ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1614B

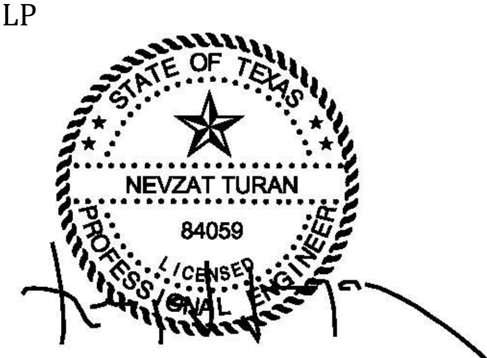
MAJOR PERMIT AMENDMENT APPLICATION

VOLUME 3 OF 7

Prepared for

Pine Hill Farms Landfill TX, LP

May 2024



05/20/2024

Prepared by

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Project No. 0120-076-11-106

This document is intended for permitting purposes only.

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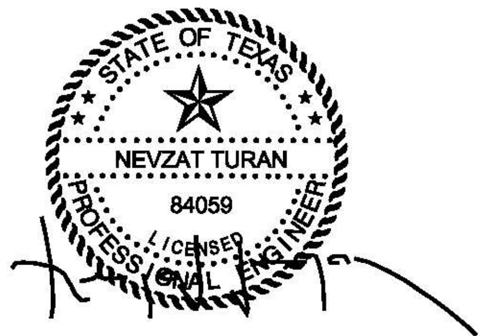
CONTENTS



05/20/2024

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1614B

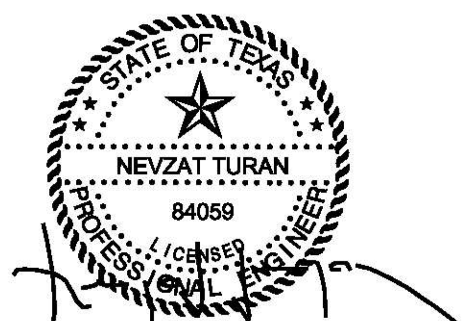
MAJOR PERMIT AMENDMENT APPLICATION

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

Prepared for

Pine Hill Farms Landfill TX, LP

May 2024



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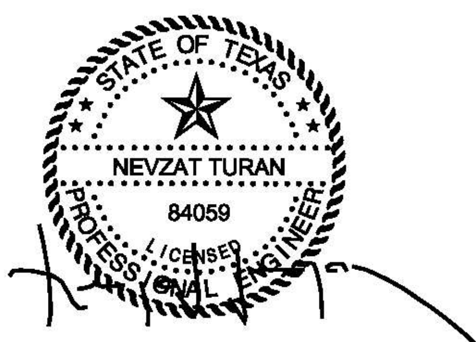
CONTENTS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER
05/20/2024

TABLES



05/20/2024

1 INTRODUCTION

1.1 Purpose and Scope

The proposed continued development of the Royal Oaks Landfill includes an alternative liner for the undeveloped subtitle D portion of the landfill. The purpose of this appendix is to demonstrate that the proposed alternative liner system 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 the maximum contaminant levels (MCLs) listed in Table 1 in §330.331(a)(1) in the uppermost aquifer at the POC.

Section 1.2 provides a description of the alternative liner system design, and Section 1.3 provides an overview of the alternative liner POC demonstration.

1.2 Proposed Alternative Liner Design

The alternative liner system design is shown on Figure 1-2. As shown on Figure 1-2, the proposed alternative liner system for future cells 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 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.

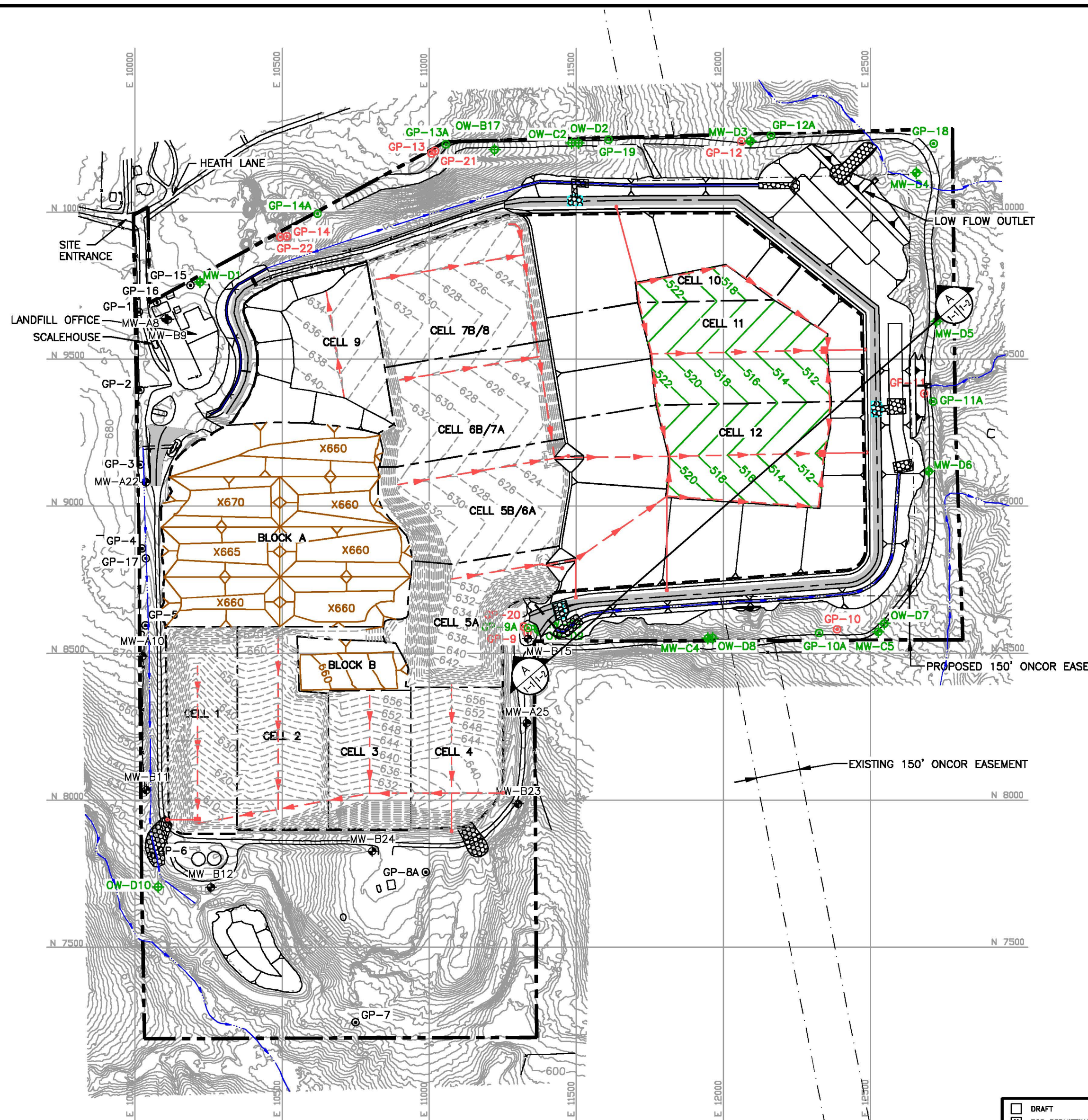
Details for the alternative liner system are provided in Appendix IIIA-A – Liner and Final Cover System Details. The design of the leachate collection is presented in Appendix IIIC – Leachate and Contaminated Water Management Plan. The stability of the liner system is analyzed in Appendix IIIE-A and the liner settlement analysis is provided in Appendix IIIE-B.

1.3 POC Demonstration Overview

The purpose of the POC demonstration is to show that the proposed alternative liner system design 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 proposed design (i.e., alternative liner system shown on Figure 1-2) will minimize eliminate leachate seepage into the groundwater below the containment system; therefore, 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).

Section 2 provides a discussion of the site's geology, groundwater quality, and leachate quality. The landfill configurations analyzed and the POC demonstration methods are discussed further in Section 3. A summary of the POC demonstration is provided in Section 4.



N

0 200 400

SCALE IN FEET

LEGEND

PERMIT BOUNDARY

LIMIT OF WASTE

CELL BOUNDARY

EXISTING EASEMENT

PROPOSED EASEMENT

E 10500 SITE GRID

610 EXISTING CONTOUR (SEE NOTE 1)

624 TOP OF LINER CONTOUR

X 660 APPROXIMATE TOP OF PRE-SUBTITLE D LINER (SEE NOTE 8)

CHANNEL CENTERLINE

LEACHATE COLLECTION PIPE

LEACHATE COLLECTION SUMP

LEACHATE RISER PIPE

MW-10 EXISTING GROUNDWATER MONITORING WELL

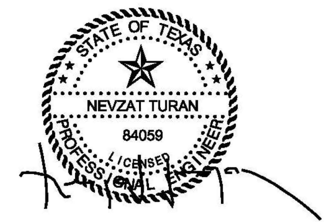
MW-D1 PROPOSED GROUNDWATER MONITORING WELL

OW-D7 PROPOSED OBSERVATION WELL

GP-1 EXISTING GAS PROBE

GP-10A PROPOSED GAS PROBE

3H:1V



05/20/2024

NOTES:

1. EXISTING CONTOURS DEVELOPED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN NOVEMBER 10, 2022. THE GRID SYSTEM IS BASED ON A SITE GRID SYSTEM. ELEVATIONS ARE BASED ON NAVD 88.
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 504.0 FT-MSL.
5. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA DRAWINGS I/IIA.4 THROUGH I/IIA.8.
6. REFER TO APPENDIX IIIF FOR DRAINAGE DESIGN INFORMATION.
7. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY STANGER SURVEYING COMPANY, DATED APRIL 1995.
8. TOP OF PRE-SUBTITLE D LINER ARE APPROXIMATE AND WAS REPRODUCED FROM CROSS-SECTIONS INCLUDED IN THE 1983 PERMIT APPLICATION PREPARED BY STOKES & ASSOCIATES.

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2024
FILE: 0120-76-11
CAD: 1-1 LINER PLAN.DWG

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: NT

PREPARED FOR

PINE HILL FARMS LANDFILL TX, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
TOP OF LINER PLAN

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

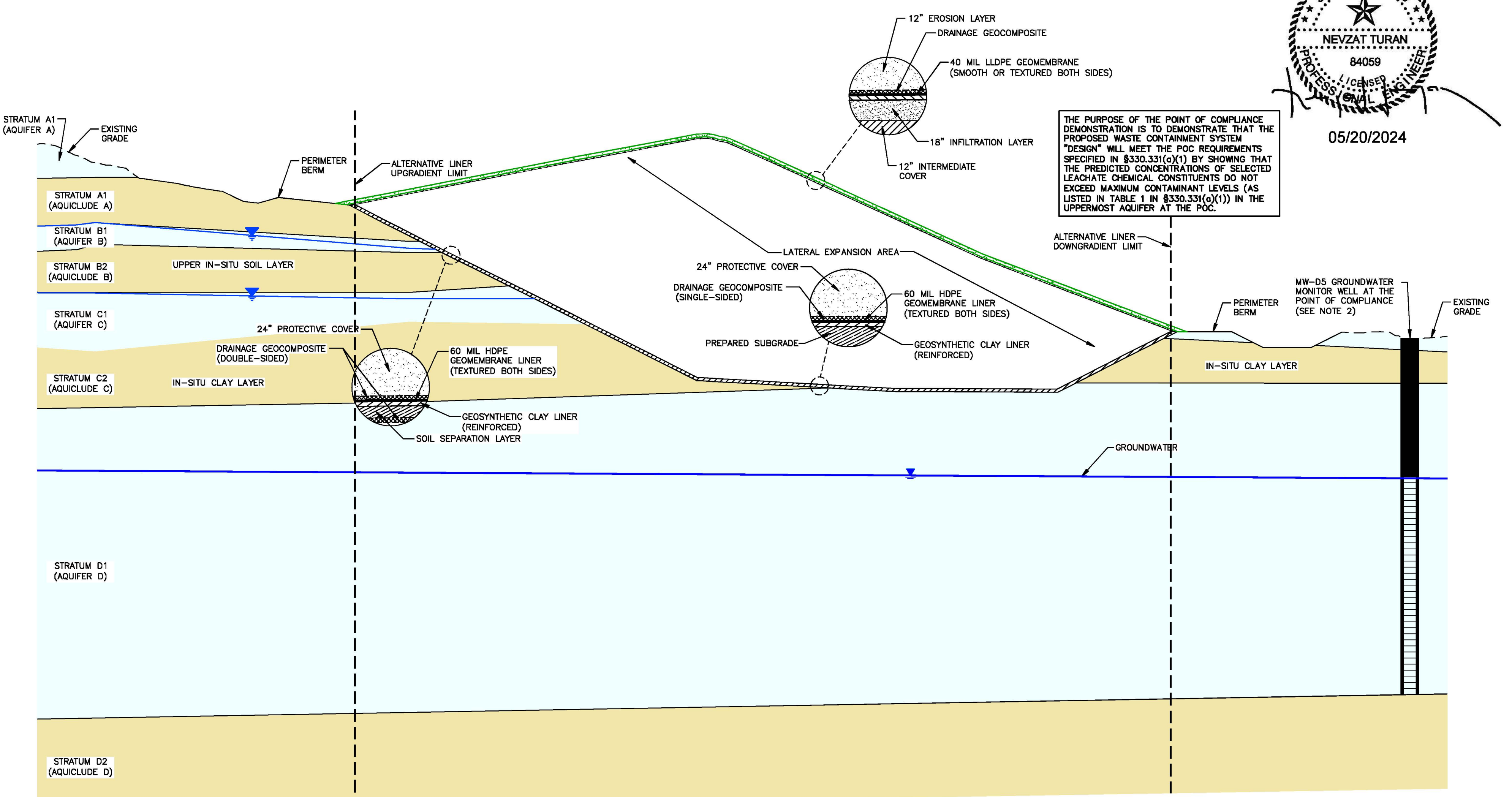
Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

WWW.WCGRP.COM

FIGURE 1-1

SHEET IIIB-2A

O:\0120\76\EXPANSION 2023\PART III\IIIB\1-1 TOP OF LINER PLAN.dwg, byoung, 1:2



STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

05/20/2024

TYPICAL SECTION A

0 60 120
HORIZONTAL SCALE IN FEET

0 50 100
VERTICAL SCALE IN FEET

NOTES:

1. TYPICAL GEOLOGIC PROFILE DEVELOPED FROM CROSS-SECTIONS INCLUDED IN APPENDIX IIIG.
2. THE MODEL IS DEVELOPED CONSERVATIVELY USING THE DOWNGRADIENT MONITORING WELL THAT IS CLOSEST TO THE LIMIT OF WASTE, THE LARGEST TWO-DIMENSIONAL WASTE FILL AREA (I.E., LONGEST DISTANCE LEACHATE BETWEEN THE UPGRADIENT AND DOWNGRADIENT LIMIT OF WASTE), AND HIGHEST GROUNDWATER SURFACE GRADIENT.

SHEET IIIB-2B

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2024
FILE: 0120-76-11
CAD: 1-2 WASTE CONTAINMENT.DWG

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: JAE

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
PINE HILL FARMS LANDFILL TX, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
WASTE CONTAINMENT SYSTEM

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

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FIGURE 1-2

O:\0120\76\EXPANSION 2023\PART III\IIIB\1-2 WASTE CONTAINMENT.dwg, byoung, 1:2

2 SITE INFORMATION

This section describes the site information related to the POC demonstration, including a discussion on the geologic conditions, groundwater quality, and leachate quality.

2.1 Site Geology

Detailed lithological and hydrogeological information for the area associated with the landfill is presented in Appendix IIIG – Geology Report of the SDP. The subsurface characterization of the site is supported by data from 88 advanced borings at locations shown in Figure IIIG-B-1 in Appendix IIIG – Geology Report. The borings were advanced during 10 drilling events conducted between 1981 and 2023. The subsurface investigation data and geologic cross sections indicate that the facility's geology can be divided into five site-specific stratigraphic units (Surficial Sediments, Stratum A, Stratum, B, Stratum C, and Stratum D) with the lowermost four strata comprised of aquifer and aquiclude subunits. The following subsections related to the site geology have been summarized from Appendix IIIG – Geology Report.

2.1.1 Surficial Sediments

At ground surface in undeveloped areas across the western and southern permit boundary areas lies the surficial sediments site-specific stratum which is comprised of Sparta Sand and uppermost Weches formation sediments. The surficial sediments are discontinuous across the permit boundary and have been removed from within the constructed limits of waste. The remaining surficial sediments are present within the western and southern permit boundary and the existing developed limits of waste. The surficial sediments do not exist within the eastern half of the permit boundary and proposed expansion area.

The uppermost Surficial Sediments are present due to the in-situ weathering of Sparta Sand Formation sediments which are composed predominately of unconsolidated dry to moist sand and silty sand, with lesser proportions of sandy silt, silt, and clayey sand, and ferrous interbedding.

2.1.2 Stratum A

Stratum A is discontinuous across the permit boundary and is comprised of lower Weches Formation sediments which have been removed from within the constructed limits of waste. The remaining Stratum A sediments are present within the western and southern permit boundary and the existing developed limits of waste. Stratum A is comprised of substrata A1 and A2.

Stratum A1 (Aquifer A) is characterized as course-grained moist to wet sediments with an average thickness of approximately 12 feet. Stratum A1 is comprised predominately of loose to poorly consolidated glauconitic sand and silty sand, with lesser sandy silt and silt and ferrous interbedding.

Stratum A2 (Aquiclude A) is characterized as fine-grained dry to moist sediments that function as the lower confining unit to groundwater within the overlying Aquifer A substrata with an average thickness of approximately 25 feet. Stratum A2 is comprised predominately of loose to poorly consolidated interbedded glauconitic silty clay, clayey silt, and sandy clay, with lesser sandy silt and silty sand, and occasional ironstone nodules and ferrous staining.

2.1.3 Stratum B

Stratum B is discontinuous across the permit boundary and is comprised of upper Queen City Formation sediments which have been partially removed from within the constructed limits of waste but are continuous beneath the developed landfill unit. Stratum B sediments are present across the majority of the permit boundary but are not observed in the easternmost expansion area footprint and permit boundary area where the existing ground surface elevation drops below an elevation of approximately 570 ft-amsl. Stratum B is comprised of substrata B1 and B2. Substrata B1 contains the facility's second monitorable groundwater zone (Aquifer B) which is hydraulically separated from underlying groundwater zones by substrata B2 (Aquiclude B).

Stratum B1 (Aquifer B) is characterized as course-grained moist to wet sediments with an average thickness of approximately 13 feet. Stratum B1 is comprised predominately of loose to poorly consolidated interbedded sand and silty sand, with lesser sandy silt, silt, clayey sand, ironstone nodules, and ferrous staining.

Stratum B2 (Aquiclude B) is characterized as fine-grained dry to moist sediments that function as the lower confining unit to groundwater within the overlying Aquifer B substrata with an average thickness of approximately 25 feet. Stratum B2 is comprised predominately of loose to poorly consolidated interbedded glauconitic silty clay, clayey silt, and sandy clay, with lesser sandy silt, silty sand, ironstone nodules, and ferrous staining.

2.1.4 Stratum C

Stratum C is continuous across the permit boundary and is comprised of middle Queen City Formation sediments that are continuous beneath the developed landfill unit and generally observed between elevations of 490 and 590 ft-amsl. Stratum C is comprised of substrata C1 and C2. Substrata C1 contains the facility's third monitorable groundwater zone (Aquifer C) which is hydraulically separated from underlying groundwater zones by substrata C2 (Aquiclude C).

Stratum C1 (Aquifer C) is characterized as course-grained moist to wet sediments with an average thickness of approximately 25 feet. Stratum C1 sediments are generally observed around an elevation of 570 ft-amsl. Stratum C1 is comprised predominately of loose to very dense sand and silty sand, with, lignite, and lesser silt, sandy silt, sandy clay, ironstone nodules, ironstone concretions, and ferrous staining.

Stratum C2 (Aquiclude C) is characterized as interbedded fine-grained dry to moist sediments that function as the lower confining unit to groundwater within the overlying Aquifer C substrata with an average thickness of approximately 46 feet. Stratum C1 sediments are generally observed around an elevation of 555 ft-amsl. Stratum C2 is comprised predominately of hard interbedded clay, silty clay, clayey silt, and sandy clay, with lesser lignite, sandy silt, silty sand, ironstone nodules, ironstone concretions, and ferrous staining.

2.1.5 Stratum D

Stratum D is continuous across the permit boundary and is comprised of lower Queen City Formation sediments that are continuous beneath the property boundary and generally observed below an elevation of 490 ft-amsl. Stratum D is comprised of substrata D1 and D2. Substrata D1 contains the facility's fourth monitorable groundwater zone (Aquifer D) which is hydraulically separated from underlying groundwater zones by substrata D2 (Aquiclude D).

Stratum D1 (Aquifer D) comprises the Uppermost Aquifer beneath the proposed expansion area and is characterized by unconsolidated very dense moist to wet sediments with a total thickness ranging from 48 to 209 feet and average thickness of approximately 122 feet. Stratum D1 is comprised predominately of silty sand and sand with lesser silt, sandy silt, and minor sandstone, lignite, siltstone, sandy clay, silty clay, ironstone nodules, and ironstone concretions. The silt composition of Stratum D1 is largely elastic and very dense.

Stratum D1 (Aquifer D) sediments are underlain by low permeability fine-grained dry to moist clayey sediments of substrata D2 (Aquiclude D). Stratum D2 (Aquiclude D) is characterized as interbedded fine-grained dry to moist sediments that function as the Lower Confining Unit to groundwater within the overlying Aquifer D substrata.

