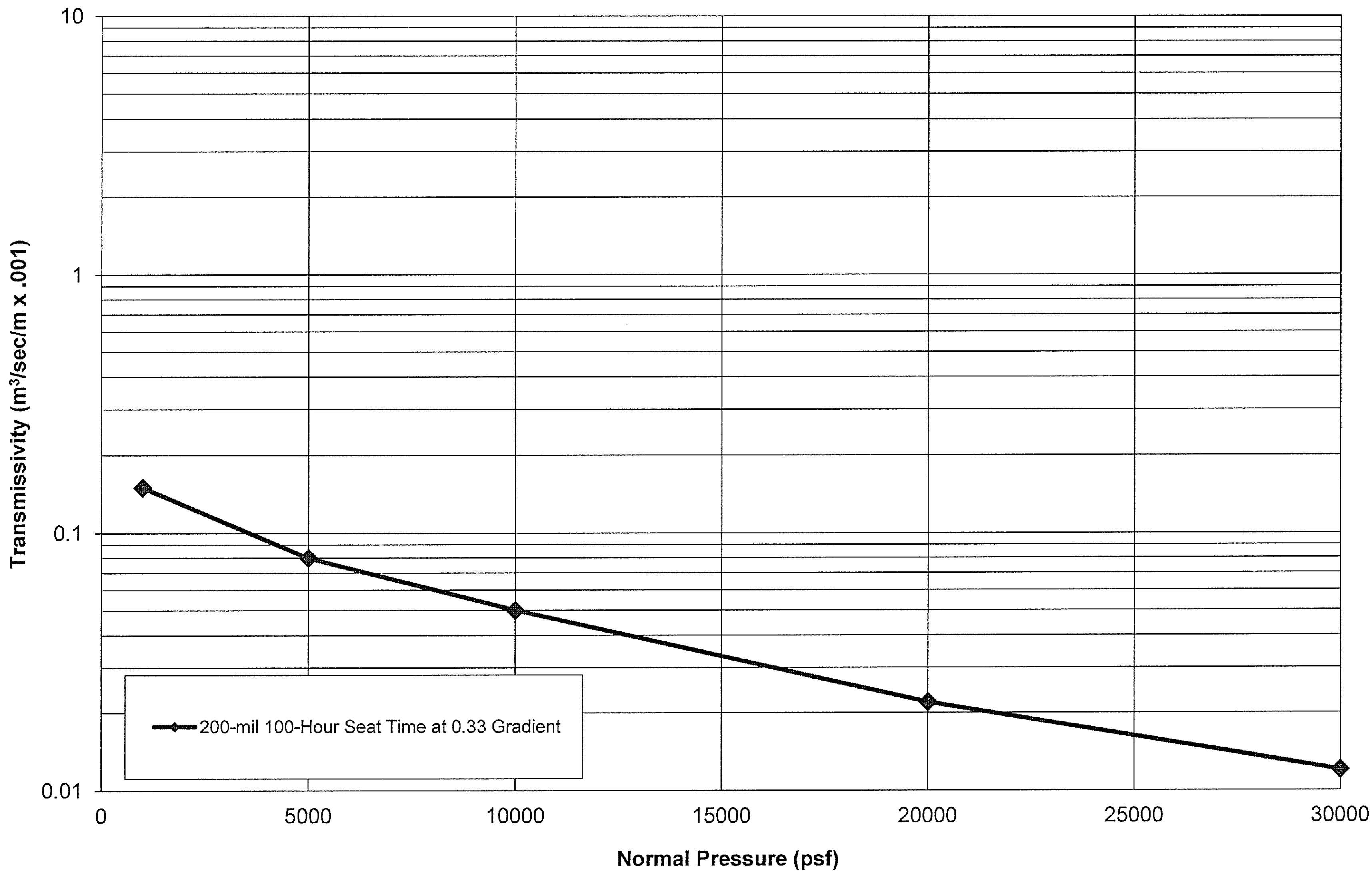
As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the graph shown on Sheet IIIC-A.2-11 will provide a drainage layer that will maintain less than twelve inches of head on the liner system.

The drainage geocomposite required transmissivity values will be measured at a gradient of 0.33 under normal pressures of 1,000, 15,000 and 24,950 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seat 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 maximum normal stress (i.e., 24,950 psf) with all the same assumptions as the first three tests. The minimum transmissivity will be 2.65 $x10^{-5}$ m^2/s.

Note:

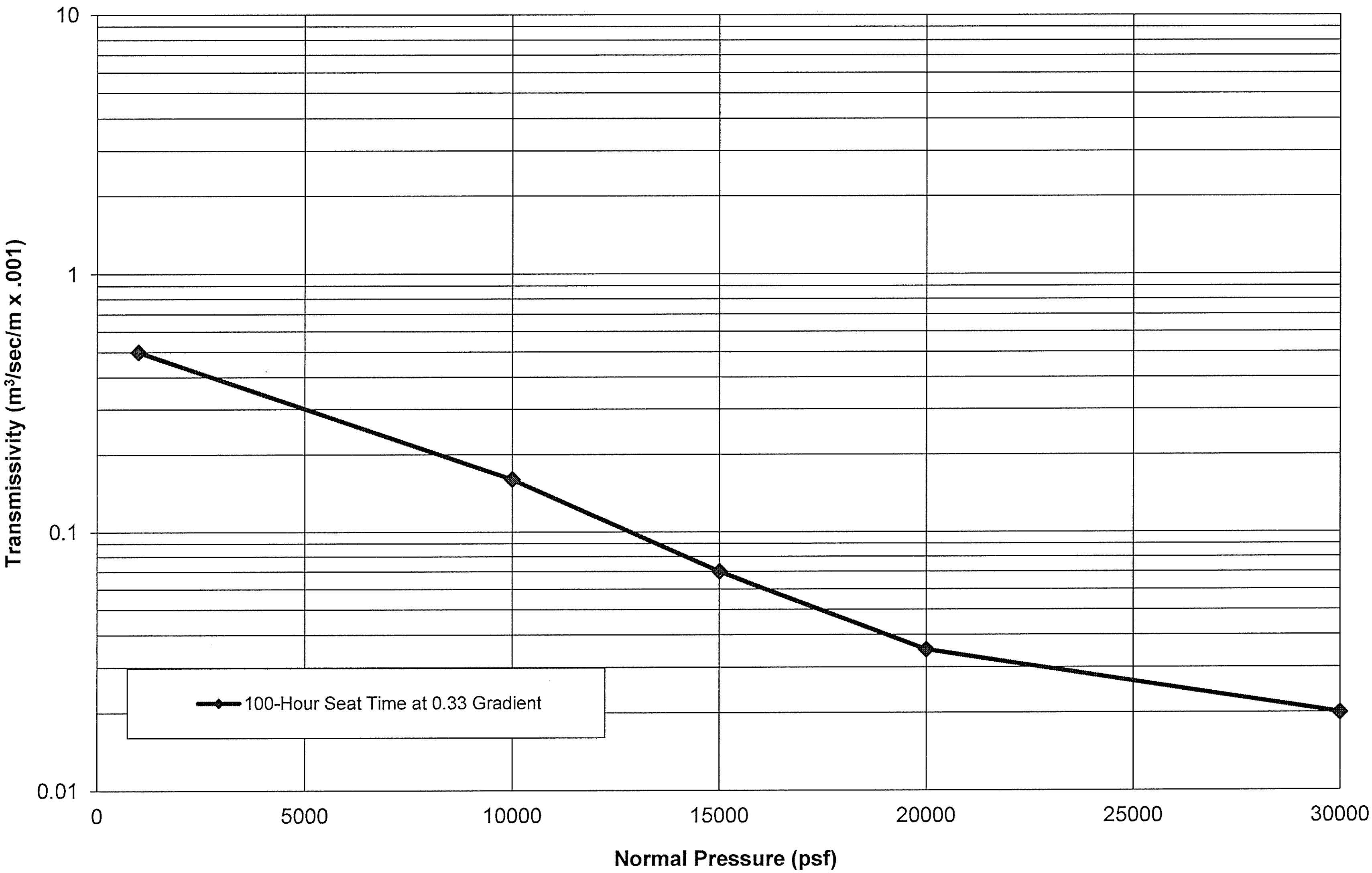
Reference to "geocomposite thickness" within these calculations refers to thickness of geonet, not the overall thickness of geocomposite. Actual manufacturer's specified thickness for a geocomposite incorporating the specified geonet thickness may be greater. The transmissivity values used for these calculations may or may not be representative of actual transmissivity values for every manufacturer, and may require a prospective material supplier provide a geocomposite that varies in thickness or composition from the geocomposite assumed for these calculations in order to meet minimum transmissivity criteria set forth in the Appendix IIID - Liner Quality Control Plan.

TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE
8 oz/sy Polypropylene Geotextiles with 200-mil Drainage Net
(Soil/Geocomposite/Geomembrane)



TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE

6/8 oz/sy Polypropylene Geotextiles with 250-mil Drainage Net
(Soil/Geocomposite/Geomembrane)



CITY OF ARLINGTON LANDFILL
0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
DEVELOPED AREAS - SECTORS 2-5 - SIDESLOPE

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (290 FT WASTE)	CLOSED (290 FT WASTE)
GENERAL	Case No.	1	2	3	4	5
INFORMATION	No. of Years	10	10	10	10	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	86.1	86.7	86.7	86.7	79.5
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	70	80	80	90	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	12
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
GEOCOMPIOSITE	Thickness (in)					0.300
DRAINAGE	Porosity (vol/vol)					0.8500
LAYER	Field Capacity (vol/vol)					0.0100
(Texture = 0)	Wilting Point (vol/vol)					0.0050
	Init. Moisture Content (vol/vol)					0.0100
	Hyd. Conductivity (cm/s)					12.17
	Slope (%)					5.0
	Slope Length (ft)					1000
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
COMPACTED	Thickness (in)					18.00
CLAY LINER	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)	600	1200	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6277	0.6174	0.6174	0.6148
	Field Capacity (vol/vol)	0.5185	0.5156	0.5127	0.5127	0.5114
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			900	1980	1980
(Texture = 0)	Porosity (vol/vol)			0.5348	0.4976	0.4976
	Field Capacity (vol/vol)			0.4892	0.4786	0.4786
	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
COVER	Porosity (vol/vol)	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
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.190	0.179	0.155	0.130	0.129
COLLECTION	Porosity (vol/vol)	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
(Texture = 0)	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	0.73	0.40	0.18	0.11	0.09
	Slope (%)	33.0	33.0	33.0	33.0	33.0
	Slope Length (ft)	120	120	120	120	120
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	1	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	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
	Wilting Point (vol/vol)	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
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	38.39	38.39	38.39	38.39	35.65
RUNOFF	Average Annual (in)	2.10	2.43	2.37	2.63	1.22
EVAPOTRANSPIRATION	Average Annual (in)	27.84	27.68	27.37	27.31	25.50
LATERAL	Average Annual (cf/year)	5,097.4	22,736.3	23,413.9	33,293.6	21,669.3
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	54.7	133.2	132.5	189.1	187.8
LATERAL	Average Annual (cf/year)	509.7	2,273.6	2,341.4	3,329.4	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	5.5	13.3	13.2	18.9	
HEAD ON LINER	Average Annual (in)	0.000	0.003	0.007	0.016	0.013
	Peak Daily (in)	0.003	0.041	0.047	0.037	0.061

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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: BPY
Date: 5/20/2022

CITY OF ARLINGTON LANDFILL
0023-403-11-104
HELP VERSION 3.07 SUMMARY SHEET
UNDEVELOPED AREA - SECTORS 6-12 - SIDESLOPE

Chkd By: NT/DEP
Date: 5/20/2022

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (310 FT WASTE)	CLOSED (310 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6	7
INFORMATION	No. of Years	1	10	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	86.1	86.7	86.7	86.7	86.7	81.2
	Model Area (acre)	1	1	1	1	1	1	1
	Runoff Area (%)	0	70	80	80	80	90	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	10	12
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
GEOCOMPIOSITE	Thickness (in)							0.300
DRAINAGE	Porosity (vol/vol)							0.8500
LAYER	Field Capacity (vol/vol)							0.0100
(Texture = 0)	Wilting Point (vol/vol)							0.0050
	Init. Moisture Content (vol/vol)							0.0100
	Hyd. Conductivity (cm/s)							12.17
	Slope (%)							25.0
	Slope Length (ft)							420
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
COMPACTED	Thickness (in)							18.00
CLAY LINER	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)	120	600	1200	1500	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6376	0.6277	0.6174	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5185	0.5156	0.5127	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	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	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)				900	2100	2220	2220
(Texture = 0)	Porosity (vol/vol)				0.5348	0.4935	0.4893	0.4893
	Field Capacity (vol/vol)				0.4892	0.4775	0.7463	0.4863
	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	24
COVER	Porosity (vol/vol)	0.3980	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	0.2440
	Wilting Point (vol/vol)	0.1360	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	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.248	0.235	0.214	0.164	0.144	0.143	0.143
COLLECTION	Porosity (vol/vol)	0.8500	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	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	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	0.0100
	Hyd. Conductivity (cm/s)	3.94	2.09	1.22	0.38	0.15	0.15	0.13
	Slope (%)	33.0	33.0	33.0	33.0	33.0	33.0	33.0
	Slope Length (ft)	120	120	120	120	120	120	120
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	1	1	1	1	1	1	1
(Texture = 36)	Install. Defects (holes/acre)	1	1	1	1	1	1	1
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	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	0.4180
	Wilting Point (vol/vol)	0.3670	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	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	47.30	38.39	38.39	38.39	38.39	38.39	35.65
RUNOFF	Average Annual (in)	0.00	2.30	2.74	2.43	2.37	2.63	1.45
EVAPOTRANSPIRATION	Average Annual (in)	34.70	28.01	27.94	27.68	27.37	27.31	25.55
LATERAL	Average Annual (cf/year)	892.2	4,306.4	17,184.9	20,445.9	31,447.1	32,826.6	23,704.5
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	26.4	39.9	82.8	95.5	189.1	189.3	206.8
LATERAL	Average Annual (cf/year)		478.5	1,909.4	2,271.8	3,494.1	3,647.4	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)		4.4	9.2	10.6	21.0	21.0	
HEAD ON LINER	Average Annual (in)	0.000	0.000	0.001	0.003	0.013	0.013	0.010
	Peak Daily (in)	0.053	0.046	0.049	0.021	0.062	0.061	0.030

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[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.

APPENDIX IIIC-B

LEACHATE COLLECTION SYSTEM DESIGN CALCULATIONS

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIC-B-1 through IIIC-B-73

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER
5-19-2022

CONTENTS

LEACHATE 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 sector in the developed and the undeveloped areas 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 Sectors:
From the HELP model results in Appendix IIIC-A (highest leachate generation values used from all HELP runs for developed sectors).

CONDITION	PEAK cfd/ac	PEAK gpd/ac
Interim, 50' Waste	74.4	556.2
Interim, 100' Waste	178.9	1,338.2
Interim, 200' Waste	119.7	895.6
Interim, 290' Waste	187.8	1,405.0

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

For the developed sectors the largest area draining to a leachate collection pipe is 13.2 acres (pipe in Sector 5).

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 2.1 ac
2. Interim condition, 100' waste over 3.7 ac
3. Interim condition, 100' waste over 4.6 ac
4. Interim condition, 180' waste over 2.8 ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Interim, 50' Waste	2.1	556.2	1,168.0	1.81E-03
Interim, 100' Waste	3.7	1,338.2	4,951.2	7.66E-03
Interim, 200' Waste	4.6	895.6	4,119.8	6.37E-03
Interim, 290' Waste	2.8	1,405.0	3,933.9	6.09E-03
Total =	13.2		14,172.9	2.19E-02

Undeveloped Sectors:
From the HELP model results in Appendix IIIC-A (highest leachate generation values used from all HELP runs for undeveloped sectors including the overliner since portions of the overliner drain to the pipes in adjacent Subtitle D sectors).

CONDITION	PEAK[1] cfd/ac	PEAK gpd/ac
Active, 10' Waste	31.3	234.4
Interim, 50' Waste	56.1	419.5
Interim, 100' Waste	126.5	946.3
Interim, 200' Waste	135.5	1,013.8
Interim, 300' Waste	206.1	1,541.3
Interim, 310' Waste	206.0	1,541.0

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

For the undeveloped sectors, the largest area draining to a leachate collection pipe is 111.4 acres (pipe in Sector 7). The leachate from Sector 2 through 5 and portions of the overliner drain to this pipe. Note, it is a conservative assumption that all the leachate will drain to a singluar pipe as leachate will likely be split between multiple pipes in Sector 7.

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	12.0	ac
2. Interim condition, 50' waste over	18.7	ac
3. Interim condition, 100' waste over	20.7	ac
4. Interim condition, 200' waste over	26.5	ac
4. Interim condition, 300' waste over	21.5	ac
5. Interim condition, 310' waste over	12.0	ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Active, 10' Waste	12.0	234.4	2,812.9	4.35E-03
Interim, 50' Waste	18.7	419.5	7,844.0	1.21E-02
Interim, 100' Waste	20.7	946.3	19,588.5	3.03E-02
Interim, 200' Waste	26.5	1,013.8	26,865.2	4.16E-02
Interim, 300' Waste	21.5	1,541.3	33,138.9	5.13E-02
Interim, 310' Waste	12.0	1,541.0	18,492.6	2.86E-02
Total=	111.4		108,742.0	1.68E-01

Developed Sectors Peak Leachate Production = 2.19E-02 cfs

Undeveloped Sectors Peak Leachate Production = 1.68E-01 cfs

IKK The undeveloped sectors peak leachate production rate was used for the pipe capacity calculation for a 6" SDR 17 pipe.

Determination of flow capacity (Q_{full}) for proposed 6-inch SDR 17 perforated pipe:

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

I+A105:A10 R = Hydraulic radius of pipe in feet under full flow conditions
S = Design slope of pipe
n = Manning's number

From Pipe Structural Stability Calculations:

Standard Dimension Ratio (SDR) = 17.0

ID = 5.845 in
= 0.487 ft

A = 0.186 sq ft

R = 0.122 ft

S^1 = 0.006 ft / ft

[1]The 0.6 percent slope was chosen as the minimum slope for the leachate collection pipes. Refer to Appendix IIIE-B.

n = Manning's number n = 0.015

Q_{full} =	0.351	cfs

Compare Peak Q_{max} and Q_{full} for the 6" SDR 17 pipe:

Q_{full} =	0.351	cfs	>>	Q_{max} =	0.1683	cfs

An SDR 17 pipe with a nominal diameter of 6 inches exceeds flow capacity requirements.

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

	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

	D_{85} =	25	mm
	=	0.984	in
Standard hole diameter	d =	0.5	in

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 2.0 > 1.7 \quad \text{p}$$

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.

OVERLINER LEACHATE COLLECTION 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) :

CONDITION	PEAK cfd/ac	PEAK gpd/ac
Active, 10' Waste	38.4	287.3
Interim, 50' Waste	88.9	664.8
Interim, 100' Waste	166.0	1,241.6
Interim, 200' Waste	105.9	791.9
Interim, 280' Waste	151.0	1,129.7

The largest overliner area draining to a pipe is 16.7 acres.

Therefore, the maximum leachate production expected in the leachate collection pipe for the overliner area is predicted to occur assuming the following scenario:

1. Active, 10' Waste	1.4	ac
2. Interim, 50' Waste	3.5	ac
3. Interim, 100' Waste	4.8	ac
4. Interim, 200' Waste	5.6	ac
5. Interim, 280' Waste	1.4	ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Active, 10' Waste	1.4	287.3	402.2	6.22E-04
Interim, 50' Waste	3.5	664.8	2,326.8	3.60E-03
Interim, 100' Waste	4.8	1,241.6	5,959.5	9.22E-03
Interim, 200' Waste	5.6	791.9	4,434.9	6.86E-03
Interim, 280' Waste	1.4	1,129.7	1,581.6	2.45E-03
Total=	16.7		14,704.9	2.28E-02

The total pre-Subtitle D overliner peak leachate production (cfs)= 2.28E-02

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
S = Design slope of pipe
n = Manning's number

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^1 = 0.0001 ft / ft

[1]The 0.01 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 0.01 percent slope after settlement. Refer to Appendix IIIE-B.

n = 0.015

$\boxed{Q_{full} = 0.045 \text{ cfs}}$

Compare Peak Q_{max} and Q_{full}:

Q_{full} =	4.535E-02 cfs	>>	Q_{max} =	2.28E-02	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:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} = 7.9 > 2.0 \quad \text{(acceptable)}$$

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:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 2.0 > 1.7 \quad \text{(acceptable)}$$

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.

LEACHATE COLLECTION PIPE
STRUCTURAL STABILITY

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-24 and IIIC-B-25 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)

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 = 120 pcf

P_D =	1.67	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 @	120	pcf =	240	psf	
3.5	ft final & intrm cover @	120	pcf =	420	psf	
310.0	ft solid waste/soil @	75	pcf =	23,250	psf	Highest waste column thickness
			Σ =	23,910	psf	over a 6" LCS pipe.

P_T =	166.0	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	166.0	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

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 =	166.0	psi
P_{DES1} =	221.4	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-24), 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-25), 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-25).

2c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\ 2} \tag{1}$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} \tag{2}$$

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)

$$H_e = \pm r_{sd}\, p\left(\frac{H}{B_c}\right) \tag{3}$$

Where:

r_{sd}	=	Settlement ratio
p	=	Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \tag{4}$$

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:

$$r_{sd} = \frac{S_m - dc}{S_m} \tag{5}$$

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} = -0.66

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} =	221.4	psi
D =	6.625	in
E_s =	3,000	psi

S_m =	0.489	in

Step 3: Calculate dc using Equation (5):

$dc = S_m\,(1 - r_{sd})$

dc =	0.811	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 =	27,000	psi (refer to chart 25 on page IIIC-B-26, based on P_{DES1} above)
t =	0.390	in (SDR 17 pipe)
I =	0.005	in^4/in
r =	3.3	in
E' =	3,000	psi

$\boxed{W_c = 605 \text{ lb/in}}$

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\ 2}}$$

Composite unit weight for waste and soil:

5.5	ft soil @	120	pcf =	660	psf
310.0	ft waste @	75	pcf =	23,250	psf
			Total =	23,910	psf

γ =	75.78	pcf (weighted average based on above table)
B_c =	6.625	in

$\boxed{C_c = 314.5 \text{ (unitless)}}$

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	310	ft
H/B_c =	561.5	

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	
$(H/B_c - H_e/B_c)$ =	559.3	
$e^{-2k\mu(He/Bc)}$ =	0.56	

Left-hand-side of equation (LHS) = 315
Right-hand-side of equation (RHS) = 315

<u>Step 7:</u> 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
kμ =	0.13
H/B_c =	561.5
H_e/B_c =	2.23
r_{sd} =	-0.66
LHS =	370
RHS =	370

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 =	605	lb/in
D =	6.6	in
P_{DES2} =	91	psi

A summary table for the structural stability analysis is provided on page IIIC-B-23 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} = 91 psi

S_A =	731.1	psi
FS =	2.1	

Compare calculated and suggested factor of safety:	2.1	> 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 =	18,000	psi for 50 years based on S_A above (see chart page IIIC-B-27)
P_{DES2} =	91	psi

P_{cb} =	127.7	psi
FS =	1.4	

Compare calculated and suggested factor of safety:	1.4	> 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} = 91 psi
E' = 3,000 psi

$\boxed{E_S = 3.0\ \%}$

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} = 3.0 %

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.

CITY OF ARLINGTON LANDFILL
0023-404-11-104
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE

Adjusted load to account for soil arching = 91 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	1,439.3	1.0	13,000	3,000	41.1	0.4	8.1	3,000	3.0	2.7
26.0	1,500	1,142.3	1.3	13,000	3,000	57.4	0.6	6.5	3,000	3.0	2.1
21.0	1,500	913.8	1.6	15,000	3,000	84.9	0.9	5.2	3,000	3.0	1.7
19.0	1,500	822.5	1.8	16,500	3,000	103.5	1.1	4.7	3,000	3.0	1.5
17.0 [1]	1,500	731.1	2.1	18,000	3,000	127.7	1.4	4.2	3,000	3.0	1.4
15.5	1,500	662.5	2.3	19,000	3,000	150.8	1.6	3.9	3,000	3.0	1.3
13.5	1,500	571.6	2.6	21,000	3,000	194.8	2.1	3.4	3,000	3.0	1.1
11.0	1,500	456.9	3.3	23,000	3,000	277.4	3.0	2.7	3,000	3.0	0.9

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-27), 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).

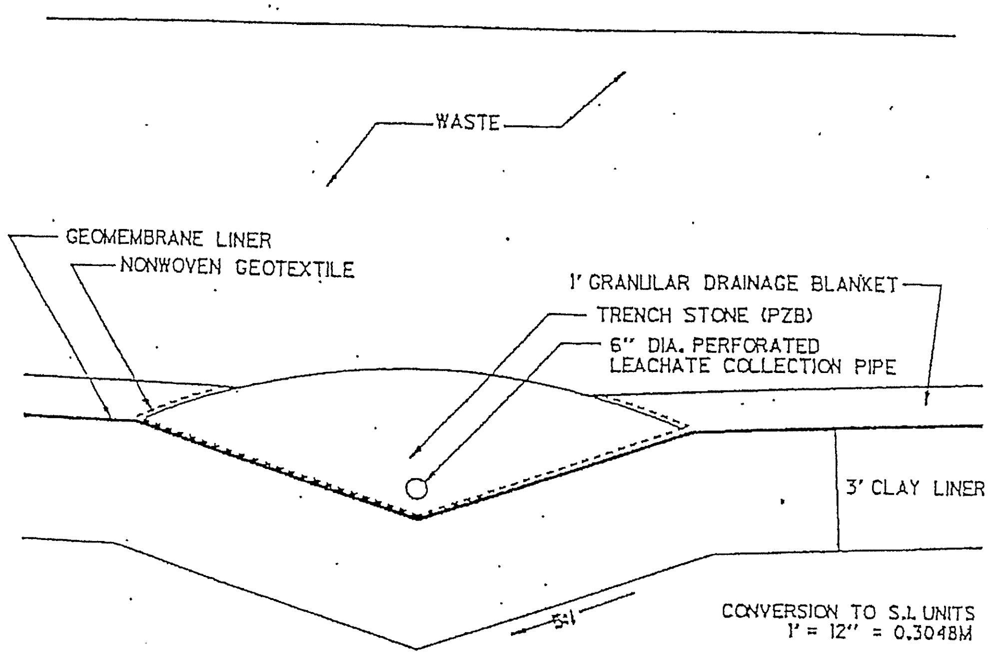


FIGURE 1: TYPICAL V-SHAPED TRENCH FOR LANDFILLS WITH COMPOSITE LINERS

. /ol/users/Jow/prgetren.dgn

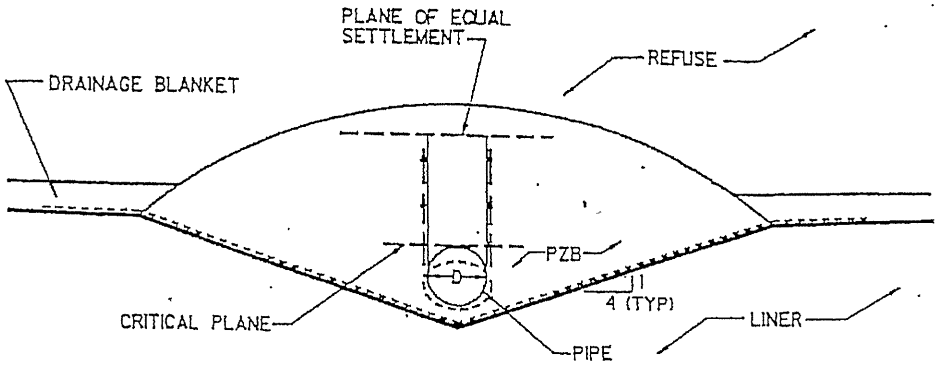


FIGURE 2: SETTLEMENT OF LEACHATE PIPE INDUCING SHEAR STRESSES IN PZB

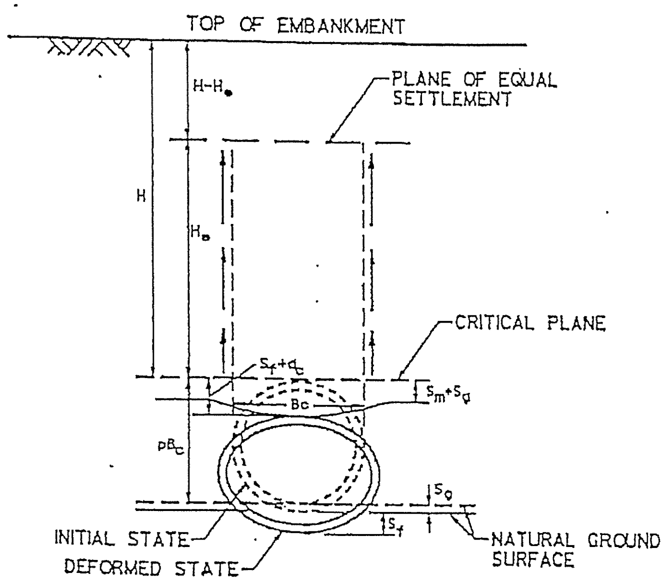


FIGURE 3: CASE OF AN INCOMPLETE DITCH CONDITION FOR A POSITIVE PROJECTING CONDUIT

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here: S_A = Actual compressive stress, psi
SDR = Standard Dimension Ratio
P_T = External Pressure, psi

Safety Factor = 1500 psi ÷ S_A where 1500 psi is the Compressive Yield Strength of Driscopipe.

Design by Wall Buckling: Local wall buckling is a longitudinal wrinkling of the pipe wall. Tests of *non-pressurized* Driscopipe show that buckling and collapse do not occur when the soil envelope is in full contact with the pipe and is compacted to a dense state. However, it can be forced to occur over the long term in *non-pressurized* pipe if the total external soil pressure, P_t, is allowed to exceed the pipe-soil system's critical buckling pressure, P_{cb}. If $P_t > P_{cb}$, gradual collapse may occur over the long term. A calculated, conservative value for the critical buckling pressure may be obtained by the following approximate formula. All pipe diameters with the same SDR in the same burial situation have the same critical collapse and critical buckling endurance

$$P_{cb} = 0.8\sqrt{E' \times P_c}$$

Where:

P_t = Total vertical soil pressure at the top of the pipe, psi

P_{cb} = Critical buckling soil pressure at the top of the pipe, psi

E' = Soil modulus in psi calculated as the ratio of the vertical soil pressure to vertical soil strain at a specified density

P_c = Hydrostatic, critical-collapse differential pressure, psi

$$P_c = \frac{2E\,(t/D)^3\,(D_{MIN}/D_{MAX})^3}{(1-\mu^2)}$$

$$P_c = \frac{2.32\,E}{(SDR)^3}$$

Where: $(D_{MIN}/D_{MAX}) = .95$
μ = Poission's Ratio
μ = .45 for Driscopipe
E = stress and time dependent tensile modulus of elasticity, psi

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

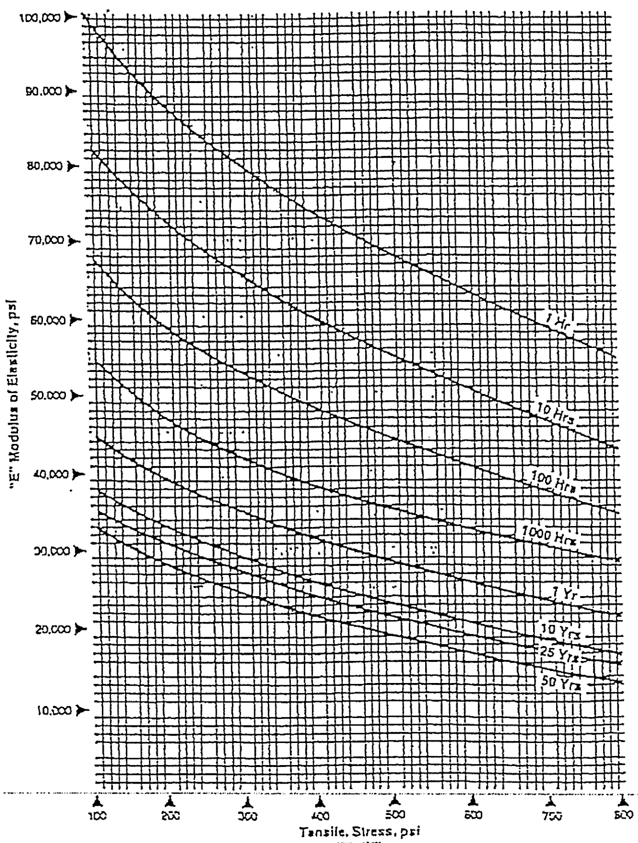
Design by Wall Buckling Guidelines:
Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_t < P_{cb}$.

1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe.
2. Calculate the stress "S_A" in the pipe wall according to the formula:

$$S_A = \frac{(SDR-1)\,P_t}{2}$$

3. Based upon the stress "S_A" and the estimated time duration of non-pressurization, use Chart 25 to find the value of the pipe's modulus of elasticity, E, in psi.

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.

DRISCOPIPE

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. Soil Modulus, psi* 1000	2000	3000	Maximum External Pressure psi Soil Modulus, psi* 1000	2000	3000	Maximum Deflection, % after installation Soil Modulus, psi* 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

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-24 and IIIC-B-25 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)

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 = 120 pcf

P_D =	1.67	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 gravel & cover @	120	pcf =	240	psf
3.5	ft final & intrm cover @	120	pcf =	420	psf
130	ft solid waste/soil @	75	pcf =	9,750	psf
			Σ =	10,410	psf

P_T =	72.3	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	72.3	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

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 =	72.3	psi

P_{DES1} =	96.4	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-24), 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-25), 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-25).

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

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \qquad (4)$$

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} = -0.68

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} =	96.4	psi
D =	18	in
E_s =	3,000	psi

S_m =	0.578	in

Step 3: Calculate dc using Equation (5):

$dc = S_m (1 - r_{sd})$

dc =	0.971	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-26, based on P_{DES1} above)
t =	1.059	in (SDR 17 pipe)
I =	0.099	in^4/in
r =	9.0	in
E' =	3,000	psi

W_c =	728	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:

5.5	ft soil @	120	pcf =	660	psf
130.0	ft waste/soil @	75	pcf =	9,750	psf
			Total =	10,410	psf

γ =	76.8	pcf (weighted average based on above table)
B_c =	18	in

C_c =	50.6	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	136	ft
H/B_c =	90.3	

Assume: H_e/B_c = 2.27

$k\mu$ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.45	
$-2k\mu$ =	-0.26	
$(H/B_c - H_e/B_c)$ =	88.1	
$e^{-2k\mu(He/Bc)}$ =	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.

$$\left[\frac{1}{2k\mu} \pm \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) \pm \frac{r_{sd}\,p}{3}\right] \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} \pm \frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$

$$\pm \frac{r_{sd}\,p}{3}\left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} - \frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right) \mp \left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right) = \pm r_{sd}\,p\left(\frac{H}{B_c}\right)$$

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 =	90.3
H_e/B_c =	2.265
r_{sd} =	-0.68
LHS =	61
RHS =	61

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 =	728	lb/in
D =	18.0	in

P_{DES2} =	40	psi

A summary table for the structural stability analysis is provided on page IIIC-B-38 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.

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

$P_{DES2} =$ 40 psi

$S_A =$	323.6	psi
FS =	4.6	

Compare calculated and suggested factor of safety:	4.6	> 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 =	23,500	psi for 50 years based on S_A above (see chart page IIIC-B-27)
$P_{DES2} =$	40	psi

$P_{cb} =$	146.0	psi
FS =	3.6	

Compare calculated and suggested factor of safety:	3.6	> 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} =	40	psi
E' =	3,000	psi

E_S =	1.3	%

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} = 1.3 %

Allowable ring deflection, RD_{all} = 4.20 %

$RD_{act} < RD_{all}$, design is acceptable

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0023-404-11-104
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
18"-DIA PIPE

Adjusted load to account for soil arching = 40 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	637.2	2.4	16,500	3,000	46.3	1.1	8.1	3,000	1.3	6.0
26.0	1,500	505.7	3.0	19,000	3,000	69.4	1.7	6.5	3,000	1.3	4.8
21.0	1,500	404.5	3.7	21,500	3,000	101.7	2.5	5.2	3,000	1.3	3.9
19.0	1,500	364.1	4.1	22,500	3,000	120.9	3.0	4.7	3,000	1.3	3.5
17.0 [1]	1,500	323.6	4.6	24,000	3,000	147.5	3.6	4.2	3,000	1.3	3.1
15.5	1,500	293.3	5.1	25,000	3,000	172.9	4.3	3.9	3,000	1.3	2.9
13.5	1,500	253.0	5.9	26,000	3,000	216.7	5.4	3.4	3,000	1.3	2.5
11.0	1,500	202.3	7.4	28,000	3,000	306.1	7.6	2.7	3,000	1.3	2.0

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-27), 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 COLLECTION PIPE STRUCTURAL STABILITY

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-24 and IIIC-B-25 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)

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 = 120 pcf

P_D =	1.67	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 @	120	pcf =	240	psf	
3.5	ft final & intrm cover @	120	pcf =	420	psf	
280.0	ft solid waste/soil @	79	pcf =	22,120	psf	Highest waste column thickness
			Σ =	22,780	psf	over a 6" LCS pipe.

P_T =	158.2	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	158.2	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

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 =	158.2	psi
P_{DES1} =	210.9	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-24), 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-25), 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-25).

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

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \qquad (4)$$

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} = -0.66

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} =	210.9	psi
D =	6.625	in
E_s =	3,000	psi

S_m =	0.466	in

Step 3: Calculate dc using Equation (5):

$dc = S_m (1 - r_{sd})$

dc =	0.772	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 =	27,000	psi (refer to chart 25 on page IIIC-B-26, based on P_{DES1} above)
t =	0.390	in (SDR 17 pipe)
I =	0.005	in^4/in
r =	3.3	in
E' =	3,000	psi

$\boxed{W_c = 577 \text{ lb/in}}$

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\ 2}}$$

Composite unit weight for waste and soil:

5.5	ft soil @	120	pcf =	660	psf
280.0	ft waste @	79	pcf =	22,120	psf
			Total =	22,780	psf

γ =	79.79	pcf (weighted average based on above table)
B_c =	6.625	in

$\boxed{C_c = 284.6 \text{ (unitless)}}$

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	280	ft
H/B_c =	507.2	

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	
$(H/B_c - H_e/B_c)$ =	504.9	
$e^{-2k\mu(He/Bc)}$ =	0.56	

Left-hand-side of equation (LHS) = 285
Right-hand-side of equation (RHS) = 285

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
kμ =	0.13
H/B_c =	507.2
H_e/B_c =	2.23
r_{sd} =	-0.66
LHS =	334
RHS =	334

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 =	577	lb/in
D =	6.6	in
P_{DES2} =	87	psi

A summary table for the structural stability analysis is provided on page IIIC-B-24 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} = 87 psi

S_A =	696.5	psi
FS =	2.2	

Compare calculated and suggested factor of safety:	2.2	> 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 =	18,000	psi for 50 years based on S_A above (see chart page IIIC-B-27)
P_{DES2} =	87	psi

P_{cb} =	127.7	psi
FS =	1.5	

Compare calculated and suggested factor of safety:	1.5	> 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} =	87	psi
E' =	3,000	psi

$\boxed{E_S = 2.9\ \%}$

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} = 2.9 %

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.

CITY OF ARLINGTON LANDFILL
0023-404-11-104
OVERLINER PIPE STRUCTURAL STABILITY
6" DIA PIPE

Adjusted load to account for soil arching = 87 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	1,371.3	1.1	13,000	3,000	41.1	0.5	8.1	3,000	2.9	2.8
26.0	1,500	1,088.3	1.4	13,000	3,000	57.4	0.7	6.5	3,000	2.9	2.2
21.0	1,500	870.7	1.7	15,000	3,000	84.9	1.0	5.2	3,000	2.9	1.8
19.0	1,500	783.6	1.9	16,500	3,000	103.5	1.2	4.7	3,000	2.9	1.6
17.0 [1]	1,500	696.5	2.2	18,000	3,000	127.7	1.5	4.2	3,000	2.9	1.4
15.5	1,500	631.2	2.4	19,000	3,000	150.8	1.7	3.9	3,000	2.9	1.3
13.5	1,500	544.6	2.8	21,000	3,000	194.8	2.2	3.4	3,000	2.9	1.2
11.0	1,500	435.3	3.4	23,000	3,000	277.4	3.2	2.7	3,000	2.9	0.9

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-27), 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).

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-57. 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, 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 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-57 Sump Drainage Areas.

Sector 6:
From the HELP model results in Appendix IIIC-A:

For the developed sectors, the largest area draining to the sump is 71.2 acres (sump located in Sector 6). For each fill condition, the highest leachate generation rate from the HELP runs for developed sectors was used to be conservative.

Condition	Average cfy/ac	Average gpd/ac
Active, 10' Waste	1,112.3	22.8
Interim, 50' Waste	5,187.1	106.3
Interim, 100' Waste	22,664.7	464.5
Interim, 200' Waste	23,512.7	481.8
Interim, 300' Waste	34,817.1	713.5
Interim, 310' Waste	36,618.4	750.4
Closed, 310' Waste	23,704.4	485.8

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

Sector 7:
From the HELP model results in Appendix IIIC-A:

For the undeveloped sectors, the largest area draining to a sump is 159.2 acres (sump located in Sector 7). For each fill condition, the highest leachate generation rate from the HELP runs for the undeveloped sectors and overliner area was used to be conservative.

Condition	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	1,112.3	22.8
Interim, 50' Waste	5,187.1	106.3
Interim, 100' Waste	22,664.7	464.5
Interim, 200' Waste	23,512.7	481.8
Interim, 300' Waste	34,817.1	713.5
Interim, 310' Waste	36,618.4	750.4
Closed, 310' Waste	23,704.4	485.8

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

Sectors 8 through 12:
From the HELP model results in Appendix IIIC-A:

For the undeveloped sectors, the largest area draining to a sump is 48.5 acres (sump located in Sector 8) .For each fill condition, the highest leachate generation rate from the HELP runs for the undeveloped sectors and overliner area was used to be conservative.

Condition	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	945.5	19.4
Interim, 50' Waste	6,096.4	124.9
Interim, 100' Waste	26,854.2	550.3
Interim, 200' Waste	23,488.4	481.4
Interim, 260' Waste	29,432.8	603.2
Closed, 260' Waste	17,566.0	360.0

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

1. Sump for Sector 6

71.2 acres

Condition	Rate (gpd/ac)	Active area (ac)	Active rate (gpd)	Inactive area (ac)	Inactive rate (gpd)	Closed area (ac)	Closed rate (gpd)
Active, 10' Waste	22.8	7.5	171.0	0.0	0.0	0.0	0.0
Interim, 50' Waste	106.3	8.7	924.8	0.0	0.0	0.0	0.0
Interim, 100' Waste	464.5	10.4	4,830.5	0.0	0.0	0.0	0.0
Interim, 200' Waste	481.8	12.5	6,023.1	0.0	0.0	0.0	0.0
Interim, 300' Waste	713.5	15.2	10,845.4	0.0	0.0	0.0	0.0
Interim, 310' Waste	750.4	9.4	7,054.0	71.2	53,430.4	0.0	0.0
Closed, 310' Waste	485.8	7.5	3,643.3	0.0	0.0	71.2	34,587.4
Total		71.2	33,492.1	71.2	53,430.4	71.2	34,587.4

2. Sump for Sector 7

159.2 acres

Condition	Rate (gpd/ac)	Active area (ac)	Active rate (gpd)	Inactive area (ac)	Inactive rate (gpd)	Closed area (ac)	Closed rate (gpd)
Active, 10' Waste	22.8	16.1	367.0	0.0	0.0	0.0	0.0
Interim, 50' Waste	106.3	18.1	1,924.0	0.0	0.0	0.0	0.0
Interim, 100' Waste	464.5	22.4	10,404.2	0.0	0.0	0.0	0.0
Interim, 200' Waste	481.8	25.5	12,287.1	0.0	0.0	0.0	0.0
Interim, 300' Waste	713.5	28.8	20,549.2	0.0	0.0	0.0	0.0
Interim, 310' Waste	750.4	32.2	24,163.7	159.2	119,467.9	0.0	0.0
Closed, 310' Waste	485.8	16.1	7,821.0	0.0	0.0	159.2	77,335.8
Total		159.2	77,516.2	159.2	119,467.9	159.2	77,335.8

2. Sump for Sector 8 through 12

48.5 acres

Condition	Rate (gpd/ac)	Active area (ac)	Active rate (gpd)	Inactive area (ac)	Inactive rate (gpd)	Closed area (ac)	Closed rate (gpd)
Active, 10' Waste	19.4	5.0	96.9	0.0	0.0	0.0	0.0
Interim, 50' Waste	124.9	6.7	837.1	0.0	0.0	0.0	0.0
Interim, 100' Waste	550.3	9.6	5,283.1	0.0	0.0	0.0	0.0
Interim, 200' Waste	481.4	10.3	4,957.9	0.0	0.0	0.0	0.0
Interim, 260' Waste	603.2	11.9	7,177.7	48.5	29,253.7	0.0	0.0
Closed, 260' Waste	360.0	5.0	1,799.9	0.0	0.0	48.5	17,459.1
Total		48.5	20,152.7	48.5	29,253.7	48.5	17,459.1

B. Required storage capacity of sump

Assumed porosity of drainage stone: P = 0.35

$V_{Daily\ Inflow} = V_C / P$

1. Active

	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Sector 6	33,492.1	4,477.6	12,793.0
Sector 7	77,516.2	10,363.1	29,608.9
Sectors 8 through 12	20,152.7	2,694.2	7,697.7

2. Inactive with Intermediate Cover

	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Sector 6	53,430.4	7,143.1	20,408.9
Sector 7	119,467.9	15,971.6	45,633.3
Sectors 8 through 12	29,253.7	3,910.9	11,174.1

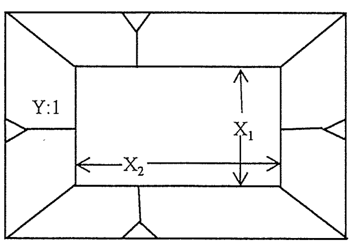
3. Closed

	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Sector 6	34,587.4	4,624.0	13,211.4
Sector 7	77,335.8	10,339.0	29,540.0
Sectors 8 through 12	17,459.1	2,334.1	6,668.9

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)
Sector 6	20	20	3	2	400	1,024	1,376
Sector 7	30	30	3	2	900	1,764	2,616
Sectors 8 through 12	15	15	3	2	225	729	906

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)
Sector 6	12,793.0	1,376	0.1
Sector 7	29,608.9	2,616	0.1
Sectors 8 through 12	7,697.7	906	0.1

2. Inactive with Intermediate Cover

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Sector 6	20,408.9	1,376	0.1
Sector 7	45,633.3	2,616	0.1
Sectors 8 through 12	11,174.1	906	0.1

3. Closed

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Sector 6	13,211.4	1,376	0.1
Sector 7	29,540.0	2,616	0.1
Sectors 8 through 12	6,668.9	906	0.1

C. Estimated rate of leachate removal.

Submersible pump capacity - Sector 6 = 60 gpm
Submersible pump capacity - Sector 7 = 100 gpm
Submersible pump capacity - Sectors 8 - 12 = 40 gpm

	Production (gpd)	Average Pump Time (min/day)	(hr/day)
Sector 6			
-Active	33,492.1	558.2	9.3
-Inactive with Interm. Cover	53,430.4	890.5	14.8
-Closed	34,587.4	576.5	9.6
Sector 7			
-Active	53,430.4	534.3	8.9
-Inactive with Interm. Cover	119,467.9	1194.7	19.9
-Closed	29,253.7	731.3	12.2
Sectors 8 through 12			
-Active	20,152.7	503.8	8.4
-Inactive with Interm. Cover	29,253.7	731.3	12.2
-Closed	17,459.1	436.5	7.3

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.

STATE OF TEXAS
RYNE J. SPICER
118934
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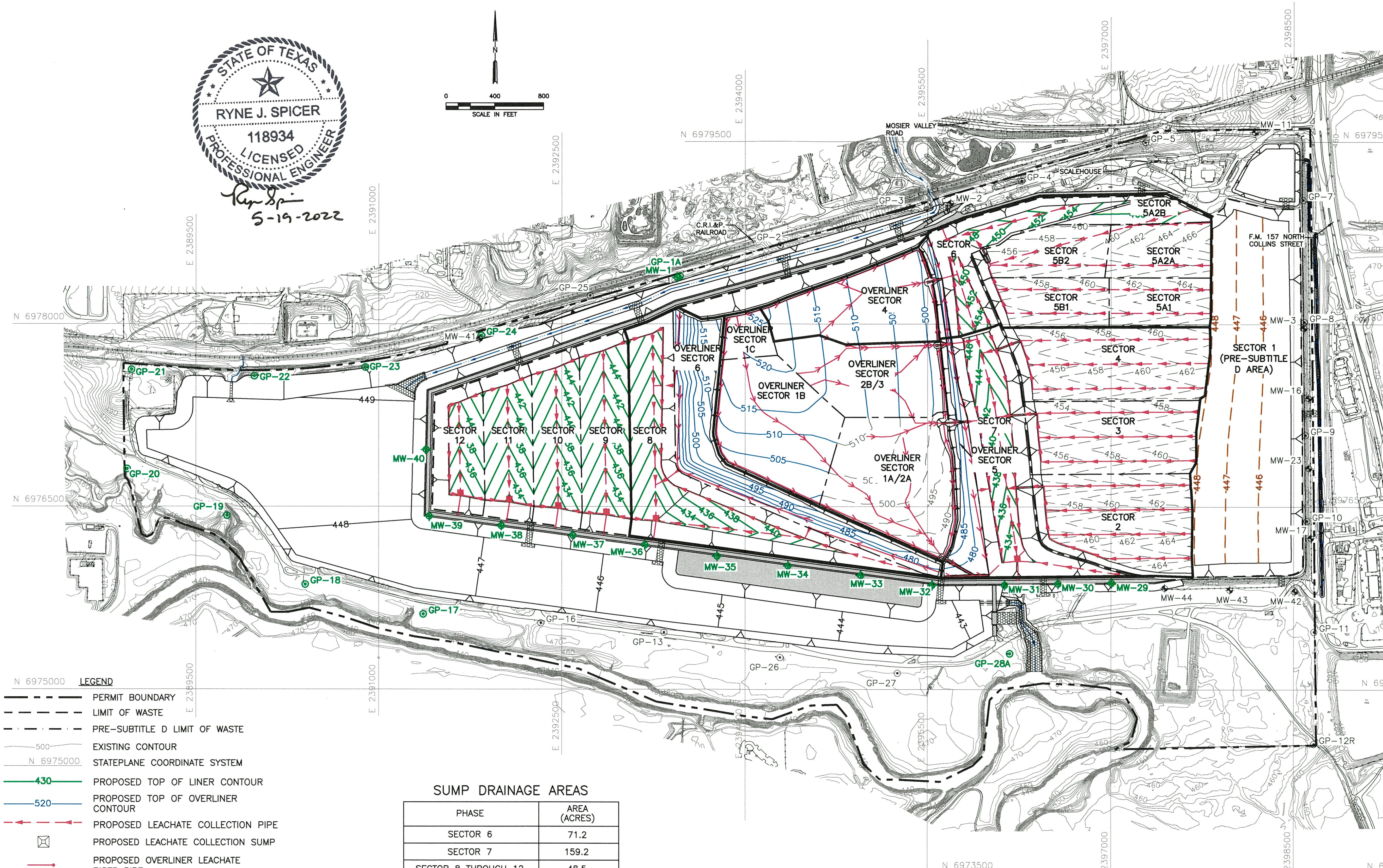
PROFESSIONAL ENGINEER
5-19-2022



LEGEND

	PERMIT BOUNDARY
	LIMIT OF WASTE
	PRE-SUBTITLE D LIMIT OF WASTE
500	EXISTING CONTOUR
N 6975000	STATEPLANE COORDINATE SYSTEM
430	PROPOSED TOP OF LINER CONTOUR
520	PROPOSED TOP OF OVERLINER CONTOUR
	PROPOSED LEACHATE COLLECTION PIPE
	PROPOSED LEACHATE COLLECTION SUMP
	PROPOSED OVERLINER LEACHATE RISER PIPE
	PROPOSED OVERLINER LEACHATE DRAINAGE PIPE
	PROPOSED OVERLINER LEACHATE DRAINAGE PIPE (MULTIPLE PIPES IN TRENCH)
MW-8	EXISTING GROUNDWATER MONITORING WELL
MW-40	PROPOSED GROUNDWATER MONITORING WELL
GP-2	EXISTING LANDFILL GAS MONITORING PROBE
GP-17	PROPOSED LANDFILL GAS MONITORING PROBE

SUMP DRAINAGE AREAS

PHASE	AREA (ACRES)
SECTOR 6	71.2
SECTOR 7	159.2
SECTOR 8 THROUGH 12	48.5

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 83.
2. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY LANDES & ASSOCIATES, INC. DATED MARCH 2011.
3. ELEVATION OF DEEPEST EXCAVATION AT THE LCS SUMP IS 424.5 FT-MSL.

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: B-58-SUMP DRAINAGE AREAS.DWG

DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
SUMP DRAINAGE AREAS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

SHEET IIIC-B-57

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: M288-17.

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 1.0×10^{-3} cm/s and the protective cover soil will consist of soils with a hydraulic conductivity less than 1.2×10^{-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-65, 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 (1.0×10^{-3} cm/s) and the protective cover (1.2×10^{-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.

$$k_{allow} = k_{ult} / ORF = (0.2 \text{ cm/s}) / 14.4$$

$$\boxed{k_{allow} = 1.4\text{E-}02 \text{ cm/s}}$$

$k_{allow} >> k_{waste}$ (1.0×10^{-3} cm/s) or $k_{protective\ cover}$ (1.2×10^{-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:

Geotextile properties should be selected considering Class 2 survivability (IIIC-B-64).

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	>	309	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 1.2×10^{-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-65, 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 (1.2×10^{-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.

$k_{allow} = k_{ult} / ORF = (0.2 \text{ cm/s}) / 14.4$

$\boxed{k_{allow} = 1.4E-02 \text{ cm/s}}$

$k_{allow} >> k_{protective\ cover}$ (1.2×10^{-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:

Geotextile properties should be selected considering Class 2 survivability (IIIC-B-64).

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	>	309	lbs
Trapezoid tear	>	56	lbs
Permeability	>=	0.2	cm/s

Table 1—Geotextile Strength Property Requirements

	Test Methods	Units	Geotextile Class[a,b]						
			Class 1A	Class 1		Class 2		Class 3	
			Elongation <50%	Elongation <50%[c]	Elongation ≥50%[c]	Elongation <50%[c]	Elongation ≥50%[c]	Elongation <50%[c]	Elongation ≥50%[c]
Grab strength	ASTM D4632/ D4632M	N	[e]	1400	900	1100	700	800	500
Sewn seam strength[d]	ASTM D4632/ D4632M	N	[e]	1260	810	990	630	720	450
Tear strength	ASTM D4533/ D4533M	N	[e]	500	350	400[f]	250	300	180
Puncture strength	ASTM D6241	N	[e]	2750	1925	2200	1375	1650	990
Permittivity	ASTM D4491	sec^{-1}	Refer to Table 6.	Minimum property values for permittivity, AOS, and UV stability are based on geotextile application. Refer to Table 2 for subsurface drainage; Table 3 and Table 4 for separation, Table 5 for stabilization, and Table 7 for permanent erosion control.					
Apparent opening size	ASTM D4751	mm	Refer to Table 6.						
Ultraviolet stability (retained strength)	ASTM D4355/ D4355M	%	Refer to Table 6.	T					

[a] Required geotextile class is designated in Table 2, 3, 4, 5, 6, or 7 for the indicated application. The severity of installation conditions for the application generally dictates the required geotextile class. Class 1A and Class 1 are specified for more severe or harsh installation conditions where there is a greater potential for geotextile damage, and Classes 2 and 3 are specified for less severe conditions.

[b] All numeric values represent MARV in the weaker principal direction. (See Section 8.1.2.)

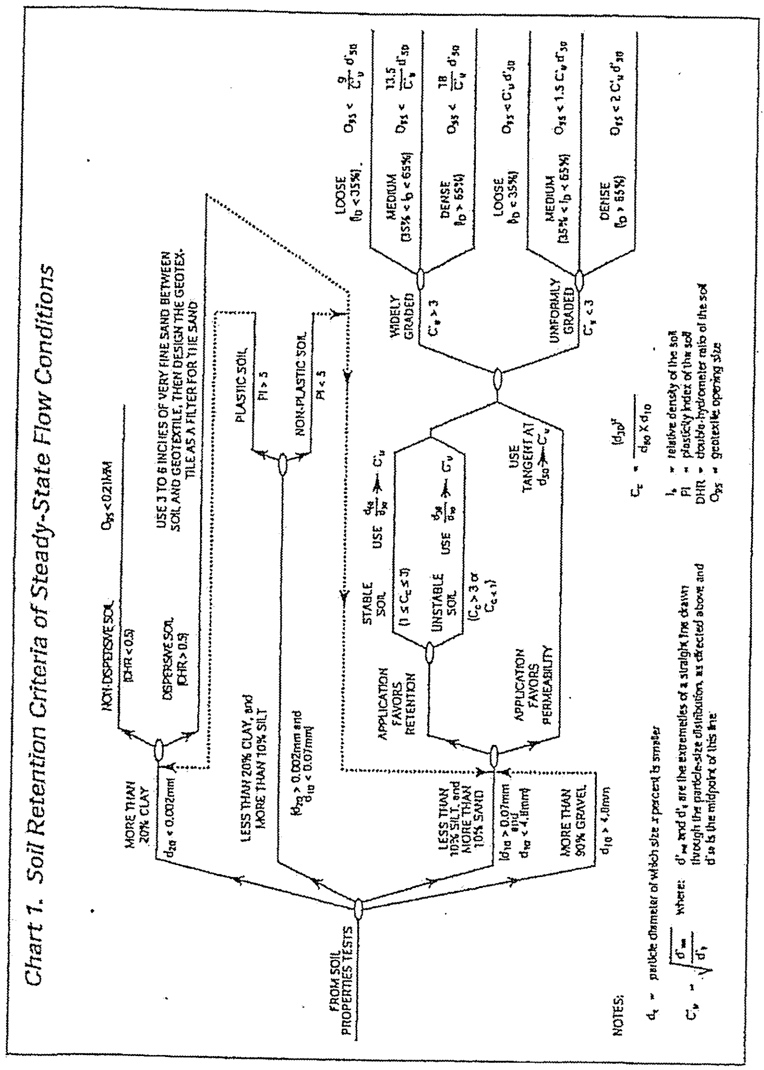
[c] As measured in accordance with ASTM D4632/D4632M.

[d] When sewn seams are required. Refer to Appendix X1 for overlap seam requirements.

[e] Property requirement not applicable to Class 1A. Refer to Table 6 for enhancement for wide width tensile property requirement.

[f] The required MARV tear strength for woven monofilament geotextiles is 250 N.

Chart 1. Soil Retention Criteria of Steady-State Flow Conditions



CHIMNEY DRAIN CALCULATIONS

CITY OF ARLINGTON LANDFILL
0023-404-11-104
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.
3. HELP results from Appendix IIIC, Appendix IIIC-A.

Solution:

1. **Determine the maximum leachate inflow rate into the chimney drain.**

A comparison of the developed and undeveloped areaS , was developed to determine the worst case scenario (i.e., which scenario generates the maximum leachate inflow rate).The peak daily generation rate is from HELP model analyses in Appendix IIIC, Appendix IIIC-A.

Sectors	**Peak Daily Generation Rate, q**		**Maximum Drainage Length, L**[1]	**Inflow Rate, Q_{req}**
	(cf/ac/day)	**(cfs/sf)**	**(ft)**	**(cfs)**
Developed Areas (Sectors 2 through 5)	187.8	4.99E-08	430	2.15E-05
Undeveloped Areas (Sectors 6 and 7)	206.1	5.48E-08	330	1.81E-05
Undeveloped Areas (Sectors 8 through 12)	176.8	4.70E-08	740	3.48E-05

[1] The maximum drainage length as shown takes in to account both sides draining to the chimney drain.