2.2 Uppermost Aquifer

Stratum D1 (Aquifer D) comprises the uppermost aquifer beneath the proposed expansion area and is the aquifer considered for this demonstration as it is the uppermost aquifer below the floor of the undeveloped Subtitle D area which will receive any potential leakage from the alternative liner area. Groundwater zones B and C are not considered as they are not below the proposed alternative liner areas. These two groundwater zones are drained via groundwater dewatering systems that disconnects these zones from the alternative liner areas. The only groundwater zones that may be impacted from any potential leakage from the alternative liner area is zone D which is modeled in this POC demonstration. Recent potentiometric groundwater contours are provided in Figure 3-1.

2.3 Groundwater Monitoring System

The only groundwater monitoring zone associated with this POC demonstration is Aquifer D. The proposed groundwater monitoring system network buildout is illustrated on Figure IIIH-A-2 and IIIH-A-3 in Appendix IIH and includes the addition of groundwater monitoring networks for Aquifer D. The groundwater monitoring system design is further discussed in the Groundwater Sampling and Analysis Plan provided in Appendix IIIH.

The MCL's listed in §330.331(a)(1) and the current groundwater constituent levels are listed in Table 2-1. As shown in the table, current constituent levels at the site are below the MCLs set forth in §330.331(a)(1).

Table 2-1
Chemical Constituent MCLs and Current Groundwater Conditions

Constituent	MCL Listed in §330.331(a)(1) (mg/l)	Current Site Groundwater Concentrations[1] (mg/l)
Arsenic	0.05	0.0403
Barium	1.0	0.114
Benzene[2]	0.005	0.0005
Cadmium[2]	0.01	0.001
Carbon tetrachloride[2]	0.005	0.0025
Chromium (hexavalent)[2]	0.05	0.01
2,4-Dichlorophenoxy acetic acid	0.1	--
1,4-Dichlorobenzene[2]	0.075	0.001
1,2-Dichloroethane[2]	0.005	0.0005
1,1-Dichloroethylene	0.007	--
Endrin	0.0002	--
Fluoride	4	--
Lindane	0.004	--
Lead[2]	0.05	0.0075
Mercury	0.002	--
Methoxychlor	0.1	--
Nitrate	10	--
Selenium[2]	0.01	0.005
Silver[2]	0.05	0.005
Toxaphene	0.005	--
1,1,1-Trichloroethane[2]	0.2	0.0005
Trichloroethylene[2]	0.005	0.0025
2,4,5-Trichlorophenoxy acetic acid	0.01	--
Vinyl Chloride[2]	0.002	0.001

1 Current Groundwater concentrations are reproduced from the analytical from tests performed in June 2023.
2 For constituents not detected at reporting limits, one-half of the reporting limit is listed.

2.4 Leachate Quality

The demonstration was conducted by showing that the alternative liner design will not allow the concentrations of the 24 EPA listed chemical constituents shown in Table 2-2 (the same constituents listed in Table 1 of Title 30 TAC §330.331(a)(l)) 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:

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

The input leachate concentrations are based on recommended input concentrations from USEPA's "Draft Background Summary of Data on Municipal Solid Waste Landfill Leachate Characteristics: July 1988", and the Toxicity Characteristic Leaching Procedure (TCLP) in 40 CFR 261.62. The greater of the two values for each constituent was used as the recommended input concentration. Table 2-2 lists these data. As noted in the above equation, the DAF represents the factor by which the constituent concentration is expected to decrease between the landfill and the POC. As shown in Table 2-2, the required DAFs range from less than 100 to 260. When the constituent's concentration in leachate is divided by the model predicted DAF, the resulting concentration must be less than the allowable maximum contaminant levels (MCLs) in groundwater for the chemical parameters listed in Table 1 included in Title 30 TAC §330.331(a)(1).

The highest listed DAF is 260, which indicates that if a trichloroethylene concentration of 1.3 mg/l exists within the landfill, then the concentration would have to be reduced by a factor of 260 prior to the constituent reaching the POC to meet the 0.005 mg/l MCL for this constituent $(DAF = \frac{1.3 mg/l}{0.005 mg/l} = 260)$. A DAF of 260 has been the historical standard used in POC demonstrations approved by the TCEQ and is the standard discussed in the original TCEQ guidance document for POC demonstrations (*Texas Water Commission Alternate Liner Design Handbook*, August 1993). A substantial amount of leachate quality data has been generated from Subtitle D landfills since 1993. Based on WCG's experience in Texas, the initial concentrations for the 24 constituents shown on Table 2-2 are conservative compared to site specific leachate quality from the Royal Oaks Landfill and other Texas MSW landfills.

Table 2-2
Chemical Constituent Concentrations in Leachate

Constituent	MCL (mg/L) Listed in §330.331(a)(1)	Site Specific[1] 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	0.0364	5.0	1 to 100	100
Barium[2]	1.0	0.0025	100.0	100	100
Benzene[2]	0.005	--	0.814	163	163
Cadmium[2]	0.01	0.0025	1.0	1 to 100	100
Carbon tetrachloride	0.005	--	0.5	100	100
Chromium[2] (hexavalent)	0.05	0.0025	5.0	1 to 100	100
2,4-Dichlorophenoxy acetic acid	0.1	--	10.0	100	100
1,4-Dichlorobenzene	0.075	--	7.5	100	100
1,2-Dichloroethane	0.005	--	0.5	100	100
1-1-Dichloroethylene	0.007	--	0.7	100	100
Endrin	0.0002	--	0.05	250	250
Fluoride	4	--	--	--	--
Lindane	0.004	--	0.4	100	100
Lead[2]	0.05	0.0025	5.0	1 to 100	100
Mercury	0.002	--	0.2	100	100
Methoxychlor	0.1	--	--	--	--
Nitrate	10	--	--	--	--
Selenium[2]	0.01	0.00325	1.0	1 to 100	100
Silver[2]	0.05	0.0025	5.0	1 to 100	100
Toxaphene	0.005	--	0.5	100	100
1,1,1-Trichloroethane	0.2	--	--	--	--
Trichloroethylene	0.005	--	1.3	260	260
2,4,5-Trichlorophenoxy acetic acid	0.01	--	1.0	100	100
Vinyl Chloride	0.002	--	0.2	100	100

1 Leachate concentrations listed represent maximum concentrations from a leachate sample collected August 2023 from onsite leachate tanks.
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 2.3 (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.

3 POINT OF COMPLIANCE DEMONSTRATION METHODS

This section describes the point of compliance (POC) demonstration using (1) the HELP model to estimate leachate percolation through the alternative liner system and (2) MODFLOW to perform pollutant fate and transport simulations between the landfill and the point of compliance. The following subsections discuss the landfill configurations analyzed and the POC demonstration methods using the HELP and MODFLOW models. The demonstration set forth in this appendix is applicable to the entire undeveloped alternative liner area (i.e., Cells 10 through 12).

3.1 Landfill Configurations Analyzed

3.1.1 Section Development

The location of Section A was developed to represent the area that will receive the alternative liner system and the distance between the liner area and the POC, which is shown on Figure 3-1. Section A was selected to represent the shortest, downgradient distance within the uppermost aquifer between the alternative liner area and the POC. Groundwater will flow northeast towards monitor well MW-D5.

Figure 3-2 is presented to show how Section A is developed. In the waste disposal area, Figure 3-2 shows each element of the containment system (e.g., alternative liner system and Subtitle D final cover system). In addition, the site-specific subsurface soils and hydrogeologic information reproduced from Appendix IIIG 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 3-2, the model is divided into three zones to estimate percolation and groundwater recharge throughout the active life of the landfill and throughout the postclosure period. Zone I is located within the limits of the landfill footprint where alternative liner may be installed. The estimated percolation rate during the life of the landfill footprint is discussed in detail in Section 3.3. However, one conservative assumption is the percolation through the alternative liner system was assumed to flow directly to groundwater (i.e., unsaturated zone between the bottom of the liner and the top of the saturated zone is not included). This assumption ignores travel time, absorption, and consumption of water that occurs within the in-situ subsurface soils. Groundwater recharge is modeled between the landfill and the POC which occurs in Zone III. An estimate of recharge was developed using the HELP model. It is assumed that no recharge occurs in Zone II (i.e., perimeter berm), located between the groundwater recharge zone and the limits of waste. The percolation zones are summarized in Table 3-1.

Table 3-1
Summary of Percolation Zones

Percolation Zone	Description
Zone I (Alternative Liner Area)	This percolation zone models the impact of percolation through the alternative liner system.
Zone II (Perimeter Berm)	This percolation zone represents the perimeter berm area. The berm is considered well-drained where no recharge occurs.
Zone III (Offsite Recharge Area)	This percolation zone models the in-situ soils where offsite recharge occurs.

3.1.2 Sequence of Site Development

As shown on Figure 3-2, the alternative liner area is expected to receive waste between 2026 and 2041. Therefore, three timeframes are considered: (1) the active case, which represents the time period beginning when waste is first placed and is expected to last 1 year, (2) the interim case, which represents the time period between the active case until final cover is installed and is expected to last 14 years, and (3) the closed case, which represents the period after final cover is placed and is modeled for 30 years. Sequencing plans for the site are presented in Appendix I/IIA.

3.2 HELP Model Demonstration

3.2.1 HELP Model

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07, 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, run-off, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage. The HELP Model was used to estimate the rate of percolation through the alternative liner system and through the in-situ soils that contribute to recharge outside of the containment system. The percolation rate was determined for various landfill configurations, as discussed in Section 3.2.2.

3.2.2 Configurations Modeled in HELP

A HELP model simulation was performed to obtain an assumed current leachate percolation rate through the bottom of the alternative liner area and through the approximately 80 feet of in-situ soils to the top of the highest measured groundwater surface below this area. This simulation assumes the maximum waste column thickness (200 feet) and the average waste column thickness (100 feet) to determine a worst-case percolation rate.

Four HELP Model simulations were performed to obtain percolation rates through the alternative liner system and offsite recharge area. Table 3-2 summarizes the landfill configurations modeled using HELP.

Table 3-2
HELP Model Configurations

Area	Case	Description
Alternative Liner Area (Zone I)	Active, 10 ft waste	The alternative liner area models the impact of percolation through the alternative liner system under expected filling conditions for both active, interim, and closed conditions.
	Interim, 200 ft waste	
	Closed, 200 ft waste	
Off-Site Recharge (Zone III)	80 ft in-situ soil	The off-site recharge area of the in-situ soils between the perimeter berm and the point of compliance was modeled to estimate recharge.

3.2.3 HELP Model Input

Each case listed in Table 3-2 was modeled for various periods with synthetically generated precipitation data using normal mean monthly precipitation data from the National Oceanic and Atmospheric Administration (NOAA) from the Jacksonville, Texas weather station for the years 1991 through 2020. Temperature and solar radiation data were also synthetically generated by the HELP Model using program defaults for Shreveport, Louisianna.

The active and interim conditions for the alternative liner area were modeled for 1 year and 14 years respectively, based on the expected active life of waste placement over the alternative liner area, as discussed in Section 3.1.2. The closed cases were modeled for 30 years to represent the postclosure period. The National Resources Conservation Service (NRCS) runoff curve numbers were calculated by HELP based on soil data and expected ground cover, surface slope, and slope length.

Additional HELP input information is provided in Appendix IIIB-A.

3.3 Percolation Rate Summary

The percolation rates for Zones I through III, which include the results for the HELP cases listed in Section 3.2.2, are summarized below in Table 3-3. The output files and HELP summary table are included in Appendix IIIB-A.

Table 3-3
Percolation Rate Summary

Percolation Zone	Case	Leachate Generation Rate[1]	Percolation Rate
Zone I (Alternative Liner Area)	Active Case (10 ft waste)	27,907.4 gal/ac/yr	0.0003 mm/yr
	Interim Case (200 ft waste)	206,850.4 gal/ac/yr	0.0003 mm/yr
	Closed Case (200 ft waste)	109,321.0 gal/ac/yr	0.0003 mm/yr
Zone II (Perimeter Berm)	N/A	N/A	0.0 mm/yr
Zone III (Off-Site Recharge)	In-situ Soil Case (80 ft waste)	N/A	259.6 mm/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.

As shown in the results included in Table 3-3, there is a small amount of percolation predicted by the HELP model for the alternative liner area. Therefore, the percolation rates shown in Table 3-3 will be utilized in the fate and transport modeling discussed in Section 3.4.

3.4 MODFLOW

Various computer programs are available to model contaminant transport for point of compliance (POC) demonstrations. The model selected to support this additional POC 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 Waterloo Hydrogeolic, has been used for the simulations included in this appendix.

3.4.1 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.

Table 2-2 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 a leachate sample obtained from the Royal Oaks Landfill and (2) the leachate quality input data historically used for POC demonstrations in Texas. As noted in Table 2-2, the DAFs range from less than 1 to 260. Refer to Section 2.3 for a detailed discussion.

3.4.2 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, storativity) in the preconditioned set of matrices. The inner iterations continue until the final convergence criteria are met. The PCG2 solver is described in the USGS Water-Resources Investigations Report 90-4048 (Hill, 1990). 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. The projected year waste filling begins in the expansion area for 1 year.
- Interim Landfill Condition. The projected year of waste filling operations in the expansion area after the first year through the projected year of Subtitle D final cover construction over the alternative liner area (e.g., 14 years).
- Closed Landfill Condition. The projected year of Subtitle D final cover construction over the alternative liner area through the projected year of the end of the postclosure care period for the landfill (i.e., 30 years).

The model divides each stress period into "time steps" which are incremental steps between each landfill condition. The time step factor of 10, the default factor in MODFLOW, is used in the simulations. For example, the time step for a 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 are 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 uppermost 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.

3.4.3 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.

<u>MT3D Code</u>

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 the 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 3.2). 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

Fate and transport results and outputs are discussed in Section 4. The MT3DMS fate and transport modeling was performed for a period of 45 years (1 year active, 14 years interim, 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.

3.4.4 Parameter Selection

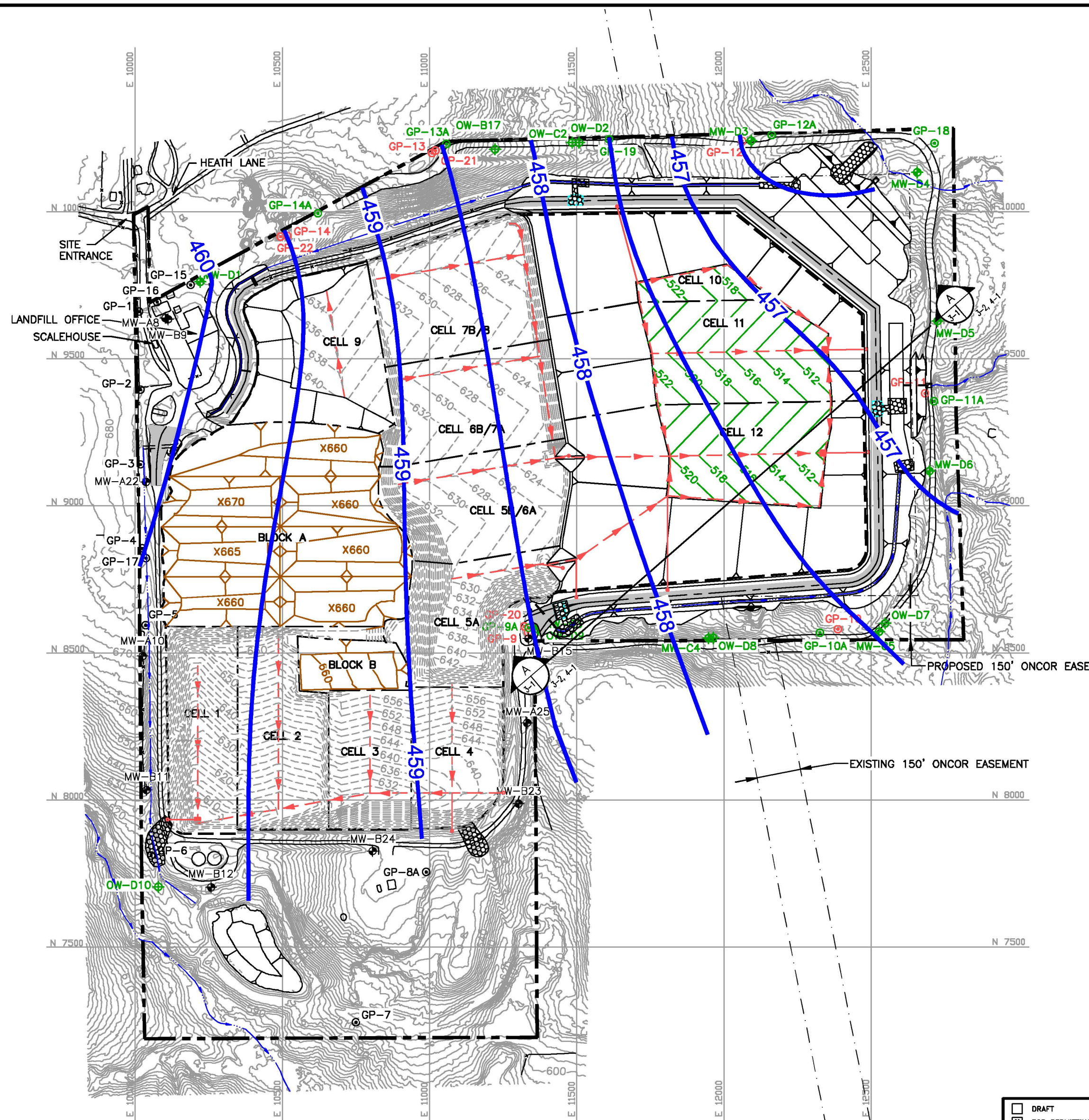
The following summarizes the model input key parameters.

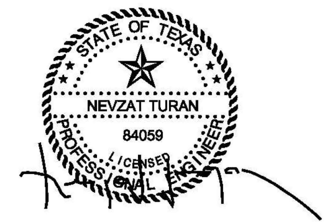
- **Landfill Area Modeled.** The entire alternative liner area is modeled in the two-dimensional MODFLOW simulations as a section.
- **Time Frame.** The alternative liner area is expected to be in the active and interim condition (i.e., without final cover) for approximately 15 years. The modeling is performed for the duration from the initial placement of waste on the alternative liner area (starting the year of 2026 as shown on Figure 3-2) to the postclosure of the site, the year 2041 (final closure year 2071).
- **Percolation Rates.** The percolation rates were estimated as discussed in Section 3.3.
- **Subsurface Information.** The site geology and hydrogeology information is reproduced from Appendix IIIG. The key MODFLOW input parameters are listed in Table 3-4. The saturated subsurface consists of only Stratum D1 soils.
- **Groundwater.** Starting groundwater contours have been obtained from the groundwater contours generated based on the groundwater measurements obtained from the site on December 2023 as presented on Figure 3-1.

Table 3-4
MODFLOW Model Input Parameters

Layer	Maximum Hydraulic Conductivity (cm/s)[1]	Specific Storage (1/ft)[2]	Specific Yield[3]	Effective Porosity[3]	Total Porosity
Saturated Sand Layer (Aquifer D)	2.34×10^{-4}	1.0×10^{-5}	.30	.30	.45

1 Maximum hydraulic conductivity values for subsurface soils obtained from Appendix IIIG.
2 Specific storage values for subsurface soils obtained from Domenico and Mifflin (1965).
3 Specific yield and effective porosity values for subsurface soils obtained from the Morrison and Johnson (1967).





05/20/2024

0 200 400
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- CELL BOUNDARY
- EXISTING EASEMENT
- PROPOSED EASEMENT
- E 10500 SITE GRID
- 610 EXISTING CONTOUR (SEE NOTE 1)
- 624 TOP OF LINER CONTOUR
- X660 APPROXIMATE TOP OF PRE-SUBTITLE D LINER (SEE NOTE 8)
- CHANNEL CENTERLINE
- LEACHATE COLLECTION PIPE
- LEACHATE COLLECTION SUMP
- LEACHATE RISER PIPE
- 456 GROUNDWATER POTENTIOMETRIC SURFACE CONTOUR IN FT-MSL (SEE NOTE 9)
- MW-10 EXISTING GROUNDWATER MONITORING WELL
- MW-D1 PROPOSED GROUNDWATER MONITORING WELL
- OW-D7 PROPOSED OBSERVATION WELL
- GP-1 EXISTING GAS PROBE
- GP-10A PROPOSED GAS PROBE

NOTES:

1. EXISTING CONTOURS DEVELOPED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN NOVEMBER 10, 2022. THE GRID SYSTEM IS BASED ON A SITE GRID SYSTEM. ELEVATIONS ARE BASED ON NAVD 88.
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 504.0 FT-MSL.
5. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA DRAWINGS I/IIA.4 THROUGH I/IIA.8.
6. REFER TO APPENDIX IIIF FOR DRAINAGE DESIGN INFORMATION.
7. PERMIT BOUNDARY WAS REPRODUCED FROM LEGAL DESCRIPTION PROVIDED BY STANGER SURVEYING COMPANY, DATED APRIL 1995.
8. TOP OF PRE-SUBTITLE D LINER ARE APPROXIMATE AND WAS REPRODUCED FROM CROSS-SECTIONS INCLUDED IN THE 1983 PERMIT APPLICATION PREPARED BY STOKES & ASSOCIATES.
9. GROUNDWATER ELEVATIONS MEASURED BY WCG IN SEPTEMBER 2023 AND POSTED BY MEASUREMENT LOCATIONS IN FT-MSL. GROUNDWATER CONTOURS INTERPOLATED BETWEEN MEASUREMENT LOCATIONS. ACTUAL GROUNDWATER ELEVATIONS MAY VARY FROM THOSE ILLUSTRATED IN THIS FIGURE.