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} = 3.48E-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. 3 ft, as shown in Appendix IIIA-A, Drawing A.4

k =	0.2	cm/s	=	6.56E-03	fps	(Ref. 1)
i =	1					
w =	3	ft				

Q_{ult} = 1.97E-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} = 1.37E-03 cfs

Q_{allow} = 1.37E-03 cfs >> Q_{req} = 3.48E-05 cfs

The predicted flow does not exceed the capacity of the chimney drain geotextile. The chimney drain design is adequate to convey the generated leachate to the leachate collection pipe.

OVERLINER CHIMNEY DRAIN CALCULATIONS

Required: Evaluate the adequacy of the overliner chimney drain design 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.

Note: The maximum leachate impingement rate is from HELP model analyses for the overliner in Appendix IIIC-A.

Peak daily leachate generation rate, q = 166.0 cf/acre/day
= 4.41E-08 cfs/sf

Maximum leachate inflow rate to the chimney drain per unit length (1 ft):

$$Q_{req} = L * 1 * q$$

where:

Q_{req} = Maximum leachate inflow rate into chimney drain, cfs
L = Maximum length draining to chimney drain
= 800 ft
q = Peak daily leachate generation rate from HELP model listed above, cfs/sf

$\boxed{Q_{req} = 3.53E\text{-}05 \text{ cfs}}$

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.12.

k = 0.2 cm/s = 6.56E-03 fps (Ref. 1)
i = 1
w = 4 ft

$\boxed{Q_{ult} = 2.62E\text{-}02 \text{ cfs}}$

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} =	3.53E-05	cfs

The predicted flow does not exceed the capacity of the chimney drain geotextile. The chimney drain design is adequate to convey the generated leachate to the leachate collection pipe.

APPENDIX IIIC-C

CONTAINMENT BERM AND DIVERSION BERM CALCULATIONS

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIC-C-1 through IIIC-C-8

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. NOAA Atlas 14 - Precipitation-Frequency Atlas of the United States, Volume 11, Version 2.0: Texas (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, 2018)
2. Texas Department of Highways and Public Transportation, Bridge Division Hydraulic Manual, 3rd Ed, December 1985.
3. Dodson and Associates, Inc., *ProHec-1 Program Documentation*, 1993.

SOLUTION: **Containment Berm Calculations**

1. Based on Reference 1, the 25-year, 24-hour rainfall depth for Tarrant County is:

$R \approx$ 7.16 in

2. Determine the volume of storage required, V_R.

$V_R = CAR$

Where:

C =	Runoff coefficient	=	0.5	
A =	Drainage area	=	varies	ac
R =	25-year, 24-hour rainfall depth	=	7.16	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.

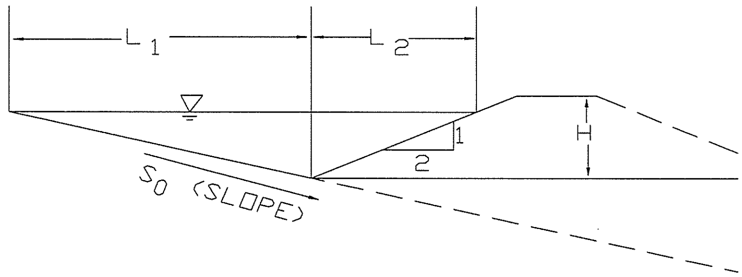
$V_C = A_s W$

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:

$$L_1 = \frac{H}{S_o} \text{ (ft)}$$

$L_2 =$ 2H (ft)

$S_o =$ Slope of active cell (ft/ft)

Example calculations:

1. Non-sloping water storage area:

Variables:	$S_o =$	0.00	%	R =	7.2	in
	$A_{stor} =$	0.25	ac	C =	0.5	
	A =	0.50	ac	W =	100	ft
Volume:	$V_R =$	6,498	cf			
Height:	H =	0.597	ft			

2. Sloping water storage area:

Variables:

S_o =	1.00	%	R =	7.2	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 Sheet IIIC-C-5 and page IIIC-C-8 for summary.

3. Sloping water storage area:

Variables:

S_o =	2.00	%	R =	7.2	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 = 1.7 ft

Check to ensure that the above berm height is adequate:

L_1 =	85.00	ft
L_2 =	3.40	ft
A_s =	75.14	sf
V_C =	7,514	cf

V_C is larger than V_R; berm has adequate height. See Sheet IIIC-C-5 and page IIIC-C-8 for summary.

Prep By: BPY
Date: 5/19/2022

CITY OF ARLINGTON LANDFILL
0023-404-11-104
CONTAINMENT BERM
CALCULATIONS SUMMARY

Chkd By: NT
Date: 5/19/2022

Drainage Area	Storage Area	Volume Required	Slope	Berm Height	Required Berm Height	Cross Sectional Area	Width	Water Surface Area	Volume Provided	L_1[1]	L_2[1]
(ac)	(ac)	(cf)	(%)	(ft)	(ft)	(sf)	(ft)	(ac)	(cf)	(ft)	(ft)
0.5	0.25	6,498	0	0.60	1.60						
			1	1.18	2.18	71.01	100	0.276	7,101	118.0	2.4
			2	1.64	2.64	69.93	100	0.196	6,993	82.0	3.3
1.0	0.50	12,995	0	0.60	1.60						
			1	1.66	2.66	140.54	100	0.389	14,054	166.0	3.3
			2	2.32	3.32	139.94	100	0.277	13,994	116.0	4.6
2.0	1.00	25,991	0	0.60	1.60						
			1	2.35	3.35	281.65	100	0.550	28,165	235.0	4.7
			2	3.28	4.28	279.72	100	0.392	27,972	164.0	6.6
4.0	2.00	51,982	0	0.60	1.60						
			1	3.32	4.32	562.14	100	0.777	56,214	332.0	6.6
			2	4.64	5.64	559.77	100	0.554	55,977	232.0	9.3

[1] L_1 and L_2 are shown on Sheet 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 page IIIC-C-8.

The swales were analyzed by the Rational Method.

From Reference 2 for Tarant County:

$Q = C\,I\,A$

C = 0.5 (intermediate cover)
I = 7.72 intensity, in/hr (see calculation below)
A = varies drainage area, ac

$$I = \frac{b}{(t_c + d)^e}$$

b = 79.1811
d = 10.4421
e = 0.7715

t_c is assumed to be 10 min. for all cases

I = 7.72 in/hr

Diversion Berm Flow Rate Summary

Area(ac)	Flow Rate (cfs)
0.5	1.9
1	3.9
1.5	5.8
2	7.7
2.5	9.6
3	11.6

Prep By: BPY
Date: 5/19/2022

CITY OF ARLINGTON LANDFILL
0023-404-11-104
DIVERSION BERM
CALCULATION SUMMARY

Chkd By: NT
Date: 5/19/2022

For 33H:1V Diversion Berm Area Slope

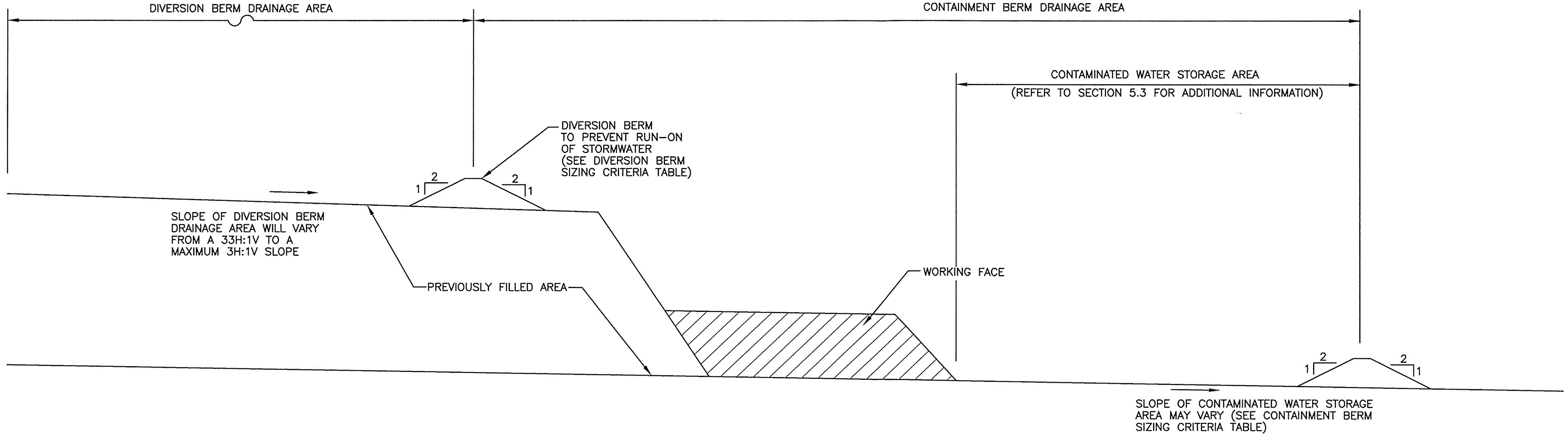
Drainage Area	Flow Rate (cfs)	Bottom Slope(ft/ft)	Manning's n	Side Slope (left)	Side Slope (right)	Bottom Width(ft)	Normal Depth(ft)	Flow Vel. (fps)	Froude Number	Velocity Head(ft)	Energy Head(ft)	Flow Area (sf)	Flow Top Width(ft)
0.5	1.9	0.01	0.03	2	33.0	0	0.28	1.35	0.632	0.03	0.31	1.41	9.92
1	3.9	0.01	0.03	2	33.0	0	0.37	1.61	0.660	0.04	0.41	2.42	13.00
1.5	5.8	0.01	0.03	2	33.0	0	0.43	1.78	0.676	0.05	0.48	3.26	15.10
2	7.7	0.01	0.03	2	33.0	0	0.48	1.91	0.688	0.06	0.54	4.03	16.79
2.5	9.6	0.01	0.03	2	33.0	0	0.52	2.02	0.697	0.06	0.58	4.75	18.24
3	11.6	0.01	0.03	2	33.0	0	0.56	2.12	0.705	0.07	0.63	5.48	19.59

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	1.9	0.01	0.03	2	3	0	0.60	2.11	0.681	0.07	0.67	0.90	3.00
1	3.9	0.01	0.03	2	3	0	0.79	2.53	0.711	0.10	0.88	1.54	2.93
1.5	5.8	0.01	0.03	2	3	0	0.91	2.78	0.727	0.12	1.03	2.08	4.56
2	7.7	0.01	0.03	2	3	0	1.01	3.00	0.743	0.14	1.15	2.57	5.07
2.5	9.6	0.01	0.03	2	3	0	1.10	3.17	0.752	0.16	1.26	3.03	5.51
3	11.6	0.01	0.03	2	3	0	1.18	3.31	0.759	0.17	1.35	3.50	5.92

Note: Calculations were performed using the HYDROCALC Hydraulics for Windows developed by Dodson and Associates (Version 1.2a, 1996).



DIVERSION BERM SIZING CRITERIA *

DIVERSION BERM DRAINAGE AREA (ACRES)	MINIMUM 3% FLOW RATE (CFS)	MINIMUM 3% FLOW DEPTH (FT)	MINIMUM 3% REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)	MAXIMUM 33% FLOW RATE (CFS)	MAXIMUM 33% FLOW DEPTH (FT)	MAXIMUM 33% REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)
0.5	1.9	0.28	1.28	1.9	0.60	1.60
1	3.9	0.37	0.37	3.9	0.79	1.79
1.5	5.8	0.43	1.43	5.8	0.91	1.91
2	7.7	0.48	1.48	7.7	1.01	1.01
2.5	9.6	0.52	1.52	9.6	1.10	2.10
3	11.6	0.56	1.56	11.6	1.18	2.18

* 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.

CONTAINMENT BERM SIZING CRITERIA *

CONTAINMENT BERM DRAINAGE AREA (ACRES)	CONTAMINATED WATER STORAGE AREA (ACRES)	FLOOR SLOPE OF CONTAMINATED WATER STORAGE AREA	CALCULATED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)	REQUIRED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)
0.5	0.25	0 % 1 % 2 %	0.60 1.18 1.64	1.60 2.18 2.64
1.0	0.50	0 % 1 % 2 %	0.60 1.66 2.32	1.60 2.66 3.32
2.0	1.00	0 % 1 % 2 %	0.60 2.35 3.28	1.60 3.35 4.28
4.0	2.00	0 % 1 % 2 %	0.60 3.32 4.64	1.60 4.32 5.64

* 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.

STATE OF TEXAS
RYNE J. SPICER
118934
LICENSED
PROFESSIONAL ENGINEER
5-19-2022

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☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: IIIC-C-8 DMR BERM.DWG
DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE AND CONTAMINATED WATER PLAN

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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SHEET IIIC-C-8

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APPENDIX IIIC-D

STORAGE TANK AND FORCEMAIN CAPACITY CALCULATIONS

STATE OF TEXAS
RYNE J. SPICER
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PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIC-D-1 through IIIC-D-16

Required: Determine the required leachate storage capacity for the site using HELP model results.

Method:
1. Determine the leachate volume using predicted leachate generation values from the HELP model.
2. Design the secondary containment area for the leachate storage tank.

Note: The site will have leachate storage tank(s) with a minimum storage capacity of 200,000 gallons. The following demonstration shows that a minimum of 200,000 gallons of leachate is sufficient to meet the leachate production needs of the site.

Solution: 1. **Determine the leachate volume using predicted leachate generation values from the HELP model.**

Results from the HELP model in Appendix IIIC-A.

Developed Areas:

Condition	Average[1] cfy/ac	Average gpd/ac
Interim, 50' Waste	6,014.9	123.3
Interim, 100' Waste	26,856.3	550.4
Interim, 200' Waste	23,415.4	479.9
Interim, 290' Waste	33,372.2	683.9
Closed, 290' Waste	21,669.3	444.1

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

Undeveloped Areas:

Condition	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	1,112.3	22.8
Interim, 50' Waste	5,187.1	106.3
Interim, 100' Waste	22,664.7	464.5
Interim, 200' Waste	23,512.7	481.8
Interim, 300' Waste	34,817.1	713.5
Interim, 310' Waste	36,618.4	750.4
Closed, 310' Waste	23,704.4	485.8

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.
[2]For each fill condition the highest leachate generation rate from all the undeveloped area HELP runs was used to be conservative.

Overliner Area:

Condition	Average cfy/ac	Average gpd/ac
Active, 10' Waste	1,290.4	26.4
Interim, 50' Waste	6,700.9	137.3
Interim, 100' Waste	25,605.0	524.7
Interim, 200' Waste	23,121.4	473.8
Interim, 280' Waste	31,761.4	650.9
Closed, 280' Waste	20,756.7	425.4

Assume the following fill scenarios:

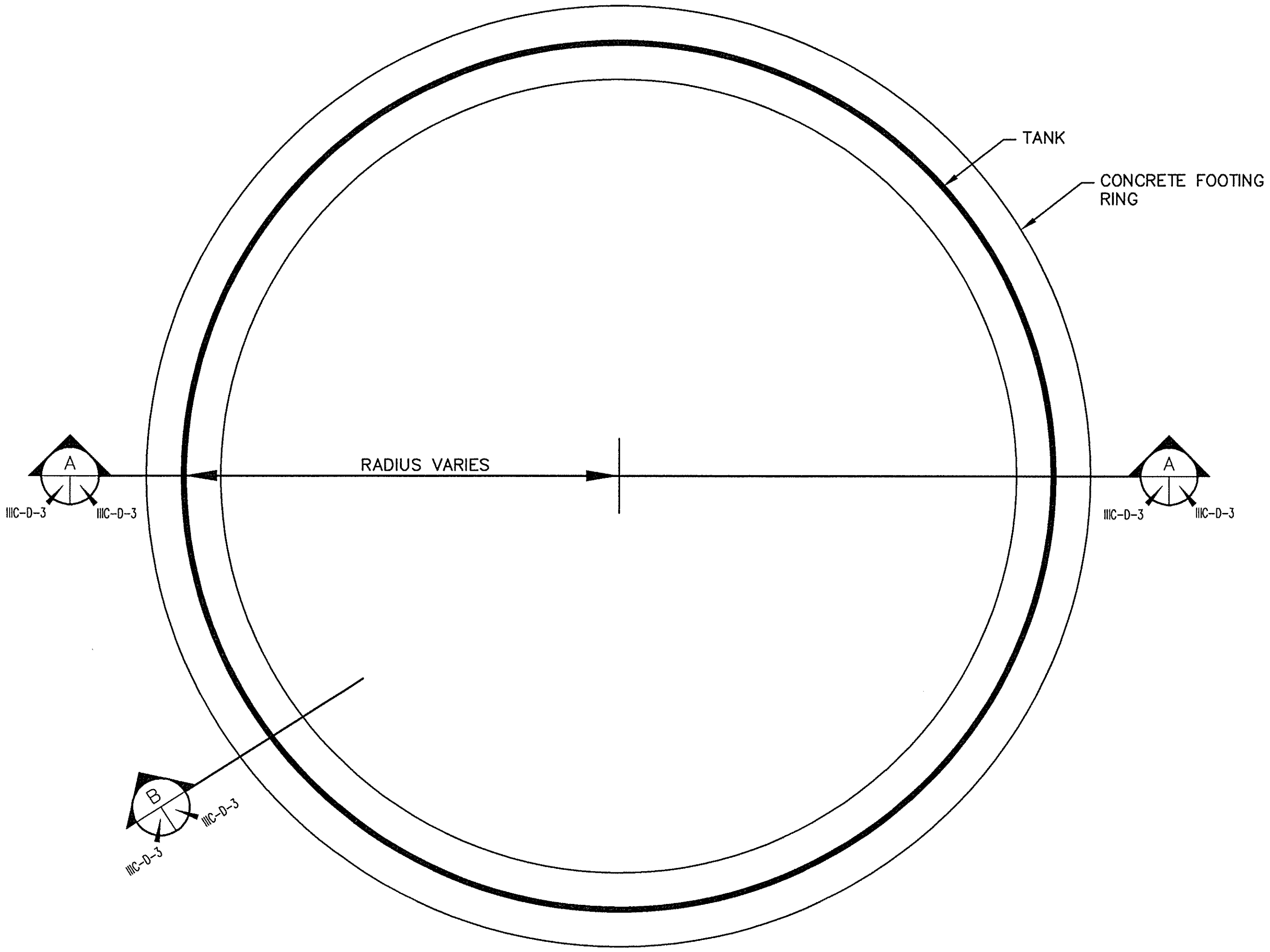
	Storage Tanks					
Condition	Developed Areas Sectors 2 through 5 (98.1 acres)		Undeveloped Areas Sectors 6 through 12 (148.7 acres)		Overliner Area (87.7 acres)	
	(ac)	(gpd)	(ac)	(gpd)	(ac)	(gpd)
Active, 10' Waste			17.5	399	11.3	299
Interim, 50 Waste	16.9	2,083	20.4	2,169	14.5	1,991
Interim, 100' Waste	19.8	10,897	21.5	9,986	15.8	8,291
Interim, 200' Waste	23.2	11,133	24.3	11,709	16.9	8,008
Interim, 280' Waste					19.2	12,497
Interim, 290' Waste	26.2	17,918				
Interim, 300' Waste			28.7	20,478		
Interim, 310' Waste			21.3	15,984		
Closed	12.0	5,329	15.0	7,287	10.0	4,254
Total:	98.1	47,360	148.7	68,011	87.7	35,339
Total:					150,710	gpd

Leachate Storage Tank Management Plan

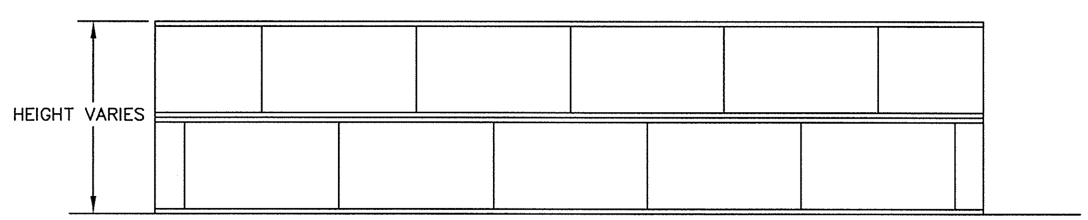
Total Size	Leachate Generation, gallons per day	Management Plan
200,000 gallons (minimum)	150,710	Over 40,000 gallons of the storage tank(s) will remain empty and available to store leachate during emergency situations.

2. **Design the secondary containment area for the leachate storage tank.**

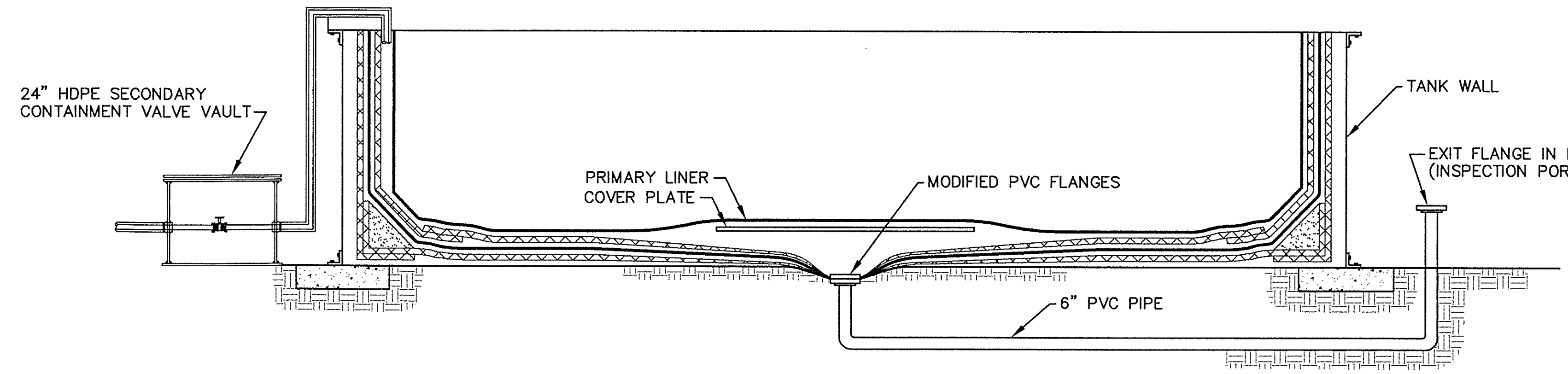
The storage tank(s) location are shown on Figure 4-1 in Appendix IIIC. The storage tank(s) is a double-walled steel tank that contains an inner tank ("storage vessel") consisting of a geomembrane liner. The secondary geomembrane liner, attached to the inner surface of the steel tank, collects any leachate that may infiltrate through the primary geomembrane liner.



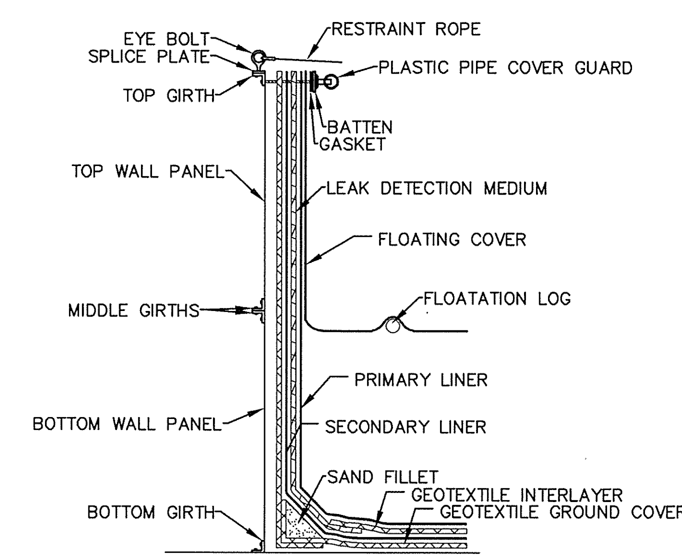
MODULAR TANK
PLAN
NTS



MODULAR TANK
ELEVATION
NTS



A TYPICAL SECTION AT LEAK DETECTION SUMP
NTS
IIIC-D-3 IIIC-D-3



B TYPICAL SECTION
NTS
IIIC-D-3 IIIC-D-3

STATE OF TEXAS
RYNE J. SPICER
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PROFESSIONAL ENGINEER
5-19-2022

NOTE:

1. THE 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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☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: D-4-LEACHATE STORAGE TANK.DWG

DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE STORAGE TANK DETAILS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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SHEET IIIC-D-4

O:\0023\404\EXPANSION 2021\PART III\IIIC\D\D-4 TANK DETAILS.dwg, rarrington, 1:2

REQUIRED: Size the leachate forcemain collection pipe.

METHOD:

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 pipe.

C. Calculate the maximum pressure experienced by the forcemain pipe.

D. Evaluate the flow velocity in the forcemain pipe.

E. Conclusion.

REFERENCES:

1. Driscopipe Systems Design, Phillips 66. 1992 Phillips Driscopipe, Inc. 1235-91 A 01

SOLUTION:

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 FLOW		TOTAL FLOW	FLOW
	ac	cfy[2]	gpd/ac	gpd	cfs
10' to 50' Waste	28	1,290	26	740	0.0011
50' to 100' Waste	35	6,701	137	4,806	0.0074
100' to 200' Waste	39	26,856	550	21,464	0.0332
200' to 300' Waste	47	23,513	482	22,647	0.0350
300' to 310' Waste	25	34,817	714	17,838	0.0276
Total =	174				0.1044

[1]Total limits of the Subtitle D and overliner area (approximately 174 acres) directed to the North Forcemain 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-25 and IIIC-A-28. The highest values for a given waste thickness have been used for demonstration purposes.

Total maximum leachate production = Q =	0.1044	cubic feet per second (cfs)
Q =	47	gallons per minute (gpm)
Q =	67,496	gallons per day (gpd)

Required capacity of leachate forcemain pipe =	67,496	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-11
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}:

ΔP_{100}= (P - Δh) / (L/100)

where:

P = Pipe strength, psi
Δh = Geometric head difference, psi
L = Pipe length, ft

P = 160 psi (refer to page IIIC-D-10 for SDR11 pipe)

Calculate Δh:

Elevation at the low point of forcemain =	483	ft-msl
Elevation at the high point of forcemain =	483	ft-msl
Δh =	0	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)

Δh = 0.00 psi

Pipe Strength Available for Friction Loss = P - Δh

Pipe Strength for Friction Loss = 160.00 psi

L= 7,499 ft

(Note: Forcemain length is assumed to be the total length of the forcemain serving the North Forcemain (refer to Figure 4-1 in Appendix IIIC for location). This is a conservative assumption given that it is assumed that the design pipe flow travels the maximum distance for estimating the total head loss.)

ΔP_{100} = (160 - 15.60)/(3,782/100)

ΔP_{100} = 2.13 psi

Calculate maximum capacity of the 3-inch pipe by using Equation 2 above:

C = 155 (refer to page IIIC-D-11)
D = 2.864 inches, internal diameter of forcemain (refer to page IIIC-D-10)

$Q = [(\Delta P_{100} C^{1.85} D^{4.86})/452]^{(1/1.85)}$

$Q = [(3.82*155^{1.85}*2.864^{4.86})/452]^{(1/1.85)}$

Q = 136 gpm

$\boxed{Q = 195{,}824 \text{ gpd}}$

The above calculated value reflects the maximum capacity of the pipe, which is greater than the required capacity (i.e., 195,824 gpd > 67,496 gpd).

C. Calculate the maximum pressure experienced by the forcemain pipe.

Calculate head loss in the 2-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 =	47	gpm (from Step A)
C =	155	From Chart 4 on Page IIIC-D-11
D =	2.864	inches, diameter of discharge pipe contained in a 6-inch diameter containment pipe

ΔP_{100} = 0.30 psi

Total head loss ($\Sigma\Delta P$) = ΔP_{100} * (L/100) = 0.30 psi x (7499/100)

$\Sigma\Delta P$= 22.30 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.= 26.76 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} = 26.76 psi + 0.00 psi

P=	26.76	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 =	47	gpm (from Step A)
D =	2.864	inches

V=	2.33	fps

E. Conclusion.

The pipe capacity (136 gpm) is not exceeded by the expected flow of 47 gpm.

The forcemain can withstand 160 psi, and the maximum pressure calculated as 26.76 psi; therefore, the pipe strength is acceptable.

The calculated velocity of the 3-inch forcemain for 47 gpm of flow is well within acceptable flow velocity range.

Throughout the life of the site, the flow rate in the forcemain will range from 0 to 47 gpm. Excessive sediment accumulation in the forcemain will be prevented by the system operation. For example, the pump will operate on a periodic basis. When the pump activates, flow in the forcemain will surge and the velocity will increase periodically which will transport sediment to the discharge point. This variation in Q will functionally minimize the sediment build-up potential in the pipe.

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

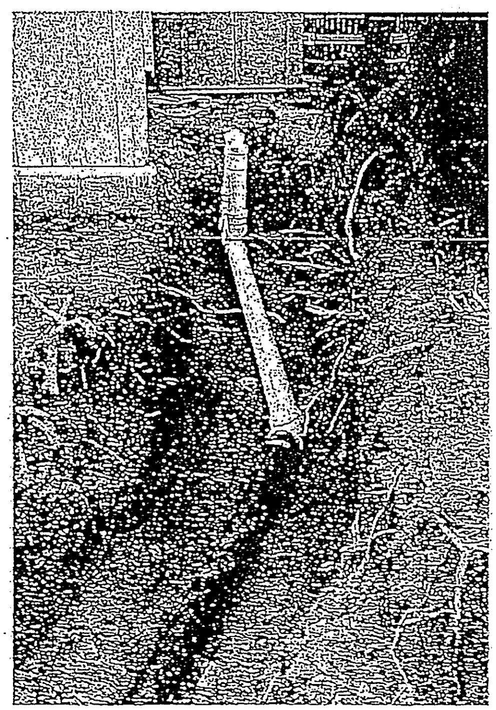
Fitting Pressure Drop: Listed below in Chart 5 are various common piping system components and the associated pressure loss through the fitting expressed as an equivalent length of straight pipe in terms of diameters. The inside diameter (in feet) multiplied by the equivalent length diameters gives the 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).



REQUIRED: Size the leachate forcemain collection pipe.

METHOD:

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 pipe.

C. Calculate the maximum pressure experienced by the forcemain pipe.

D. Evaluate the flow velocity in the forcemain pipe.

E. Conclusion.

REFERENCES:

1. Driscopipe Systems Design, Phillips 66. 1992 Phillips Driscopipe, Inc. 1235-91 A 01

SOLUTION:

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 FLOW		TOTAL FLOW	FLOW
	ac	cfy[2]	gpd/ac	gpd	cfs
10' to 50' Waste	25	1,290	26	661	0.0010
50' to 100' Waste	32	6,701	137	4,394	0.0068
100' to 200' Waste	36	26,856	550	19,813	0.0307
200' to 300' Waste	44	23,513	482	21,201	0.0328
300' to 310' Waste	22	34,817	714	15,697	0.0243
Total =	159				0.0956

[1]Total limits of the Subtitle D and overliner area (approximately 159 acres) directed to the North Forcemain 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-25 and IIIC-A-28. The highest values for a given waste thickness have been used for demonstration purposes.

Total maximum leachate production = Q =	0.0956	cubic feet per second (cfs)
Q =	43	gallons per minute (gpm)
Q =	61,767	gallons per day (gpd)

Required capacity of leachate forcemain pipe =	61,767	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-11
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 = 160 psi (refer to page IIIC-D-10 for SDR11 pipe)

Calculate Δh:

Elevation at the low point of forcemain =	483	ft-msl
Elevation at the high point of forcemain =	483	ft-msl
Δh =	0	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 = 0.00 psi

Pipe Strength Available for Friction Loss = P - Δh

Pipe Strength for Friction Loss = 160.00 psi

L= 2,760 ft

(Note: Forcemain length is assumed to be the total length of the forcemain serving the South Forcemain (refer to Figure 4-1 in Appendix IIIC for location). This is a conservative assumption given that it is assumed that the design pipe flow travels the maximum distance for estimating the total head loss.)

$$\Delta P_{100} = (160 - 15.60)/(3{,}782/100)$$

ΔP_{100} = 5.80 psi

Calculate maximum capacity of the -inch pipe by using Equation 2 above:

C = 155 (refer to page IIIC-D-11)
D = 2.864 inches, internal diameter of forcemain (refer to page IIIC-D-10)

$$Q = [(\Delta P_{100} C^{1.85} D^{4.86})/452]^{(1/1.85)}$$

$$Q = [(3.82*155^{1.85}*2.864^{4.86})/452]^{(1/1.85)}$$

Q =	233	gpm
Q =	336,133	gpd

The above calculated value reflects the maximum capacity of the pipe, which is greater than the required capacity (i.e., 336,133 gpd > 61,767 gpd).

C. Calculate the maximum pressure experienced by the forcemain pipe.

Calculate head loss in the 2-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 =	43	gpm (from Step A)
C =	155	From Chart 4 on Page IIIC-D-11
D =	2.864	inches, diameter of discharge pipe contained in a 6-inch diameter containment pipe

$\Delta P_{100} =$ 0.25 psi

Total head loss ($\Sigma\Delta P$) = ΔP_{100} * (L/100) = 0.25 psi x (2760/100)

$\Sigma\Delta P =$ 6.97 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.= 8.36 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} = 8.36 psi +0 psi

$\boxed{P = 8.36 \text{ psi}}$

D. Evaluate the flow velocity in the forcemain pipe.

$$V = 0.408 * (Q/D^2) \qquad \text{(Ref. 1)}$$

where:

Q = Rate of flow, gpm
D = Pipe internal diameter, inches

Q =	43	gpm (from Step A)
D =	2.864	inches

V=	2.13	fps

E. Conclusion.

The pipe capacity (223 gpm) is not exceeded by the expected flow of 43 gpm.

The forcemain can withstand 160 psi, and the maximum pressure calculated as 8.36 psi; therefore, the pipe strength is acceptable.

The calculated velocity of the 3-inch forcemain for 43 gpm of flow is well within acceptable flow velocity range.

Throughout the life of the site, the flow rate in the forcemain will range from 0 to 43 gpm. Excessive sediment accumulation in the forcemain will be prevented by the system operation. For example, the pump will operate on a periodic basis. When the pump activates, flow in the forcemain will surge and the velocity will increase periodically which will transport sediment to the discharge point. This variation in Q will functionally minimize the sediment build-up potential in the pipe.

APPENDIX IIIC-E

SITE LEACHATE GENERATION INFORMATION

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LICENSED
PROFESSIONAL ENGINEER

5-19-2022

Includes pages IIIC-E-1 through IIIC-E-15

CONTENTS

This appendix includes the following leachate generation information.

- Sheet IIIC-E-2. Summary table listing the leachate generation information for 2015 to 2018 for the City of Arlington 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-8. 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-9 through IIIC-E-11. Leachate depth on liner calculations for the actual leachate generation rates.
- Sheets IIIC-E-12 through IIIC-E-15. HELP summary sheets for the postclosure cases.

This information is summarized in Section 6 of the Appendix IIIC.

Purpose: Summarize the leachate information for the City of Arlington Landfill. The leachate generation information was provide by Republic site personnel.

Leachate Generation Summary

Year	Annual Rainfall[1] (in)	Lined Area (acres)	Leachate Generated (gal/year)	Leachate Generated (gal/ac/year)
2016	35.4	80.0	1,415,744	17,697
2017	32.1	88.7	1,783,975	20,112
2018	37.4	88.7	2,029,477	22,880
2019	30.2	98.0	2,533,947	25,857
2020	38.0	98.0	2,801,221	28,584
Average	34.6	NA	2,112,873	23,026

[1] The rainfall data NOAA from the Arlington Municipal Airport.

CITY OF ARLINGTON LANDFILL
0023-404-11-104
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 generatioı information from City of Arlington 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 Arington Landfill obtained from Republic site personnel.

Procedure:

1. Determine the approximate sector development sequence.

2. Estimate the leachate generation volume of each stage of development.

Solution:

1. **Determine the approximate sector development sequence.**

   The approximate sector development sequence is shown on Table IIIC-E-2. Leachate generation volumes will be compared for the following years.

   2022
   2030
   2040
   2050
   2054
   2054 through 2063 - First 10 years of postclosure period
   2064 through 2074 - Second 10 years of postclosure period
   2075 through 2084 - Third 10 years of postclosure period

   Note that the sequence of development used for this analysis is conservative because it assumes that final cover will not be installed until the near the end of the site's life. As shown in Parts I/II , Appendix I/IIA, final cover will be installed as the site develops which will decrease the amount of leachate generated.

2. **Estimate the leachate generation volume of each stage of development.**

   This information is provided on Sheet IIIC-E-4.

TABLE IIIC-E-1
LEACHATE GENERATION VOLUME OVER THE LIFE OF THE SITE USING ACTUAL LEACHATE GENERATION INFORMATION

Year	Sectors Developed	Lined Area (acres)	Leachate Generation Rate (gallons/acre)	Total Leachate Generated (gallons)	Source of Information
2022	Sector 2 through 5 and Overliner sectors O1 and O2.	142.6	23,026	3,283,277	Leachate generation information from Arlington Landfill (average of 2016 to 2020) was used on a per acre basis to estimate the leachate generation rate.
2030	Sector 2 through 5 and Overliner sectors O1 through O5.	185.0	23,026	4,259,809	
2040	Sector 2 through 5, Overliner sectors O1 through O6, and Sectors 6 and 7.	235.4	23,026	5,421,241	
2050	Sector 2 through 5, Overliner sectors O1 through O7, and Sectors 6 through 12.	333.4	23,026	7,677,558	
2054	Sector 2 through 5, Overliner sectors O1 through O7, and Sectors 6 through 12.	333.4	23,026	7,677,558	
SITE CLOSURE IN 2054					
2054 through 2063	All Sectors	333.4	2,303	767,756	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 decrease to 10% for the first 10 years for the Subtitle D Sectors, and for the second and third 10 years, the leachate generation was assumed to decrease 2% for these sectors.
2064 through 2073	All Sectors	333.4	461	153,551	
2074 through 2083	All Sectors	333.4	461	153,551	

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 analysis included in Appendices IIIC-A and IIIC-E.

Procedure:

1. The sector development sequence established on Sheet IIIC-E-4 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-2. The HELP model summary information is provided on Table IIIC-E-3.

TABLE IIIC-E-2
LEACHATE GENERATION VALUE DURING THE LIFE OF THE SITE
USING HELP MODEL

Year	Sector Development	Lined Area (acres)	Total Leachate Generated Average (gal/year)	Total Leachate Generated Peak (gal/year)	Source of Information
2022	Sector 2 through 5 and Overliner sectors O1 and O2.	142.6	19,405,761	42,861,959	Sectors 2-5 assume a 200-foot waste column thickness; and Overliner Sectors O1 and O2 assumes a 50-foot waste column thickness to determine the average and peak leachate generation rate.
2030	Sector 2 through 5 and Overliner sectors O1 through O5.	185.0	33,828,824	71,461,596	Sectors 2-5 assume a 200-foot waste column thickness; and Overliner Sectors O1 through O5 assumes a 100-foot waste column thickness to determine the average and peak leachate generation rate.
2040	Sector 2 through 5, Overliner sectors O1 through O6, and Sectors 6 and 7.	235.4	40,792,329	74,162,990	Sectors 2-5 assume a 200-foot waste column thickness; and Overliner Sectors O1 through O6 assumes a 200-foot waste column thickness; Sectors 6 and 7 assumes a 100-foot waste column thickness to determine the average and peak leachate generation rate.
2050	Sector 2 through 5, Overliner sectors O1 through O7, and Sectors 6 through 12.	333.4	65,525,689	123,588,595	Sectors 2-5 assume a 290-foot waste column thickness; and Overliner Sectors O1 through O7 assumes a 200-foot waste column thickness; Sectors 6 and 7 assumes a 200-foot waste column thickness; Sectors 8 through 12 assumes a 200-foot waste column thickness to determine the average and peak leachate generation rate.
2054	Sector 2 through 5, Overliner sectors O1 through O7, and Sectors 6 through 12.	333.4	80,590,095	154,426,882	Sectors 2-5 assume a 290-foot waste column thickness; and Overliner Sectors O1 through O7 assumes a 280-foot waste column thickness; Sectors 6 and 7 assumes a 310-foot waste column thickness; Sectors 8 through 12 assumes a 260-foot waste column thickness to determine the average and peak leachate generation rate.
SITE CLOSURE IN 2085					
2054 through 2063	All Sectors	333.4	26,549,379	39,742,544	All sectors assumed a closed case to determine the average and peak leachate generation rates. The final moisture contents of the waste layers calculated in the closed HELP runs were input as the initial moisture contents in the HELP run for years 2054 to 2063.
2064 through 2073	All Sectors	333.4	23,605,905	34,582,971	All sectors assumed a closed case to determine the average and peak leachate generation rates. The final moisture contents of the waste layers calculated in the HELP runs for years 2054-2063 were input as the initial moisture contents in the HELP run for years 2064 to 2073.
2074 through 2083	All Sectors	333.4	27,217,178	29,076,264	All sectors assumed a closed case to determine the average and peak leachate generation rates. The final moisture contents of the waste layers calculated in the HELP runs for years 2064-2073 were input as the initial moisture contents in the HELP run for years 2074 to 2083.

Table IIIC-E-3[1]
Summary of Leachate Generation Rates

Developed Area (Sector 2 through 5)				
	Average (cf/year/acre)	**Average (gal/year/acre)**	**Peak (cf/day/acre)**	**Peak (gal/day/acre)**
Interim 50 ft	6,014.9	44,994.6	74.4	556.2
Interim 100 ft	26,856.3	200,898.9	178.9	1,338.3
Interim 200 ft	23,415.4	175,159.5	119.7	895.7
Interim 290 ft	33,372.2	249,641.7	187.8	1,405.1
Closed	21,669.3	162,097.6	187.7	1,404.4
Postclosure (First 10 Years)	10,905.7	81,580.4	48.0	358.9
Postclosure (Second 10 Years)	9,582.8	71,684.3	42.1	314.6
Postclosure (Third 10 Years)	8,468.2	63,346.5	35.2	263.0
Undeveloped Area (Sectors 6-7)				
	Average (cf/year/acre)	**Average (gal/year/acre)**	**Peak (cf/day/acre)**	**Peak (gal/day/acre)**
Active	1,112.3	8,320.4	31.3	234.4
Interim 50 ft	5,187.1	38,802.0	56.1	419.5
Interim 100 ft	22,664.7	169,543.7	126.5	946.4
Interim 200 ft	23,512.7	175,886.9	135.5	1,013.9
Interim 300 ft	34,817.1	260,450.2	206.1	1,541.5
Interim 310 ft	36,618.4	273,924.7	206.0	1,541.2
Closed	23,704.4	177,321.1	201.6	1,507.9
Postclosure (First 10 Years)	11,498.1	86,011.9	51.0	381.3
Postclosure (Second 10 Years)	10,136.4	75,825.4	44.6	333.4
Postclosure (Third 10 Years)	29,613.0	221,520.4	38.1	285.2
Undeveloped Area (Sectors 8-12)				
	Average (cf/year/acre)	**Average (gal/year/acre)**	**Peak (cf/day/acre)**	**Peak (gal/day/acre)**
Active	945.5	7,073.2	30.5	228.5
Interim 50 ft	6,096.4	45,604.6	81.9	613.0
Interim 100 ft	26,854.2	200,883.6	176.8	1,322.4
Interim 200 ft	23,488.4	175,705.5	114.5	856.3
Interim 260 ft	29,432.8	220,172.3	154.3	1,154.6
Closed	17,566.0	131,402.6	153.3	1,146.6
Postclosure (First 10 Years)	9,958.3	74,493.3	39.1	292.8
Postclosure (Second 10 Years)	8,691.2	65,014.7	33.2	248.5
Postclosure (Third 10 Years)	7,752.5	57,992.5	29.7	221.9

[1]Refer to this appendix and Appendix IIIC-A for HELP analyses results.

Table IIIC-E-3 (cont.)[1]
Summary of Leachate Generation Rates

Overliner Area				
	Average (cf/year/acre)	Average (gal/year/acre)	Peak (cf/day/acre)	Peak (gal/day/acre)
Active 10 ft	1,290.4	9,653.0	38.4	287.3
Interim 50 ft	6,700.9	50,126.2	88.9	664.8
Interim 100 ft	25,605.0	191,538.5	166.0	1,241.6
Interim 200 ft	23,121.4	172,960.4	105.9	792.0
Interim 280 ft	31,761.4	237,591.7	151.0	1,129.8
Closed	20,756.7	155,271.2	149.0	1,114.8
Postclosure (First 10 Years)	10,570.1	79,069.9	40.3	301.6
Postclosure (Second 10 Years)	9,274.7	69,379.8	32.5	242.9
Postclosure (Third 10 Years)	8,231.1	61,573.0	28.4	212.8

[1]Refer to this appendix and Appendix IIIC-A for HELP analyses results.

Required: Determine the leachate depth on the liner system using the actual leachate generated information provided on Sheet IIIC-E-4.

References:

1. Giroud, J.P. et al., Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers, *Geosynthetics International*, Vol 7, 2000.

Procedure:

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

Solution:

Developed Areas - Sectors 2 through 5 (200 mil geocomposite)

β= 1.15 °
$\tan\beta$= 0.020
$\tan^2\beta$= 0.0004
$\cos\beta$= 1.00
L= 215 ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_1 (in/s)	T_{max} (in)
Interim 50 ft	23,026	2.69E-08	3.31	0.0010
Interim 100 ft	23,026	2.69E-08	2.14	0.0016
Interim 200 ft	23,026	2.69E-08	1.18	0.0029
Interim 290 ft	23,026	2.69E-08	1.06	0.0033
Closed	23,026	2.69E-08	0.92	0.0038
Postclosure (First 10 Years)	2,303	2.69E-09	0.92	0.0004
Postclosure (Second 10 Years)	461	5.38E-10	0.92	0.0001
Postclosure (Third 10 Years)	461	5.38E-10	0.92	0.0001

Undeveloped Areas - Sectors 6 and 7 (250 mil geocomposite)

β= 1.15 °
$\tan\beta$= 0.020
$\tan^2\beta$= 0.0004
$\cos\beta$= 1.00
L= 165 ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_1 (in/s)	T_{max} (in)
Active 10 ft	23,026	2.69E-08	10.29	0.0003
Interim 50 ft	23,026	2.69E-08	5.63	0.0005
Interim 100 ft	23,026	2.69E-08	3.17	0.0008
Interim 200 ft	23,026	2.69E-08	1.63	0.0016
Interim 300 ft	23,026	2.69E-08	1.05	0.0025
Interim 310 ft	23,026	2.69E-08	1.02	0.0026
Closed	23,026	2.69E-08	0.89	0.0030
Postclosure (First 10 Years)	2,303	2.69E-09	0.89	0.0003
Postclosure (Second 10 Years)	461	5.38E-10	0.89	0.0001
Postclosure (Third 10 Years)	461	5.38E-10	0.89	0.0001

Undeveloped Areas - Sectors 8 through 12 (250 mil geocomposite)

β= 1.15 °
$\tan\beta$= 0.020
$\tan^2\beta$= 0.0004
$\cos\beta$= 1.00
L= 370 ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_1 (in/s)	T_{max} (in)
Active 10 ft	23,026	2.69E-08	10.29	0.0006
Interim 50 ft	23,026	2.69E-08	5.63	0.0011
Interim 100 ft	23,026	2.69E-08	3.17	0.0019
Interim 200 ft	23,026	2.69E-08	1.63	0.0037
Interim 260 ft	23,026	2.69E-08	1.21	0.0049
Closed	23,026	2.69E-08	1.05	0.0057
Postclosure (First 10 Years)	2,303	2.69E-09	1.05	0.0006
Postclosure (Second 10 Years)	461	5.38E-10	1.05	0.0001
Postclosure (Third 10 Years)	461	5.38E-10	1.05	0.0001

Overliner Area (300 mil geocomposite)

β=	0.86	°
$\tan\beta$=	0.015	
$\tan^2\beta$=	0.0002	
$\cos\beta$=	1.00	
L=	800	ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_1 (in/s)	T_{max} (in)
Active 10 ft	23,026	2.69E-08	5.03	0.0034
Interim 50 ft	23,026	2.69E-08	4.61	0.0037
Interim 100 ft	23,026	2.69E-08	3.68	0.0047
Interim 200 ft	23,026	2.69E-08	2.59	0.0066
Interim 280 ft	23,026	2.69E-08	3.59	0.0048
Closed	23,026	2.69E-08	1.59	0.0109
Postclosure (First 10 Years)	2,303	2.69E-09	1.59	0.0011
Postclosure (Second 10 Years)	461	5.38E-10	1.59	0.0002
Postclosure (Third 10 Years)	461	5.38E-10	1.59	0.0002

CITY OF ARLINGTON LANDFILL
0023-404-11-104
HELP VERSION 3.07 SUMMARY SHEET
DEVELOPED AREAS - SECTORS 2-5

		POST-CLOSURE 2054-2063	POST-CLOSURE 2064-2073	POST-CLOSURE 2074-2083
GENERAL	Case No.	1	2	3
INFORMATION	No. of Years	10	10	10
	Ground Cover	GOOD	GOOD	GOOD
	SCS Runoff Curve No.	79.5	79.5	79.5
	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)	12	12	12
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
GEOCOMPIOSITE	Thickness (in)	0.300	0.300	0.300
DRAINAGE	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)	12.17	12.17	12.17
	Slope (%)	5.0	5.0	5.0
	Slope Length (ft)	1000	1000	1000
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
COMPACTED	Thickness (in)	18.00	18.00	18.00
CLAY LINER	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[1]	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)	0.3566	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[1]	Thickness (in)	1980	1980	1980
(Texture = 0)	Porosity (vol/vol)	0.4976	0.4976	0.4976
	Field Capacity (vol/vol)	0.4786	0.4786	0.4786
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2951	0.3467	0.3380
	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	0.2873	0.2804
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.129	0.129	0.129
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)	2.35	2.35	2.35
	Slope (%)	2.0	2.0	2.0
	Slope Length (ft)	215	215	215
FLEXIBLE	Thickness (in)	0.06	0.06	0.06
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)	1	1	1
	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)	38.39	38.39	38.39
RUNOFF	Average Annual (in)	0.97	0.97	0.97
EVAPOTRANSPIRATION	Average Annual (in)	27.98	27.98	27.98
LATERAL	Average Annual (cf/year)	10,905.7	9,582.8	8,468.2
DRAINAGE COLLECTED	Peak Daily (cf/day)	48.0	42.1	35.2
HEAD ON LINER	Average Annual (in)	0.007	0.006	0.005
	Peak Daily (in)	0.021	0.018	0.015

[1] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		POST-CLOSURE 2054-2063	POST-CLOSURE 2064-2073	POST-CLOSURE 2074-2083
GENERAL	Case No.	1	2	3
INFORMATION	No. of Years	10	10	10
	Ground Cover	GOOD	GOOD	GOOD
	SCS Runoff Curve No.	81.2	81.2	81.2
	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)	12	12	12
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
GEOCOMPIOSITE	Thickness (in)	0.300	0.300	0.300
DRAINAGE	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)	12.17	12.17	12.17
	Slope (%)	25.0	25.0	25.0
	Slope Length (ft)	420	420	420
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
COMPACTED	Thickness (in)	18.00	18.00	18.00
CLAY LINER	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[1]	Thickness (in)	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3603	0.3503	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[1]	Thickness (in)	2220	2220	2220
(Texture = 0)	Porosity (vol/vol)	0.4893	0.4893	0.4893
	Field Capacity (vol/vol)	0.4863	0.4863	0.4863
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2935	0.2858	0.3415
	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	0.2791
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.143	0.143	0.143
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)	2.26	2.26	2.26
	Slope (%)	2.0	2.0	2.0
	Slope Length (ft)	165	165	165
FLEXIBLE	Thickness (in)	0.06	0.06	0.06
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)	1	1	1
	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)	38.39	38.39	38.39
RUNOFF	Average Annual (in)	1.22	1.22	1.22
EVAPOTRANSPIRATION	Average Annual (in)	28.01	28.01	28.01
LATERAL	Average Annual (cf/year)	11,498.1	10,136.4	29,613.0
DRAINAGE COLLECTED	Peak Daily (cf/day)	51.0	44.6	38.1
HEAD ON LINER	Average Annual (in)	0.006	0.005	0.004
	Peak Daily (in)	0.018	0.015	0.014

[1] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquid: Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		POST-CLOSURE 2054-2063	POST-CLOSURE 2064-2073	POST-CLOSURE 2074-2083
GENERAL INFORMATION	Case No.	1	2	3
	No. of Years	10	10	10
	Ground Cover	GOOD	GOOD	GOOD
	SCS Runoff Curve No.	85.7	85.7	85.7
	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)	12	12	12
TOPSOIL LAYER (Texture = 10)	Thickness (in)	12	12	12
	Porosity (vol/vol)	0.3980	0.3980	0.3980
	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
GEOCOMPIOSITE DRAINAGE LAYER (Texture = 0)	Thickness (in)	0.300	0.300	0.300
	Porosity (vol/vol)	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
	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)	12.17	12.17	12.17
	Slope (%)	25.0	25.0	25.0
	Slope Length (ft)	300	300	300
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)	0.04	0.04	0.04
	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13
	Pinhole Density (holes/acre)	1	1	1
	Install. Defects (holes/acre)	4	4	4
	Placement Quality	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 0)	Thickness (in)	18.00	18.00	18.00
	Porosity (vol/vol)	0.4270	0.4270	0.4270
	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 COVER (Texture = 11)	Thickness (in)	12	12	12
	Porosity (vol/vol)	0.4640	0.4640	0.4640
	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[1] (Texture = 0)	Thickness (in)	1500	1500	1500
	Porosity (vol/vol)	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3505	0.3406	0.3320
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[1] (Texture = 0)	Thickness (in)	2220	2220	2220
	Porosity (vol/vol)	0.4893	0.4893	0.4893
	Field Capacity (vol/vol)	0.4863	0.4863	0.4863
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2966	0.2886	0.2816
	Hyd. Conductivity (cm/s)	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980
	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 COLLECTION LAYER (Texture = 0)	Thickness (in)	0.149	0.149	0.149
	Porosity (vol/vol)	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
	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)	2.68	2.68	2.68
	Slope (%)	2.0	2.0	2.0
	Slope Length (ft)	370	370	370
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13
	Pinhole Density (holes/acre)	1	1	1
	Install. Defects (holes/acre)	1	1	1
	Placement Quality	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270
	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)	38.39	38.39	38.39
RUNOFF	Average Annual (in)	2.66	2.66	2.66
EVAPOTRANSPIRATION	Average Annual (in)	28.16	28.16	28.16
LATERAL DRAINAGE COLLECTED	Average Annual (cf/year)	9,958.3	8,691.2	7,752.5
	Peak Daily (cf/day)	39.1	33.2	29.7
HEAD ON LINER	Average Annual (in)	0.009	0.008	0.007
	Peak Daily (in)	0.027	0.022	0.022

[1] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		POST-CLOSURE 2054-2063	POST-CLOSURE 2064-2073	POST-CLOSURE 2074-2083
GENERAL	Case No.	1	2	3
INFORMATION	No. of Years	37	37	37
	Ground Cover	GOOD	GOOD	GOOD
	SCS Runoff Curve No.	81.2	81.2	81.2
	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)	12	12	12
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
GEOCOMPIOSITE	Thickness (in)	0.300	0.300	0.300
DRAINAGE	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)	12.17	12.17	12.17
	Slope (%)	25.0	25.0	25.0
	Slope Length (ft)	500	500	500
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
COMPACTED	Thickness (in)	18.00	18.00	18.00
CLAY LINER	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[1]	Thickness (in)	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3546	0.3447	0.3361
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[1]	Thickness (in)	2610	2610	2610
(Texture = 0)	Porosity (vol/vol)	0.4893	0.4893	0.4893
	Field Capacity (vol/vol)	0.4863	0.4863	0.4863
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2956	0.2878	0.2809
	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)	0.222	0.222	0.222
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)	3.49	3.49	3.49
	Slope[2] (%)	1.5	1.5	1.5
	Slope Length (ft)	800	800	800
FLEXIBLE	Thickness (in)	0.06	0.06	0.06
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)	1	1	1
	Placement Quality	GOOD	GOOD	GOOD
GEOSYNTHETIC	Thickness (in)	0.25	0.25	0.25
SOIL LAYER	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
COMPACTED	Thickness (in)	12	12	12
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)	38.39	38.39	38.39
RUNOFF	Average Annual (in)	1.36	1.36	1.36
EVAPOTRANSPIRATION	Average Annual (in)	28.24	28.24	28.24
LATERAL	Average Annual (cf/year)	10,570.1	9,274.7	8,231.1
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	40.3	32.5	28.4
HEAD ON LINER	Average Annual (in)	0.021	0.019	0.017
	Peak Daily (in)	0.058	0.047	0.042

[1] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquic Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

[2] The slope of the leachate collection layer is conservatively selected considering the after settlement contours of the overliner.

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS
TCEQ PERMIT NO. MSW-358C

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIID
LINER QUALITY CONTROL PLAN

Prepared for

City of Arlington
and
Republic Waste Services of Texas, Ltd

May 2022

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

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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 on-site tests and observations. The CQA monitor performing QA/QC observation and testing will be a qualified professional meeting one of the following qualifications: NICET-certified in geotechnical engineering technology at level II or higher for soils testing; a minimum of four years of directly related experience; 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. 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 direct supervision of a qualified CQA monitor who is on-site.

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 to 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). A GCL may be used in lieu of the 2-foot-thick compacted clay liner. 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 IIIE – 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 and 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 organic matter, foreign objects, and other deleterious matter, and compacted sufficiently to provide a firm base for composite liner placement. The subgrade will also be scarified a minimum of 2 inches prior to placement of the first lift of soil liner or underdrain geocomposite. 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 (included in Appendix IIIA) 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 composite 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 composite liner. 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 composite 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 IIIE.

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 soil liner will achieve a 2-foot minimum thickness. The surface slope of the top layer of composite 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. A GCL may be used in lieu of the 2-foot-thick compacted clay liner. 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 on-site or off-site 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.

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	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 on-site soils to be used as liner material or on off-site borrow source material. The CQA monitor, Earthwork Contractor, and/or Operator will identify the clay material in on-site stockpiles or during excavation, and the clay material will be stockpiled separately, if stockpiling is required. Prior to construction of each new cell, conformance tests that include USCS classification, liquid limit, plasticity index, percent passing the No. 200 and 1-inch sieves, 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. 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 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. The liquid limit and plasticity index 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 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 on-site may be used if it has not come into contact with 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 the Excavation Plan and 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 soil 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 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 should ground pressure 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. 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 regulations. 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.

2.3.3 Overliner Subgrade and Perimeter Berm Construction

Prior to placing the overliner geosynthetics on the existing final cover, the existing erosion layer and the top 6 inches of the 18-inch-thick infiltration layer will be removed and any required subgrade fill will be placed. Fill placed below the overliner or for the perimeter berm will be constructed in accordance with Section 2.3.2.2 of the LQCP.

As part of evaluating the established subgrade, undisturbed soil samples will be collected from the foundation layer to perform hydraulic conductivity tests. Hydraulic conductivity tests will be conducted at a frequency minimum of 1 test per acre. Testing and evaluation will be conducted in conformance with the procedure described below. Field sampling will be conducted by a construction quality assurance monitor working under the direction of the POR.

1. Obtain hydraulic conductivity samples from a minimum of one sample locations per acre of overliner subgrade. Undisturbed samples will be obtained from the prepared foundation layer using a thin-walled tube sampler. The sample from each test location will be sealed and transported to the laboratory.
2. Determine the hydraulic conductivity of each sample.

3. Boreholes created by taking soil cores will be backfilled with bentonite or a bentonite/infiltration layer soil mixture consisting of at least 20 percent bentonite.

If the evaluation indicates hydraulic conductivity values greater than 1×10^{-6} cm/s, the POR will implement corrective action for the failed area. If the integrity of the sample appears to have been compromised during the transportation of the sample prior to testing, an additional sample will be collected and tested. In addition, if a sample hydraulic conductivity test does not comply with the maximum allowable value, an additional sample collected at the same location may be tested to determine compliance with the hydraulic conductivity requirements. The POR will provide a detailed justification of the use of the additional sample, if applicable, in the GLER.

If the additional sample passes, the area will be considered in compliance. If the additional sample fails, 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.