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2024
FILE: 0120-76-11
CAD: 3-1 LINER PLAN.DWG

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: NT

PREPARED FOR
PINE HILL FARMS LANDFILL TX, LP

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

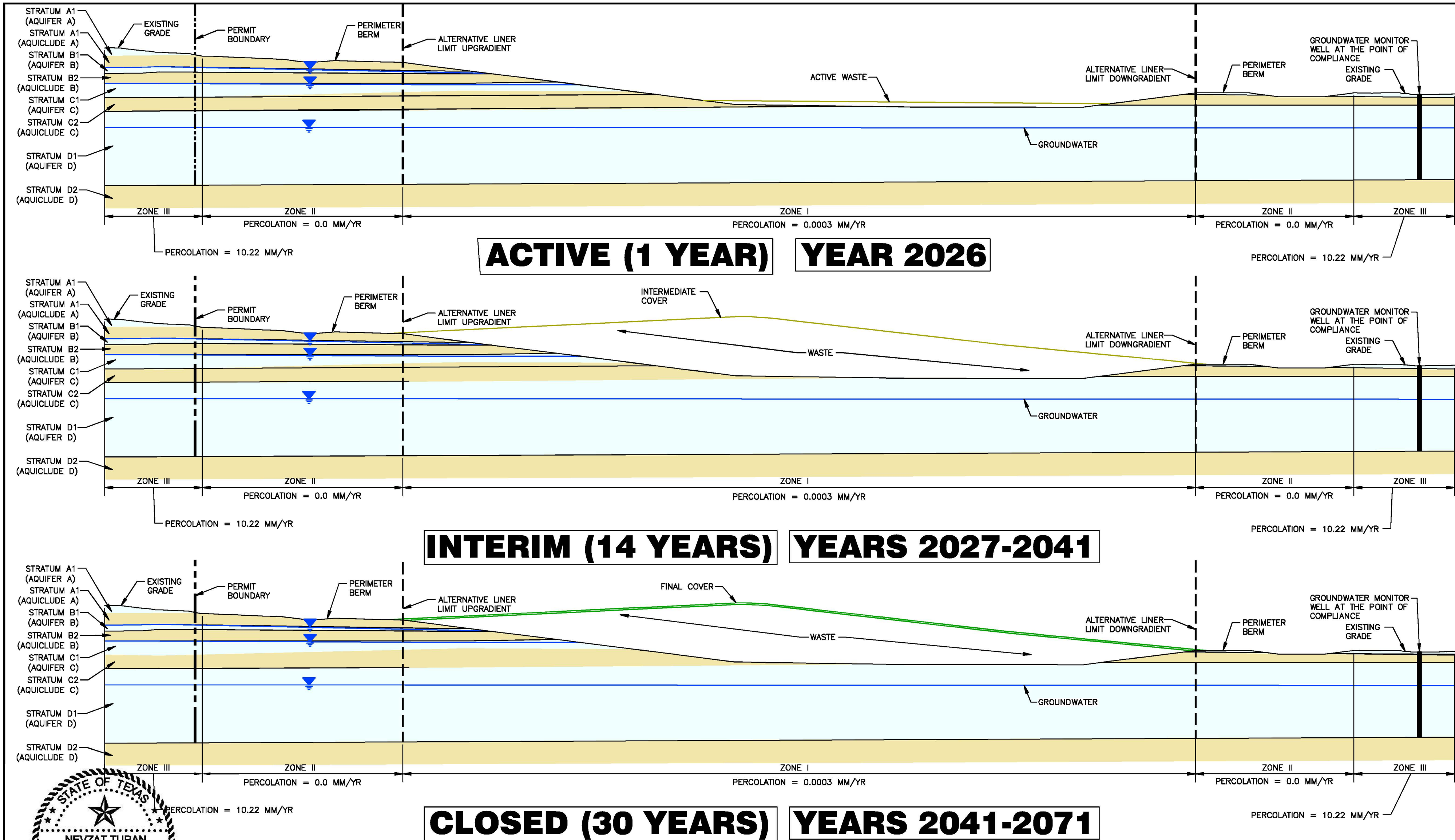
MAJOR PERMIT AMENDMENT
SECTION LOCATION

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE 3-1

SHEET IIIB-18A



STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

05/20/2024

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE

SECTION A

A
3-1|3-2

0 60 120
HORIZONTAL SCALE IN FEET

0 100 200
VERTICAL SCALE IN FEET

SHEET IIIB-18B

☐ DRAFT
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PREPARED FOR
PINE HILL FARMS LANDFILL TX, LP

DATE: 05/2024	DRAWN BY: JDW
FILE: 0120-76-11	DESIGN BY: BPY
CAD: 3-2-SECTION.DWG	REVIEWED BY: NT

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
SECTION A SEQUENCE OF EVENTS

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

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FIGURE 3-2

O:\0120\76\EXPANSION 2023\PART III\IIIB\3-2 SECTION.dwg, byoung, 1:2

4 POINT OF COMPLIANCE DEMONSTRATION RESULTS

The results of the POC demonstration are summarized in Table 4-1 and graphically illustrated on Figure 4-1. The demonstration results in a DAF well in excess of the minimum required value of 260 and is expected that only natural groundwater background levels will be detected on the POC. As shown on Figure 4-1, vertical dispersion in the approximately 100-foot deep aquifer and a shallow hydraulic gradient are the main contributors to the no detect result. 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 4-1
Summary of MODFLOW Simulation Results

Model Section	Calculated DAF	Minimum Required DAF	Design Compliant with §330.331(a)(1)
Section A	7.2×10^{10}	260	Yes

Tables 4-2 and 4-3 have been developed to further illustrate how the DAF is used to determine the constituent level at the POC. As summarized on Tables 4-2 and 4-3, 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 4-1 through 4-3, the waste containment system produces DAFs that are well above the required minimum value.

Table 4-2
Summary of Constituent Levels at the POC
(Using Site Specific Leachate Data)

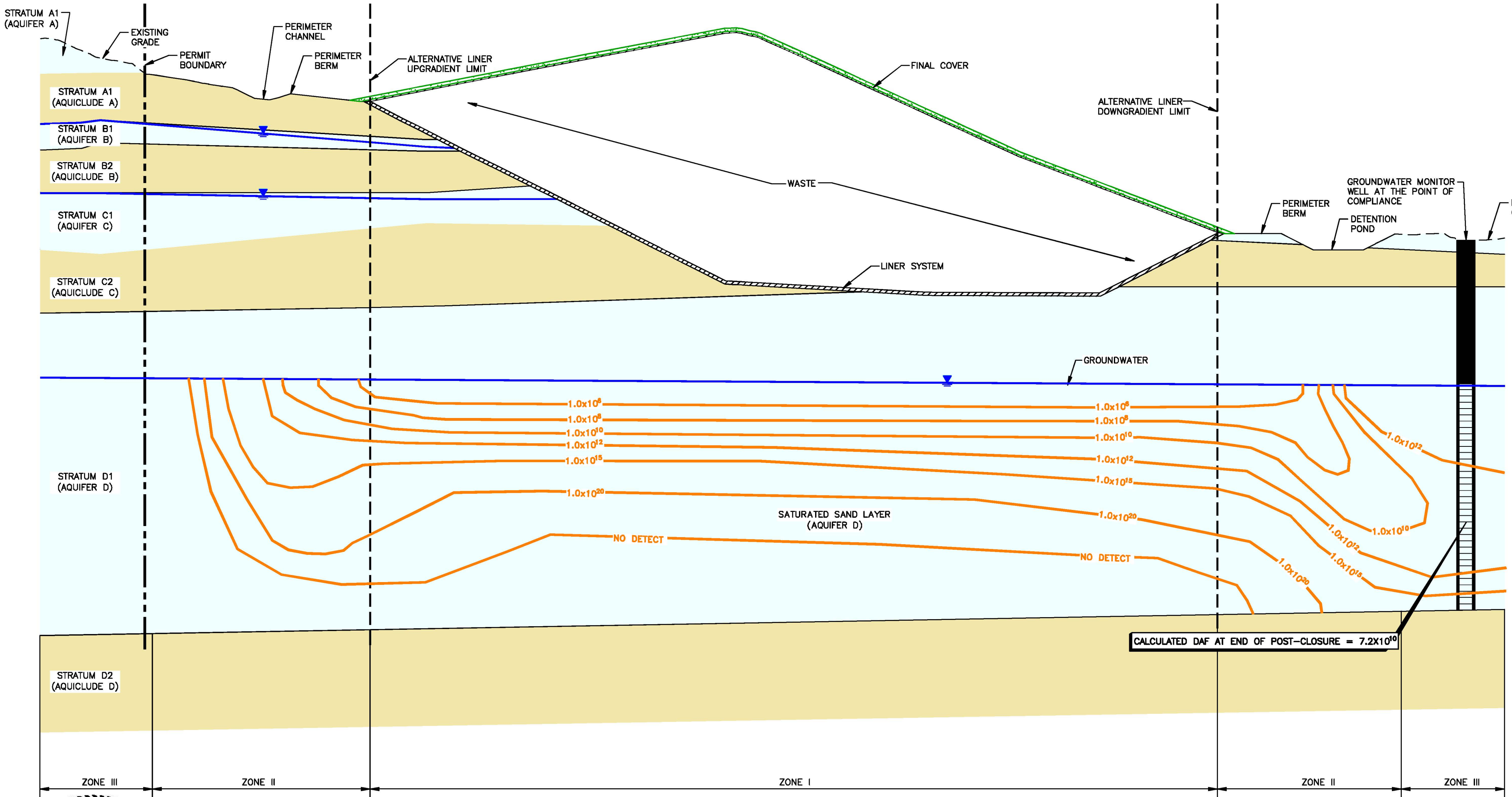
Constituent	C_{BG}, Background Concentration[1] (mg/l)	C_O[2]		DAF[3] (mg/l)	=	CP (mg/l) (Constituent Concentration at the POC due to Estimated Leachate Percolation)	$C_{BG} + C_P = C_T$ at POC (mg/l)	MCL (mg/l) Listed in §330.331(a)(1)	C_T at POC < MCL
Arsenic	0.0403	0.0364	/	7.2E+10	=	5.0E-13	0.040	0.05	YES
Barium	0.432	0.0025	/	7.2E+10	=	3.5E-14	0.432	1	YES
Benzene	00.0005	--	/	7.2E+10	=	--	0.0005	0.005	YES
Cadmium	0.001	0.0025	/	7.2E+10	=	3.5E-14	0.001	0.01	YES
Carbon tetrachloride	0.0025	--	/	7.2E+10	=	--	0.0025	0.005	YES
Chromium (hexavalent)	0.01	0.0025	/	7.2E+10	=	3.5E-14	0.01	0.05	YES
2,4-Dichlorophenoxy acetic acid	--	--	/	7.2E+10	=	--	--	0.1	--
1,4-Dichlorobenzene	0.001	--	/	7.2E+10	=	--	0.001	0.075	YES
1,2-Dichloroethane	0.0005	--	/	7.2E+10	=	--	0.0005	0.005	YES
1,1-Dichloroethylene	--	--	/	7.2E+10	=	--	--	0.007	--
Endrin	--	--	/	7.2E+10	=	--	--	0.0002	--
Fluoride	--	--	/	7.2E+10	=	--	--	4	--
Lindane	--	--	/	7.2E+10	=	--	--	0.004	--
Lead	0.0075	0.0025	/	7.2E+10	=	3.5E-14	0.0075	0.05	YES
Mercury	--	--	/	7.2E+10	=	--	--	0.002	--
Methoxychlor	--	--	/	7.2E+10	=	--	--	0.1	--
Nitrate	---	--	/	7.2E+10	=	--	--	10	--
Selenium	0.005	0.00325	/	7.2E+10	=	4.5E-14	0.005	0.01	YES
Silver	0.005	0.0025	/	7.2E+10	=	3.5E-14	0.005	0.05	YES
Toxaphene	--	--	/	7.2E+10	=	--	--	0.005	--
1,1,1-Trichloroethane	0.0005	--	/	7.2E+10	=	--	0.0005	0.2	YES
Trichloroethylene	0.0025	--	/	7.2E+10	=	--	0.0025	0.005	YES
2,4,5-Trichlorophenoxy acetic acid	--	--	/	7.2E+10	=	--	--	0.01	--
Vinyl Chloride	0.001	--	/	7.2E+10	=	--	0.001	0.002	YES

1 Background concentrations have been obtained from Table 2-1.
2 Leachate concentrations (C_0, Site Specific Concentrations) represent levels obtained from the leachate sample analysis results provided in Table 2-3.
3 DAF value for Section A is presented on Figure 4-1.

Table 4-3
Summary of Constituent Levels at the POC
(Using Historical Guidance Information)

Constituent	C_{BG}, Background Concentration[1] (mg/l)	C_O[2]		DAF[3] (mg/l)	=	CP (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	0.0403	5.0	/	7.2E+10	=	6.9E-11	0.0403	0.05	YES
Barium	0.432	100	/	7.2E+10	=	1.4E-09	0.4320	1	YES
Benzene	0.0005	0.5	/	7.2E+10	=	6.9E-12	0.0005	0.005	YES
Cadmium	0.001	1.0	/	7.2E+10	=	1.4E-11	0.0010	0.01	YES
Carbon tetrachloride	0.0025	0.5	/	7.2E+10	=	6.9E-12	0.0025	0.005	YES
Chromium (hexavalent)	0.01	5.0	/	7.2E+10	=	6.9E-11	0.0100	0.05	YES
2,4-Dichlorophenoxy acetic acid	--	10.0	/	7.2E+10	=	1.4E-10	1.4E-10	0.1	YES
1,4-Dichlorobenzene	0.001	7.5	/	7.2E+10	=	1.0E-10	0.0010	0.075	YES
1,2-Dichloroethane	0.0005	0.5	/	7.2E+10	=	6.9E-12	0.0005	0.005	YES
1,1-Dichloroethylene	--	0.7	/	7.2E+10	=	9.7E-12	9.7E-12	0.007	YES
Endrin	--	0.02	/	7.2E+10	=	2.8E-13	2.8E-13	0.0002	--
Fluoride	--	--	/	7.2E+10	=	--	--	4	--
Lindane	--	0.4	/	7.2E+10	=	5.5E-12	5.5E-12	0.004	YES
Lead	0.0075	5.0	/	7.2E+10	=	6.9E-11	0.0075	0.05	YES
Mercury	--	0.2	/	7.2E+10	=	2.8E-12	2.8E-12	0.002	YES
Methoxychlor[4]	--	--	/	7.2E+10	=	--	--	0.1	--
Nitrate[4]	---	--	/	7.2E+10	=	--	--	10	--
Selenium	0.005	1	/	7.2E+10	=	1.4E-11	0.0050	0.01	YES
Silver	0.005	5.0	/	7.2E+10	=	6.9E-11	0.0050	0.05	YES
Toxaphene	--	0.5	/	7.2E+10	=	6.9E-12	6.9E-12	0.005	YES
1,1,1-Trichloroethane[4]	0.0005	--	/	7.2E+10	=	--	--	0.2	--
Trichloroethylene	0.0025	0.5	/	7.2E+10	=	6.9E-12	0.0025	0.005	YES
2,4,5-Trichlorophenoxy acetic acid	--	1.0	/	7.2E+10	=	1.4E-11	1.4E-11	0.01	YES
Vinyl Chloride	0.01	0.2	/	7.2E+10	=	2.8E-12	0.0010	0.002	YES

1 Background concentrations have been obtained from Table 2-1.
2 Initial concentrations, C_O, has been reproduced from historical standard information utilized by TCEQ as discussed in Section 2.3 and provided in Table 2-2.
3 DAF value for the design case, Section A is presented on Figure 4-1.



STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
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05/20/2024

NOTES:

1. TYPICAL GEOLOGIC PROFILE DEVELOPED FROM CROSS-SECTIONS INCLUDED IN APPENDIX IIIG.

LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- GROUNDWATER SURFACE
- $1.0X10^{15}$ DAF CONTOUR AT END OF POSTCLOSURE

SECTION A (A 3-1 4-1)

HORIZONTAL SCALE IN FEET: 0 60 120

VERTICAL SCALE IN FEET: 0 50 100

SHEET IIIB-21A

☐ DRAFT
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☐ ISSUED FOR CONSTRUCTION

DATE: 05/2024
FILE: 0120-76-11
CAD: 4-1 WASTE CONTAINMENT.DWG

DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: JAE

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
PINE HILL FARMS LANDFILL TX, LP

REVISIONS		
NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
MODFLOW RESULTS

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

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FIGURE 4-1

O:\0120\76\EXPANSION 2023\PART III\IIIB\4-1 WASTE CONTAINMENT.dwg, byoung, 1:2

APPENDIX IIIB-A

HELP MODEL ANALYSIS

Includes pages IIIB-A-1 through IIIB-A-36

STATE OF TEXAS
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LICENSED
PROFESSIONAL ENGINEER

05/20/2024

HELP MODEL ANALYSIS

The following HELP model simulations were run to obtain percolation rates through the undeveloped Subtitle D alternative liner.

Table 1
Landfill Configurations

Case	Description
Case 1: Active, 10 ft Waste	Active landfill with 10 feet of waste modeled for 1 year.
Case 2: Interim, 200 ft Waste	Interim landfill with 200 feet of waste above the liner modeled for 14 years.
Case 3: Closed, 200 ft Waste	Closed landfill with 200 feet of waste above the liner modeled for 30 years.
Case 4: Offsite Recharge, 80 in-situ soil	Offsite recharge area with 80 feet of soil modeled for 30 years.

For input information such as climate data, field capacity and moisture content, and landfill profile information, refer to Appendix IIIC-A.

Alternative Liner System

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.

Help Output

The HELP summaries and output files are presented starting on page IIIB-A-2.

ROYAL OAKS LANDFILL
0120-076-11-106
HELP VERSION 3.07 SUMMARY SHEET
POINT OF COMPLIANCE DEMONSTRATION

			ACTIVE (10 FT WASTE)	INTERIM (200 FT WASTE)	CLOSED (200 FT WASTE)	OFF-SITE RECHARGE[2]
GENERAL INFORMATION		Case No.	1	2	3	4
		Output Page	IIIB-A-4	IIIB-A-12	IIIB-A-20	IIIB-A-31
		No. of Years	1	14	30	30
		Ground Cover	FAIR	GOOD	GOOD	EXCELLENT
		SCS Runoff Curve No.	80.3	85.6	81.2	67.6
		Model Area (acre)	1	1	1	1
		Runoff Area (%)	0	90	100	100
		Maximum Leaf Area Index	0.0	2.0	4.5	4.5
		Evaporative Zone Depth (inch)	10	10	12	30
IN-SITU SOILS	SILTY SAND LAYER (Texture = 7)	Thickness (in)				120
		Porosity (vol/vol)				0.4730
		Field Capacity (vol/vol)				0.2220
		Wilting Point (vol/vol)				0.1040
		Init. Moisture Content (vol/vol)				0.2220
		Hyd. Conductivity (cm/s)				5.2E-04
	CLAYEY SAND 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)				5.7E-07
	SILTY SAND LAYER (Texture = 7)	Thickness (in)				720
		Porosity (vol/vol)				0.4730
		Field Capacity (vol/vol)				0.2220
		Wilting Point (vol/vol)				0.1040
		Init. Moisture Content (vol/vol)				0.2220
		Hyd. Conductivity (cm/s)				5.2E-04
Final Cover	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)			0.250	
		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)			6.63	
		Slope (%)			4	
		Slope Length (ft)			180	
	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	
	INFILTRATION LAYER (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	INTERMEDIATE COVER (Texture = 10)	Thickness (in)		12	12	
		Porosity (vol/vol)		0.3980	0.3980	
		Field Capacity (vol/vol)		0.2440	0.2440	
		Wilting Point (vol/vol)		0.1360	0.1360	
		Init. Moisture Content (vol/vol)		0.2440	0.2440	
		Hyd. Conductivity (cm/s)		1.2E-04	1.2E-04	
Waste	WASTE TOP[1] (Texture = 0)	Thickness (in)	120	1500	1500	
		Porosity (vol/vol)	0.6649	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)	0.3800	0.3800	0.3800	
		Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	
	WASTE BOTTOM[1] (Texture = 0)	Thickness (in)		900	900	
		Porosity (vol/vol)		0.5348	0.5348	
		Field Capacity (vol/vol)		0.4892	0.4892	
		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	
Alternative Liner	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)	0.248	0.164	0.162	
		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)	0.27	0.87	0.87	
		Slope[3] (%)	2.0	2.0	2.0	
		Slope Length (ft)	250	250	250	
	FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06	
		Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	
		Pinhole Density (holes/acre)	1	1	1	
		Install. Defects (holes/acre)	4	4	4	
		Placement Quality	GOOD	GOOD	GOOD	
	GEOSYNTHETIC CLAY LINER (Texture = 0)	Thickness (in)	0.25	0.25	0.25	
		Porosity (vol/vol)	0.7500	0.7500	0.7500	
		Field Capacity (vol/vol)	0.7470	0.7470	0.7470	
		Wilting Point (vol/vol)	0.4000	0.4000	0.4000	
		Init. Moisture Content (vol/vol)	0.7500	0.7500	0.7500	
		Hyd. Conductivity (cm/s)	5.0E-09	5.0E-09	5.0E-09	
PRECIPITATION		Average Annual (in)	56.27	46.52	45.72	45.72
RUNOFF		Average Annual (in)	0.00	3.22	1.94	0.24
EVAPOTRANSPIRATION		Average Annual (in)	36.67	29.38	28.58	33.53
HEAD ON LINER		Average Annual (in)	0.023	0.053	0.028	
LEACHATE GENERATION		Average Annual (cf/yr)	3,730.6	27,651.9	14,614.1	
		Average Annual (gal/yr)	27,907.0	206,850.4	109,321.0	
PERCOLATION THROUGH			Alternative Liner	Alternative Liner	Alternative Liner	Bottom of 80 ft In-Situ Soil
PERCOLATION VALUES		Average Annual (in/yr)	0.00001	0.00001	0.00001	10.22
		Average Annual (mm/yr)	0.0003	0.0003	0.0003	259.6

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] Estimated recharge occurs onsite, between the landfill berm and downgradient model boundary where the POC monitoring wells exist.