Once the extent of the unsatisfactory area is determined, the constructed overliner subgrade will be reworked or removed and reconstructed (see reconstruction procedures below) until all the samples obtained from the failed area meet the hydraulic conductivity requirements. At a minimum, one hydraulic conductivity test will be performed, given that the reworked/reconstructed overliner area is not larger than one acre (i.e., one hydraulic conductivity test per one acre of reconstructed overliner area). The reconstructed overliner geomembrane subgrade area will be tied into the currently constructed subgrade with a 5H:1V transition slope. Reconstruction activities, including additional testing and surveying, will be incorporated into the GCLER/GLER.

In areas where waste will be relocated (e.g., during the installation of perimeter leachate collection trenches), fill placed over the excavated waste will be placed in two lifts. Each lift will consist of eight inches of uniformly placed material that will be compacted consistent with the procedure listed above for the subgrade fill.

Prior to placement of the geosynthetics, the top of the subgrade will be proof rolled with heavy, rubber tired smooth drum roller construction equipment to detect soft zones and provide a smooth geomembrane subgrade surface. Soft zones will be undercut to firm material and refilled with suitable compacted soil fill. The fill will be free of foreign objects and other deleterious matter, and compacted sufficiently to provide a firm base for overliner geosynthetics placement. The top of overliner subgrade will be smooth and free of organic material, foreign objects, and other deleterious materials. Standing water or excessive water on the overliner subgrade will not be allowed.

Visual examination of the subgrade preparation by the CQA monitor will generally be sufficient to evaluate its suitability as a foundation for geosynthetics placement. The CQA monitor may find that physical testing is necessary to evaluate the prepared subgrade or fill placed in large voids. The CQA monitor will approve the prepared subgrade prior to the placement of overliner GCL. Approval will be based on a review of test information, if applicable, and CQA monitoring of the subgrade preparation. The POR will incorporate the subgrade-related information into the GCLER/GLER.

Surveying will be performed to verify that the finished overliner subgrade layer and perimeter berm meet the minimum design slope requirements and 12-inch thickness. 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/or granular bentonite) and compacted to establish a firm, uniform, and smooth surface. The survey grid locations will be established by a qualified surveyor on a 100-foot grid. The POR or CQA monitor will verify that the subgrade is uniform between each point. Note that the subgrade elevation may vary due to settlement that may occur prior to construction, however, the configuration of the overliner shall meet the minimum design slopes.

A subgrade thickness drawing showing the survey measurement grid points will be provided. Coordinates defining the perimeter of the overliner subgrade will be labeled on one of the final as-built drawings. The subgrade drawing will be sealed by a Texas registered surveyor. The certification drawings will be included in the GCLER/GLER. A statement that confirms that the as-built slopes are consistent with the approved top of overliner plan will be included in the GCLER/GLER.

2.3.4 General Fill/Structural Fill

General fill/structural fill material will be uncontaminated earthen fill. General fill material placed below the composite bottom liner (e.g., over-excavated areas within the liner construction area), below the overliner, or for the perimeter berm 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. The fill placed below the liner will be compacted to at least 95 percent of Standard Proctor maximum dry density (ASTM D 698) at a moisture content range at or above the optimum moisture content when it is used for below liner grades. Structural fill material will be placed in uniform lifts which do not exceed 12 inches in loose thickness and will be compacted to at least 90 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 project plans and specifications. 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 organic matter, 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 and POR. 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 qualified surveyor or professional engineer with a minimum 2 reference points. Thickness may be verified with settlement plates. 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 uncontaminated earthen material and 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 or groundwater. 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. Ponding of stormwater over the overliner subgrade is not likely because both the existing pre-Subtitle D final cover that will be disturbed to install the overliner system and the overliner, once established, will have positive drainage. During the preparation of overliner subgrade, ponding of water will be prevented. Soil or geosynthetic placement will not be completed in standing water. The overliner subgrade area may have a temporary sump area to collect water entering the subgrade and be graded to allow drainage. 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 soil 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 the 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 appendix.

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

Qualified CQA monitors 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 6938	In-place density and water content of soil and soil-aggregate by nuclear methods (shallow depth)
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

Standard Test Method	Test Description
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, overliner subgrade, and overliner perimeter berm 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 Soil Liner, Overliner Subgrade, and Overliner Perimeter Berm

Parameter	Frequency	Test Method	Passing Criteria
Field Density and Moisture	Soil Liner/Overliner Subgrade 1 each per 8,000 SF per 6-inch parallel lift Overliner Perimeter Berm 1 test per 100 linear feet of berm per 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 and 1-inch)	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 (#200) 100 percent minimum (1-inch)
Atterberg Limits	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 qualified surveyor	Survey subgrade and top of soil liner and protective cover layer	2 feet minimum compacted soil 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.

2.4.3 Soil Liner Testing

CQA testing of the soil liner will be performed as the liner is being constructed. 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.

Soil liner field density and moisture testing will be completed on each 6-inch compacted lift at a frequency of one test per 8,000 square feet of soil liner installed. Passing tests will be achieved with a minimum of 95 percent compaction of the Standard Proctor maximum dry density at a moisture content at or above optimum moisture content. Areas that do not receive satisfactory field density and moisture testing will be moisture conditioned and recompacted to achieve satisfactory results.

Hydraulic conductivity samples will be obtained by pushing a sampler through each lift of the constructed clay liner prior to construction of the next lift. 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 and compacted by hand tamping.

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.

2.4.4 Material Strength Requirements

The geotechnical analysis is included in Appendix IIIE – Geotechnical Report and includes slope stability, foundation heave, and settlement analyses. Soil parameters used in the geotechnical analysis were obtained from subsurface investigations and geotechnical reports, as well as from geotechnical testing performed on soil samples recovered at the site. The POR will verify that the proposed liner material meets the minimum soil properties used in the geotechnical analysis included in Appendix IIIE prior to liner construction, as applicable. These soil properties include unit weight, moisture content, cohesion, friction angle, and consolidation strength parameters used in the slope stability and settlement analyses. The POR will verify that the underlying material below the composite liner is consistent with design assumptions. If the POR determines that the underlying material or borrow material is not consistent with design assumptions, the appropriate geotechnical analysis (e.g., slope stability) will be updated consistent with the procedures in Appendix IIIE. The updated analysis will be incorporated into the SLER/GLER.

2.5 Reporting

The POR will submit to the TCEQ a SLER for approval of each Subtitle D soil liner area. Documentation for the overliner subgrade and perimeter berm will be submitted to TCEQ as part of the GCLER. 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
  - Floor Grades: 60-mil HDPE – smooth or textured on both sides
  - Sideslopes: 60-mil HDPE – textured on both sides
- 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 or textured on both sides on the floor and textured on both sides on the sideslopes. 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.

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 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 manufacturing plant by the third-party testing laboratory or 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 200,000 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	ASTM D 7238 ASTM D 5885	Per each formulation
	Asperity Height	ASTM D 7466	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 Lowest individual reading Lowest individual of 8 of 10 readings	ASTM D 5199 (smooth) ASTM D 5994 (textured)	60 54 NA	57 51 54
Density, g/cc	ASTM D 1505/D 792	0.94	0.94
Asperity Height, mils	GRI GM12	N/A	16
Tensile Properties[1] 1. Yield Strength, lb/in 2. Break Strength, lb/in 3. Yield Elongation, % 4. Break Elongation, %	ASTM D 638 (Type IV Specimen @ 2 in/min) (ASTM D 6693 may be used as an alternative upon approval by POR)	126 228 12 700	126 90 12 100
Tear Resistance, lb	ASTM D 1004	42	42
Puncture Resistance, lb	ASTM D 4833	108	90
Stress Crack Resistance[2], hrs	ASTM D 5397	500	500
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 High Pressure OIT, minutes	ASTM D 3895 ASTM D 5885	100 400	100 400
Oven Aging at 85ºC Standard OIT – % retained after 90 days High Pressure OIT – % retained after 90 days	ASTM D 5721 ASTM D 3895 ASTM D 5885	55 80	55 80
UV Resistance[6] High Pressure OIT[7] – % retained after 1600 hrs	ASTM D 7238 ASTM D 5885	50	50
Seam Properties (5 out of 5 specimens, per GRI-GM19) 1. Shear Strength, lb/in 2. Peel Strength, lb/in	ASTM D 6392	120 91 & FTB (78, Extrusion Weld)	120 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 75ºC followed by 4 hr. condensation at 60ºC.
[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. At the time of each liner construction event, an updated GRI-GM13 and GRI-GM19 will be used if available.

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. No single measurement will be less than 10 percent (15 percent for textured) below the required nominal thickness for the panel to be accepted and the average must be at least 60 mils (57 mils for textured). 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 third-party testing laboratory or CQA monitor must mark the machine direction and the manufacturer's roll identification number on the sample. The third-party testing laboratory or 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 or GCL 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 or GCL surface.
- The soil liner has been prepared in accordance with the earthwork construction plans and specifications as outlined in Section 2.
- The GCL has been prepared in accordance with the construction plans and specifications as outlined in Section 4.
- The soil liner is free of surface irregularities and protrusions. The soil liner will be rolled and compacted to ensure a clean surface.
- The soil liner or GCL surface does not contain stones or other objects that could damage the geomembrane or underlying soil liner or GCL. The surface of the soil liner or GCL 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 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 or GCL 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 or GCL.
- 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 or GCL 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 repair 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 soil liner or 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 (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 greater than 104°F, or when standing water or frost is on the ground, unless this requirement is waived by the design engineer or 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. This requirement may be waived if textured material is utilized on the floor.

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. 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 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) at intervals of at least one test per 500 linear feet. Only individual repairs (or additional seaming for failed seams) requiring more than 10 feet of seaming shall count toward the testing interval. 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). All five specimens tested in peel and shear shall meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the passing criteria listed below. Additionally, all 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 causes 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 all 5 test specimens. 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 all 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 all 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 all 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 all 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. The material used will meet the criteria outlined in Section 2.3.7.

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.

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 ft² 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[7]
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	16
Tensile Properties[1] Break Strength, lb/in Break Elongation, %	ASTM D 6693, Type IV	 60 250
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 85ºC 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 (5 out of 5 specimens, % 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 75ºC followed by 4 hr. condensation at 60ºC.
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.
7 Minimum required properties are based on GRI-GM13, except for the seam properties which are based on GRI-GM19. At the time of each liner construction event, an updated GRI-GM13 and GRI-GM19 will be used if available.

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 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 manufacturing plant by the third-party testing laboratory or 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)

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 upon recognition and prior to product installation. In addition to the conformance thickness tests, field thickness measurements must be taken at maximum 5-foot intervals along the leading edge (width of roll) of each geomembrane panel. No single measurement will be less than 15 percent below the required nominal thickness for the panel to be accepted (i.e., for 40-mil geomembrane a minimum thickness of 34 mils is required) and minimum average thickness cannot be lower than 38 mils. Additionally, 8 out of 10 measurements must result in at least 36 mils of thickness.

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 or third-party laboratory must mark the machine direction and the manufacturer's roll identification number on the sample. The CQA monitor or third-party laboratory must also assign a conformance test number to the sample and mark the sample with that number.

3.4.4 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 4.3.2, 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 15 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 3.4.6 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. 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 3.4.5 – 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 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.

3.4.5 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 3.4.6.
- 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) at intervals of at least one test per 500 linear feet. Only individual repairs (or additional seaming for failed seams) requiring more than 10 feet of seam length shall count toward the testing interval. 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). All five specimens tested in peel and shear shall meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the passing criteria listed below. Additionally, all 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 causes 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 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 all 5 test specimens. 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 all 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 all 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 all 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 all 5 specimens is at least 50 percent.

3.4.6 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 3.4.5 – Construction Testing.

3.4.7 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.

3.4.8 Folded Material

Folded geomembrane must be removed. Remnant folds evident after deployment of the roll that are due to manufacturing process are acceptable.

3.4.9 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. The material used will meet the criteria outlined in Section 2.3.7.

3.4.10 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.

3.4.11 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. Manufacturer's testing for geotextile is listed in Table 3-5.

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 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.

Reference to "geocomposite thickness" within this LQCP and in supporting calculations (Appendix IIIC) refers to the thickness of the geonet, not the overall thickness of the geocomposite. The transmissivity values used for the calculations supporting this LQCP may or may not be representative of actual transmissivity values for every geocomposite manufacturer, and may require a prospective material supplier to provide a geocomposite that varies in thickness from the geocomposite presented in this LQCP in order to meet the minimum transmissivity criteria set forth in this LQCP.

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 footnotes 2 and 3 of Table 3-5 and footnote 2 of 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). The manufacturer's testing for drainage material is also summarized in Table 3-5 and Table 3-6.

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:

- 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
Leachate Collection System 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 6241	309 lbs
		Permeability	ASTM D 4491	0.2 cm/s
Manufacturer	HDPE Geonet	Specific Gravity	ASTM D 1505	0.94 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
Third-party Laboratory	Drainage Geocomposite	Transmissivity	ASTM D 4716	See Notes 2, 3, and 5
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 will be single-sided or double-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, the transmissivity of the single-sided (or double-sided) geocomposite for Sectors 6 and 7 will be measured at a gradient of 0.02 under normal pressures of 1,000, 15,000 and 24,950 (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 geocomposite placement area, one additional transmissivity test will be performed under the maximum normal stress (i.e., 24,950 psf) or higher with all the same assumptions as the first three tests. The minimum transmissivity will be 4.69×10^{-4} m^2/s. The transmissivity of the single-sided (or double-sided) geocomposite for Sectors 8 through 12 will be measured at a gradient of 0.02 under normal pressures of 1,000, 15,000, and 21,000 (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 geocomposite placement area, one additional transmissivity test will be performed under the maximum normal stress (i.e., 21,000 psf) or higher with all the same assumptions as the first three tests. The minimum transmissivity will be 5.80×10^{-4} m^2/s. The transmissivity of the sideslope double-sided geocomposite will be measured at a gradient of 0.33 under a minimum normal pressure of 1,000, 15,000, and 24,950 (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., 24,950 psf) or higher with all the same assumptions as the first three tests. The minimum transmissivity will be 2.65×10^{-5} m^2/s.

3 Overliner: As noted in Appendix IIIC, Appendix IIIC-A, the transmissivity of the overliner double-sided geocomposite will be measured at a minimum gradient of 0.015 under a minimum normal pressure of 1,000, 15,000, and 22,580 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours. The minimum transmissivity will be 1.13×10^{-3} m^2/s. For each additional 100,000 square feet of double-sided geocomposite placement area, one additional transmissivity test will be run under a minimum normal stress of 22,580 psf with all the same assumptions as the first three tests.

4 Minimum required property values for the geotextile and drainage geocomposite transmissivity are based on calculations provided in Appendices IIIC-A and IIIC-B. 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. Actual geonet thickness, if greater than the minimum, will be determined by manufacturer quality control testing and recommendations.

5 Reference to "geocomposite thickness" within this LQCP and in supporting calculations (Appendix IIIC) refers to the thickness of the geonet, not the overall thickness of the geocomposite. The transmissivity values used for the calculations supporting this LQCP may or may not be representative of actual transmissivity values for every geocomposite manufacturer, and may require a prospective material supplier to provide a geocomposite that varies in thickness from the geocomposite presented in this LQCP in order to meet the minimum transmissivity criteria set forth in this LQCP.

Table 3-6
Dewatering System Geotextile and Drainage Geocomposite Required Testing Properties

Responsible Party	Material	Test	Standard	Required Property
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 6241	309 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
Third-party Laboratory	Drainage Geocomposite	Transmissivity[2]	ASTM D 4716	See Notes 2, 4, and 5
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 IIID-C, the transmissivity of the dewatering system double-sided geocomposite will be measured at a minimum gradient of 0.33 (sideslope) and 0.025 (floor) under a minimum normal pressure of 1,910 psf (sideslope) or 7,760 psf (floor) for a minimum seating time of 100 hours. The minimum required transmissivity will be2.5×10^{-4} m^2/s (sideslope) and 1.5×10^{-4} m^2/s (floor).

3 Minimum required property values for the geotextile and drainage geocomposite transmissivity are based on calculations provided in Appendix IIID-C. 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. Actual geonet thickness, if greater than the minimum, will be determined by manufacturer quality control testing and recommendations.

4 Reference to "geocomposite thickness" within this LQCP and in supporting calculations (Appendix IIIC) refers to the thickness of the geonet, not the overall thickness of the geocomposite. The transmissivity values used for the calculations supporting this LQCP may or may not be representative of actual transmissivity values for every geocomposite manufacturer, and may require a prospective material supplier to provide a geocomposite that varies in thickness from the geocomposite presented in this LQCP in order to meet the minimum transmissivity criteria set forth in this LQCP.

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 and may also be used in lieu of soil liner in the composite liner system. The GCL will be covered with geomembrane, drainage geocomposite, and a minimum 24-inch-thick protective cover. A geotechnical analysis of the overliner system with a GCL is included in Appendix IIIE – 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 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. 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 data (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 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. GCL rolls will be offloaded with equipment that will not damage the GCL rolls. 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 in the overliner area (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 2.3.7.

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 off-site 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	One per GCL/adjoining material type

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 performed by independent laboratory as part of 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. The nonwoven side of the GCL will be in contact with the geomembrane. Refer to Appendix IIIE – 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)	$5x10^{-9}$ (maximum)
Lab Joint Permeability[5, 6] (cm/s)	$5x10^{-9}$ (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 groundwater table.

The geology of the site generally consists of five layers: two alluvial layers (Stratum A and B), a weathered shale/shaley clay liner (Stratum C), a sandstone layer (Stratum D), and an unweathered shale layer (Stratum E). The base of the proposed excavation for Sector 6 will be founded in Stratum A, and B, and the base of the proposed excavation for Sector 7 will be found in Stratum A, B, and C. Sectors 8 through 12 will be founded in Stratum C, D, and E soils. The strata are discussed in detail in Appendix IIIG – Geology Report. Stratum C and E act as aquicludes below the facility. A temporary dewatering system will be constructed as discussed in Section 6.3.

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 has been and will be provided for the entire area that has a composite liner that is below the estimated groundwater elevation. The highest measured groundwater surface is included in Appendix IIID-A, as well as the post-construction estimated groundwater surface that was used for ballast calculations.

6.2 Highest Measured Groundwater Levels

Based on the current hydrogeologic investigation and previous subsurface investigations, the site geology consists of five strata: Alluvium (Stratum A), Alluvium with gravel (Stratum B), weathered shale (Stratum C), sandstone (Stratum D), and unweathered shale (Stratum E). Water levels from the current monitoring wells and piezometers indicate that the groundwater levels are higher than the excavation floor. As discussed in Section 6.3, two temporary dewatering systems are designed for the undeveloped portions (Sector 6 and Sectors 7 through 12) to control hydrostatic pressure that may act on the liner system. Long-term stability of the liner system will be ensured by the weight of protective cover, solid waste, and final cover to counteract potential uplift pressures created by hydrostatic forces acting on the bottom of the liner system.

A highest measured groundwater potentiometric surface map is included in Appendix IIID-A. Detailed groundwater information is presented in Appendix IIIG – Geology Report. Drawing IIID-A-1 presents the highest measured groundwater potentiometric surface at the site, as derived from previous measurements of groundwater elevations across the site. However, the current groundwater surface will be altered by the proposed drainage features constructed on the periphery of Sectors 8 through 12 and to a lesser degree at Sectors 6 and 7. Specifically, the proposed location of the Hurricane Creek drainage diversion channel to be installed along the northern periphery of Sectors 8 through 12 will intercept and divert groundwater to the perimeter drainage system and will effectively lower the current groundwater elevations to approximately the base of the channel, as groundwater is allowed to dissipate into both the channel and adjacent cell excavations during construction. Additional dewatering will also occur as a result of excavation and development of the floodplain mitigation areas located to the west and south of Sectors 8 through 12. An estimated post-development groundwater potentiometric surface used for the underdrain design and ballast demonstration is also presented on Drawing IIID-A-1. Note however that this potentiometric surface is highly conservative, as much of the bottom liner across Sectors 8 through 12 is projected to be founded in fat clay (Stratum C – Weathered Woodbine) or unweathered shale (Stratum E), both of which are assumed as non-water bearing.

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 (based on measured groundwater levels after construction of the perimeter surface drainage features). Any temporary hydrostatic relief system design different than the one presented in Appendix IIID-C will be submitted under the provisions of §305.70(j) to the TCEQ for approval as a modification to the LQCP.

In the event future cell excavations, test pits, or subsurface explorations expose clayey weathered Woodbine (Stratum C) or unweathered shale (Stratum E) at the excavation grades across the bottom and/or sideslopes of a cell, the underdrain design may be modified to limit or remove the geocomposite underdrain from beneath all or part of the bottom and/or sideslopes of the cell. A non-noticed permit modification (in accordance with Title 30 TAC §305.70(j)) will be required for this design modification prior to construction.

6.3 Temporary Dewatering System

The site will have two dewatering systems for the undeveloped areas (Sector 6 and Sectors 7 through 12). Sector 6 will be excavated in the alluvium layers, and Sectors 7 through 12 will be excavated into sandstone, weathered woodbine and unweathered shale layers. The designs for the two conditions are discussed in Appendix IIID-C.

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 systems and will remain operational until the BER is approved. The pumps will be operated automatically by pressure transducers. Dewatering pump will be selected to have a flow capacity that is equal to or larger than the estimated groundwater flow to the sump.

The temporary dewatering systems 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 will be designed and submitted to the TCEQ as a permit modification as described in Section 6.2, above.

6.4 Control of Seepage During Construction

Seepage of free water from the upper transmissive zone (Layer B) may occur during initial excavations encountering this layer but are expected to dissipate as the sand layer drains of groundwater into surrounding excavations prior to installation of the underdrain system geocomposite. Seepage from the other geological layers is not expected. The temporary dewatering system is discussed in Section 6.3 and Appendix IIID-C. During liner 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 POR will inspect the seeps and delineate the area. Per the POR's direction, 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 backfilled 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 as specified in Section 2.3.5 of this LQCP.

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Hole Diameter of Pipe Perforation}} > 1.70$$

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. Required material properties shall meet the minimum requirements specified in Appendix IIID-C and Table 3-6 of the LQCP. 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 Table 3-6 of this LQCP 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. Delivery, testing, installation, and repairs shall be consistent with Section 3.6 of this LQCP.

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 and verify groundwater discharge at the pump outlet pipe. The pumps will be equipped with pressure transducers to control pump operation. All information generated associated with 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 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 estimated 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 estimated post-construction groundwater data as described in Section 6.2 will be used for ballast demonstration. 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.

6.6.1 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 or brush, 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.

6.7 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.

6.7.1 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.

6.7.2 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.

6.8 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 estimated 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 estimated 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 set forth in Appendix IIIE-A-5 during shear strength conformance testing. A geotechnical analysis of the landfill is presented in Appendix IIIE.

The testing outlined in Table 7-1 and Appendix IIIE-A-5 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 set forth in Appendix IIIE-A-5 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 IIIE.

Table 7-1
Recommended Strength for Various Parameters for Subtitle D Liner, Geotechnical Bottom Liner, and Overliner Components[1, 2]

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 IIIE-A. Refer to Appendix IIIE-A for detailed strength information and procedures for determining acceptable shear strength parameters during conformance testing.

2 Interface and material peak and residual strength values in above table are recommendations only. Actual shear strength values may vary. The adequacy of the interface and material shear strength values will be evaluated in accordance with the Appendix IIIE-A-5 Interface Shear Strength Conformance Testing Requirements.

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 Texas registered surveyor or professional engineer.

- 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, GCLER, 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.
- A BER will be prepared and signed and sealed by a professional engineer licensed to practice in Texas.

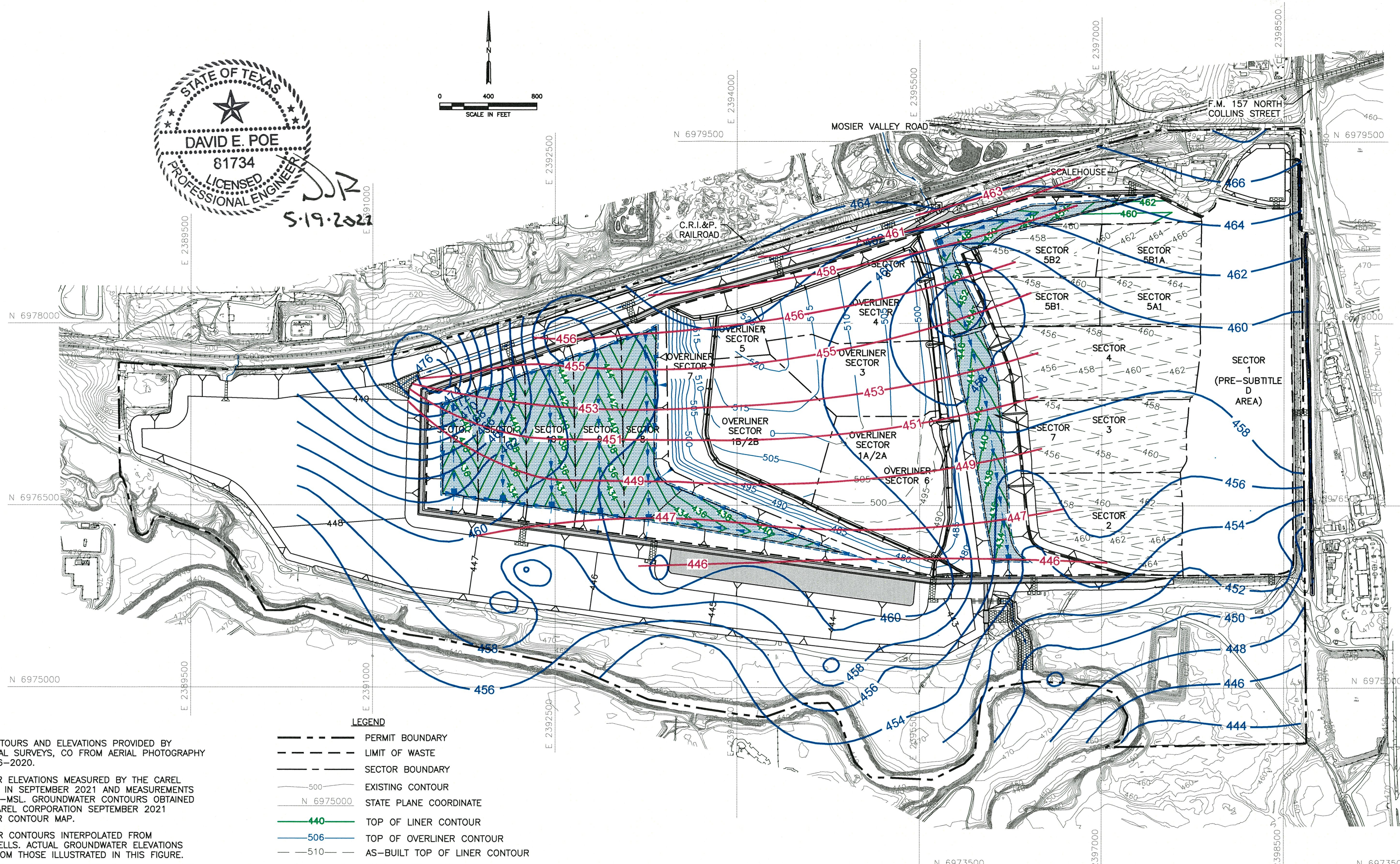
APPENDIX IIID-A

HIGHEST MEASURED GROUNDWATER INFORMATION

Includes Drawing IIID-A-1

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER

5-19-2022



NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. GROUNDWATER ELEVATIONS MEASURED BY THE CAREL CORPORATION IN SEPTEMBER 2021 AND MEASUREMENTS SHOWN IN FT-MSL. GROUNDWATER CONTOURS OBTAINED FROM THE CAREL CORPORATION SEPTEMBER 2021 GROUNDWATER CONTOUR MAP.
3. GROUNDWATER CONTOURS INTERPOLATED FROM MEASURED WELLS. ACTUAL GROUNDWATER ELEVATIONS MAY VARY FROM THOSE ILLUSTRATED IN THIS FIGURE.
4. THE ESTIMATED GROUNDWATER CONTOURS FOR THE BALLAST EVALUATION WERE DEVELOPED FROM THE UPSTREAM AND DOWNSTREAM INVERT ELEVATIONS OF THE DRAINAGE FEATURES THAT CUT OFF GROUNDWATER FLOW INTO AND BENEATH SECTORS 8 THROUGH 12. THE GROUNDWATER CONTOUR LINES SHOWN ARE ESTIMATED FROM THE UPSTREAM AND DOWNSTREAM DRAINAGE FEATURE ELEVATIONS.

LEGEND

	PERMIT BOUNDARY
	LIMIT OF WASTE
	SECTOR BOUNDARY
500	EXISTING CONTOUR
N 6975000	STATE PLANE COORDINATE
440	TOP OF LINER CONTOUR
506	TOP OF OVERLINER CONTOUR
510	AS-BUILT TOP OF LINER CONTOUR
	UNDERDRAIN COLLECTION PIPE
	UNDERDRAIN COLLECTION SUMP
	UNDERDRAIN RISER PIPE
	LIMITS OF UNDERDRAIN
450	HIGHEST MEASURED GROUNDWATER ELEVATION CONTOUR IN FT-MSL
450	ESTIMATED GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 4)

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: IIID-C-1-GROUNDWATER CONTOURS.DWG

DRAWN BY: RAA
DESIGN BY: DEP
REVIEWED BY: DEP/RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
HIGHEST ASSUMED
GROUNDWATER MAP

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIID-A-1

O:\0023\404\EXPANSION 2021\PART III\IIID\IIID-A-1 -HIGHEST ASSUMED GROUNDWATER MAP.dwg, jwilson, 1:2

APPENDIX IIID-B

EXAMPLE BALLAST THICKNESS CALCULATIONS

Includes pages IIID-B-1 through IIID-B-8

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

BALLAST THICKNESS CALCULATIONS

The ballast requirements evaluated in this appendix are based on the assumed groundwater contours shown on Drawing IIID-A-1. As shown on Drawing IIID-B-1, the groundwater contours are projected across the site to facilitate ballast calculations. As described in Section 6.2, the groundwater contours used for the underdrain design and ballast demonstration were estimated based on the post-construction grades of the surface drainage systems installed around the periphery of the future expansion areas. The required ballast shown on Drawing IIID-B-1 is established using the following two-step procedure.

1. The estimated groundwater contours shown on Drawing IIID-A-1 are utilized to estimate the uplift pressures shown for selected analysis points on Drawing IIID-B-1.
2. After Step 1 is complete, the actual ballast required to offset the hydraulic uplift pressures on the bottom liner is calculated as shown on Sheet IIID-B-7.