HELP MODEL OUTPUT

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


TIME:  31:34     DATE:   1/ 2/2024


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     TITLE:  Royal Oaks Landfill - Point of Compliance - 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
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POROSITY                    =      0.6649 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
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            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.   =  0.270000011000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                       LAYER  4
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            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
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   INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS    =      4.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  5
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              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     =      6.649  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
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NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	58
END OF GROWING SEASON (JULIAN DATE)	=	331
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 19

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.82	5.12	5.51	2.78	4.62	2.12
	3.81	7.13	5.43	2.54	4.98	6.41
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	2.330	2.818	3.669	2.629	4.154	3.462
	3.038	3.511	4.457	1.769	2.739	2.089
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	0.0004	0.0004	0.0000	0.0177
	0.0481	0.0846	0.1282	0.2485	0.2400	0.2598
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)

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  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES               0.0000   0.0000   0.0001   0.0001   0.0000   0.0048
                           0.0127   0.0223   0.0349   0.0655   0.0654   0.0685

    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   19 THROUGH   19
--------------------------------------------------------------------------------
                                    INCHES            CU. FEET       PERCENT
                               -------------------   --------------   ---------
 PRECIPITATION                  56.27    (   0.000)     204260.0     100.00

 RUNOFF                          0.000   (  0.0000)          0.00      0.000

 EVAPOTRANSPIRATION             36.666   (  0.0000)     133096.47     65.160

 LATERAL DRAINAGE COLLECTED      1.02772 (  0.00000)      3730.623    1.82641
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00001 (  0.00000)         0.019     0.00001
   LAYER  5

 AVERAGE HEAD ON TOP             0.023 (    0.000)
   OF LAYER  4

 CHANGE IN WATER STORAGE        18.577   (  0.0000)      67433.02     33.013

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              PEAK DAILY VALUES FOR YEARS   19 THROUGH   19
   ------------------------------------------------------------------------
                                                    (INCHES)      (CU. FT.)
                                                   ----------    -------------
     PRECIPITATION                                    2.73          9909.900
```

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.01111	40.34374
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00016
AVERAGE HEAD ON TOP OF LAYER 4	0.091	
MAXIMUM HEAD ON TOP OF LAYER 4	0.179	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	3.6 FEET	
SNOW WATER	0.42	1525.7992
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4163	
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 19

LAYER	(INCHES)	(VOL/VOL)
1	47.9150	0.3993
2	6.4461	0.2686
3	0.0739	0.2980
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              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\RO\B\I18\DATA4.D4
TEMPERATURE DATA FILE:        C:\RO\B\I18\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\RO\B\I18\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\RO\B\I18\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\RO\B\I18\DATA10.D10
OUTPUT DATA FILE:             C:\RO\B\I18\OUTPUT1.OUT


TIME:  31:46     DATE:   1/ 2/2024


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     TITLE:  Royal Oaks Landfill - Point of Compliance - 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  10
           THICKNESS                  =     12.00   INCHES
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```
  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  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
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            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.16   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.870000005000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                        LAYER  6
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      4.00   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 #10 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  500. FEET.

SCS RUNOFF CURVE NUMBER              =     85.60
FRACTION OF AREA ALLOWING RUNOFF     =     90.0    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     =    920.973  INCHES
TOTAL INITIAL WATER                  =    920.973  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR




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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA

     STATION LATITUDE                         =  32.28 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   2.00
     START OF GROWING SEASON (JULIAN DATE)    =     58
     END OF GROWING SEASON (JULIAN DATE)      =    331
     EVAPORATIVE ZONE DEPTH                   =  12.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   8.60 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  70.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  72.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  72.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
```

COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.54	4.24	3.80	3.38	4.26	4.04
3.40	3.07	3.55	4.75	4.24	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 17 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.18	4.50	3.82	3.68	4.46	4.83
	3.33	2.65	3.86	3.89	4.43	3.90
STD. DEVIATIONS	1.94	1.82	1.44	1.81	1.86	2.47
	2.02	2.37	2.09	2.02	1.08	2.82
RUNOFF						
TOTALS	0.157	0.416	0.164	0.098	0.307	0.463

```
                         0.191    0.132    0.226    0.531    0.265    0.271

  STD. DEVIATIONS        0.259    0.482    0.244    0.179    0.496    0.532
                         0.369    0.304    0.258    0.735    0.154    0.552

 EVAPOTRANSPIRATION
 ------------------
  TOTALS                 1.778    2.181    2.932    2.803    3.589    3.252
                         3.128    2.207    2.547    1.885    1.451    1.627

  STD. DEVIATIONS        0.239    0.293    0.871    1.056    1.074    1.326
                         1.663    1.508    1.332    0.785    0.349    0.194

 LATERAL DRAINAGE COLLECTED FROM LAYER  5
 ----------------------------------------
  TOTALS                 0.6189   0.5926   0.6520   0.6342   0.6573   0.6276
                         0.6549   0.6421   0.6246   0.6400   0.6229   0.6506

  STD. DEVIATIONS        0.1288   0.0710   0.0649   0.0665   0.0788   0.0580
                         0.0725   0.0697   0.0739   0.0707   0.0698   0.0806

 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               0.0506   0.0533   0.0533   0.0536   0.0538   0.0530
                         0.0536   0.0525   0.0528   0.0523   0.0526   0.0532

  STD. DEVIATIONS        0.0105   0.0064   0.0053   0.0056   0.0064   0.0049
                         0.0059   0.0057   0.0062   0.0058   0.0059   0.0066

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   17 THROUGH   30
```

	INCHES	CU. FEET	PERCENT
PRECIPITATION	46.52 (8.894)	168862.4	100.00
RUNOFF	3.221 (1.7027)	11691.40	6.924
EVAPOTRANSPIRATION	29.378 (4.2976)	106643.75	63.154
LATERAL DRAINAGE COLLECTED FROM LAYER 5	7.61760 (0.80277)	27651.877	16.37539
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.037	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.053 (0.006)		
CHANGE IN WATER STORAGE	6.302 (4.9749)	22875.40	13.547

****

****

PEAK DAILY VALUES FOR YEARS 17 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.94	14302.200
RUNOFF	2.052	7446.9922
DRAINAGE COLLECTED FROM LAYER 5	0.02996	108.76262
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00014
AVERAGE HEAD ON TOP OF LAYER 6	0.076	
MAXIMUM HEAD ON TOP OF LAYER 6	0.150	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	3.1 FEET	
SNOW WATER	0.78	2832.5435

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3792

```
MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1360


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

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

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




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

                   FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            2.5728         0.2144

                      2          655.3370         0.4369

                      3          344.4102         0.3827

                      4            6.6319         0.2763

                      5            0.0582         0.3546

                      6            0.0000         0.0000

                      7            0.1875         0.7500

                   SNOW WATER      0.000

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

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


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


TIME:  32:16     DATE:  12/ 6/2023


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

     TITLE:  Royal Oaks Landfill - Point of Compliance - Closed 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  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                   =      0.25   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.   =   6.63000011000     CM/SEC
  SLOPE                       =      4.00   PERCENT
  DRAINAGE LENGTH             =    180.0    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  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                        LAYER  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                    =    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  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                   =      0.16   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.870000005000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                        LAYER 10
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      4.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER 11
                        --------

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


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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    =    931.590  INCHES
TOTAL INITIAL WATER                 =    931.590  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

```
STATION LATITUDE                        =  32.28 DEGREES
MAXIMUM LEAF AREA INDEX                 =   4.50
START OF GROWING SEASON (JULIAN DATE)   =     58
END OF GROWING SEASON (JULIAN DATE)     =    331
EVAPORATIVE ZONE DEPTH                  =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED               =   8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.54	4.24	3.80	3.38	4.26	4.04
3.40	3.07	3.55	4.75	4.24	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA AND STATION LATITUDE = 32.28 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	4.06	3.66	3.91	3.61	4.07	4.22
	3.38	2.64	3.32	4.70	4.22	3.92
STD. DEVIATIONS	2.78	1.82	1.66	1.52	1.88	2.72
	1.70	2.24	1.86	2.59	1.43	2.47
RUNOFF						
TOTALS	0.162	0.146	0.063	0.034	0.117	0.276
	0.114	0.072	0.110	0.513	0.107	0.230
STD. DEVIATIONS	0.428	0.276	0.127	0.083	0.233	0.406
	0.237	0.174	0.228	0.834	0.088	0.475
EVAPOTRANSPIRATION						
TOTALS	1.730	2.131	2.966	3.241	3.405	3.076
	2.940	2.179	2.473	1.803	1.234	1.405
STD. DEVIATIONS	0.187	0.403	0.728	0.927	1.132	1.575
	1.317	1.424	1.146	0.873	0.226	0.202
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.4196	1.6307	1.0844	0.4815	0.6772	0.9315
	0.3962	0.3728	0.5029	1.9176	2.4589	2.3237
STD. DEVIATIONS	2.3570	1.3815	1.1689	0.5418	0.9091	1.1421
	0.5167	0.7152	0.7830	1.4816	1.2878	2.0416
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001
	0.0000	0.0000	0.0000	0.0002	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.3331	0.3176	0.3490	0.3362	0.3460	0.3314
	0.3428	0.3424	0.3281	0.3392	0.3250	0.3350
STD. DEVIATIONS	0.0992	0.1100	0.1237	0.1179	0.1205	0.1108

```
                        0.1153   0.1110   0.1069   0.1125   0.1044   0.1069

 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             0.0316   0.0291   0.0121   0.0037   0.0114   0.0183
                        0.0064   0.0064   0.0083   0.0553   0.0287   0.0399

   STD. DEVIATIONS      0.0445   0.0401   0.0170   0.0052   0.0275   0.0294
                        0.0136   0.0161   0.0177   0.0729   0.0165   0.0569

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   AVERAGES             0.0272   0.0285   0.0285   0.0284   0.0283   0.0280
                        0.0280   0.0280   0.0277   0.0277   0.0275   0.0274

   STD. DEVIATIONS      0.0081   0.0099   0.0101   0.0100   0.0099   0.0094
                        0.0094   0.0091   0.0090   0.0092   0.0088   0.0087

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



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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                   INCHES             CU. FEET       PERCENT
                             -------------------   -------------   ---------
 PRECIPITATION                 45.72    (   8.166)     165946.7     100.00

 RUNOFF                         1.943   (  1.4253)       7054.32      4.251

 EVAPOTRANSPIRATION            28.583   (  3.6101)     103757.41     62.525

 LATERAL DRAINAGE COLLECTED    15.19686 (  5.20318)     55164.598   33.24236
   FROM LAYER  2
```

```
 PERCOLATION/LEAKAGE THROUGH     0.00062 (  0.00030)         2.243     0.00135
   LAYER  4

 AVERAGE HEAD ON TOP             0.021 (    0.011)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED      4.02592 (  1.30902)     14614.088    8.80650
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH     0.00001 (  0.00000)         0.024     0.00001
   LAYER 11

 AVERAGE HEAD ON TOP             0.028 (    0.009)
   OF LAYER 10

 CHANGE IN WATER STORAGE        -4.034   (  1.3622)     -14643.76    -8.824

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



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

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
       PRECIPITATION                              6.92         25119.600

       RUNOFF                                     3.628        13168.5488

       DRAINAGE COLLECTED FROM LAYER  2           2.08349       7563.06934

       PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000316         1.14858

       AVERAGE HEAD ON TOP OF LAYER  3            4.598

       MAXIMUM HEAD ON TOP OF LAYER  3            7.622

       LOCATION OF MAXIMUM HEAD IN LAYER  2
             (DISTANCE FROM DRAIN)               30.5 FEET

       DRAINAGE COLLECTED FROM LAYER  9           0.02806        101.85973

       PERCOLATION/LEAKAGE THROUGH LAYER 11       0.000000         0.00013

       AVERAGE HEAD ON TOP OF LAYER 10            0.071
```

```
MAXIMUM HEAD ON TOP OF LAYER 10           0.141

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)               2.8 FEET

SNOW WATER                                3.18         11547.1094


MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3849

MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1360


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

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

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




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

             FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1            2.6644         0.2220

                2            0.0025         0.0100

                3            0.0000         0.0000

                4            7.6860         0.4270

                5            2.9280         0.2440

                6          517.0857         0.3447

                7          273.8399         0.3043

                8            6.1529         0.2564

                9            0.0199         0.1225
```

10	0.0000	0.0000
11	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:\RO\B\REC\DATA4.D4
TEMPERATURE DATA FILE:      C:\RO\B\REC\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\B\REC\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\B\REC\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\B\REC\DATA10.D10
OUTPUT DATA FILE:           C:\RO\B\REC\OUTPUT1.OUT


TIME:  32:13     DATE:   1/ 2/2024


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

     TITLE:  Royal Oaks Landfill - Point of Compliance - Offsite Recharge

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


     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   7
           THICKNESS                  =    120.00   INCHES
```

```
  POROSITY                      =      0.4730 VOL/VOL
  FIELD CAPACITY                =      0.2220 VOL/VOL
  WILTING POINT                 =      0.1040 VOL/VOL
  INITIAL SOIL WATER CONTENT    =      0.2220 VOL/VOL
  EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                     =    240.00   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 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   7
  THICKNESS                     =    720.00   INCHES
  POROSITY                      =      0.4730 VOL/VOL
  FIELD CAPACITY                =      0.2220 VOL/VOL
  WILTING POINT                 =      0.1040 VOL/VOL
  INITIAL SOIL WATER CONTENT    =      0.2220 VOL/VOL
  EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  2.%
         AND A SLOPE LENGTH OF  200. FEET.
```

SCS RUNOFF CURVE NUMBER	=	67.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	30.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.660	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	14.190	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.120	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	245.040	INCHES
TOTAL INITIAL WATER	=	245.040	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	58	
END OF GROWING SEASON (JULIAN DATE)	=	331	
EVAPORATIVE ZONE DEPTH	=	30.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.54	4.24	3.80	3.38	4.26	4.04
3.40	3.07	3.55	4.75	4.24	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 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	4.06	3.66	3.91	3.61	4.07	4.22
	3.38	2.64	3.32	4.70	4.22	3.92
STD. DEVIATIONS	2.78	1.82	1.66	1.52	1.88	2.72
	1.70	2.24	1.86	2.59	1.43	2.47
RUNOFF						
TOTALS	0.022	0.019	0.002	0.001	0.007	0.024
	0.009	0.002	0.007	0.112	0.000	0.038
STD. DEVIATIONS	0.116	0.052	0.010	0.005	0.032	0.048
	0.033	0.008	0.027	0.339	0.001	0.097
EVAPOTRANSPIRATION						
TOTALS	1.726	2.222	3.296	4.602	4.529	4.089
	3.689	2.463	2.742	1.833	1.091	1.244
STD. DEVIATIONS	0.204	0.299	0.592	0.702	1.415	2.332
	1.648	1.820	1.323	0.786	0.158	0.230

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	1.0371	0.9420	0.9430	0.8020	0.5996	0.5784
	0.6711	0.7769	0.8412	0.9724	0.9860	1.0705
STD. DEVIATIONS	0.5378	0.5018	0.5016	0.4971	0.5556	0.5255
	0.5733	0.6293	0.6023	0.6053	0.5279	0.5203

****

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.72	(8.166)	165946.7	100.00
RUNOFF	0.243	(0.3789)	881.64	0.531
EVAPOTRANSPIRATION	33.526	(4.8391)	121699.95	73.337
PERCOLATION/LEAKAGE THROUGH LAYER 3	10.22013	(4.72606)	37099.059	22.35601
CHANGE IN WATER STORAGE	1.726	(7.3679)	6266.00	3.776

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	6.92	25119.600
RUNOFF	1.815	6587.2964
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.092863	337.09125
SNOW WATER	3.18	11547.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3894
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	33.1225	0.2760
2	66.1032	0.2754
3	197.5993	0.2744
SNOW WATER	0.000	

****
****

ROYAL OAKS LANDFILL
CHEROKEE COUNTY
TCEQ PERMIT NO. MSW-1614B

MAJOR PERMIT AMENDMENT APPLICATION

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

Prepared for

Pine Hill Farms Landfill TX, LP

May 2024

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

05/20/2024

Prepared by

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817-735-9770

WCG Project No. 0120-076-11-106

This document is intended for permitting purposes only.

STATE OF TEXAS
NEVZAT TURAN
84059
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05/20/2024

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STATE OF TEXAS
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05/20/2024

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 Royal Oaks Landfill was prepared consistent with Title 30 Texas Administrative Code (TAC) §§330.305(c), 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 and final cover systems are included in Part III, Appendix IIIA-A – Liner 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. This report covers the design and demonstrations for the future liner area leachate collection system and demonstrations showing that the currently installed leachate collection system will function as desired.

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 Royal Oaks 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 Royal Oaks Landfill will manage stormwater 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 and stormwater diversion ditches. 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 – Cell 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, soil daily and intermediate cover areas 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 consists of: (1) a collection layer placed over the liner system, (2) the leachate collection piping, and (3) the leachate collection sumps and pumps. 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 and Final Cover System Details. The existing leachate collection system has also been analyzed to demonstrate that the proposed change in site configuration will not adversely impact the existing leachate collection system.

3.1.2 Design Criteria

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

The leachate collection system layout is shown on Figure 3-1. Subtitle D Cell 1 through 9 have been constructed to date. For the Subtitle D cells, 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 cells. 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.

The leachate collection layer will be placed directly over the liner system. The leachate collection system for the undeveloped cells (Cells 10 through 12) have been designed for the estimated overburden pressure that will be created by the proposed landfill completion condition. Material specifications are included in the following subsections for cells 10 through 12. Table 3-1 shows that the maximum leachate depth for cells 10 through 12 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 cell and also the maximum depth of leachate over the liner based on the HELP generated peak flow and the actual leachate generation information.

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

Cell[3]	Location	Initial Slope	Post-Settlement Slope[4]	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
Developed Areas Cell 1 through 9	Slope between cell ridgeline and leachate collection pipe	2.8%	2.5%	2.5%	0.065 inches	0.0022 inches	Yes
	Slope of leachate collection pipe	2.0%	1.8%	1.8%	Peak flow less than the capacity of the collection pipe[2]	Peak flow less than the capacity of the collection pipe[2]	
Undeveloped Areas Cells 10 through 12	Slope between cell ridgeline and leachate collection pipe	2.8%	2.0%	2.0%	0.208 inches	0.0313 inches	Yes
	Slope of leachate collection pipe	2.0%	1.7%	1.5%	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 post-settlement slope. Refer to Appendices IIIC-A, IIIC-A.1, IIIC-A.2, 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 Cells 1 through 9 – 200-mil-thick single-sided geocomposite; Undeveloped Cells 10 through 12 – 250-mil-thick single-sided geocomposite (floors) and 250-mil-thick double-sided geocomposite (sideslopes).
4 Foundation settlement is discussed in Appendix IIIE.

3.2 Leachate Collection Layer

The leachate collection layer for the undeveloped cells will be placed directly over the liner system to collect and transfer leachate to the leachate collection system pipes and sumps. The leachate collection layer placed over the floor grades for the undeveloped portion of the site will consist of a 250-mil-thick HDPE geonet with a 6 oz/sy (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 layers (after accounting for losses due to clogging) are presented in Appendix IIIC-A and IIIC-A.2. The drainage geocomposite for the undeveloped cells will comply with the specifications listed in Table 3-2. Geocomposites with higher thickness meeting all the requirements of this design may be utilized.

An analysis of the existing Subtitle D areas is also included in Appendix IIIC-A. Cells 1 through 9 were constructed with a 200-mil-thick geocomposite. A 200-mil-thick geocomposite was modeled for all of the developed areas (Cells 1 through 9) and is sufficient to maintain less than 12 inches of head above the bottom liner with the overburden pressure resulting from the closed landfill condition.

3.2.1 Chimney Drains

The chimney drains will be installed above the LCS pipes and the top of the chimney drain gravel will be extended to (or may exceed) the top of protective cover grades. 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

The liner and overlying leachate collection layer will slope to drain toward the LCS trenches, which will contain a perforated leachate collection pipe encased in drainage stone and separated from the protective cover and waste layers by a geotextile fabric. The leachate collection pipe will direct the leachate to the LCS sumps. The existing leachate collection pipes are perforated 6-inch ADS N-12 HDPE smooth wall pipes in Sectors 1 through 6B/7A and HDPE SDR 17 smooth wall pipes in Sectors 7B/8 and 9. The leachate collection pipes will be SDR 17 HDPE smooth wall pipe (refer to Appendix IIIC-B for LCS pipe designs for the Subtitle D area). The existing leachate collection pipes are perforated 6-inch SDR 17 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 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 on the liner system at the sump rim. The leachate sump operating plan is included in Table 3-2.

Each leachate sump is sized based on the amount of leachate generation taking into consideration from the areas draining to each sump. As shown on Figure 3-1, the undeveloped Cell 12 sump will receive leachate from the constructed Cells 5 through 8, and the undeveloped Cell 11 sump will receive leachate from Cells 11 and 10. The size and capacity of the sumps for all the undeveloped cells 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). Other gradients will require hydraulic conductivity testing to demonstrate that 1.0 cm/s hydraulic conductivity is provided by the drainage stone. 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 layer. If the pump malfunctions, the pump will be removed, repaired, and replaced, or a new pump will be used (see Table 3-2 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 and Final Cover System Details.

The specified pump for each cell 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 cell (Cell 12 with a contributing area of 32.5 acres) is approximately 18,111.4 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 3-2
Leachate Sump Operating Plan

<table>
<tr><th>Leachate Level Description</th><th>Condition</th><th>Action Required</th></tr>
<tr><td>Leachate level between lip of sump and pump intake at the bottom of the sump.</td><td>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).</td><td>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.</td></tr>
<tr><td>Leachate level between the lip of the sump and 30 cm (or 12 inches) above the lip of the sump.</td><td>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.</td><td rowspan="2">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 cell, 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.</td></tr>
<tr><td>Leachate level over 12 inches above the lip of the sump.</td><td>System not functioning as designed and the design standard listed in §330.331(a)(2) has been exceeded.</td></tr>
</table>

3.5 Drainage Stone (Coarse Aggregate)

Granular drainage material around the leachate collection pipes and in the LCS sumps in the 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 size criteria:

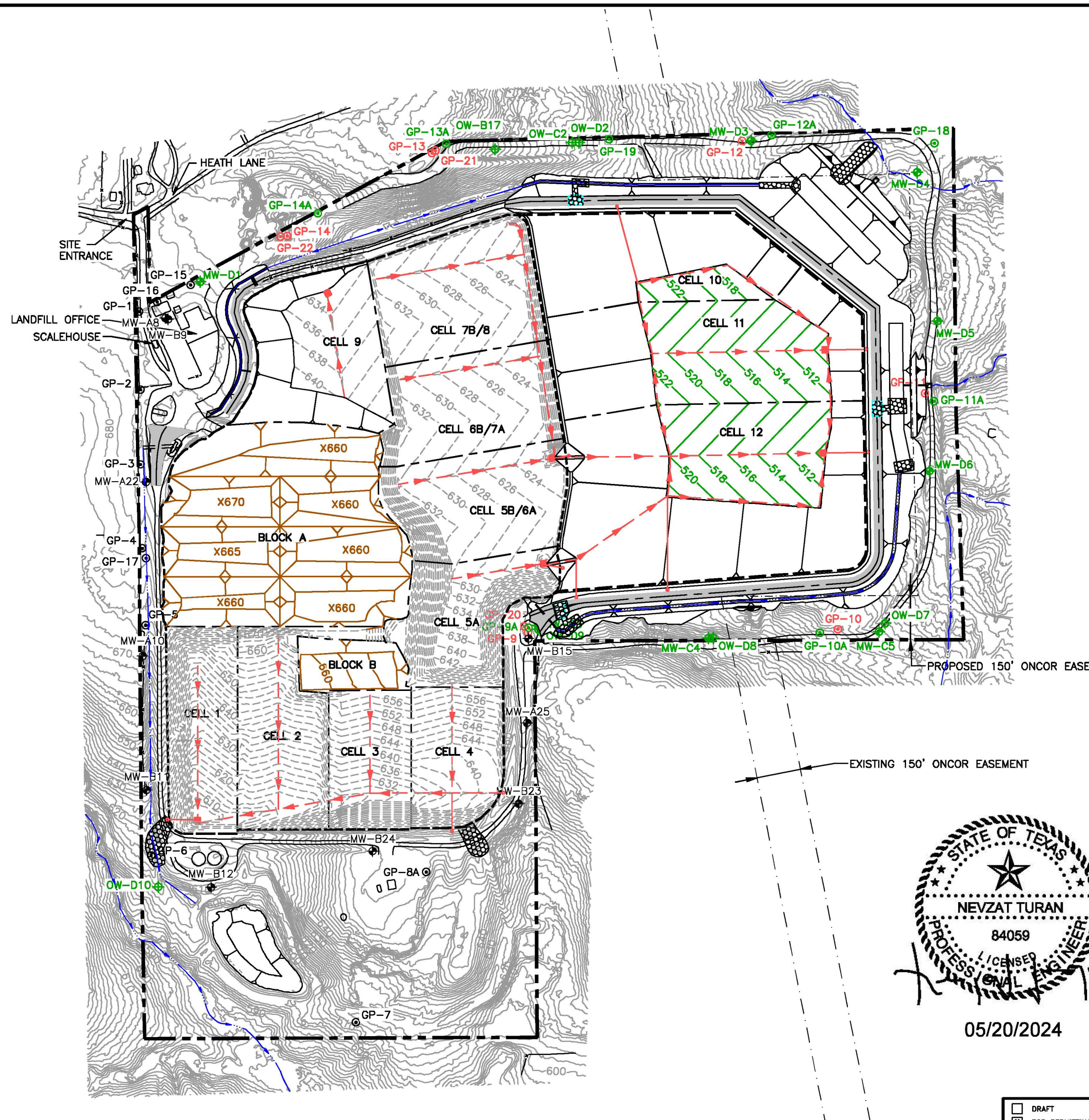
For circular holes:

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

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.



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SCALE IN FEET

LEGEND

PERMIT BOUNDARY
PERMITTED LIMIT OF WASTE
PROPOSED LIMIT OF WASTE
CELL BOUNDARY
EXISTING EASEMENT
PROPOSED EASEMENT
E 10500 SITE GRID
610 EXISTING CONTOUR (SEE NOTE 1)
516 TOP OF LINER CONTOUR
X660 APPROXIMATE TOP OF PRE-SUBTITLE D LINER (SEE NOTE 3)
CHANNEL CENTERLINE
LEACHATE COLLECTION PIPE
LEACHATE COLLECTION SUMP
LEACHATE CLEANOUT RISER
MW-10 EXISTING GROUNDWATER MONITORING WELL
MW-D1 PROPOSED GROUNDWATER MONITORING WELL
OW-D7 PROPOSED OBSERVATION WELL
GP-1 EXISTING GAS PROBE
GP-10A PROPOSED GAS PROBE

NOTES:

1. EXISTING CONTOURS DEVELOPED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN NOVEMBER 10, 2022. THE GRID SYSTEM IS BASED ON A SITE GRID SYSTEM. ELEVATIONS ARE BASED ON NAVD 88.
2. ELEVATION OF DEEPEST EXCAVATION AT THE LCS SUMP IS 504.0 FT-MSL.
3. TOP OF PRE-SUBTITLE D LINER ARE APPROXIMATE AND WAS REPRODUCED FROM CROSS-SECTIONS INCLUDED IN THE 1983 PERMIT APPLICATION PREPARED BY STOKES & ASSOCIATES. THIS INFORMATION IS PROVIDED FOR COMPLETENESS AND NO NEW EXPANSION WASTE PLACEMENT IS PROPOSED OVER THE PRE-SUBTITLE D AREAS.

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

05/20/2024

SHEET IIIC-11A

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2024
FILE: 0120-76-11
CAD: 3-1 LEACHATE COLLECTION PLAN.DWG

DRAWN BY: RAA
DESIGN BY: JBM
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
PINE HILL FARMS LANDFILL TX, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE COLLECTION SYSTEM PLAN

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE 3-1

O:\0120\76\EXPANSION 2023\PART III\IIIC\3-1 LEACHATE COLLECTION SYSTEM PLAN.dwg, byoung, 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 sump size and pump requirements have been based on the amount of leachate generated. 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 cells/areas. The estimated leachate generation rate is based on the average leachate generation estimated by the HELP model analysis. As shown in Section 6, the site-specific leachate generation is significantly less than what is estimated by the HELP model. Therefore, the use of the average annual leachate generation rate estimated 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 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 3-2. 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 tanks is discussed in Section 4.3. The location of the leachate storage tanks are 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 cell 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														
	Cells 1 and 9[1] (Developed Area)					Cell 12[1] (Undeveloped Area)					Cells 10 and 11[1] (Undeveloped Area)				
	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	7,511.3	785	6.3	0.7	20	7,699.1	1,723	6.4	1.4	20	7,176.1	779	6.0	0.6	20
Interim	7,699.1	785	6.4	0.7	20	18,100.7	1,723	15.1	1.4	20	8,187.1	779	6.8	0.6	20
Closed	3,640.2	79	3.0	0.1	20	8,187.1	173	6.8	0.1	20	4,402.5	78	3.7	0.1	20

1 Sumps for the largest drainage areas are shown. Refer to Appendix IIIC-B, Sheet IIIC-B-40 – Sump Drainage Areas for cell layout and sump drainage areas.
2 Refer to Appendix IIIC-B, page IIIC-B-39 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 leachate generation value listed in Table 6-1 was used (i.e., 19,349 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 offsite wastewater treatment facility. Contaminated water may be stored in the leachate tanks; however, comingled contaminated water and leachate will not be recirculated (refer to section 5).

4.3 Onsite Storage Tank(s)

As presented in Appendix IIIC-D, two 100,000 gallon leachate tanks provides 5.4 days storage for the maximum daily leachate generation rate of 36,992 gallons estimated by the HELP model. Note that this estimate of leachate generation is conservative, as actual site leachate generation information (as presented in Appendix IIIC-E) demonstrates that actual leachate generation at the Royal Oaks Landfill is significantly less than as estimated by the HELP model. The location of the existing storage tank(s) are shown on Figure 4-1 and described in Table 4-2 (including tank composition, secondary containment, level controls, etc.).

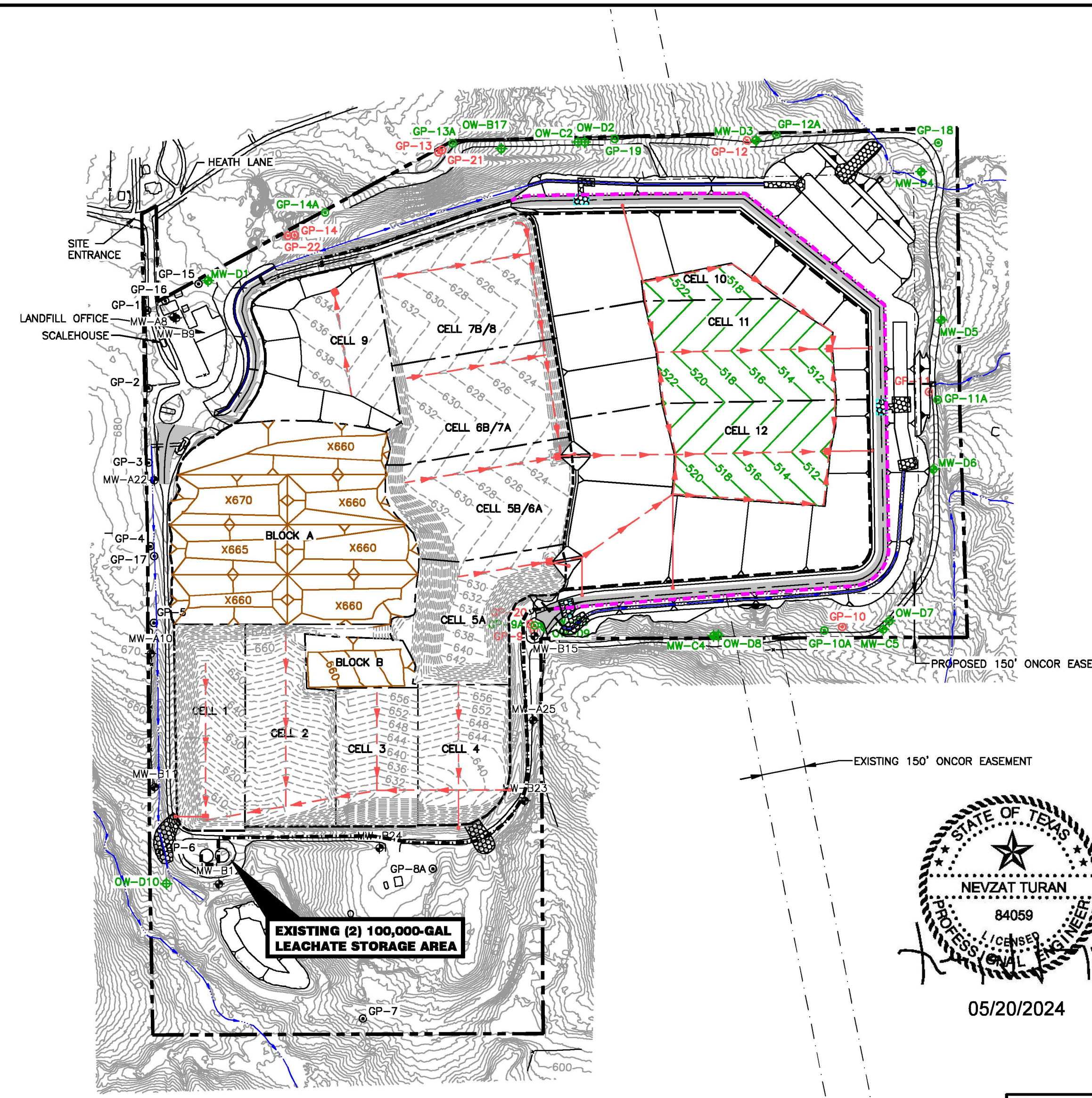
The storage tank(s) consists of a double-lined leachate tank that contains an inner tank ("storage vessel") consisting of a primary and secondary geomembrane liners. The liners will be placed inside a steel tank that is placed over concrete foundation to provide stability for the tank. The secondary geomembrane liner collects any leachate that may leak through the primary geomembrane liner. Any leachate that leaks 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. 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.

Leachate levels within the tanks will be controlled by discharging leachate to the existing City of Jacksonville sanitary sewer connection which discharges to the City of Jacksonville POTW. Refer to Appendix IIIC-F for more information on the City of Jacksonville Industrial Wastewater Discharge Permit. Alternatively, leachate will be transferred from the storage tanks to a tanker truck and transported to a properly permitted off-site treatment facility.

Table 4-2
Existing Tanks

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) 37,024 (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	100,000 (total) 37,024 (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

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 7.88 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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SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- PERMITTED LIMIT OF WASTE
- PROPOSED LIMIT OF WASTE
- CELL BOUNDARY
- EXISTING EASEMENT
- PROPOSED EASEMENT
- E 10500 — SITE GRID
- 610 — EXISTING CONTOUR (SEE NOTE 1)
- 516 — TOP OF LINER CONTOUR
- X660 — APPROXIMATE TOP OF PRE-SUBTITLE D LINER (SEE NOTE 3)
- CHANNEL CENTERLINE
- LEACHATE COLLECTION PIPE
- LEACHATE COLLECTION SUMP
- LEACHATE CLEANOUT RISER
- MW-10 — EXISTING GROUNDWATER MONITORING WELL
- MW-D1 — PROPOSED GROUNDWATER MONITORING WELL
- OW-D7 — PROPOSED OBSERVATION WELL
- GP-1 — EXISTING GAS PROBE
- GP-10A — PROPOSED GAS PROBE
- EXISTING FORCEMAIN
- PROPOSED FORCEMAIN

NOTES:

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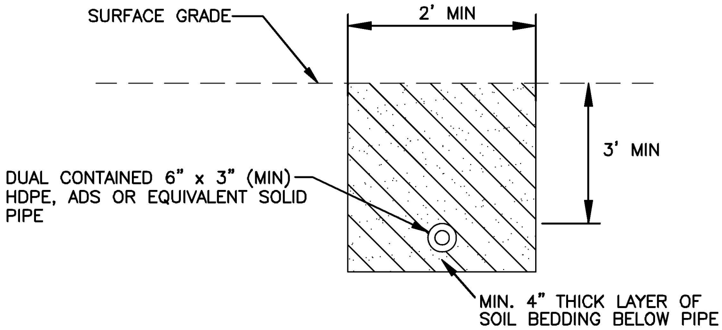
STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

05/20/2024

☐ DRAFT ☒ FOR PERMITTING PURPOSES ONLY ☐ ISSUED FOR CONSTRUCTION	PREPARED FOR PINE HILL FARMS LANDFILL TX, LP	MAJOR PERMIT AMENDMENT FORCEMAIN AND STORAGE TANK PLAN
DATE: 05/2024 FILE: 0120-76-11 CAD: 4-1 FORCEMAIN AND STORAGE PLAN.DWG DRAWN BY: RAA DESIGN BY: JBM REVIEWED BY: NT	REVISIONS NO. / DATE / DESCRIPTION	ROYAL OAKS LANDFILL CHEROKEE COUNTY, TEXAS
Weaver Consultants Group TBPE REGISTRATION NO. F-3727		WWW.WCGRP.COM — FIGURE 4-1

SHEET IIIC-15A

O:\0120\76\EXPANSION 2023\PART III\IIIC\4-1 LEACHATE STORAGE TANK AND FORCEMAIN PLAN.dwg, byoung, 1:2



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

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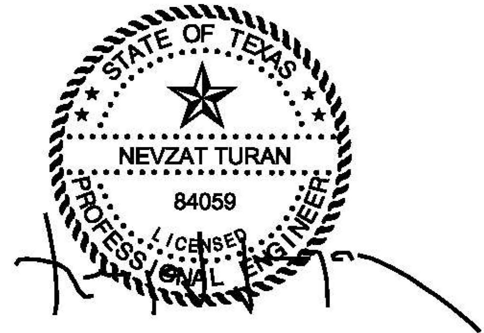
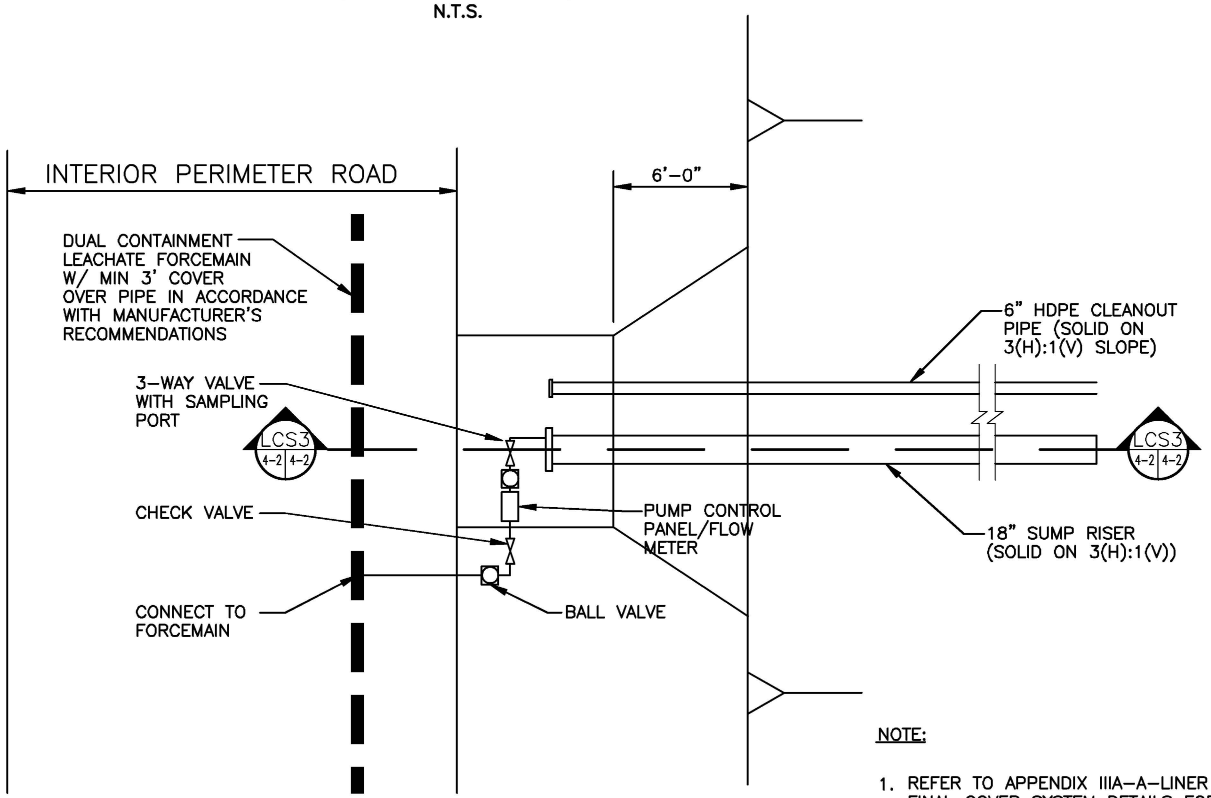


05/20/2024

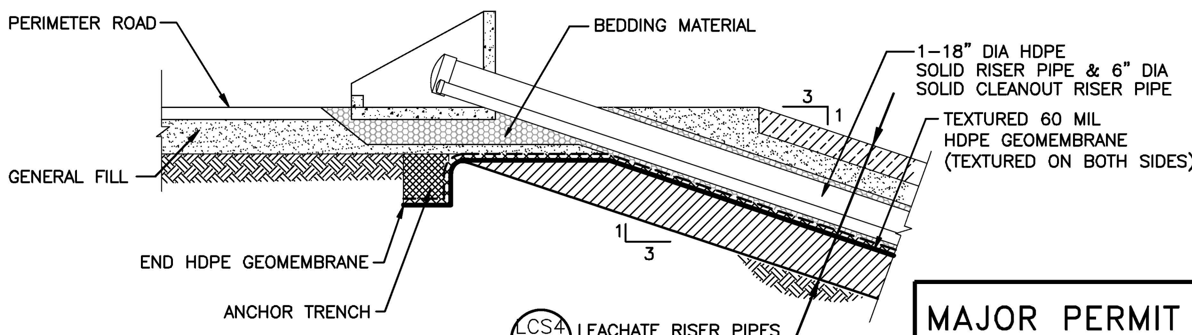


FORCEMAIN CONNECTION LCS2 4-1 4-2

N.T.S.

NOTE:

1. REFER TO APPENDIX IIIA-A-LINER AND FINAL COVER SYSTEM DETAILS FOR LINER INFORMATION.
2. MULTIPLE 6-INCH CLEANOUT RISERS MAY BE INSTALLED DEPENDING ON THE NUMBER OF LCS PIPES DRAINING TO SUMP.



LEACHATE RISER/CLEANOUT LCS3 4-2 4-2

0 4 8
SCALE IN FEET

SHEET IIIC-15B

MAJOR PERMIT AMENDMENT
LEACHATE FORCEMAIN DETAILS

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

DRAWN BY: BPY	DATE: 05/2024	FILE: 0120-076-11
REVIEWED BY: BPY	CAD: 4-2 FORCEMAIN DTLS.DWG	FIGURE 4-2

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5 LEACHATE AND CONTAMINATED WATER DISPOSAL

5.1 Leachate Storage System Operation and Disposal