Based on the uniformity of both the bottom liner and the estimated groundwater contours across the site, the required elevation of waste for ballasting was calculated for the bottom liner only, anticipating that the adjacent sideslopes would be filled to a similar waste elevation for ballasting.

The evaluation points on Drawing IIID-B-1 correspond to the areas where the dewatering system is designed to be installed and ballast is necessary for long-term liner stability. The temporary dewatering system is designed to control groundwater until enough ballast is in place. The design of this system is presented in Appendix IIID-C.

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-5 through IIID-B-7. 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 estimated groundwater potentiometric surface elevations will be determined from the updated (post-construction) water level data as 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.

$P_{H2O}=\gamma_{H2O}*H$

where:

γ_{H2O} = unit weight of water (pcf)

H = vertical distance from the bottom of the liner (ft)

P_{H2O} = 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.

$\Sigma R_{i,v} = \Sigma(\gamma_i*T_{i,})$

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

$\Sigma R_{i,n}=\Sigma(\gamma_i*T_{i,n})$

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.

Required: Provide example calculations to be used to estimate the amount of ballast required for the floor of the liner prior to decommissioning the dewatering system.

Solution:

An example calculation using Evaluation Point No. 5 is shown below. A summary of the calculation results for the evaluation points on the floor of liner are presented on Sheet IIID-B-7. Drawing IIID-B-1 shows the location of the evaluation points and the top of waste elevation required for ballast at each evaluation point.

Definition of terms/variables:

E_{H2O} = Estimated potentiometric surface elevation, ft-msl
E_{liner} = Elevation of geomembrane/GCL liner, ft-msl
H = Maximum groundwater head above top of clay liner, ft
γ_{H2O} = Unit weight of water, pcf
P_{H2O} = Maximum uplift pressure created by groundwater head, psf
T_{pc} = Thickness of protective cover as ballast, ft
γ_{pc} = Unit weight of protective cover, pcf
E_{pc} = Elevation of top of protective cover, ft-msl
R_{pc} = Counteracting ballast pressure from protective cover, psf
FS_{pc} = Calculated factor of safety with protective cover installed
γ_{waste} = Unit weight of waste, lb/cy (Assumed to be 1,200 lb/cy per 30 TAC Section 330.337(h)(2))
T_{waste} = Required waste thickness needed for ballast, ft
E_{waste} = Required top of waste elevation needed for ballast, ft-msl
E_{fc} = Design top of final cover elevation, ft-msl (Refer to Appendix IIIA for the Completion Plan)
T_{fc} = Thickness of final cover including intermediate cover, ft
$E_{top\ waste}$ = Design top of waste elevation, ft-msl

Example calculation using Evaluation Point No. 5:

Parameters:

E_{H2O} =	450.8	ft-msl	γ_{waste} =	1,200	lb/cy
E_{liner} =	436.1	ft-msl	E_{fc} =	648.4	ft-msl
γ_{H2O} =	62.4	pcf	T_{fc} =	3.5	ft-msl
T_{pc} =	2.0	ft			
γ_{pc} =	120	pcf			

Calculate the maximum groundwater head above the top of geomembrane.

$H = E_{H20} - E_{liner}$

$H = 14.7$ ft

Calculate the maximum hydrostatic uplift pressure created by the groundwater head.

$P_{H20} = (\gamma_{H20} \times H)$

$P_{H20} = 917$ psf

Calculate the counteracting ballast pressure from the protective cover.

$R_{pc} = (\gamma_{pc} \times T_{pc})$

$R_{pc} = 240$ psf

Compare the uplift pressure to the ballast pressure by calculating the factor of safety with protective cover as ballast.

$FS_{pc} = R_{pc}/P_{H20} = 0.3$

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 offset the hydrostatic uplift pressure acting at the top of geomembrane. If the factor of safety were 1.2 or greater, 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.

Determine amount of additional ballast in the form of waste necessary to offset the hydrostatic uplift pressure acting at the top of clay liner. Use a factor of safety of 1.5 for protective cover and solid waste.

$T_{waste} = [(1.5 \times P_{H20}) - R_{pc}]/\gamma_{waste}$

$T_{waste} = 25.6$ ft

$E_{waste} = E_{liner} + T_{pc} + T_{waste}$

$E_{waste} = 463.7$ ft-msl

Check to verify that the required top of waste elevation is less than the design top of waste elevation.

$E_{top\ waste} = E_{fc} - T_{fc}$

$E_{top\ waste} = 644.9$ ft-msl

$E_{top\ waste} > E_{waste}$

$644.9 > 463.7$

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.

Unit Weight of Water = 62.4 pcf
Unit Weight of Protective Cover = 120 pcf
Unit Weight of Waste = 1200 pcy
Unit Weight of Final Cover = 120 pcf

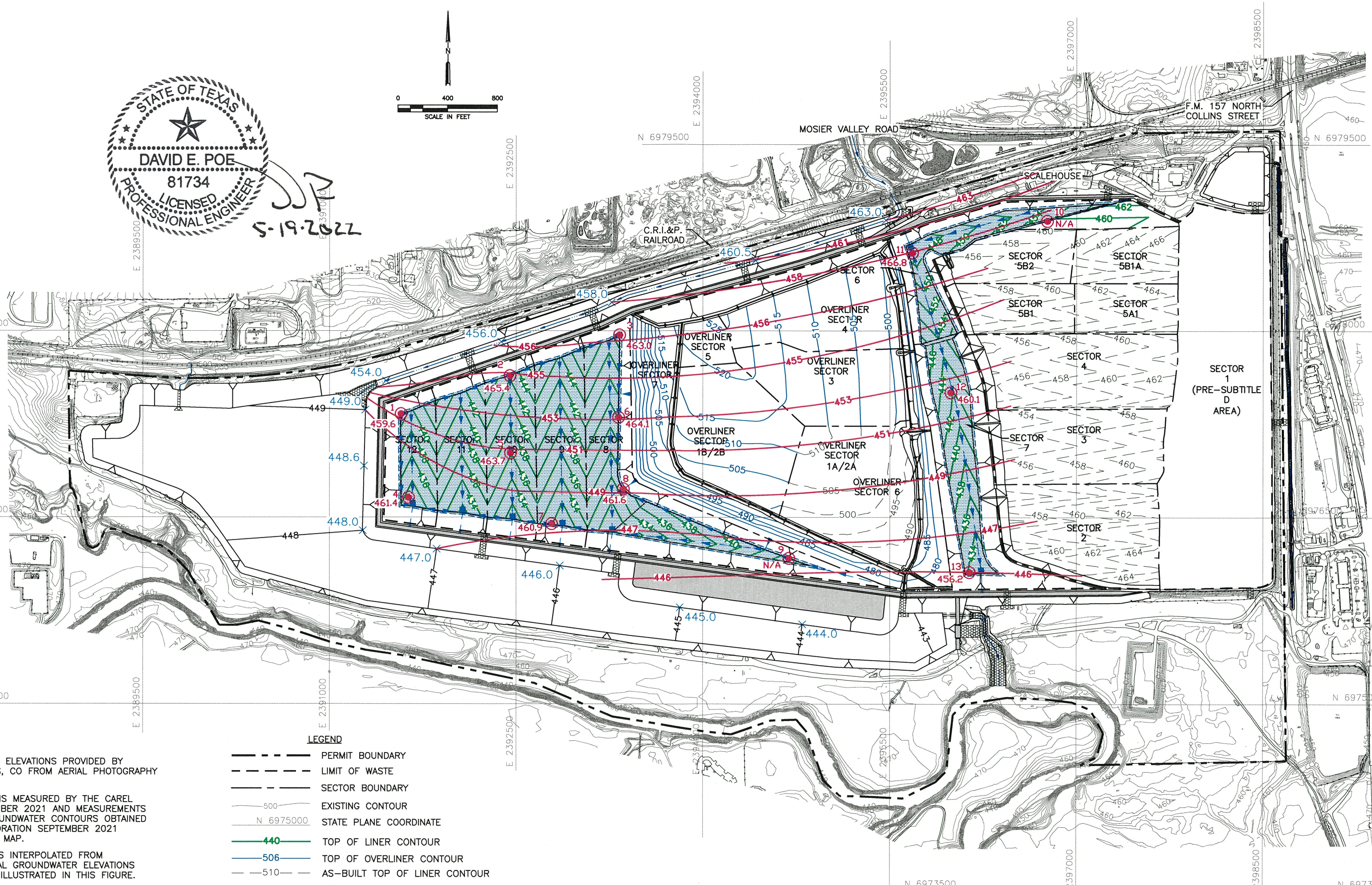
Thickness of Protective Cover - Normal = 2.0 ft
Thickness of Final Cover/Int Cover = 3.5 ft

Evaluation Point	Estimated Potentiometric Surface Elevation[2,3] E_{H20} (ft-msl)	Excavation Grade (GCL)[3] E_{liner} (ft-msl)	Maximum Groundwater Head Above Top of Clay Liner H (ft)	Maximum Uplift Pressure Created by Groundwater Head P_{H20} (psf)	Elevation of Top of Protective Cover E_{pc} (ft-msl)[3]	Counteracting Ballast Pressure from Protective Cover, R_{pc} (psf)	Calculated Factor of Safety with Protective Cover Installed FS_{pc}	Factor of Safety > 1.2?	Required Waste Thickness Needed for Ballast T_{waste} (ft)[1]	Required Top of Waste Elevation Needed for Ballast E_{waste} (ft-msl)	Design Top of Waste Elevation $E_{top\ waste}$ (ft-msl)	Required Waste Needed for Ballast Elevation < Design Top of Waste Elevation?
1	451.5	441.1	10.4	649	443.1	240	0.4	NO	16.5	459.6	511.5	YES
2	454.9	442.3	12.6	786	444.3	240	0.3	NO	21.1	465.4	510.3	YES
3	456.3	447.2	9.1	568	449.2	240	0.4	NO	13.8	463.0	507.2	YES
4	448.3	433.4	14.9	930	435.4	240	0.3	NO	26.0	461.4	530.7	YES
5	450.8	436.1	14.7	917	438.1	240	0.3	NO	25.6	463.7	648.4	YES
6	453.1	440.1	13.0	811	442.1	240	0.3	NO	22.0	464.1	661.2	YES
7	447.4	432.1	15.3	955	434.1	240	0.3	NO	26.8	460.9	520.2	YES
8	449.2	434.9	14.3	892	436.9	240	0.3	NO	24.7	461.6	608.5	YES
9	446.5	444.9	1.6	100	446.9	240	2.4	YES	N/A	N/A	515.1	N/A
10	457.6	455.9	1.7	106	457.9	240	2.3	YES	N/A	N/A	508.1	N/A
11	457.9	446.8	11.1	693	448.8	240	0.3	NO	18.0	466.8	525.2	YES
12	452.3	442.2	10.1	630	444.2	240	0.4	NO	15.9	460.1	751.4	YES
13	446.0	433.7	12.3	768	435.7	240	0.3	NO	20.5	456.2	516.6	YES

[1] The required waste thickness needed for ballast, T_{waste}, 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 in this calculation. In addition, ballast calculations will be adjusted for updated estimated potentiometric surface. The estimated potentiometric surface can only be adjusted upward.

[2] Refer to Section 6.2 for discussion on groundwater contours used for demonstration. Also see Drawing IIID-A-1 in Appendix IIID-A.

[3] Analysis performed for GCL bottom liner option only.



NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. GROUNDWATER ELEVATIONS MEASURED BY THE CAREL CORPORATION IN SEPTEMBER 2021 AND MEASUREMENTS SHOWN IN FT-MSL. GROUNDWATER CONTOURS OBTAINED FROM THE CAREL CORPORATION SEPTEMBER 2021 GROUNDWATER CONTOUR MAP.
3. GROUNDWATER CONTOURS INTERPOLATED FROM MEASURED WELLS. ACTUAL GROUNDWATER ELEVATIONS MAY VARY FROM THOSE ILLUSTRATED IN THIS FIGURE.
4. BALLAST EVALUATION POINT IS SHOWN WITH CALCULATED TOP OF WASTE ELEVATION REQUIRED FOR BALLASTING (FT-MSL).
5. THE ESTIMATED GROUNDWATER CONTOURS FOR THE BALLAST EVALUATION WERE DEVELOPED FROM THE UPSTREAM AND DOWNSTREAM INVERT ELEVATIONS OF THE DRAINAGE FEATURES THAT CUT OFF GROUNDWATER FLOW INTO AND BENEATH SECTORS 8 THROUGH 12. THE GROUNDWATER CONTOUR LINES SHOWN ARE ESTIMATED FROM THE UPSTREAM AND DOWNSTREAM DRAINAGE FEATURE ELEVATIONS.

LEGEND

	PERMIT BOUNDARY
	LIMIT OF WASTE
	SECTOR BOUNDARY
500	EXISTING CONTOUR
N 6975000	STATE PLANE COORDINATE
440	TOP OF LINER CONTOUR
506	TOP OF OVERLINER CONTOUR
510	AS-BUILT TOP OF LINER CONTOUR
	UNDERDRAIN COLLECTION PIPE
	UNDERDRAIN COLLECTION SUMP
	UNDERDRAIN RISER PIPE
	LIMITS OF UNDERDRAIN
451	ESTIMATED GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 5)
1 459.6	BALLAST EVALUATION POINT (SEE NOTE 4)
448.0 ×	SURFACE ELEVATION POINT

SHEET IIID-B-8

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DATE: 04/2022
FILE: 0023-404-11
CAD: IIID-C-1-GROUNDWATER CONTOURS.DWG

DRAWN BY: RAA
DESIGN BY: DEP
REVIEWED BY: DEP/RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
BALLAST EVALUATION POINTS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIID-B-1

0:\0023\404\EXPANSION 2021\PART III\IIID\IIID-B-1 -BALLAST EVALUATION POINTS.dwg, jwilson, 1:2

APPENDIX IIID-C

TEMPORARY DEWATERING SYSTEM DESIGN

Includes pages IIID-C-1 through IIID-C-61

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

TEMPORARY DEWATERING SYSTEM DESIGN

The site will have temporary underdrain dewatering system installed for the undeveloped areas, including Sectors 6 and 7 through 12. The Sector 6 analysis is presented separate of the Sectors 7 through 12 analysis in this appendix. The design used for the underdrain is summarized below.

- **Dewatering System for Sectors 6 and 7-12.** A double-sided geocomposite groundwater collection layer, collection trenches, and a collection sump will be used to intercept groundwater potentially contacting the bottom liner system. Any seepage occurring will be collected in the geocomposite layer and will drain to the collection trenches and the trenches will convey the liquid to sumps as shown on Drawing IIID-C-1. The 4 and 6-inch diameter groundwater collection pipes will drain to an 18-inch-diameter SDR17 riser pipe installed in each respective sump.

Any water collected in the sumps 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 for the landfill. The pumps will be activated upon installation of the dewatering systems 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 systems 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 plan of the required waste ballast depths across the future lined areas is provided as Drawing IIID-B-1.

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 of 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, removal of the underdrain system, 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 prior to implementation.

STATE OF TEXAS
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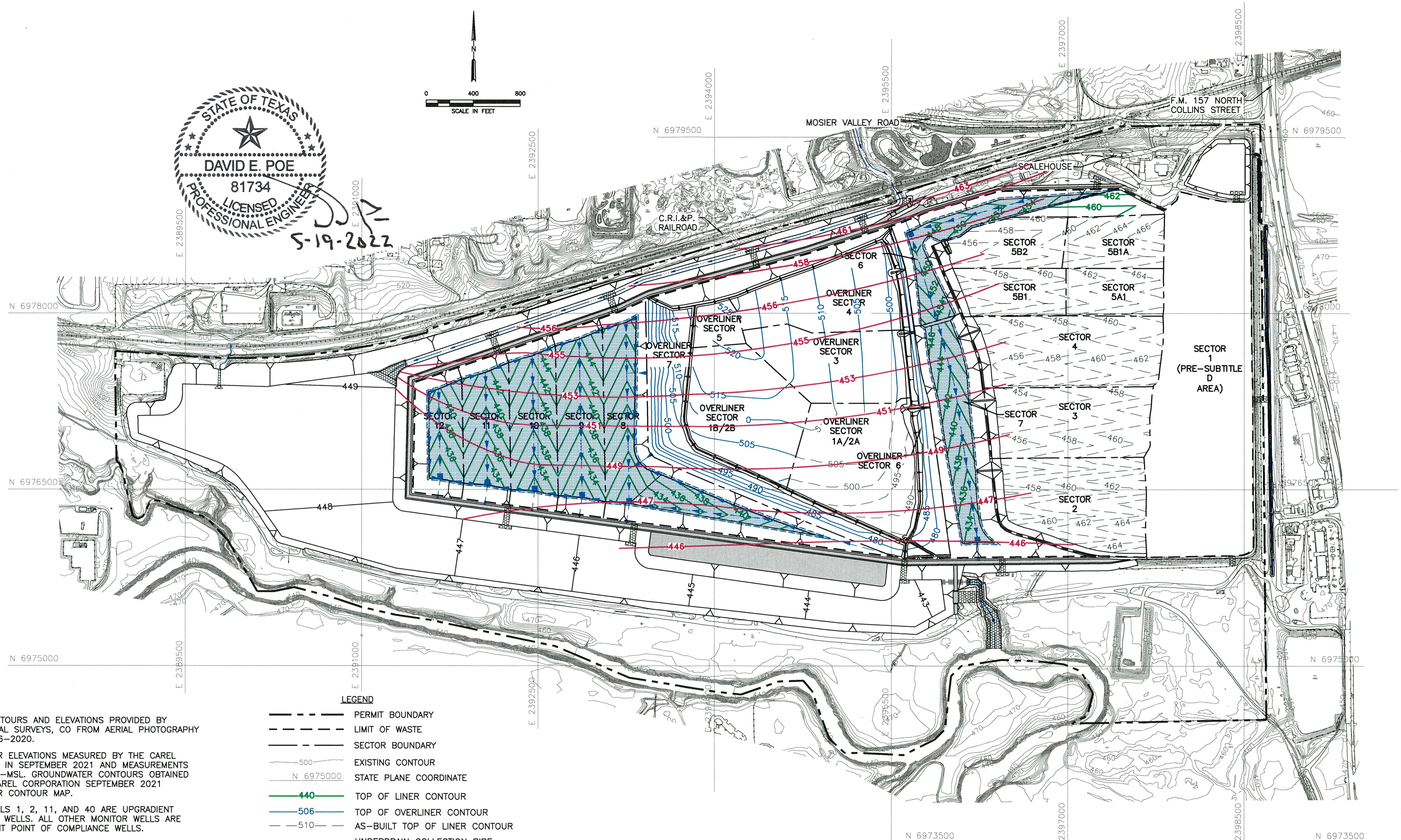
PROFESSIONAL ENGINEER
5-19-2022



NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. GROUNDWATER ELEVATIONS MEASURED BY THE CAREL CORPORATION IN SEPTEMBER 2021 AND MEASUREMENTS SHOWN IN FT-MSL. GROUNDWATER CONTOURS OBTAINED FROM THE CAREL CORPORATION SEPTEMBER 2021 GROUNDWATER CONTOUR MAP.
3. MONITOR WELLS 1, 2, 11, AND 40 ARE UPGRADIENT BACKGROUND WELLS. ALL OTHER MONITOR WELLS ARE DOWNGRADIENT POINT OF COMPLIANCE WELLS.
4. GROUNDWATER CONTOURS INTERPOLATED FROM MEASURED WELLS. ACTUAL GROUNDWATER ELEVATIONS MAY VARY FROM THOSE ILLUSTRATED IN THIS FIGURE.
5. THE ESTIMATED GROUNDWATER CONTOURS FOR THE BALLAST EVALUATION WERE DEVELOPED FROM THE UPSTREAM AND DOWNSTREAM INVERT ELEVATIONS OF THE DRAINAGE FEATURES THAT CUT OFF GROUNDWATER FLOW INTO AND BENEATH SECTORS 8 THROUGH 12. THE GROUNDWATER CONTOUR LINES SHOWN ARE ESTIMATED FROM THE UPSTREAM AND DOWNSTREAM DRAINAGE FEATURE ELEVATIONS.

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- SECTOR BOUNDARY
- 500 EXISTING CONTOUR
- N 6975000 STATE PLANE COORDINATE
- 440 TOP OF LINER CONTOUR
- 506 TOP OF OVERLINER CONTOUR
- 510 AS-BUILT TOP OF LINER CONTOUR
- UNDERDRAIN COLLECTION PIPE
- UNDERDRAIN COLLECTION SUMP
- UNDERDRAIN RISER PIPE
- LIMITS OF UNDERDRAIN
- 451 ESTIMATED GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 5)

SHEET IIID-C-1a

☐ DRAFT	
☒ FOR PERMITTING PURPOSES ONLY	
☐ ISSUED FOR CONSTRUCTION	
DATE: 05/2022	DRAWN BY: RAA
FILE: 0023-404-11	DESIGN BY: DEP
CAD: IIID-C-1-GROUNDWATER CONTOURS.DWG	REVIEWED BY: DEP/RJS

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
DEWATERING SYSTEM LAYOUT–GROUNDWATER CONTOURS

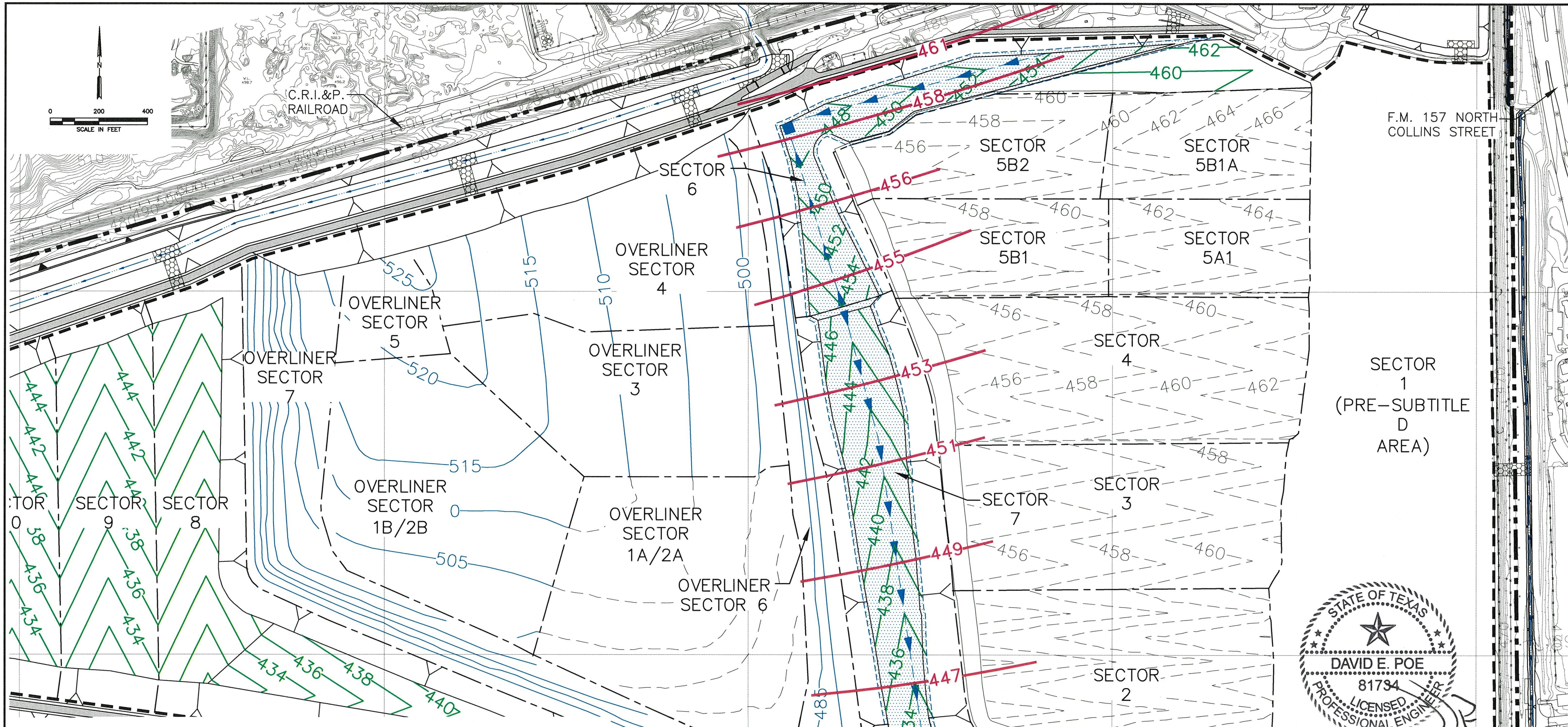
CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

WWW.WCGRP.COM

DRAWING IIID-C-1

O:\0023\404\EXPANSION 2021\PART III\IIID\IIID-C-1 GROUNDWATER CONTOURS.dwg, jwilson, 1:2



NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (e.g., CHANNELS) ARE TYPICALLY 3H:1V.
4. MINIMUM EXCAVATION ELEVATION AT UNDERDRAIN SUMP IS 440.3 FT-MSL.
5. THE ESTIMATED GROUNDWATER CONTOURS FOR THE BALLAST EVALUATION WERE DEVELOPED FROM THE UPSTREAM AND DOWNSTREAM INVERT ELEVATIONS OF THE DRAINAGE FEATURES THAT CUT OFF GROUNDWATER FLOW INTO AND BENEATH SECTORS 8 THROUGH 12. THE GROUNDWATER CONTOUR LINES SHOWN ARE ESTIMATED FROM THE UPSTREAM AND DOWNSTREAM DRAINAGE FEATURE ELEVATIONS.

LEGEND

	PERMIT BOUNDARY
	LIMIT OF WASTE
	PRE-SUBTITLE D LIMIT OF WASTE
500	EXISTING CONTOUR
N 6975000	STATEPLANE COORDINATE SYSTEM
430	PROPOSED EXCAVATION CONTOUR
520	PROPOSED TOP OF OVERLINER CONTOUR
	UNDERDRAIN COLLECTION PIPE
	UNDERDRAIN COLLECTION SUMP
	LIMITS OF UNDERDRAIN
451	ESTIMATED GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 5)

SHEET IIID-C-1b

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: IIID-C-2-SECTORS 6 AND 7.DWG

DRAWN BY: RAA
DESIGN BY: DEP
REVIEWED BY: DEP

PREPARED FOR
CITY OF ARLINGTON
AND
REPUBLIC WASTE SERVICES OF TEXAS, LTD

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT DEWATERING SYSTEM LAYOUT SECTORS 6 AND 7

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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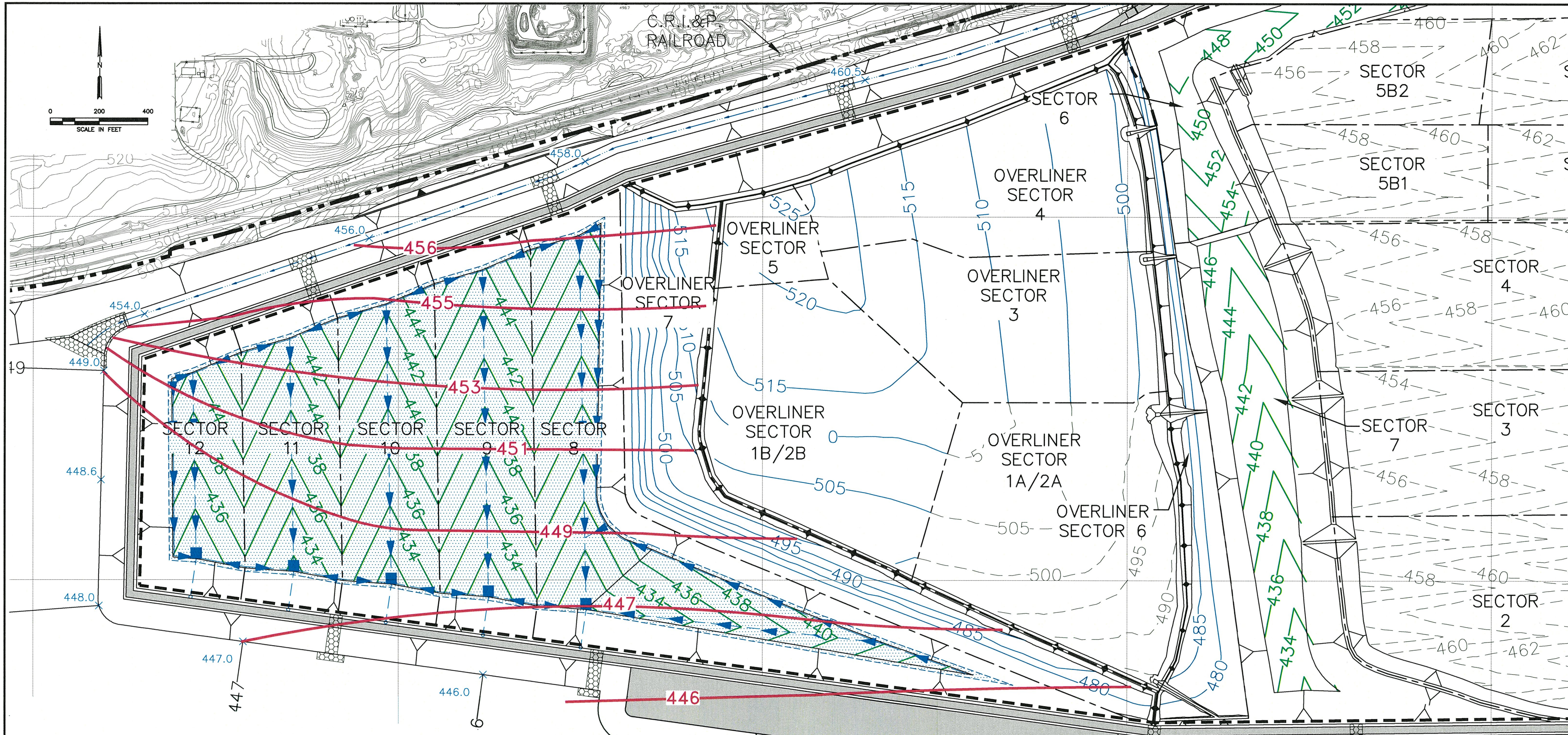
SHEET IIID-C-2



NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (e.g., CHANNELS) ARE TYPICALLY 3H:1V.
3. ELEVATION of DEEPEST EXCAVATION AT THE LCS SUMP IS 424.5 FT-MSL.
4. THE ESTIMATED GROUNDWATER CONTOURS FOR THE BALLAST EVALUATION WERE DEVELOPED FROM THE UPSTREAM AND DOWNSTREAM INVERT ELEVATIONS OF THE DRAINAGE FEATURES THAT CUT OFF GROUNDWATER FLOW INTO AND BENEATH SECTORS 8 THROUGH 12. THE GROUNDWATER CONTOUR LINES SHOWN ARE ESTIMATED FROM THE UPSTREAM AND DOWNSTREAM DRAINAGE FEATURE ELEVATIONS.