Leachate that is generated at the site will be conveyed to the leachate collection sumps. Leachate levels in the sumps are measured and recorded to evaluate leachate production and fluctuations. A form to record leachate measurements is kept in the Site Operating Record and is used to evaluate the effectiveness of the leachate monitoring and control facilities. The depth of leachate in the sump will be monitored by the pressure transducer which will be calibrated to provide direct read-out of the leachate level in the sump (e.g., typically the leachate level is shown on a continuous digital display at the sump, as the pressure transducers provide a constant determination of the leachate levels in the sump). As noted in Part IV – SOP, Section 4.23, 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 storage tank(s) will provide approximately 5.4 days of leachate storage.

The collected leachate is transported by forcemain to the leachate storage tank(s) and then is discharged to the existing City of Jacksonville sanitary sewer which discharges to the City of Jacksonville Waste Water Treatment Facility (refer to Appendix IIIC-F), POTW, or recirculated back into the landfill (refer top Section 5.2). The storage tanks will be operated so that leachate is pumped from the storage tank to the City of Jacksonville sewer line at a rate that matches daily generation rate (i.e., the leachate pumps will cycle on and off throughout the day to provide for efficient system operations; however, the discharge rate to the sewer line will match the incoming daily leachate generation rate). Alternatively, leachate will be transferred from the storage tanks to a tanker truck and transported to a properly permitted off-site treatment facility. For leachate that is transferred to tanker trucks, sampling and analysis will be based on the disposal facility's requirements.

Leachate levels in the storage tanks will be measured once per day only when the sanitary sewer line is out of service for emergencies to verify that the system is operating in conformance with this plan. During normal operations a flow measuring device, installed on the outlet pipe from the tanks, records the amount of leachate discharge. The quantity of leachate pumped from the system is also recorded on a monthly basis. This information is maintained in the Site Operating Record.

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 or areas with alternative liner). 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 following performance standards will govern the application rate of leachate recirculation.

- Recirculation will not exceed 2,341 gallons per day.
- 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 16 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 cell that flows to the sump which contains the pump that is operating near capacity. If this occurs, recirculation activities will move to another cell.

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

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 the leachate tanks, a properly permitted privately-owned treatment facility, or a POTW for treatment. Contaminated water will be removed as soon as practicable from the area inside the 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 Royal Oaks 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 estimated 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 2018 through 2022. 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 19,349 gal/acre/year and the maximum leachate generation has been 23,079 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)
2018	60.6	499,384	30.8	16,214
2019	42.8	710,819	30.8	23,079
2020	52.4	722,719	36.3	19,910
2021	47.7	772,770	36.3	21,228
2022	39.4	674,510	41.5	16,253
Average	48.6	NA	NA	19,349

[1] The rainfall data was provided by Republic site personnel.

6.3 Leachate Generation Comparison

The existing site leachate generation rates and the leachate generation rates estimated 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 daily leachate generation information for undeveloped cells developed cells, and the Cell 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 the average annual leachate generation information for the undeveloped cells, developed cells, and the Cell 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 Royal Oaks Landfill for the 2018-2022 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.

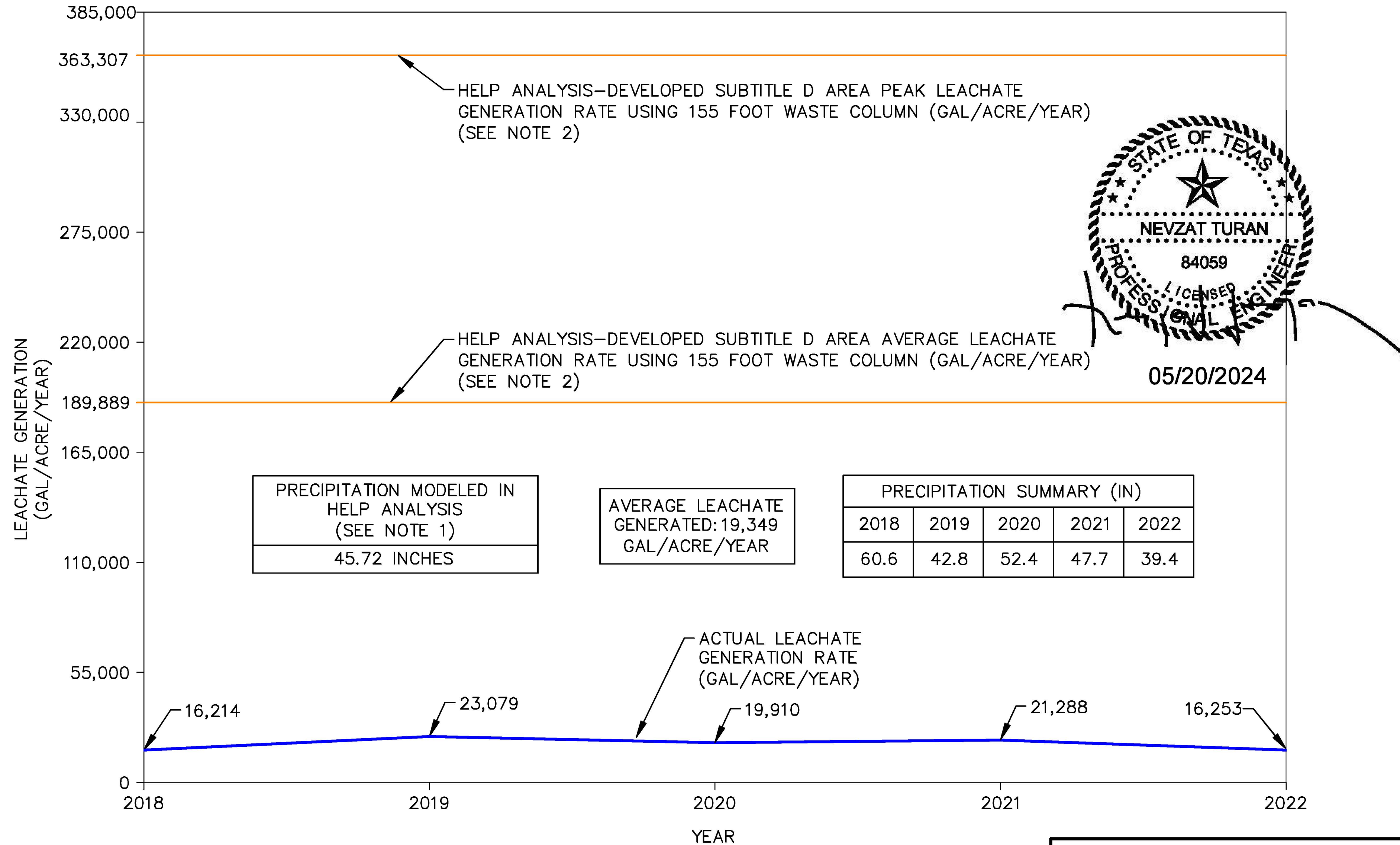
As shown on Figure 6-2, the leachate generation rate over the life of the site that was determined from actual leachate generation information is less than both the average and the peak values estimated by the HELP model for most of the life of the site and during the post-closure period.

6.4 Comparison of Leachate Depth on Liner

Figures 6-3 and 6-4 provide leachate depth information for the Subtitle D area. The leachate depths for each area are also compared to the compressed thickness of the geocomposite. Figures 6-3 and 6-4 show that when flow rates based on actual leachate generation rates are used the depth of leachate on the liner is negligible. Additionally, in each case the peak head on the liner using the flow rates estimated by the HELP model 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 significantly less that those predicted by the HELP model and result in a smaller volume of leachate for the life of site as shown on Figure 6-2.



NOTES:

1. THE AVERAGE ANNUAL PRECIPITATION MODELED IN HELP OVER 30 YEARS IS 45.72 INCHES.
2. REPRESENTATIVE VALUES WERE SELECTED FROM THE AVERAGE LEACHATE GENERATION RATES FOR THE DEVELOPED AREA HELP RUN CASES. REFER TO APPENDIX IIIC–A.1 FOR HELP RUN OUTPUT.

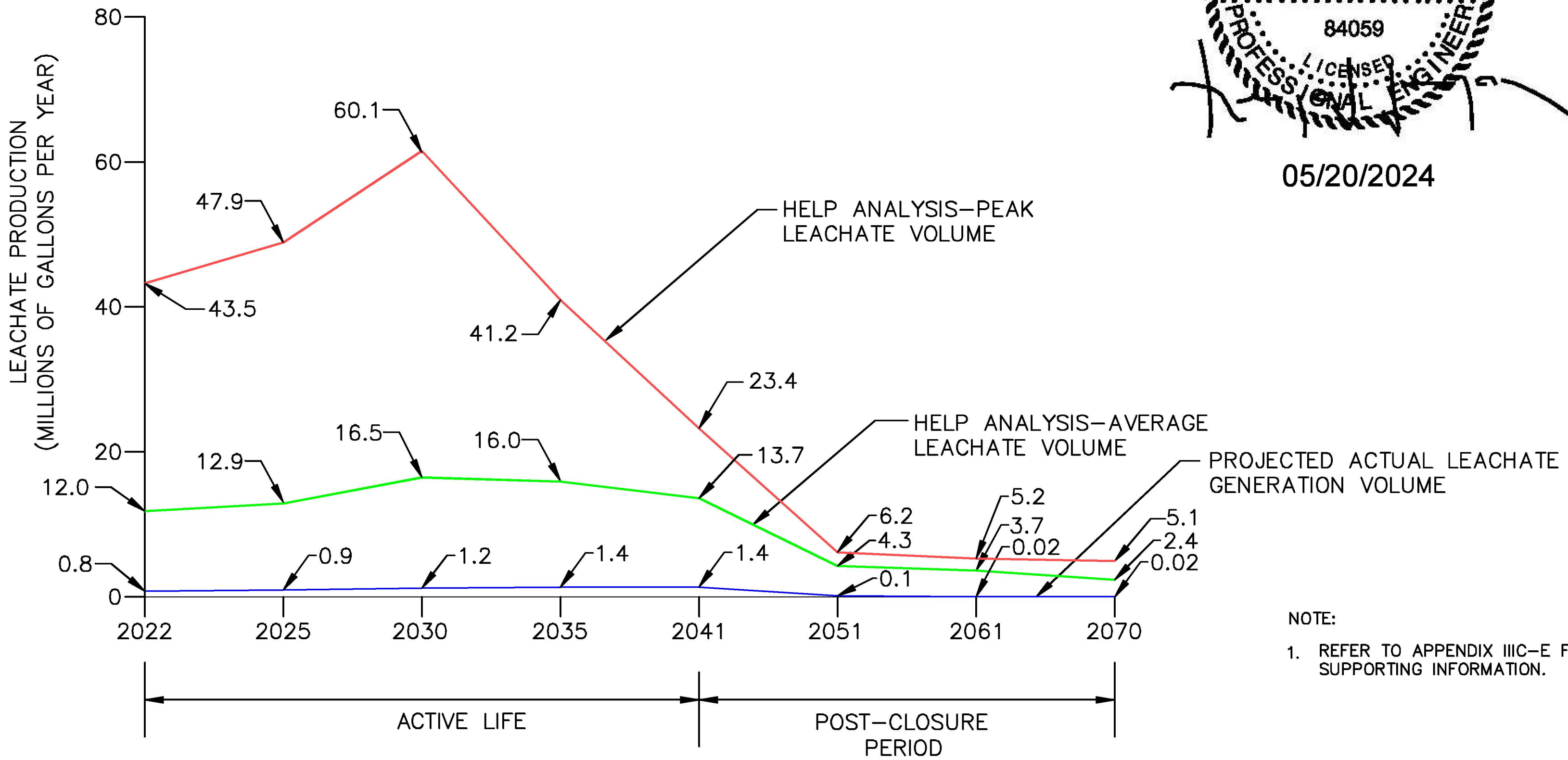
LEACHATE GENERATION RATE COMPARISON

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

DRAWN BY: RAA	DATE: 05/2024	FILE: 0120-076-11
REVIEWED BY: JBM	CAD: FIG 6-1.DWG	FIGURE 6-1

O:\0120\76\EXPANSION 2023\PART III\IIIC\FIGURE 6-1.dwg, byoung, 1:1



STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

05/20/2024

NOTE:

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

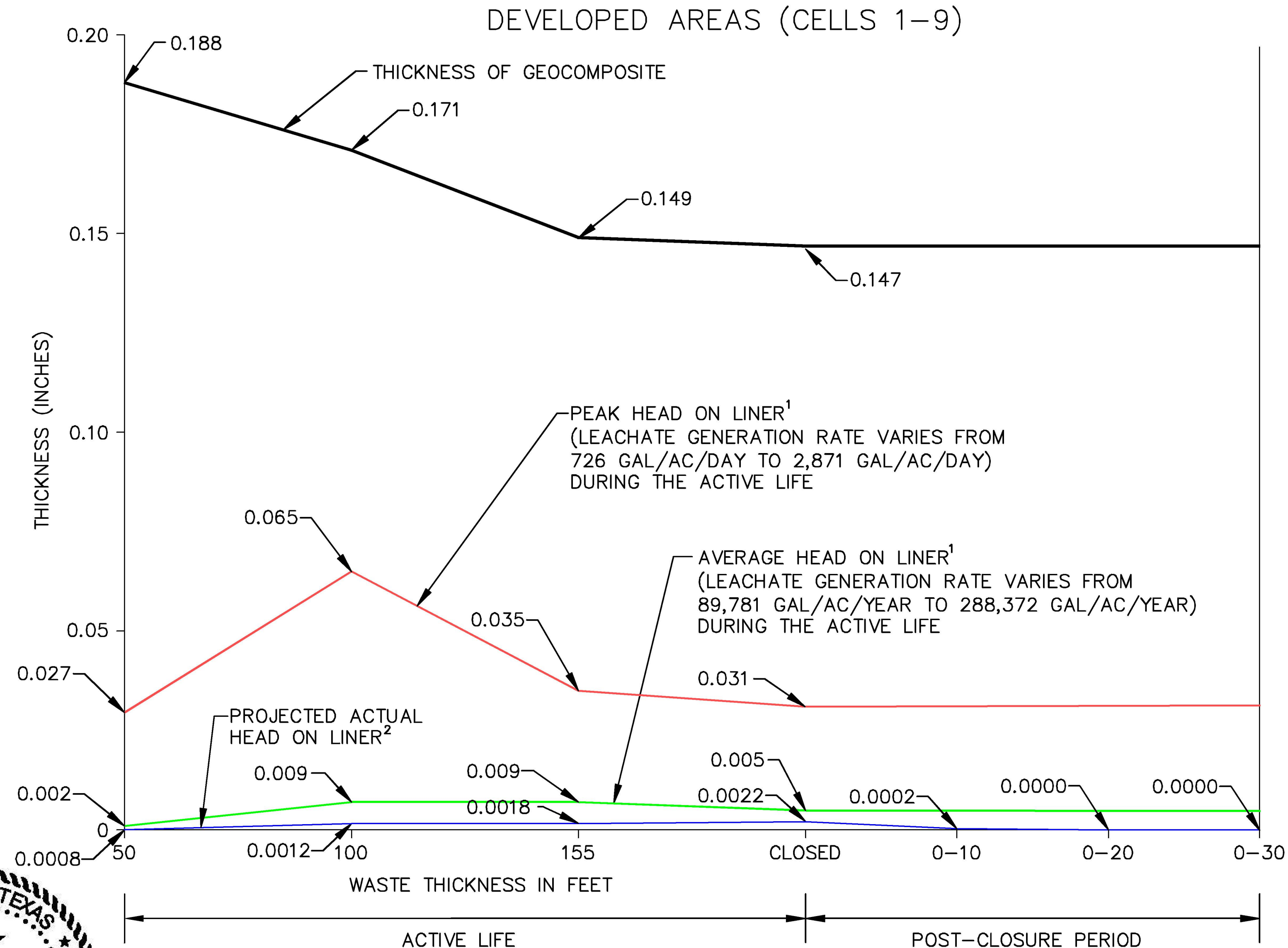
LEACHATE GENERATION VOLUME ESTIMATION

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

Weaver Consultants Group
TBPE REGISTRATION NO. F–3727

DRAWN BY: RAA	DATE: 05/2024	FILE: 0120–076–11
REVIEWED BY: JBM	CAD: FIG 6–2.DWG	FIGURE 6–2

O:\0120\76\EXPANSION 2023\PART III\IIIC\FIGURE 6–2.dwg, byoung, 1:1



STATE OF TEXAS
NEVZAT TURAN
84059
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PROFESSIONAL ENGINEER

05/20/2024

[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.1.

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

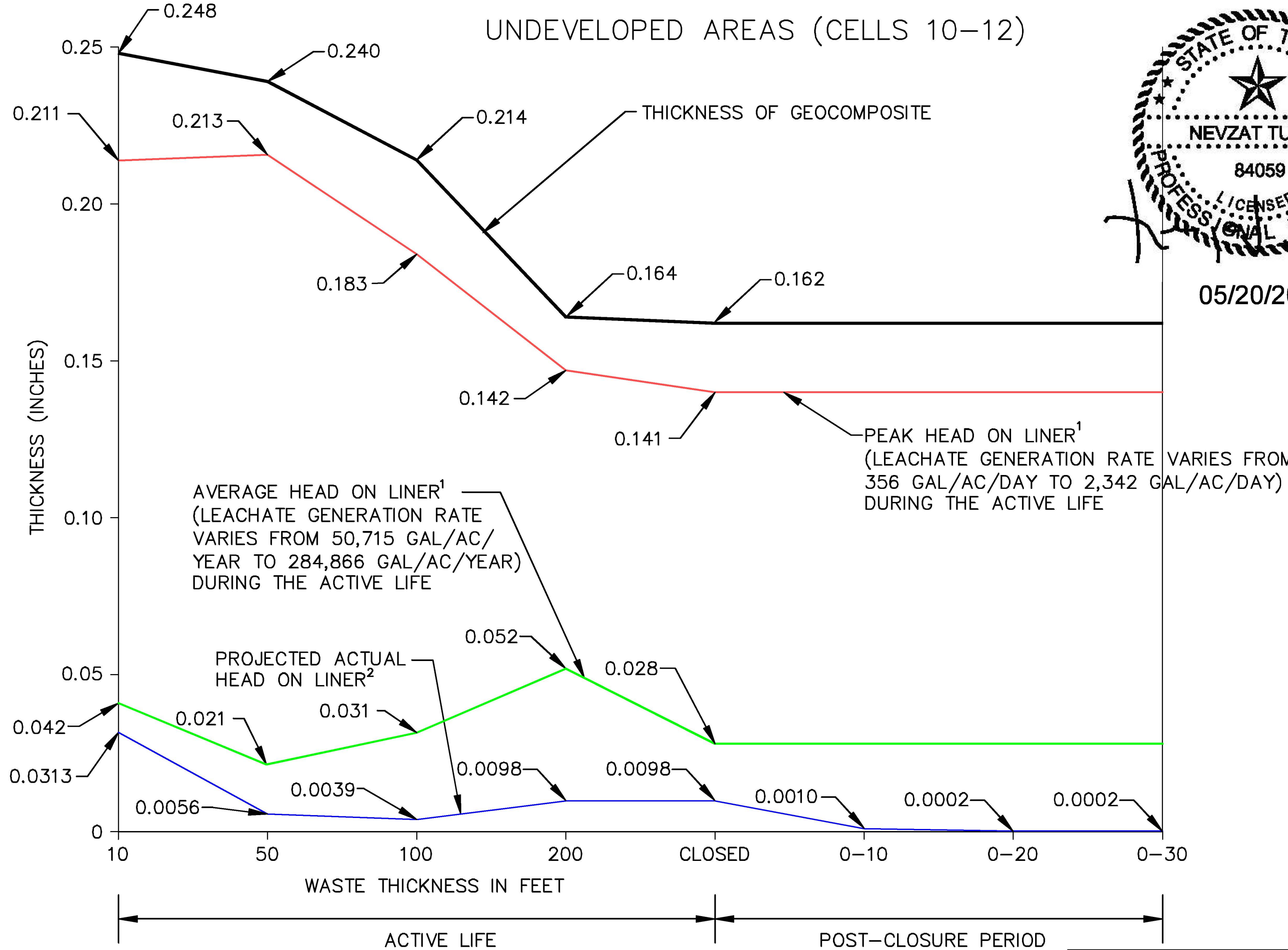
ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

DRAWN BY: RAA	DATE: 05/2024	FILE: 0120-076-11
REVIEWED BY: JBM	CAD: FIG 6-3.DWG	FIGURE 6-3

O:\0120\76\EXPANSION 2023\PART III\IIIC\FIGURE 6-3.dwg, byoung, 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.

STATE OF TEXAS
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84059
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05/20/2024

ESTIMATION OF LEACHATE THICKNESS ON LINER SYSTEM

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

Weaver Consultants Group
TBPE REGISTRATION NO. F–3727

DRAWN BY: RAA	DATE: 05/2024	FILE: 0120–076–11
REVIEWED BY: JBM	CAD: FIG 6–4.DWG	FIGURE 6–4

O:\0120\76\EXPANSION 2023\PART III\IIIC\FIGURE 6-4.dwg, byoung, 1:1

APPENDIX IIIC-A

LEACHATE GENERATION MODEL

Includes pages IIIC-A-1 through IIIC-A-57

STATE OF TEXAS
NEVZAT TURAN
84059
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05/20/2024

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 Royal Oaks 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 the undeveloped area (Cells 10-12):

- 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
- 200 feet of waste with final cover

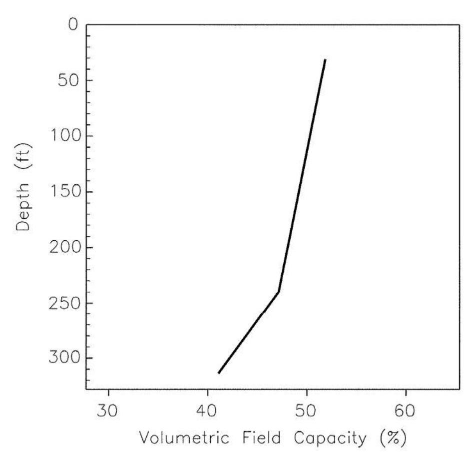
The active stage was modeled for one year with no intermediate or daily cover. The interim stages with intermediate cover were modeled for various lengths of time selected based on the projected duration each condition is likely to occur. The closed landfill condition was modeled for 30 years. The evaporative 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 USDA National Resources Conservation Service (NRCS) 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 84.9 and 85.6 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 95 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.

VOLUMETRIC FIELD CAPACITY AS A
FUNCTION OF
WASTE DEPTH



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 National Oceanic and Atmospheric Administration (NOAA) for the Jacksonville, Texas weather station. The average annual precipitation over the modeled 30-year period was 45.72 inches. Solar radiation data were synthetically generated by the HELP model using program defaults for Shreveport, Louisiana.

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.

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 0 installation defect and 0 pinhole per acre. Default characteristics from the HELP model were selected for the HDPE geomembrane hydraulic conductivity. Default soil characteristics from the HELP model were also selected for the compacted clay liner.

Leachate Collection System

Undeveloped areas, Cells 10 through 12, will be constructed with an LCS that includes a 250-mil-thick single-sided geocomposite (floor grades). The required transmissivity of the 250-mil-thick geocomposite was determined using HELP model. The slope length was determined from post-settlement slopes as analyzed in Appendix IIIE-B. The 250-mil-thick geocomposite calculations are shown on pages IIIC-A-5 through IIIC-A-9. 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). 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).

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 $1\text{x}10^{-3}$ cm/s. A lower hydraulic conductivity of $1\text{x}10^{-4}$ cm/s was used for the bottom layer because the additional overburden pressure will cause additional consolidation to this layer that will likely lower the hydraulic conductivity. The moisture content, field capacity, and porosity values were selected as discussed previously.

Intermediate Cover

The intermediate cover consists of a 12-inch-thick layer of soil placed over the waste. Default soil characteristics were selected from HELP to represent the available onsite soils with a hydraulic conductivity of $1.2\text{x}10^{-4}$ cm/s.

Final Cover

The composite final cover over the landfill 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 $1\text{x}10^{-5}$ 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-10.

Required: Determine the minimum requirements of the 250-mil geocomposite leachate collection layer for Cells 10 through 12.

Method:

1. Determine the 250-mil geocomposite leachate collection layer thickness under the expected loading conditions.
2. Use HELP model to determine the minimum required hydraulic conductivity of the 250-mil geocomposite leachate collection layer at the expected loading conditions.
3. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
4. Compute the design transmissivity of the 250-mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses, the hydraulic conductivity, 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] (cm)
Active - 10'	10	2	49	720	0.248	0.630
Interim - 50'	50	3	49	2,795	0.236	0.599
Interim - 100'	100	3	57	6,045	0.214	0.544
Interim - 200'	200	3	71	14,545	0.164	0.416
Closed - 200'	200	5.5	71	14,833	0.162	0.412

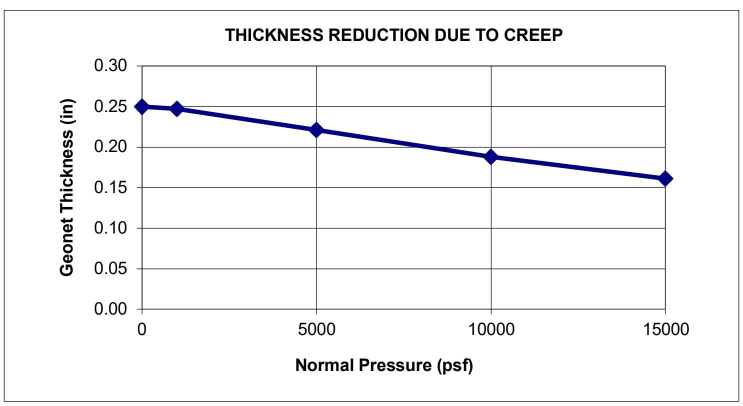
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[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. Use HELP model to determine the minimum required hydraulic conductivity of the 250-mil geocomposite leachate collection layer at the expected loading conditions. HELP model results are shown in Sheet IIIC-A-10

3. 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)	Closed
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.20	3.15	3.96	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.

4. Compute the design transmissivity of the 250-mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses, the hydraulic conductivity, and the reduction factors.

Table 3 - Required Transmissivity for Subtitle D Areas

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (cm)	k[4] (cm/s)	T_{DES}[5] (m^2/s)	ORF[6]	T[7] (m^2/s)
Active - 10'	10	720	0.630	0.27	1.70E-05	2.20	3.75E-05
Interim - 50'	50	2,795	0.599	1.39	8.32E-05	3.15	2.62E-04
Interim - 100'	100	6,045	0.544	2.05	1.12E-04	3.96	4.42E-04
Interim - 200'	200	14,545	0.416	0.87	3.62E-05	5.02	1.81E-04
Closed - 200'	200	14,833	0.412	0.87	3.58E-05	5.72	2.05E-04

[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] k is obtained the HELP model design as shown on Sheet IIIC-A-10.

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

$$T_{DES} = (k * t)/100$$

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

[7] T is the design transmissivity value calculated using the following equation:

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

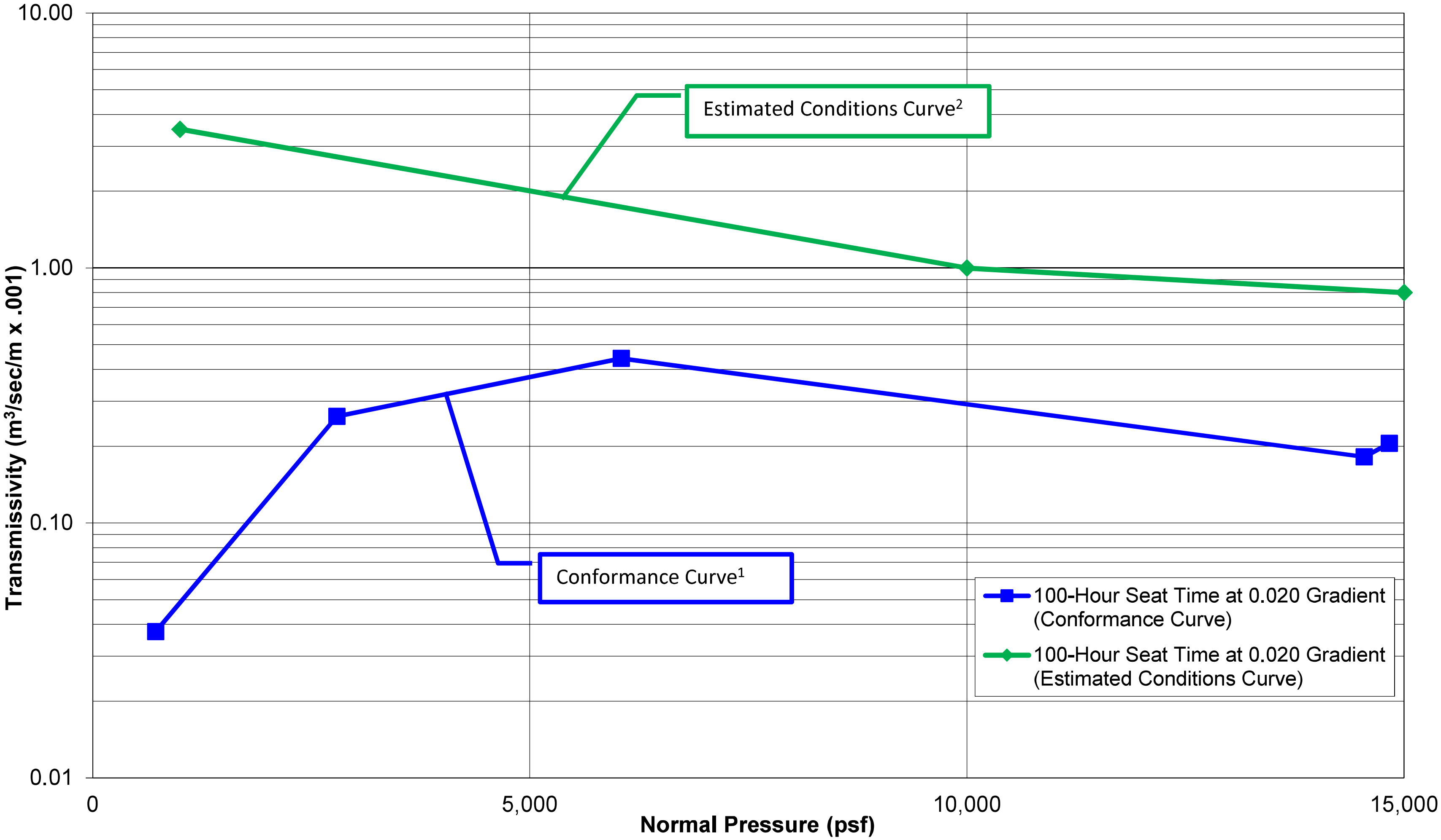
5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the conformance curve on the graph shown on Sheet IIIC-A-9 will provide a drainage layer that will maintain less than twelve inches of head on the liner system. The estimated conditions curve was developed based on engineering judgement and experience with similar geocomposite products at numerous MSW sites in Texas and is provided to verify the selected drainage geocomposite transmissivity provides greater conveyance than the specified transmissivity in these calculations.
The drainage geocomposite required transmissivity values will be measured at a gradient of 0.020 under normal pressures of 1,000, 10,000 and 14,833 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., 14,833 psf) with all the same assumptions as the first three tests.

Refer to the conformance curve plotted on Sheet IIIC-A-9 for the minimum transmissivity requirements.

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.

TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE
6 oz/sy Polypropylene Geotextile with 250-mil Drainage Net
(Soil/Geocomposite/Geomembrane)



[1] The transmissivity shall be greater than the Conformace Curve to be considered passing.
[2] These values are developed based on engineering judgement and experience with similar geocomposite products at numerous MSW sites in Texas and is provided to verify the selected drainage geocomposite transmissivity provides greater conveyance than the specified transmissivity in these calculations.

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	CLOSED (200 FT WASTE)
GENERAL	Case No.	1	2	3	4	6
INFORMATION	Output Page	IIIC-A-12	IIIC-A-20	IIIC-A-29	IIIC-A-38	IIIC-A-47
INFORMATION	No. of Years	1	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	84.9	85.6	85.6	81.2
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	0	70	80	90	100
	Maximum Leaf Area Index	0.0	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)					0.250
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)					6.63
	Slope (%)					4.0
	Slope Length (ft)					180
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
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
WASTE TOP[2]	Thickness (in)	120	600	1200	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6483	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5215	0.5156	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	0.2500	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	900
(Texture = 0)	Porosity (vol/vol)				0.5348	0.5348
	Field Capacity (vol/vol)				0.4892	0.4892
	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	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)	0.248	0.240	0.214	0.164	0.162
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)	0.27	1.39	2.05	0.87	0.87
	Slope (%)	2.0	2.0	2.0	2.0	2.0
	Slope Length (ft)	250	250	250	250	250
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0
	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)	56.27	45.34	45.34	45.34	45.72
RUNOFF	Average Annual (in)	0.00	1.67	2.14	2.41	1.94
EVAPOTRANSPIRATION	Average Annual (in)	36.34	28.77	28.78	28.78	28.58
LATERAL	Average Annual (cf/year)	6,779.5	17,754.8	38,081.1	27,177.0	14,614.1
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	47.6	248.1	313.0	102.5	101.9
LATERAL	Average Annual (cf/year)		1,775.5	3,808.1	2,717.7	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)		24.8	31.3	10.3	
HEAD ON LINER	Average Annual (in)	0.042	0.021	0.031	0.052	0.028
	Peak Daily (in)	0.211	0.213	0.183	0.142	0.141

[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.

HELP MODEL OUTPUT FOR UNDEVELOPED AREAS (CELLS 10 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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\RO\1\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\1\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\1\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\1\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\U\A10\DATA10.D10
OUTPUT DATA FILE:           C:\RO\U\A10\OUTPUT1.OUT


TIME:  17:30     DATE:  11/30/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - 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.   =  0.270000011000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                      LAYER  4
                      --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
```

```
   INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                         LAYER  5
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #18 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
          A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER              =     80.30
FRACTION OF AREA ALLOWING RUNOFF     =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      2.500  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      6.376  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.770  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =     46.106  INCHES
TOTAL INITIAL WATER                  =     46.106  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


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

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	58
END OF GROWING SEASON (JULIAN DATE)	=	331
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 19

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.82	5.12	5.51	2.78	4.62	2.12
	3.81	7.13	5.43	2.54	4.98	6.41
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	2.320	2.821	3.685	2.615	4.039	3.365
	3.014	3.652	4.334	1.724	2.683	2.091
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	0.0053	0.0950	0.1457	0.1480
	0.1649	0.1355	0.2220	0.3573	0.2713	0.3226
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   0.0014   0.0259   0.0384   0.0403
                           0.0434   0.0357   0.0605   0.0942   0.0739   0.0850

    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   19 THROUGH   19
---------------------------------------------------------------------------
                                    INCHES          CU. FEET      PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  56.27    (   0.000)     204260.0     100.00

 RUNOFF                          0.000   (  0.0000)          0.00      0.000

 EVAPOTRANSPIRATION             36.343   (  0.0000)    131925.47     64.587

 LATERAL DRAINAGE COLLECTED      1.86764 (  0.00000)     6779.538    3.31907
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.008    0.00000
   LAYER  5

 AVERAGE HEAD ON TOP             0.042 (    0.000)
   OF LAYER  4

 CHANGE IN WATER STORAGE        18.059   (  0.0000)     65555.10     32.094

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



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

             PEAK DAILY VALUES FOR YEARS   19 THROUGH   19
   ------------------------------------------------------------------------
                                                    (INCHES)      (CU. FT.)
                                                   ----------    -------------
    PRECIPITATION                                     2.73         9909.900
```