LEGEND

	PERMIT BOUNDARY
	LIMIT OF WASTE
	SECTOR BOUNDARY
500	EXISTING CONTOUR
N 6975000	STATE PLANE COORDINATE
440	TOP OF LINER CONTOUR
506	TOP OF OVERLINER CONTOUR
510	AS-BUILT TOP OF LINER CONTOUR
	UNDERDRAIN COLLECTION PIPE
	UNDERDRAIN COLLECTION SUMP
	UNDERDRAIN RISER PIPE
	LIMITS OF UNDERDRAIN
451	ESTIMATED GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 4)
448.0 ×	SURFACE ELEVATION POINT

STATE OF TEXAS
DAVID E. POE
81734
LICENSED PROFESSIONAL ENGINEER
5-19-2022

SHEET IIID-C-1c

☐ DRAFT
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☐ ISSUED FOR CONSTRUCTION

DATE: 05/2022
FILE: 0023-404-11
CAD: IIID-C-3-SECTORES 8-12.DWG

DRAWN BY: RAA
DESIGN BY: DEP
REVIEWED BY: DEP

PREPARED FOR
CITY OF ARLINGTON
AND
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REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
DEWATERING SYSTEM LAYOUT
SECTORS 8-12
CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIID-C-3

O:\0023\404\EXPANSION 2021\PART III\IIID\IIID-C-3 -GW CONTOURS SECTORS 8-12.dwg, jwilson, 1:2

TEMPORARY DEWATERING SYSTEM DESIGN

CITY OF ARLINGTON LANDFILL
APPENDIX IIID-C
TEMPORARY UNDERDRAIN DEWATERING SYSTEM GEOCOMPOSITE AND PIPING ANALYSIS (ALL SECTORS)

Required

The purpose of these calculations is to demonstrate the adquacy of the cell floor and cell sideslope temporary underdrain dewatering systems proposed for Sector 6, and Sectors 7 through 12. The demonstration for Sector 6 is made separate of the demonstration for Sectors 7-12.

The underdrain systems are designed to provide hydrostatic pressure relief below the Subtitle D composite liner for the areas excavated below the groundwater table as shown on Drawings IIID-C-1, IIID-C-2 and IIID-C-3.

Assumptions - Sideslopes

For the 3H:1V cell sideslopes the calculations were performed assuming a 15 foot groundwater table acting on the 3H:1V sideslope liners. A slope length of 50 feet was assumed for the 3H:1V slopes.

For the cell sideslope analysis it was assumed that the entire sideslope exposes the Stratum D - Transmissive Zone, as described in the Appendix IIIG - Geology Report. This is a highly conservative assumption based on the sporatic presence of Stratum D at or below the excavation grades. The geometric mean horizontal hydraulic conductivity was used for the analysis.

The overburden pressure causing compression of the geocomposite layer for the slideslope analysis and Sector 6 analysis was limited to approximaely 2 times the perched groundwater hydrostatic pressure (1,910 psf) acting on the bottom liner that requires ballasting. Additional compression of the geocomposite resulting from overburden pressure greater than the required ballasting pressure was not considered for the demonstration.

Assumptions - Cell Floor Analysis (Sectors 7-12)

For the Sector 7-12 cell floors, the analysis was performed for Sector 9 as being representative of these cells.

For the Sectors 7-12 cell floor analysis, it was assumed that the cell excavations penetrate Strata A, B and are founded in Strata C, D and E (weathered shale, transmissive sandstone, and unweathered shale). An average of the geometric mean vertical hydraulic conductivities for Strata C, D and E (as obtained from Appendix IIIG - Geology Report) was used for the analysis.

The overburden pressure causing compression of the geocomposite layer for the cell floor underdrain was calculated using an assumed maximum interim fill height of approximately 100 feet of waste over the cell floor (or 7,760 psf), which exceeds the required ballasting pressure.

Assumptions - Sector 6 Analysis

For the Sector 6 analysis, it was assumed that the cell excavations are founded in Stratum B, and the vertical permeability of the stratum (as obtained from Appendix IIIG - Geology Report) was used for the analysis.

CITY OF ARLINGTON LANDFILL
APPENDIX IIID-C
TEMPORARY UNDERDRAIN DEWATERING SYSTEM
GEOCOMPOSITE AND
PIPING ANALYSIS (ALL SECTORS)

Method

1. Estimate the hydraulic conductivity of the foundation soils based on strata identified in the Appendix IIIG - Geology Report
2. Estimate the flow into the geocomposite drainage layer.
3. Determine the flow capacity of the geocomposite drainage layer.
4. Compare geocomposite flow capacity with inflow to determine suitability of selected geocomposite.
5. Estimate the flow into the dewatering pipe.
6. Determine the flow capacity of the dewatering pipe.
7. Determine required pipe perforation based on characteristics of the surrounding drainage media.
8. Evaluate the storage capacity and pump cycling for the sump.

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. GSE Drainage Design Manual, May 2004.
5. *Dewatering and Groundwater Control,* TM5-818-5, November 1983.
6. Phillips 66 Driscopipe, System Design, 1991.
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.
8. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
9. Geosynthetic Institute, GRI Standard GC-8, 2001.

Solution

1. Estimate the flow into the geocomposite drainage layer - Landfill Sideslope (Sectors 7-12)

The maximum flow length of dewatering geocomposite on the sideslope to a toe trench is approximately 50 feet (based on a 15-foot perched groundwater table within the cell and against the 3H:1V sideslopes). This assumes that the sideslope underdrain dewatering layer discharges into a toe drain installed at the toe of the sideslope.

$Q = kiA$

where:

- Q = groundwater inflow rate into geocomposite (cfs/ft)
- k = For the cell sideslope analysis it was assumed that the entire sideslope exposes the Stratum D - Transmissive Zone, as described in the Appendix IIIG - Geology Report. This is a highly conservative assumption based on the sporatic presence of Stratum D at or below the excavation grades. The geometric mean horizontal hydraulic conductivity was used for the analysis.
- i = gradient (ft/ft). For the sideslope calcuations and perched groundwater conditions, it was assumed that the gradient is represented by the 3H:1V slope that bisects the groundwater table.
- L= maximum flow length (ft) on sideslope
- A = inflow area (sf) (area per unit width of dewatering)

k =	3.80E-06	cm/s =	1.25E-07	ft/s
i =	0.33	ft/ft		
L=	50	ft		
A =	50	sf (Maximum flow length multiplied by a unit width of 1 foot)		

$Q_{max, sideslope}$ = 2.06E-06 cfs/ft width of geocomposite

2. Determine the flow capacity of the geocomposite drainage layer - Landfill Sideslope (Sectors 7-12)

Assume the geocomposite leachate collection layer will undergo compression due to the weight of liner, protective cover, and waste.

Unloaded Geocomposite Thickness (200 mil) =	0.20	in
Unit Weight of Soil =	120	pcf

Table 1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Grading, Liner and LCS Layers Installed	0	5.5	120	660	0.199	0.0051
Waste Thickness - Sideslope (see Note 4 below)	25	5.5	50	1,910	0.192	0.0049

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

[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite underdrain 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 underdrain collection layer due to the weight of the waste and soil. This value has been back-calculated into a value representative of approximately 30 feet hydraulic uplift (2X actual value of 15 feet) acting on sideslope liner system.

[5] t is the thickness of the geocomposite underdrain collection layer after being subjected to compression based on the chart below adapted from Reference 7.

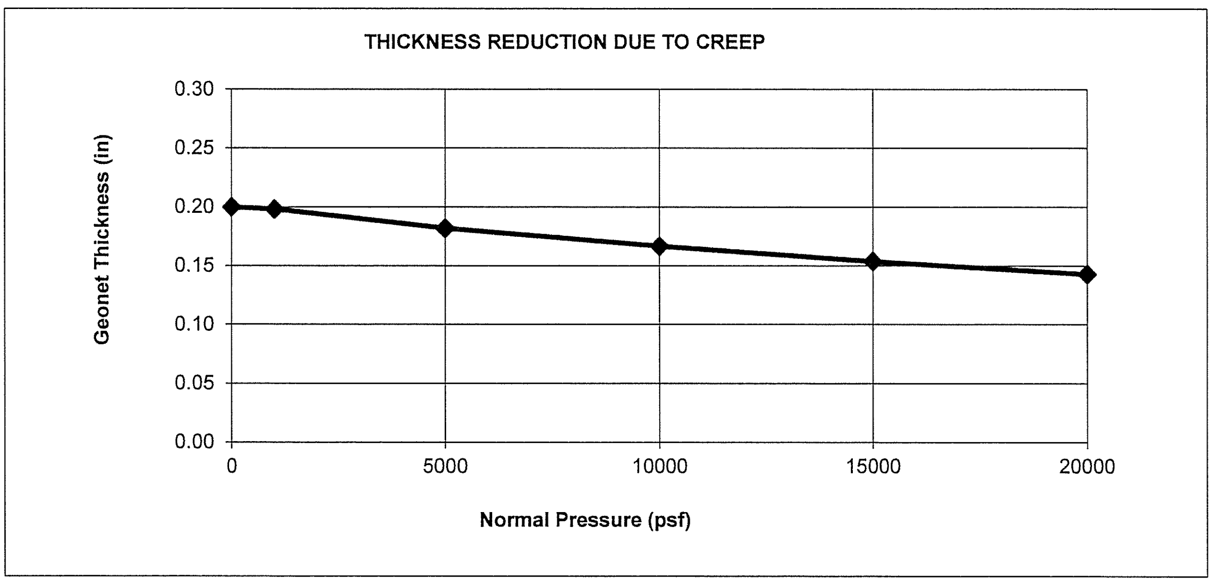


Table 2 - Reduction Factors and Factor of Safety (Sideslopes)

Reduction Factors[1]		Fill Condition: Liner Protective Cover Installed	Fill Condition: Maximum Waste Column in Place
RF_{IN}	Delayed Intrusion	1.0	1.2
RF_{CC}	Chemical Clogging	1.0	1.1
RF_{BC}	Biological Clogging	1.0	1.0
Total Reduction Factor[2]		1.00	1.32
Overall Factor of Safety to Account For Uncertainties		2.0	2.0
FS Factor[3]		2.00	2.64

[1] Values are obtained from References 3, 8, and 9.

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

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

[4] Chemical and biological clogging are assumed neglible due to short time underdrain utilized prior to ballasting. Some minor chemical clogging may occur over time due to groundwater mineralization.

Manufacturer's Transmissivity Data

The required minimum transmissivity for the 200-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown in table below. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites evaluated by WCG in the US.

Compute the design transmissivity (T) of the geocomposite.

Table 3 - Design Transmissivity (Sideslopes)

Fill Condition	t[1] (in)	T[2] (m^2/s)	FS Factor[3]	T_{DES}[4] (m^2/s)	T_{DES} (cfs/ft)
Liner and Protective Cover Installed	0.199	3.00E-04	2.00	1.50E-04	1.61E-03
Maximum Waste Thickness as Ballast	0.192	2.50E-04	2.64	9.47E-05	1.02E-03

[1] t is the calculated geocomposite thickness from Table 1.

[2] T is the transmissivity values obtained from review of representative geocomposite products similar to proposed for project. Representative transmissivity values for 200-mil geocomposite shown on Sheet IIID-C-21.

[3] FS Factor is the product of the factors of safety from Table 2.

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

$$T_{DES} = T \ / \ (\text{FS Factor})$$

Design Flow Capacity

Unit Width of Geocomposite in dewatering: 1 ft

From Tables 3A and 3B above, the minimum design transmissivity of the geocomposite drainage layer is:

$Q_{design,\ sideslope}$ = 1.02E-03 cfs/ft

$Q_{max,\ sideslope}$ = 2.06E-06 cfs/ft

The flow capacity of the 200 mil geocomposite ($Q_{design,\ sideslope}$) is significantly greater than the estimated flow of groundwater into the geocomposite ($Q_{max,\ sideslope}$). Therefore the design use of 200-mil geocomposite for the sideslope installation is acceptable.

3. Estimate the flow into the dewatering pipe - Sideslope (Sectors 7-12)

$$Q = kiA$$

where:

Q =	inflow rate (cfs/ft)	
k =	hydraulic conductivity (cm/s)	
i =	gradient (ft/ft)	
A =	largest area flowing to a dewatering pipe (sf)	

k =	3.80E-06	cm/s	
	1.25E-07	ft/s	
i =	0.33	ft/ft	
A =	3,000	sf	(200 ft slope length x 50 ft slope)

$Q_{max,\ sideslope}$ =	1.23E-04	cfs

4. Determine the flow capacity of the dewatering pipe (Sector 7-12 Sideslope Toe Drain).

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

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

S = Design slope of pipe (2%) S = 0.02 ft / ft
n = Manning's number n = 0.009 from Ref. 6

Q_{full} =	0.38	cfs
=	171	gpm

$Q_{max,\ sideslope}$ =	1.23E-04	cfs (from Step 3)
=	0.055	gpm

The flow capacity of the 4-inch-diameter pipe (171 gpm) is significantly larger than the maximum calculated flow from the geocomposite (0.055 gpm) into the toe dewatering pipe. Note also that these calculations do not account for the future dewatering of the Stratum D or absence of Stratum D, which may greatly reduce flow into the underdrain system.

5. **Estimate the flow into the geocomposite drainage layer - Sectors 7-12 Floor**

The maximum flow length of dewatering geocomposite on the cell floor (from edge of cell to the cell centerline) is approximately 220 feet. This assumes that the cell floor underdrain discharges into a drainage pipe installed down the centerline of each cell, as shown on Figure IIID-C-3.

$Q = kiA$

where:

Q = groundwater inflow rate into geocomposite (cfs/ft)
k = hydraulic conductivity (cm/s) was assumed as the average of the geometric mean vertical hydraulic conductivity values from the previous field and laboratory tests referenced in Appendix IIIG - Geology Report for Strata C, D and E (weathered shale, transmissive sandstone, and unweathered shale).

Q = groundwater inflow rate into geocomposite (cfs/ft)
k = hydraulic conductivity (cm/s) was assumed as the average of the
i = gradient (ft/ft)
The gradient is determined as follows:
$T_{aquifer}$ = thickness of water bearing zone, ft (bottom of excavation minus bottom of water bearing zone)
H_{H2O} = height of groundwater from bottom of water bearing zone, ft (the groundwater surface during dewatering is within the drainage geocomposite)
During dewatering it is assumed that H_{H2O} is equal to $T_{aquifer}$.

$$i = \frac{T_{aquifer}}{H_{H2O}} = 1$$

slope that bisects the groundwater table.

L= maximum flow length (ft) on sideslope
A = inflow area (sf) (area per unit width of dewatering)

k =	5.53E-08	cm/s =	1.81E-09	ft/s
i =	1.00	ft/ft		
L=	220	ft		
A =	220	sf (Maximum flow length multiplied by a unit width of 1 foot)		

	$Q_{max, floor}$ = 3.99E-07 cfs/ft width of geocomposite

6. Determine the flow capacity of the geocomposite drainage layer - Sectors 7-12 Cell Floor

Assume the geocomposite leachate collection layer will undergo compression due to the weight of liner, protective cover, and waste.

Unloaded Geocomposite Thickness (200 mil) = 0.20 in
Unit Weight of Soil = 120 pcf

Table 1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Grading, Liner and LCS Layers Installed	0	5.5	120	660	0.199	0.0051
Waste Thickness - Cell Bottom (see Note 4 below)	100	5.5	71	7,760	0.172	0.0044

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

[2] d_S is the depth of soil (clay liner, protective cover, and intermediate cover above the geocomposite underdrain 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 underdrain collection layer due to the weight of the waste and soil for an interim condition of 100 feet of waste installed over the cell.

[5] t is the thickness of the geocomposite underdrain collection layer after being subjected to compression based on the chart below adapted from Reference 7.

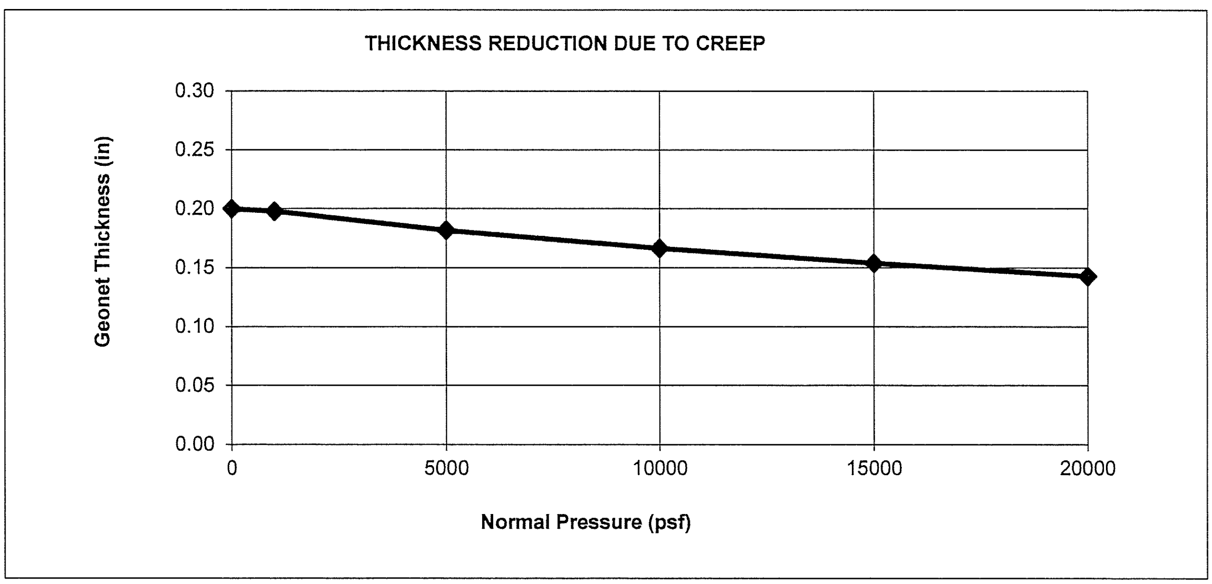


Table 2 - Reduction Factors and Factor of Safety (Cell Floor)

Reduction Factors[1]		Fill Condition: Liner Protective Cover Installed	Fill Condition: Maximum Waste Column in Place
RF_{IN}	Delayed Intrusion	1.0	1.2
RF_{CC}	Chemical Clogging	1.0	1.1
RF_{BC}	Biological Clogging	1.0	1.0
Total Reduction Factor[2]		1.00	1.32
Overall Factor of Safety to Account For Uncertainties		2.0	2.0
FS Factor[3]		2.00	2.64

[1] Values are obtained from References 3, 8, and 9.

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

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

[4] Chemical and biological clogging are assumed neglible due to short time underdrain utilized prior to ballasting. Some minor chemical clogging may occur over time due to groundwater mineralization.

Manufacturer's Transmissivity Data

The required minimum transmissivity for the 200-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown in table below. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites evaluated by WCG in the US.

Compute the design transmissivity (T) of the geocomposite.

CITY OF ARLINGTON LANDFILL
APPENDIX IIID-C
TEMPORARY UNDERDRAIN DEWATERING SYSTEM
TYPICAL CELL FLOOR GEOCOMPOSITE AND PIPING ANALYSIS (SECTORS 7-12)

Table 3 - Design Transmissivity (Cell Floor)

Fill Condition	t[1] (in)	T[2] (m^2/s)	FS Factor[3]	T_{DES}[4] (m^2/s)	T_{DES} (cfs/ft)
Liner and Protective Cover Installed	0.199	3.00E-04	2.00	1.50E-04	1.61E-03
Maximum Waste Thickness as Ballast	0.172	1.50E-04	2.64	5.68E-05	6.12E-04

[1] t is the calculated geocomposite thickness from Table 1.

[2] T is the transmissivity values obtained from review of representative geocomposite products similar to proposed for project. Representative transmissivity values for 200-mil geocomposite shown in the graph on Sheet IIID-C-21.

[3] FS Factor is the product of the factors of safety from Table 2.

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

$$T_{DES} = T \,/\, (\text{FS Factor})$$

Design Flow Capacity

Unit Width of Geocomposite in dewatering: 1 ft

From Tables 3A and 3B above, the minimum design transmissivity of the geocomposite drainage layer is:

$Q_{design,floor}$ = 6.12E-04 cfs/ft

$Q_{max,\ floor}$ = 3.99E-07 cfs/ft

The flow capacity of the 200 mil geocomposite (Qdesign, floor) is significantly greater than the estimated flow of groundwater into the geocomposite (Qmax, floor). Therefore the design use of 200-mil geocomposite for the cell floor installation is acceptable.

7. Estimate the flow into the dewatering pipe - Cell Floor (Cell 9 used for calculations)

Q =kiA

where:

	Q =	inflow rate (cfs/ft)
	k =	hydraulic conductivity (cm/s)
	i =	gradient (ft/ft)
	A =	largest area flowing to a dewatering pipe (sf)

Cell Floor:

k =	5.53E-08	cm/s	
	1.81E-09	ft/s	
i =	1	ft/ft	
A =	540,000	sf	(12.4 acres, entire Sector 9 floor)

Cell Sideslope (discharges into cell floor drainage pipe):

k =	3.80E-06	cm/s	
	1.25E-07	ft/s	
i =	0.33	ft/ft	
A =	6,000	sf	(6,000 feet of sideslope)

$Q_{max,\ floor}$ =	9.80E-04	cfs
$Q_{max,\ sideslope}$ =	2.47E-04	cfs
$Q_{max,\ floor\ +\ sideslope}$ =	1.23E-03	cfs
=	0.6	gpm

0.550486772

8. Determine the flow capacity of the dewatering 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

Using a 6-inch SDR 17 pipe: ID = 5.85 in
= 0.488 ft

$A = \frac{(\pi \times d^2)}{4}$ A = 0.187 sq ft

R = d / 4 R = 0.122 ft

S = Design slope of pipe (2%) S = 0.02 ft / ft
n = Manning's number n = 0.009 from Ref. 6

Q_{full} =	1.07	cfs
=	481	gpm

$Q_{max,\ floor\ +\ sideslope}$ =	0.001	cfs (from Step 3)
=	0.6	gpm

The flow capacity of the 6-inch-diameter pipe (481 gpm) is significantly larger than the maximum calculated flow from the geocomposite (0.6 gpm) into the cell underdrain centerline drainage pipe.

9. <u>Determine required pipe perforation based on characteristics of the surrounding drainage media (for all underdrain piping).</u>

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. Alternative stone gradations may be selected at time of design based on calculations performed for selected stone.

<u>For dewatering pipes with circular holes:</u>

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} > 1.0$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is a minimum ASTM D number 57 aggregate

D_{85} = 19 mm
= 0.748 in

Hole diameter d = 0.5 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 1.5 > 1.0 \quad \text{(acceptable)}$$

10. Conclusions (Cell bottom and sideslope underdrain geocomposite and piping - Sectors 7-12)

1. The proposed 200-mil geocomposite provides sufficient groundwater flow capacity for the worst-case scenario calculated for the cell floors and sideslopes. The analysis considered the effects of creep, as well as environmental effects of the underdrain system.

2. The proposed 4-inch-diameter toe drainage pipe (SDR-17) provides greater discharge capacity than calculated for a single sideslope draining into the slope toe trench. The 6-inch-diameter centerline cell floor drainage pipe (SDR-17) provides greater discharge capacity than calculated for the cell floor and sideslope combined.

3. Pipe perforations proposed for the pipe are acceptable based on a Grade 57 stone. Actual stone sizes and perforation sizes can be evaluated independently during cell design. Use of alternative stone meeting the criteria is acceptable.

4. Representative pipe stability calculations (crushing, buckling and ring deflection) for the 4, 6, and 18-inch-diameter SDR 17 pipe are presented on sheets IIID-C-25 through IIID-C-61 of this appendix. The calculations demonstrate that the SDR 17 pipe remains stable for the worst case conditions estimated for this temporary installation.

1. Estimate the flow into the geocomposite drainage layer - Floor and Sideslope (Sector 6 only)

The maximum flow length of dewatering geocomposite on the cell floor (from edge of cell to the cell centerline) is approximately 130 feet, which includes 50 feet up the 3H:1V sideslope (calculated as a single surface). This assumes that the cell floor underdrain discharges into a drainage pipe installed down the centerline of the cell, as shown on Figure IIID-C-2.

$Q = kiA$

where:

Q = groundwater inflow rate into geocomposite (cfs/ft)
k = hydraulic conductivity (cm/s) was assumed as the geometric mean vertical hydraulic conductivity value from the previous field and laboratory tests referenced in Appendix IIIG - Geology Report for Strata B (upper transmissive zone).

Q = groundwater inflow rate into geocomposite (cfs/ft)
k = hydraulic conductivity (cm/s) was assumed as the average of the arithmetic
i = gradient (ft/ft)
The gradient is determined as follows:
$T_{aquifer}$ = thickness of water bearing zone, ft (bottom of excavation minus bottom of water bearing zone)
H_{H2O} = height of groundwater from bottom of water bearing zone, ft (the groundwater surface during dewatering is within the drainage geocomposite)
During dewatering it is assumed that H_{H2O} is equal to $T_{aquifer}$.

$$i = \frac{T_{aquifer}}{H_{H2O}} = 1$$

slope that bisects the groundwater table.

L= maximum flow length (ft) on sideslope
A = inflow area (sf) (area per unit width of dewatering)

k =	7.10E-06	cm/s =	2.33E-07	ft/s
i =	1.00	ft/ft		
L=	130	ft		
A =	130	sf' (Maximum flow length multiplied by a unit width of 1 foot)		

	$Q_{max, sector\ 6}$ =	3.03E-05	cfs/ft width of geocomposite

2. Determine the flow capacity of the geocomposite drainage layer - Floor and Sideslopes

Assume the geocomposite leachate collection layer will undergo compression due to the weight of liner, protective cover, and waste.

Unloaded Geocomposite Thickness (200 mil) = 0.20 in
Unit Weight of Soil = 120 pcf

Table 1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Grading, Liner and LCS Layers Installed	0	5.5	120	660	0.199	0.0051
Waste Thickness - Cell Bottom (see Note 4 below)	25	5.5	50	1,910	0.192	0.0049

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

[2] d_S is the depth of soil (clay liner, protective cover, and intermediate cover above the geocomposite underdrain 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 underdrain collection layer due to the weight of the waste and soil. This value has been back-calculated into a value representative of approximately 30 feet hydraulic uplift (2X actual value of 15 feet) acting on Sector 6 liner system.

[5] t is the thickness of the geocomposite underdrain collection layer after being subjected to compression based on the chart below adapted from Reference 7.

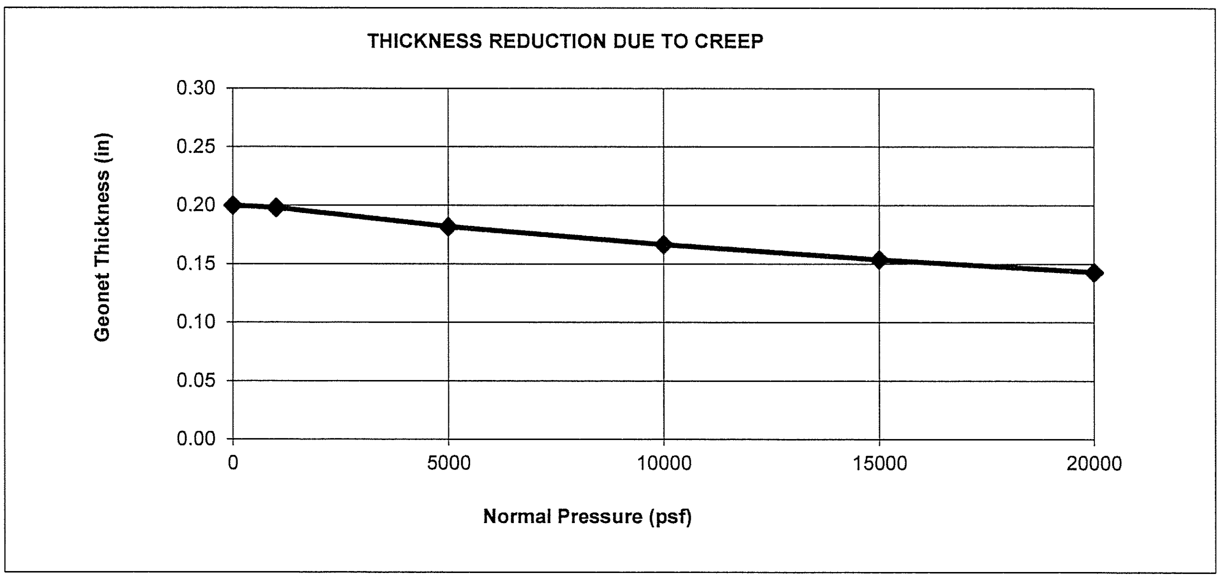


Table 2 - Reduction Factors and Factor of Safety (Sector 6)

Reduction Factors[1]		Fill Condition: Liner Protective Cover Installed	Fill Condition: Maximum Waste Column in Place
RF_{IN}	Delayed Intrusion	1.0	1.2
RF_{CC}	Chemical Clogging	1.0	1.1
RF_{BC}	Biological Clogging	1.0	1.0
Total Reduction Factor[2]		1.00	1.32
Overall Factor of Safety to Account For Uncertainties		2.0	2.0
FS Factor[3]		2.00	2.64

[1] Values are obtained from References 3, 8, and 9.

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

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

[4] Chemical and biological clogging are assumed neglible due to short time underdrain utilized prior to ballasting. Some minor chemical clogging may occur over time due to groundwater mineralization.

Manufacturer's Transmissivity Data

The required minimum transmissivity for the 200-mil-thick double-sided geocomposite with a 6 oz/sy geotextile is shown in table below. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites evaluated by WCG in the US.

Compute the design transmissivity (T) of the geocomposite.

Table 3 - Design Transmissivity (Sector 6)

Fill Condition	t^1 (in)	T^2 (m^2/s)	FS Factor[3]	$T_{DES}{}^4$ (m^2/s)	T_{DES} (cfs/ft)
Liner and Protective Cover Installed	0.199	3.00E-04	2.00	1.50E-04	1.61E-03
Maximum Waste Thickness as Ballast	0.192	2.50E-04	2.64	9.47E-05	1.02E-03

[1] t is the calculated geocomposite thickness from Table 1.

[2] T is the transmissivity values obtained from review of representative geocomposite products similar to proposed for project. Representative transmissivity values for 200-mil geocomposite shown on Sheet IIID-C-21.

[3] FS Factor is the product of the factors of safety from Table 2.

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

$$T_{DES} = T \,/\, (\text{FS Factor})$$

Design Flow Capacity

Unit Width of Geocomposite in dewatering: 1 ft

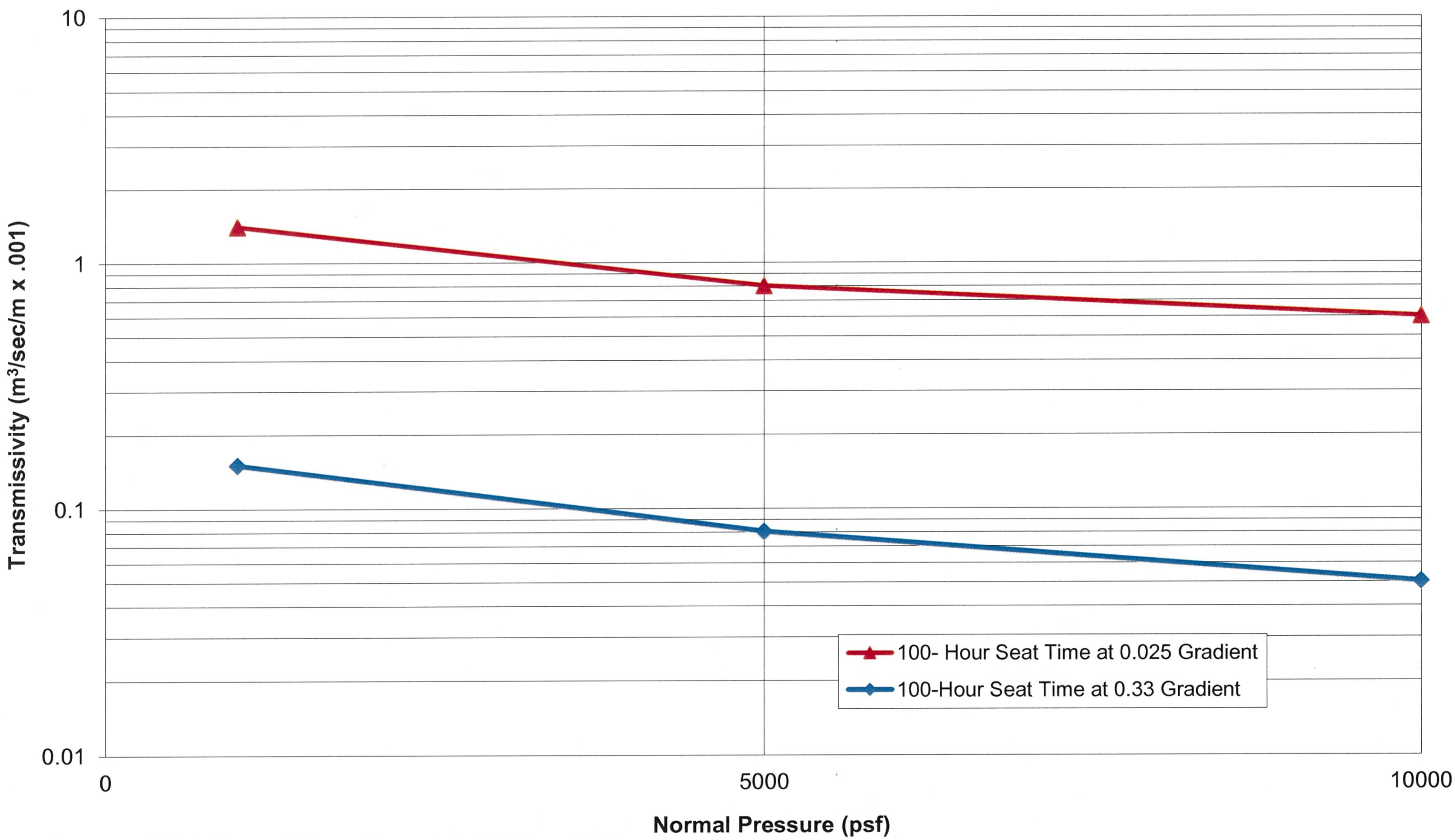
From Tables 3A and 3B above, the minimum design transmissivity of the geocomposite drainage layer is:

$Q_{design,\ Sector\ 6}$ = 1.02E-03 cfs/ft

$Q_{max,\ Sector\ 6}$ = 3.03E-05 cfs/ft

The flow capacity of the 200 mil geocomposite ($Q_{design,\ Sector\ 6}$) is significantly greater than the estimated flow of groundwater into the geocomposite ($Q_{max,\ Sector\ 6}$). Therefore the design use of 200-mil geocomposite for the Sector 6 installation is acceptable.

TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE
6/8 oz/sy Polypropylene Geotextile with 200 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



Reference: GSE Drainage Design Manual, 3rd Edition, 2004

CITY OF ARLINGTON LANDFILL
APPENDIX IIID-C
TEMPORARY UNDERDRAIN DEWATERING SYSTEM
UNDERDRAIN SUMP DESIGN

REQUIRED: Size underdrain collection sumps and demonstrate capacity provides multiple days of storage under peak conditions determined from groundwater inflow calculations.

METHOD: A. Use groundwater production rates from calculations and the sump drainage area for Sector 9 (12.4 acres) as representative of the future groundwater underdrain sumps in undeveloped cells. Underdrain piping and sump details are provided on drawings in Appendix IIIA.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Phillips 66 Driscopipe, *System Design*, 1991.

3. Heisler, Sanford I., P.E., Wiley Engineer's Desk Reference, John Wiley & Sons, Inc., New York, 1998.

SOLUTION:

A. Average Groundwater Flow Rate into Sump

Determine the per acre flow rate for a typical leachate collection sump.

The following table presents an estimate of the flow into a sump based on the caculations presented in this appendix.

Calculations performed for Sector 9 as representative of all undeveloped cells.

Condition	Underdrain Collection Area		Total Flow to Sump		
	Total Area[1] (sf)	Underdrain Seepage (ft/s)	cfs	gpm	gpd
Cell Floor	540,000	1.81E-09	9.77E-04	0.4	632
North Sideslope	6,000	1.25E-07	7.50E-04	0.3	485
South Sideslope	6,000	1.25E-07	7.50E-04	0.3	485
Total	552,000		2.48E-03	1.1	1,601

B. Storage Capacity of Sump

Total sump volume:

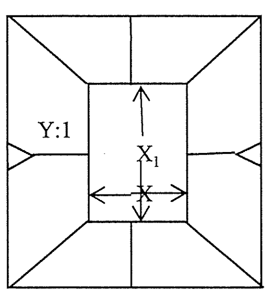
$$V_{TOT} = 1/3\left(A_1 + A_2 + \sqrt{(A_1 \cdot A_2)}\right)h$$ (Ref. 4, page 17)

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

$A_1 = X_1 * X_2$

$A_2 = (X_1 + 2(h*Y))*(X_2 + 2(h*Y))$

CITY OF ARLINGTON LANDFILL
APPENDIX IIID-C
TEMPORARY UNDERDRAIN DEWATERING SYSTEM
UNDERDRAIN SUMP DESIGN

X_1 (ft)	X_2 (ft)	Y (ft)	h (ft)	A_1 (ft^2)	A_2 (ft^2)	V_{TOT} (ft^3)
16	16	1	3	256	484	1,092

Assumed porosity of sump drainage stone: P = 0.35

$V_{EFF} = V_{TOT} / P$

V_{TOT} (ft^3)	V_{EFF} (ft^3)	V_{EFF} (gal)
1,092.0	382.2	2,858.9

Compute the number of days storage provided for the following:

$$\text{STORAGE (Detention Time)} = \frac{V_{TOT}}{V_{\text{Daily Inflow}}}$$

$V_{\text{Daily Inflow}}$ (gpd)[1]	V_{EFF} (gal)	Storage (days)
1601	2,859	1.8

C. Estimated Rate of Underdrain Groundwater Removal

Submersible pump capacity = 5 gpm

Groundwater Production (gpd)	Pump Rate (gpm)	Average Pump Time (min/day)	Average Pump Time (hr/day)
1,601.1	5	320.2	5.3

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 demonstrated (based on field records) that the actual underdrain groundwater flow rate is less than the design flow. Alternatively landfill operator may elect to periodically pump sumps using a submersible pump versus a dedicated pump. As presented in the Sector 6 calculations, a larger pump may be necessary, although actual performance data compiled during operation may demonstrate that a 5 gpm pump is sufficient for groundwater control.

REQUIRED: Analyze structural stability of the 4-inch-diameter groundwater dewatering 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 groundwater dewatering system details shown on pages IIID-C-58 and IIID-C-59 are for illustration purposes only to show parameters used in the following calculations. Groundwater dewatering system details can be found in Appendix IIIA.

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)

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 = 120 pcf

P_D =	1.67	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 @	120	pcf =	240	psf	
4.0	soil liner & prot. cover @	120	pcf =	480	psf	
100.0	ft solid waste/soil @	71	pcf =	7,100	psf	Highest waste column thickness
			Σ =	7,820	psf	over a 4" LCS pipe.

P_T =	54.3	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	54.3	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

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 = 54.3 psi

P_{DES1} =	72.4	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 groundwater dewatering system pipe and its backfill to obtain a realistic loading condition on the pipe.

2a. For the burial conditions shown on Figure 1 (page IIID-C-58), 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 IIID-C-59), 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-59).

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

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \qquad (4)$$

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 groundwater dewatering system 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} = -0.58

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} =	72.4	psi
D =	4.5	in
E_s =	3,000	psi

S_m =	0.109	in

Step 3: Calculate dc using Equation (5):

$$dc = S_m (1 - r_{sd})$$

dc =	0.171	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 IIID-C-60, based on P_{DES1} above)
t =	0.390	in (SDR 17 pipe)
I =	0.005	in^4/in
r =	2.3	in
E' =	3,000	psi

W_c =	135	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:

6.0	ft soil @	120	pcf =	720	psf
100.0	ft waste @	71	pcf =	7,100	psf
			Total =	7,820	psf

γ =	73.77	pcf (weighted average based on above table)
B_c =	4.5	in

C_c =	156.3	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	100 ft
H/B_c =	266.7

Assume: H_e/B_c = 2.06

$k\mu$ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.42	
$-2k\mu$ =	-0.26	
$(H/B_c - H_e/B_c)$ =	264.6	
$e^{-2k\mu(He/Bc)}$ =	0.58	

Left-hand-side of equation (LHS) = 156
Right-hand-side of equation (RHS) = 156

<u>Step 7:</u> 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
kμ =	0.13
H/B_c =	266.7
H_e/B_c =	2.06
r_{sd} =	-0.58
LHS =	154
RHS =	154

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 =	135	lb/in
D =	4.5	in
P_{DES2} =	30	psi

A summary table for the structural stability analysis is provided on page IIID-C-35 for the 4-inch-diameter groundwater dewatering system pipe. A pipe will be selected from this table for use in the groundwater dewatering 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} = 30 psi

S_A =	240.3	psi
FS =	6.2	

Compare calculated and suggested factor of safety:	6.2	> 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 =	27,000	psi for 50 years based on S_A above (see chart page IIID-C-60)
P_{DES2} =	30	psi

P_{cb} =	156.5	psi
FS =	5.2	

Compare calculated and suggested factor of safety:	5.2	> 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} = 30 psi
E' = 3,000 psi

$\boxed{E_S = 1.0 \; \%}$

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} = 1.0 %

Allowable ring deflection, RD_{all} = 4.20 %

$\boxed{RD_{act} < RD_{all}\text{, design is acceptable}}$

CITY OF ARLINGTON LANDFILL
APPENDIX IIID-C
TEMP. UNDERDRAIN DEWATERING SYSTEM
PIPE STRUCTURAL STABILITY - 4" DIA PIPE

Adjusted load to account for soil arching = 30 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	473.1	3.2	20,000	3,000	50.9	1.7	8.1	3,000	1.0	8.1
26.0	1,500	375.5	4.0	22,000	3,000	74.7	2.5	6.5	3,000	1.0	6.5
21.0	1,500	300.4	5.0	25,000	3,000	109.7	3.7	5.2	3,000	1.0	5.2
19.0	1,500	270.3	5.5	26,000	3,000	129.9	4.3	4.7	3,000	1.0	4.7
17.0 [1]	1,500	240.3	6.2	27,000	3,000	156.5	5.2	4.2	3,000	1.0	4.2
15.5	1,500	217.8	6.9	28,000	3,000	183.0	6.1	3.9	3,000	1.0	3.9
13.5	1,500	187.9	8.0	29,000	3,000	228.9	7.6	3.4	3,000	1.0	3.4
11.0	1,500	150.2	10.0	30,000	3,000	316.9	10.5	2.7	3,000	1.0	2.7

denotes standard size

[1] Select 4-inch-diameter HDPE SDR 17.0 pipe for use in the groundwater 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-60), 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).

REQUIRED: Analyze structural stability of the 6-inch-diameter groundwater dewatering 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 groundwater dewatering system details shown on pages IIID-C-58 and IIID-C-59 are for illustration purposes only to show parameters used in the following calculations. Groundwater dewatering system details can be found in Appendix IIIA.

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)

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 =	120	pcf

P_D =	1.67	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 @	120	pcf =	240	psf	
4.0	soil liner & prot. cover @	120	pcf =	480	psf	
100.0	ft solid waste/soil @	71	pcf =	7,100	psf	Highest waste column thickness
			Σ =	7,820	psf	over a 6" LCS pipe.

P_T =	54.3	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	54.3	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

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 = 54.3 psi

P_{DES1} =	72.4	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 groundwater dewatering system pipe and its backfill to obtain a realistic loading condition on the pipe.

   2a. For the burial conditions shown on Figure 1 (page IIID-C-58), 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 IIID-C-59), 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-59).

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

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \qquad (4)$$

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 groundwater dewatering system 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} = -0.62

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} =	72.4	psi
D =	6.625	in
E_s =	3,000	psi
S_m =	0.160	in

Step 3: Calculate dc using Equation (5):

$$dc = S_m\,(1 - r_{sd})$$

dc =	0.259	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 IIID-C-60, based on P_{DES1} above)
t =	0.390	in (SDR 17 pipe)
I =	0.005	in^4/in
r =	3.3	in
E' =	3,000	psi

W_c =	194	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:

6.0	ft soil @	120	pcf =	720	psf
100.0	ft waste @	71	pcf =	7,100	psf
			Total =	7,820	psf

γ =	73.77	pcf (weighted average based on above table)
B_c =	6.625	in

C_c =	103.8	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	100	ft
H/B_c =	181.1	

Assume: H_e/B_c = 2.16

$k\mu$ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.43	
$-2k\mu$ =	-0.26	
$(H/B_c - H_e/B_c)$ =	179.0	
$e^{-2k\mu(He/Bc)}$ =	0.57	

Left-hand-side of equation (LHS) = 104
Right-hand-side of equation (RHS) = 104

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
kμ =	0.13
H/B_c =	181.1
H_e/B_c =	2.16
r_{sd} =	-0.62
LHS =	113
RHS =	113

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 =	194	lb/in
D =	6.6	in
P_{DES2} =	**29**	**psi**

A summary table for the structural stability analysis is provided on page IIID-C-46 for the 6-inch-diameter groundwater dewatering system pipe. A pipe will be selected from this table for use in the groundwater dewatering 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} = 29 psi

S_A =	234.8	psi
FS =	6.4	

Compare calculated and suggested factor of safety:	6.4	> 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 = 27,000 psi for 50 years based on S_A above (see chart page IIID-C-60)
P_{DES2} = 29 psi

P_{cb} =	156.5	psi
FS =	5.3	

Compare calculated and suggested factor of safety:	5.3	> 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} = 29 psi
E' = 3,000 psi

$\boxed{E_S = 1.0\ \%}$

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} = 1.0 %

Allowable ring deflection, RD_{all} = 4.20 %

$\boxed{RD_{act} < RD_{all}\text{, design is acceptable}}$

CITY OF ARLINGTON LANDFILL
APPENDIX IIID-C
TEMP. UNDERDRAIN DEWATERING SYSTEM
PIPE STRUCTURAL STABILITY - 6" DIA PIPE

Adjusted load to account for soil arching = 29 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	462.2	3.2	20,000	3,000	50.9	1.7	8.1	3,000	1.0	8.3
26.0	1,500	366.8	4.1	22,000	3,000	74.7	2.5	6.5	3,000	1.0	6.6
21.0	1,500	293.5	5.1	25,000	3,000	109.7	3.7	5.2	3,000	1.0	5.3
19.0	1,500	264.1	5.7	26,000	3,000	129.9	4.4	4.7	3,000	1.0	4.8
17.0 [1]	1,500	234.8	6.4	27,000	3,000	156.5	5.3	4.2	3,000	1.0	4.3
15.5	1,500	212.8	7.0	28,000	3,000	183.0	6.2	3.9	3,000	1.0	4.0
13.5	1,500	183.6	8.2	29,000	3,000	228.9	7.8	3.4	3,000	1.0	3.5
11.0	1,500	146.7	10.2	30,000	3,000	316.9	10.8	2.7	3,000	1.0	2.8

denotes standard size

[1] Select 6-inch-diameter HDPE SDR 17.0 pipe for use in the groundwater 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-60), 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).

REQUIRED: Analyze structural stability of the 18-inch-diameter groundwater dewatering 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 groundwater dewatering system details shown on pages IIID-C-58 and IIID-C-59 are for illustration purposes only to show parameters used in the following calculations. Groundwater dewatering system details can be found in Appendix IIIA.

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)

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 =	120	pcf

P_D =	1.67	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 @	120	pcf =	240	psf
4.0	soil liner & prot. cover @	120	pcf =	480	psf
100	ft solid waste/soil @	71	pcf =	7,100	psf
			Σ =	7,820	psf

P_T =	54.3	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	54.3	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

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 = 54.3 psi

P_{DES1} =	72.4	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 groundwater dewatering system pipe and its backfill to obtain a realistic loading condition on the pipe.

2a. For the burial conditions shown on Figure 1 (page IIID-C-58), 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 IIID-C-59), 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-59).

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

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \qquad (4)$$

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 groundwater dewatering system 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} = -0.68

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} =	72.4	psi
D =	18	in
E_s =	3,000	psi

S_m =	0.434	in

Step 3: Calculate dc using Equation (5):

$$dc = S_m\,(1 - r_{sd})$$

dc =	0.729	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 IIID-C-60, based on P_{DES1} above)
t =	1.059	in (SDR 17 pipe)
I =	0.099	in^4/in
r =	9.0	in
E' =	3,000	psi

$\boxed{W_c = 547 \text{ lb/in}}$

<u>Step 5:</u> Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\,2}}$$

Composite unit weight for waste and soil:

6.0	ft soil @	120	pcf =	720	psf
100.0	ft waste/soil @	71	pcf =	7,100	psf
			Total =	7,820	psf

γ =	73.8	pcf (weighted average based on above table)
B_c =	18	in

$\boxed{C_c = 39.5 \text{ (unitless)}}$

<u>Step 6:</u> Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	106	ft
H/B_c =	70.7	

Assume: H_e/B_c = 2.28

$k\mu$ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.45	
$-2k\mu$ =	-0.26	
$(H/B_c - H_e/B_c)$ =	68.4	
$e^{-2k\mu(He/Bc)}$ =	0.55	

Left-hand-side of equation (LHS) = 40
Right-hand-side of equation (RHS) = 40

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
kμ =	0.13
H/B_c =	70.7
H_e/B_c =	2.28
r_{sd} =	-0.68
LHS =	48
RHS =	48

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 =	547	lb/in
D =	18.0	in

P_{DES2} =	30	psi

A summary table for the structural stability analysis is provided on page IIID-C-57 for the 18-inch-diameter grounwater dewatering system pipe. A pipe will be selected from this table for use in the groundwater dewatering 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} = 30 psi

S_A =	243.1	psi
FS =	6.2	

Compare calculated and suggested factor of safety:	6.2	> 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 =	26,000	psi for 50 years based on S_A above (see chart page IIID-C-60)
P_{DES2} =	30	psi

P_{cb} =	153.5	psi
FS =	5.1	

Compare calculated and suggested factor of safety:	5.1	> 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} = 30 psi
E' = 3,000 psi

$\boxed{E_S = 1.0\ \%}$

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} = 1.0 %

Allowable ring deflection, RD_{all} = 4.20 %

$\boxed{RD_{act} < RD_{all}\text{, design is acceptable}}$

CITY OF ARLINGTON LANDFILL
APPENDIX IIID-C
TEMP. UNDERDRAIN DEWATERING SYSTEM
PIPE STRUCTURAL STABILITY - 18"-DIA PIPE

Adjusted load to account for soil arching = 30 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	478.6	3.1	20,000	3,000	50.9	1.7	8.1	3,000	1.0	8.0
26.0	1,500	379.9	3.9	22,000	3,000	74.7	2.5	6.5	3,000	1.0	6.4
21.0	1,500	303.9	4.9	24,000	3,000	107.4	3.5	5.2	3,000	1.0	5.1
19.0	1,500	273.5	5.5	25,000	3,000	127.4	4.2	4.7	3,000	1.0	4.6
17.0 [1]	1,500	243.1	6.2	26,000	3,000	153.5	5.1	4.2	3,000	1.0	4.1
15.5	1,500	220.3	6.8	27,000	3,000	179.7	5.9	3.9	3,000	1.0	3.8
13.5	1,500	190.1	7.9	28,500	3,000	226.9	7.5	3.4	3,000	1.0	3.4
11.0	1,500	151.9	9.9	30,000	3,000	316.9	10.4	2.7	3,000	1.0	2.7

denotes standard size

[1] Select 18-inch-diameter HDPE SDR 17.0 pipe for use in the groundwater 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-60), 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).

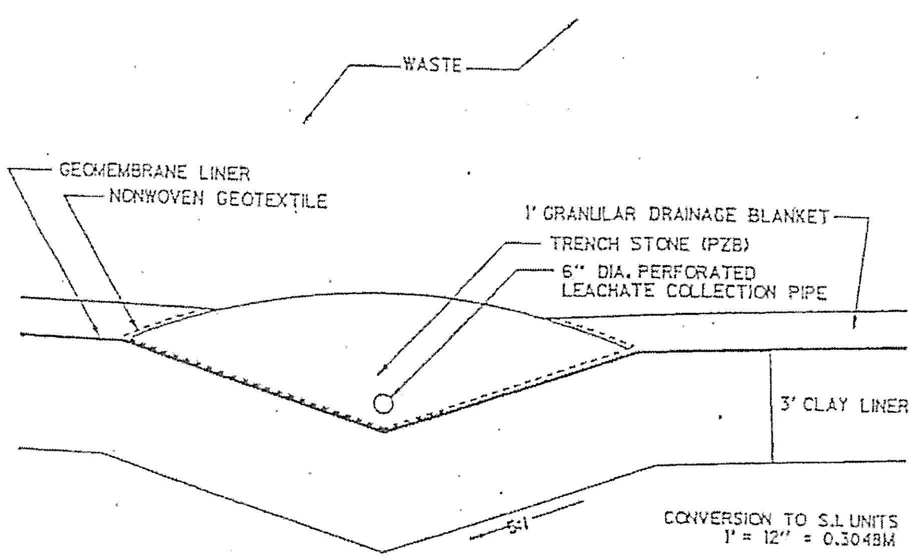


FIGURE 1: TYPICAL V-SHAPED TRENCH FOR LANDFILLS WITH COMPOSITE LINERS

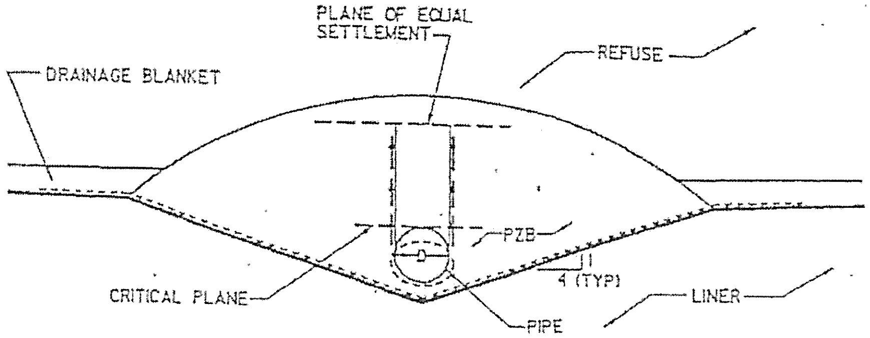


FIGURE 2: SETTLEMENT OF LEACHATE PIPE INDUCING SHEAR STRESSES IN PZB

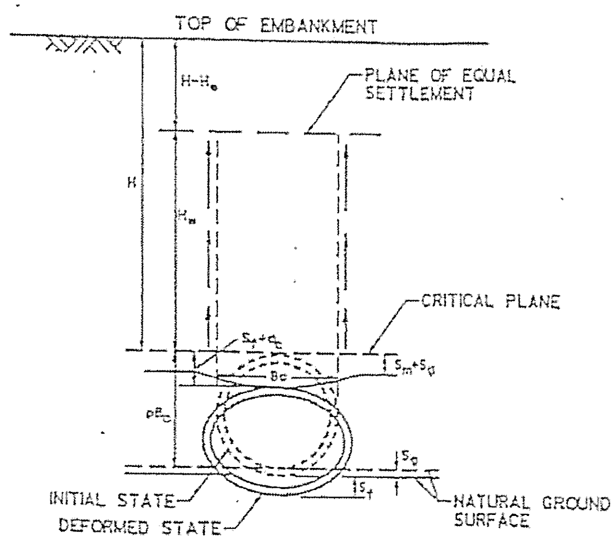


FIGURE 3: CASE OF AN INCOMPLETE DITCH CONDITION FOR A POSITIVE PROJECTING CONDUIT

/dl/users/jcw/prgetren.dgn

here: S_A = Actual compressive stress, psi
SDR = Standard Dimension Ratio
P_T = External Pressure, psi

Safety Factor = 1500 psi ÷ S_A where 1500 psi is the Compressive Yield Strength of Driscopipe.

Design by Wall Buckling: Local wall buckling is a longitudinal wrinkling of the pipe wall. Tests of *non-pressurized* Driscopipe show that buckling and collapse do not occur when the soil envelope is in full contact with the pipe and is compacted to a dense state. However, it can be forced to occur over the long term in *non-pressurized* pipe if the total external soil pressure, P_t, is allowed to exceed the pipe-soil system's critical buckling pressure, P_{cb}. If $P_t > P_{cb}$, gradual collapse may occur over the long term. A calculated, conservative value for the critical buckling pressure may be obtained by the following approximate formula. All pipe diameters with the same SDR in the same burial situation have the same critical collapse and critical buckling endurance

$$P_{cb} = 0.8\sqrt{E' \times P_c}$$

Where:

P_t = Total vertical soil pressure at the top of the pipe, psi

P_{cb} = Critical buckling soil pressure at the top of the pipe, psi

E' = Soil modulus in psi calculated as the ratio of the vertical soil pressure to vertical soil strain at a specified density

P_c = Hydrostatic, critical-collapse differential pressure, psi

$$P_c = \frac{2E\,(t/D)^3\,(D_{MIN}/D_{MAX})^3}{(1-\mu^2)}$$

$$P_c = \frac{2.32\,E}{(SDR)^3}$$

Where: $(D_{MIN}/D_{MAX}) = .95$
μ = Poisson's Ratio
μ = .45 for Driscopipe
E = stress and time dependent tensile modulus of elasticity, psi

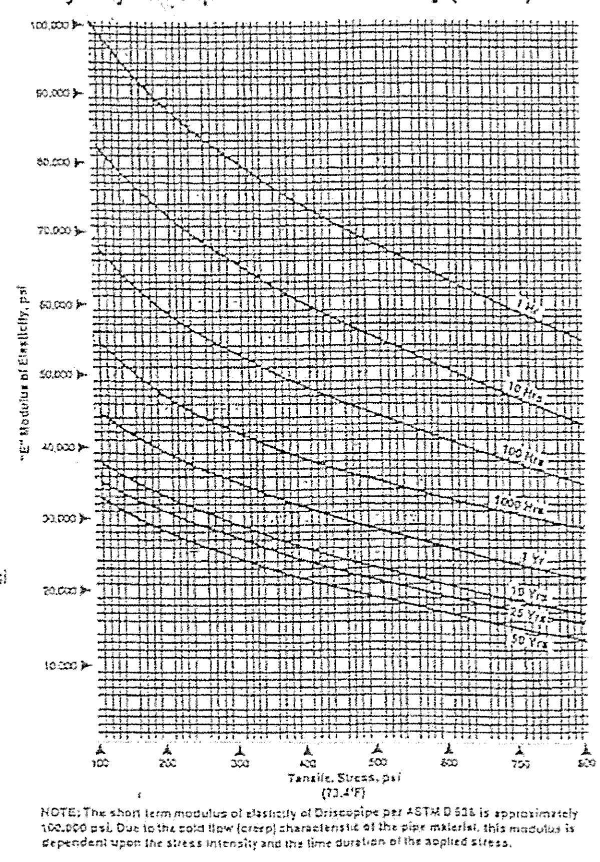
In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Design by Wall Buckling Guidelines:
Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_t < P_{cb}$.

1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe.
2. Calculate the stress "S_A" in the pipe wall according to the formula:
$$S_A = \frac{(SDR-1)\,P_t}{2}$$
3. Based upon the stress "S_A" and the estimated time duration of non-pressurization, use Chart 25 to find the value of the pipe's modulus of elasticity, E, in psi.

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.

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. Soil Modulus, psi*			Maximum External Pressure psi Soil Modulus, psi*			Maximum Deflection, % after installation 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

APPENDIX IIID-D

WASTE-AS-BALLAST PLACEMENT RECORD

Includes pages IIID-D-1 through IIID-D-2

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER

5-19-2022

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)	City of Arlington 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.