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.01313	47.64489
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00004
AVERAGE HEAD ON TOP OF LAYER 4	0.107	
MAXIMUM HEAD ON TOP OF LAYER 4	0.211	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	4.1 FEET	
SNOW WATER	0.42	1525.7992

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4053
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 19

LAYER	(INCHES)	(VOL/VOL)
1	47.4061	0.3951
2	6.4204	0.2675
3	0.0912	0.3679
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:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\U\I50\DATA10.D10
OUTPUT DATA FILE:           C:\RO\U\I50\OUTPUT1.OUT


TIME:  36:37     DATE:  11/30/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - 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  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  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                     =      0.6483 VOL/VOL
  FIELD CAPACITY               =      0.5215 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                    =      0.24   INCHES
  POROSITY                     =      0.8500 VOL/VOL
```

```
  FIELD CAPACITY              =      0.0100 VOL/VOL
  WILTING POINT               =      0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =   1.38999999000     CM/SEC
  SLOPE                       =      2.00   PERCENT
  DRAINAGE LENGTH             =    250.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                          LAYER  5
                          --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD


                          LAYER  6
                          --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.4270 VOL/VOL
  FIELD CAPACITY              =      0.4180 VOL/VOL
  WILTING POINT               =      0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
```

SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 800. FEET.

SCS RUNOFF CURVE NUMBER	=	84.90	
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	=	2.440	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.980	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.360	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	169.034	INCHES
TOTAL INITIAL WATER	=	169.034	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	58
END OF GROWING SEASON (JULIAN DATE)	=	331
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.073	0.195	0.096	0.218	0.195	0.282
	0.191	0.057	0.105	0.050	0.108	0.103
STD. DEVIATIONS	0.111	0.229	0.137	0.220	0.235	0.335
	0.340	0.140	0.160	0.070	0.060	0.232
EVAPOTRANSPIRATION						
TOTALS	1.659	2.187	2.806	3.167	3.764	3.418
	3.250	1.890	2.230	1.445	1.410	1.541
STD. DEVIATIONS	0.312	0.361	0.785	0.955	1.013	0.822

1.657	1.401	1.043	0.874	0.504	0.120

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0389	0.0332	0.0394	0.0411	0.0421	0.0394
	0.0466	0.0430	0.0404	0.0387	0.0427	0.0434
STD. DEVIATIONS	0.0363	0.0286	0.0376	0.0368	0.0359	0.0317
	0.0387	0.0336	0.0314	0.0279	0.0333	0.0327

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.3498	0.2987	0.3549	0.3700	0.3792	0.3550
	0.4198	0.3871	0.3640	0.3484	0.3842	0.3910
STD. DEVIATIONS	0.3265	0.2571	0.3383	0.3308	0.3235	0.2857
	0.3486	0.3020	0.2825	0.2509	0.2995	0.2939

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0389	0.0332	0.0394	0.0411	0.0421	0.0394
	0.0466	0.0430	0.0404	0.0387	0.0427	0.0434
STD. DEVIATIONS	0.0363	0.0286	0.0376	0.0368	0.0359	0.0317
	0.0387	0.0336	0.0314	0.0279	0.0333	0.0327

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	0.0199	0.0186	0.0202	0.0217	0.0216	0.0209
	0.0239	0.0220	0.0214	0.0198	0.0226	0.0222
STD. DEVIATIONS	0.0186	0.0159	0.0192	0.0194	0.0184	0.0168
	0.0198	0.0172	0.0166	0.0143	0.0176	0.0167

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.34	(6.841)	164573.3	100.00
RUNOFF	1.674	(0.7205)	6075.06	3.691
EVAPOTRANSPIRATION	28.768	(3.5104)	104426.44	63.453
DRAINAGE RECIRCULATED INTO LAYER 2	0.48911	(0.39825)	1775.477	1.07884
LATERAL DRAINAGE COLLECTED FROM LAYER 4	4.40201	(3.58428)	15979.295	9.70953
DRAINAGE RECIRCULATED FROM LAYER 4	0.48911	(0.39825)	1775.477	1.07884
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.007	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.021	(0.017)		
CHANGE IN WATER STORAGE	10.494	(6.6275)	38091.71	23.146

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PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.047	3799.3945
DRAINAGE RECIRCULATED INTO LAYER 2	0.00684	24.81413
DRAINAGE COLLECTED FROM LAYER 4	0.06152	223.32713

```
     DRAINAGE RECIRCULATED FROM LAYER  4        0.00684         24.81413

     PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00004

     AVERAGE HEAD ON TOP OF LAYER  5            0.108

     MAXIMUM HEAD ON TOP OF LAYER  5            0.213

     LOCATION OF MAXIMUM HEAD IN LAYER  4
           (DISTANCE FROM DRAIN)                4.1 FEET

     SNOW WATER                                 3.53         12827.0205


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3922

     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   28
    ----------------------------------------------------------------------
                   LAYER        (INCHES)       (VOL/VOL)
                   -----        --------       ---------
                     1            3.0516         0.2543

                     2          254.0714         0.4235

                     3            6.5622         0.2734

                     4            0.0370         0.1566

                     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:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\U\I100\DATA10.D10
OUTPUT DATA FILE:           C:\RO\U\I100\OUTPUT1.OUT


TIME:  17:34     DATE:  11/30/2023


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     TITLE:  Royal Oaks Landfill - Undeveloped Areas - 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  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  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.   =   2.04999995000     CM/SEC
  SLOPE                        =     2.00   PERCENT
  DRAINAGE LENGTH              =   250.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                          LAYER  5
                          --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
  THICKNESS                    =     0.06   INCHES
  POROSITY                     =     0.0000 VOL/VOL
  FIELD CAPACITY               =     0.0000 VOL/VOL
  WILTING POINT                =     0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =     0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY          =     0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS     =     0.00   HOLES/ACRE
  FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER  6
                          --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
  THICKNESS                    =    24.00   INCHES
  POROSITY                     =     0.4270 VOL/VOL
  FIELD CAPACITY               =     0.4180 VOL/VOL
  WILTING POINT                =     0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =     0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
```

SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 4.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.60	
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	=	2.440	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.980	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.360	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	475.034	INCHES
TOTAL INITIAL WATER	=	475.034	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	58	
END OF GROWING SEASON (JULIAN DATE)	=	331	
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.098	0.245	0.126	0.281	0.245	0.354
	0.240	0.074	0.137	0.067	0.149	0.127
STD. DEVIATIONS	0.145	0.280	0.168	0.274	0.286	0.405
	0.409	0.178	0.202	0.088	0.076	0.287
EVAPOTRANSPIRATION						
TOTALS	1.662	2.184	2.805	3.178	3.753	3.411
	3.262	1.894	2.237	1.447	1.410	1.539
STD. DEVIATIONS	0.315	0.361	0.786	0.948	0.999	0.828

	1.644	1.406	1.049	0.877	0.503	0.121

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0845	0.0793	0.0909	0.0838	0.0891	0.0826
	0.0881	0.0922	0.0873	0.0876	0.0891	0.0946
STD. DEVIATIONS	0.0255	0.0220	0.0159	0.0183	0.0190	0.0169
	0.0250	0.0225	0.0178	0.0194	0.0204	0.0162

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.7604	0.7138	0.8182	0.7538	0.8021	0.7432
	0.7931	0.8294	0.7859	0.7885	0.8017	0.8514
STD. DEVIATIONS	0.2298	0.1982	0.1429	0.1644	0.1713	0.1521
	0.2247	0.2024	0.1600	0.1749	0.1839	0.1461

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0845	0.0793	0.0909	0.0838	0.0891	0.0826
	0.0881	0.0922	0.0873	0.0876	0.0891	0.0946
STD. DEVIATIONS	0.0255	0.0220	0.0159	0.0183	0.0190	0.0169
	0.0250	0.0225	0.0178	0.0194	0.0204	0.0162

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	0.0293	0.0301	0.0316	0.0300	0.0309	0.0296
	0.0306	0.0320	0.0313	0.0304	0.0319	0.0328
STD. DEVIATIONS	0.0089	0.0083	0.0055	0.0066	0.0066	0.0061
	0.0087	0.0078	0.0064	0.0067	0.0073	0.0056

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.34 (6.841)	164573.3	100.00
RUNOFF	2.143 (0.8896)	7778.29	4.726
EVAPOTRANSPIRATION	28.783 (3.5398)	104483.09	63.487
DRAINAGE RECIRCULATED INTO LAYER 2	1.04907 (0.20474)	3808.111	2.31393
LATERAL DRAINAGE COLLECTED FROM LAYER 4	9.44160 (1.84266)	34272.992	20.82537
DRAINAGE RECIRCULATED FROM LAYER 4	1.04907 (0.20474)	3808.111	2.31393
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.031 (0.006)		
CHANGE IN WATER STORAGE	4.969 (5.3458)	18038.75	10.961

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PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.260	4572.7422
DRAINAGE RECIRCULATED INTO LAYER 2	0.00862	31.30087
DRAINAGE COLLECTED FROM LAYER 4	0.07761	281.70782

```
DRAINAGE RECIRCULATED FROM LAYER  4         0.00862         31.30087

PERCOLATION/LEAKAGE THROUGH LAYER  6        0.000000         0.00004

AVERAGE HEAD ON TOP OF LAYER  5             0.093

MAXIMUM HEAD ON TOP OF LAYER  5             0.183

LOCATION OF MAXIMUM HEAD IN LAYER  4
      (DISTANCE FROM DRAIN)                 3.8 FEET

SNOW WATER                                  3.53         12827.0205


MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3893

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   28
    ----------------------------------------------------------------------
                LAYER        (INCHES)       (VOL/VOL)
                -----        --------       ---------
                  1            3.0537         0.2545

                  2          504.3053         0.4203

                  3            7.0845         0.2952

                  4            0.0361         0.1685

                  5            0.0000         0.0000

                  6           10.2480         0.4270
```

```
          SNOW WATER       0.000

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\U\I200\DATA10.D10
OUTPUT DATA FILE:           C:\RO\U\I200\OUTPUT1.OUT


TIME:  17:38     DATE:  11/30/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - 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  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  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.   =  0.870000005000     CM/SEC
  SLOPE                       =      2.00   PERCENT
  DRAINAGE LENGTH             =    250.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                        LAYER  6
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  7
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
```

```
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4270 VOL/VOL
FIELD CAPACITY               =      0.4180 VOL/VOL
WILTING POINT                =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

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

SCS RUNOFF CURVE NUMBER              =     85.60
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    =      2.440  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      3.980  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.360  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    931.034  INCHES
TOTAL INITIAL WATER                  =    931.034  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         SHREVEPORT            LOUISIANA

     STATION LATITUDE                         =  32.28 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   2.00
     START OF GROWING SEASON (JULIAN DATE)    =     58
     END OF GROWING SEASON (JULIAN DATE)      =    331
     EVAPORATIVE ZONE DEPTH                   =  10.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   8.60 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  70.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  72.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85

```
RUNOFF
------
  TOTALS                 0.111    0.276    0.142    0.315    0.275    0.398
                         0.270    0.083    0.154    0.075    0.167    0.143

  STD. DEVIATIONS        0.163    0.314    0.189    0.307    0.320    0.456
                         0.460    0.199    0.227    0.098    0.085    0.323

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.661    2.185    2.807    3.182    3.756    3.403
                         3.256    1.891    2.239    1.448    1.411    1.541

  STD. DEVIATIONS        0.316    0.357    0.785    0.954    1.002    0.823
                         1.630    1.409    1.050    0.874    0.504    0.121

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                 0.0592   0.0581   0.0644   0.0625   0.0645   0.0616
                         0.0641   0.0642   0.0618   0.0640   0.0614   0.0631

  STD. DEVIATIONS        0.0128   0.0059   0.0060   0.0062   0.0066   0.0063
                         0.0056   0.0053   0.0049   0.0059   0.0041   0.0058

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.5327   0.5228   0.5794   0.5622   0.5803   0.5545
                         0.5768   0.5777   0.5558   0.5756   0.5527   0.5676

  STD. DEVIATIONS        0.1153   0.0529   0.0542   0.0560   0.0597   0.0563
                         0.0502   0.0480   0.0444   0.0529   0.0372   0.0518

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                 0.0592   0.0581   0.0644   0.0625   0.0645   0.0616
                         0.0641   0.0642   0.0618   0.0640   0.0614   0.0631

  STD. DEVIATIONS        0.0128   0.0059   0.0060   0.0062   0.0066   0.0063
                         0.0056   0.0053   0.0049   0.0059   0.0041   0.0058

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	0.0484	0.0520	0.0526	0.0528	0.0527	0.0521
	0.0524	0.0525	0.0522	0.0523	0.0519	0.0516
STD. DEVIATIONS	0.0105	0.0052	0.0049	0.0053	0.0054	0.0053
	0.0046	0.0044	0.0042	0.0048	0.0035	0.0047

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.34	(6.841)	164573.3	100.00
RUNOFF	2.408	(0.9980)	8742.70	5.312
EVAPOTRANSPIRATION	28.779	(3.5362)	104468.12	63.478
DRAINAGE RECIRCULATED INTO LAYER 2	0.74868	(0.06020)	2717.704	1.65136
LATERAL DRAINAGE COLLECTED FROM LAYER 5	6.73811	(0.54176)	24459.334	14.86227
DRAINAGE RECIRCULATED FROM LAYER 5	0.74868	(0.06020)	2717.704	1.65136
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.052	(0.004)		
CHANGE IN WATER STORAGE	7.411	(4.2588)	26903.05	16.347

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.417	5143.8730
DRAINAGE RECIRCULATED INTO LAYER 2	0.00282	10.25103
DRAINAGE COLLECTED FROM LAYER 5	0.02542	92.25927
DRAINAGE RECIRCULATED FROM LAYER 5	0.00282	10.25103
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.072	
MAXIMUM HEAD ON TOP OF LAYER 6	0.142	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.6 FEET	
SNOW WATER	3.53	12827.0205

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3812

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

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

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

****

****

FINAL WATER STORAGE AT END OF YEAR 28

LAYER	(INCHES)	(VOL/VOL)
1	3.0531	0.2544
2	645.6454	0.4304
3	339.5370	0.3773
4	6.6101	0.2754
5	0.0531	0.3237
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:\RO\30\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\30\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\30\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\30\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\U\C\DATA10.D10
OUTPUT DATA FILE:           C:\RO\U\C\OUTPUT1.OUT


TIME:  17:40     DATE:  11/30/2023



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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - Closed 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  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                   =      0.25   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.   =   6.63000011000     CM/SEC
          SLOPE                       =      4.00   PERCENT
          DRAINAGE LENGTH             =    180.0    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  10
THICKNESS                  =     12.00   INCHES
POROSITY                   =      0.3980 VOL/VOL
FIELD CAPACITY             =      0.2440 VOL/VOL
WILTING POINT              =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC


                          LAYER  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                  =    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  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                   =      0.16   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.870000005000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                       LAYER 10
                       --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER 11
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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    =    941.650  INCHES
 TOTAL INITIAL WATER                 =    941.650  INCHES
 TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

```
STATION LATITUDE                          =  32.28 DEGREES
MAXIMUM LEAF AREA INDEX                   =   4.50
START OF GROWING SEASON (JULIAN DATE)     =     58
END OF GROWING SEASON (JULIAN DATE)       =    331
EVAPORATIVE ZONE DEPTH                    =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED                 =   8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.54	4.24	3.80	3.38	4.26	4.04
3.40	3.07	3.55	4.75	4.24	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA AND STATION LATITUDE = 32.28 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	4.06	3.66	3.91	3.61	4.07	4.22
	3.38	2.64	3.32	4.70	4.22	3.92
STD. DEVIATIONS	2.78	1.82	1.66	1.52	1.88	2.72
	1.70	2.24	1.86	2.59	1.43	2.47
RUNOFF						
TOTALS	0.162	0.146	0.063	0.034	0.117	0.276
	0.114	0.072	0.110	0.513	0.107	0.230
STD. DEVIATIONS	0.428	0.276	0.127	0.083	0.233	0.406
	0.237	0.174	0.228	0.834	0.088	0.475
EVAPOTRANSPIRATION						
TOTALS	1.730	2.131	2.966	3.241	3.405	3.076
	2.940	2.179	2.473	1.803	1.234	1.405
STD. DEVIATIONS	0.187	0.403	0.728	0.927	1.132	1.575
	1.317	1.424	1.146	0.873	0.226	0.202
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.4196	1.6307	1.0844	0.4815	0.6772	0.9315
	0.3962	0.3728	0.5029	1.9176	2.4589	2.3237
STD. DEVIATIONS	2.3570	1.3815	1.1689	0.5418	0.9091	1.1421
	0.5167	0.7152	0.7830	1.4816	1.2878	2.0416
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001
	0.0000	0.0000	0.0000	0.0002	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.3331	0.3176	0.3490	0.3362	0.3460	0.3314
	0.3428	0.3424	0.3281	0.3392	0.3250	0.3350
STD. DEVIATIONS	0.0992	0.1100	0.1237	0.1179	0.1205	0.1108

```
                         0.1153   0.1110   0.1069   0.1125   0.1044   0.1069

  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             0.0316   0.0291   0.0121   0.0037   0.0114   0.0183
                         0.0064   0.0064   0.0083   0.0553   0.0287   0.0399

    STD. DEVIATIONS      0.0445   0.0401   0.0170   0.0052   0.0275   0.0294
                         0.0136   0.0161   0.0177   0.0729   0.0165   0.0569

  DAILY AVERAGE HEAD ON TOP OF LAYER 10
  -------------------------------------
    AVERAGES             0.0272   0.0285   0.0285   0.0284   0.0283   0.0280
                         0.0280   0.0280   0.0277   0.0277   0.0275   0.0274

    STD. DEVIATIONS      0.0081   0.0099   0.0101   0.0100   0.0099   0.0094
                         0.0094   0.0091   0.0090   0.0092   0.0088   0.0087

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                  -------------------  -------------  ---------
 PRECIPITATION                     45.72    (   8.166)    165946.7     100.00

 RUNOFF                             1.943   (  1.4253)      7054.32      4.251

 EVAPOTRANSPIRATION                28.583   (  3.6101)    103757.41     62.525

 LATERAL DRAINAGE COLLECTED        15.19686 (  5.20318)     55164.598   33.24236
   FROM LAYER  2
```

```
 PERCOLATION/LEAKAGE THROUGH     0.00062 (  0.00030)        2.243     0.00135
   LAYER  4

 AVERAGE HEAD ON TOP             0.021 (    0.011)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED      4.02592 (  1.30901)    14614.104    8.80651
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.009     0.00001
   LAYER 11

 AVERAGE HEAD ON TOP             0.028 (    0.009)
   OF LAYER 10

 CHANGE IN WATER STORAGE        -4.034   (  1.3622)    -14643.76     -8.824

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


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

               PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                      (INCHES)      (CU. FT.)
                                                     ----------    -------------
      PRECIPITATION                                    6.92         25119.600

      RUNOFF                                           3.628        13168.5488

      DRAINAGE COLLECTED FROM LAYER  2                 2.08349       7563.06934

      PERCOLATION/LEAKAGE THROUGH LAYER  4             0.000316         1.14858

      AVERAGE HEAD ON TOP OF LAYER  3                  4.598

      MAXIMUM HEAD ON TOP OF LAYER  3                  7.622

      LOCATION OF MAXIMUM HEAD IN LAYER  2
            (DISTANCE FROM DRAIN)                     30.5 FEET

      DRAINAGE COLLECTED FROM LAYER  9                 0.02806        101.85983

      PERCOLATION/LEAKAGE THROUGH LAYER 11             0.000000         0.00003

      AVERAGE HEAD ON TOP OF LAYER 10                  0.071
```

```
MAXIMUM HEAD ON TOP OF LAYER 10           0.141

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)               2.9 FEET

SNOW WATER                                3.18         11547.1094


MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3849

MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1360


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

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

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




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

                FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                 LAYER        (INCHES)       (VOL/VOL)
                 -----        --------       ---------
                   1            2.6644         0.2220

                   2            0.0025         0.0100

                   3            0.0000         0.0000

                   4            7.6860         0.4270

                   5            2.9280         0.2440

                   6          517.0857         0.3447

                   7          273.8399         0.3043

                   8            6.1529         0.2564

                   9            0.0199         0.1225
```

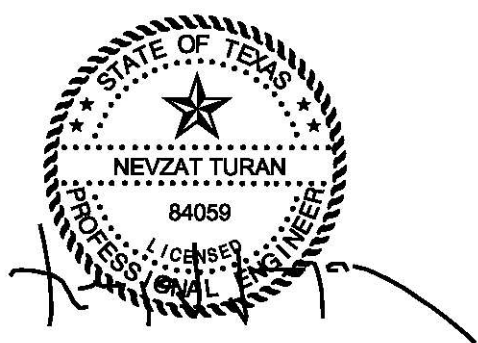
10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

****
****

APPENDIX IIIC-A.1

LEACHATE GENERATION MODEL OF DEVELOPED AREA

Includes pages IIIC-A.1-1 through IIIC-A.1-46



05/20/2024

INTRODUCTION

This appendix contains the analysis of the developed Subtitle D area. The developed areas were modeled with a LCS that includes a 200-mil-thick single-sided geocomposite (floor grades). This HELP analysis was used to demonstrate that the existing, in-place LCS in the developed area is adequate to keep the calculated head on the liner within the compressed thickness of the LCS geocomposite. The parameters in this analysis are consistent with the parameters shown in Appendix IIIC-A. This appendix includes the following:

- Sheets IIIC-A.1-2 through IIIC-A.1-6. Geocomposite calculations using transmissivity values for the developed area.
- Sheets IIIC-A.1-8. HELP summary sheet for the developed area.
- Sheets IIIC-A.1-8 and IIIC-A.1-46. HELP output files.

As shown in the following HELP model summary sheets, the existing, in-place LCS is adequate (i.e., the calculated head on the liner is within the compressed thickness of the LCS geocomposite).

ROYAL OAKS LANDFILL
0120-076-11-106
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
DEVELOPED AREA - CELLS 1 THROUGH 9

Required: Estimate the properties of the geocomposite leachate collection layer for the developed Subtitle D cells.

Note: The developed area was constructed 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] (cm)
Interim - 50'	50	3	49	2,795	0.189	0.479
Interim - 100'	100	3	57	6,045	0.171	0.435
Interim - 155'	155	3	65	10,420	0.149	0.377
Closed - 155'	155	5.5	65	10,708	0.147	0.374

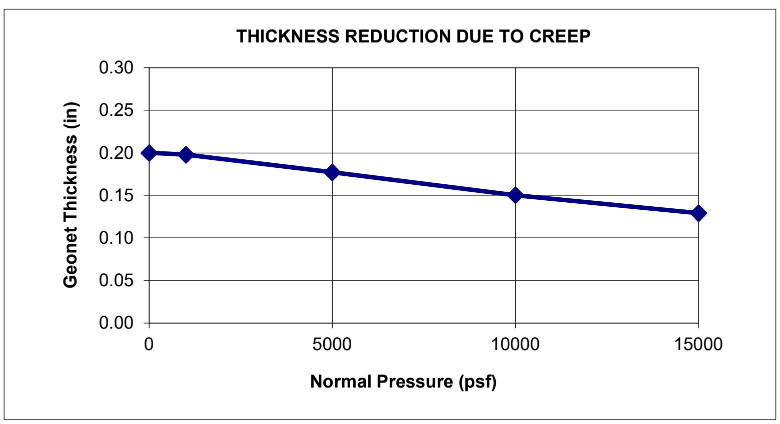
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[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			
		Interim (50' Waste)	Interim (100' Waste)	Interim (155' Waste)	Closed
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.3	1.5	1.8	2.0
RF_{BC}	Biological Clogging	1.1	1.2	1.2	1.3
Total Reduction Factor[2]		1.57	1.98	2.38	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		3.15	3.96	4.75	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 8 oz/sy geotextile is shown on Sheet IIIC-A.1-6. 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] (cm)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	2,795	0.479	1.29E-03	3.15	4.10E-04	8.55
Interim - 100'	100	6,045	0.435	9.78E-04	3.96	2.47E-04	5.67
Interim - 155'	155	10,420	0.377	6.86E-04	4.75	1.44E-04	3.82
Closed - 155'	155	10,708	0.374	6.77E-04	5.72	1.18E-04	3.16

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.1-6.

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

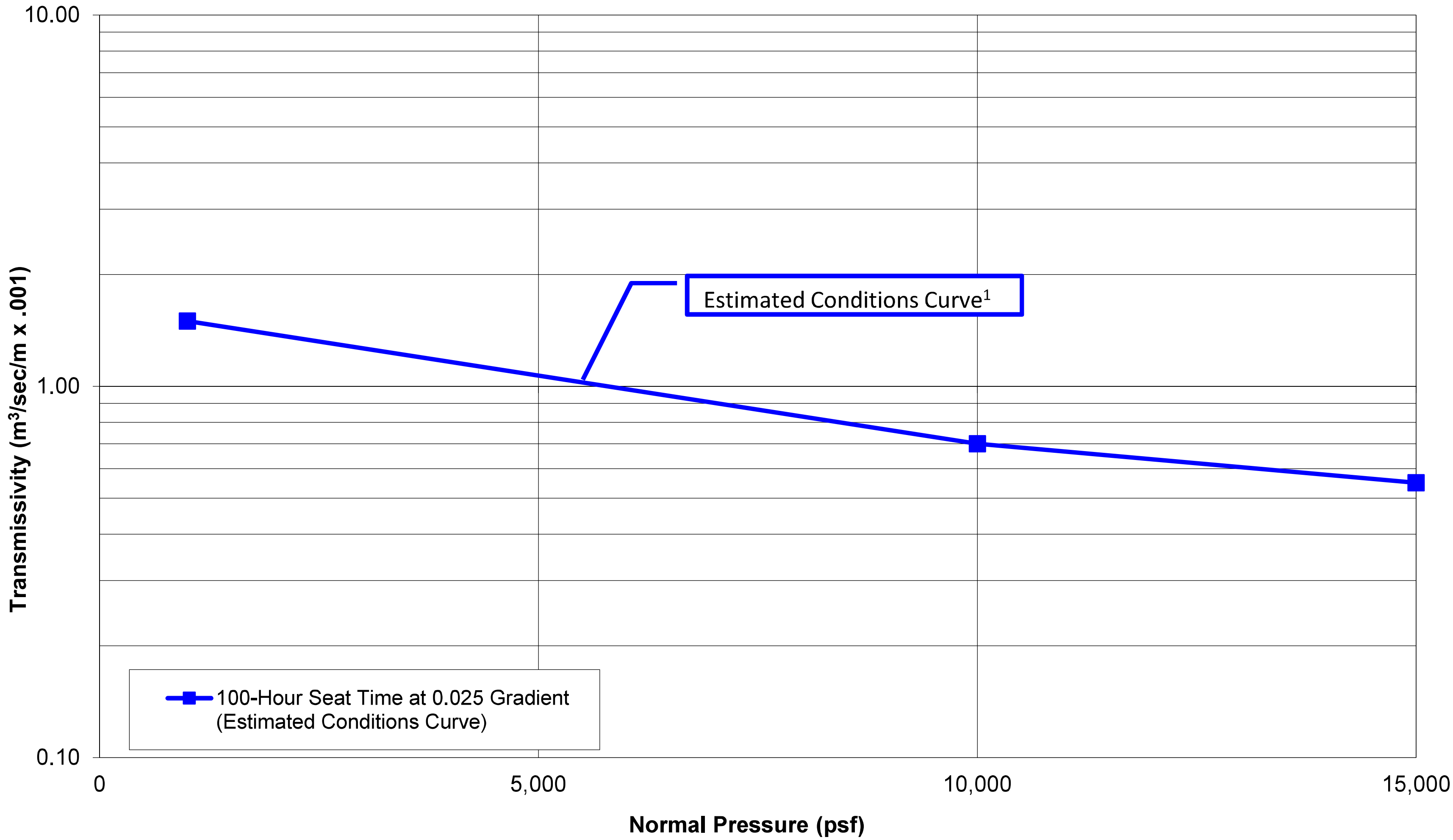
6 T_{DES} is the design transmissivity value calculated using the following equation:

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

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

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

TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE
6/8 oz/sy Polypropylene Geotextile with 200-mil Drainage Net
(Soil/Geocomposite/Geomembrane)



[1] These values are developed based on engineering judgement and experience with similar geocomposite products at numerous MSW sites in Texas and is provided to verify the selected drainage geocomposite transmissivity provides greater conveyance than the specified transmissivity in these calculations.

ROYAL OAKS LANDFILL
0120-076-11-106
HELP VERSION 3.07 SUMMARY SHEET
DEVELOPED AREA - CELLS 1 THROUGH 9

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (155 FT WASTE)	CLOSED (155 FT WASTE)
GENERAL	Case No.	1	2	3	4
INFORMATION	Output Page	IIIC-A.1-9	IIIC-A.1-18	IIIC-A.1-27	IIIC-A.1-36
	No. of Years	10	10	10	30
	Ground Cover	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	84.9	85.6	85.6	80.7
	Model Area (acre)	1	1	1	1
	Runoff Area (%)	70	80	80	100
	Maximum Leaf Area Index	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	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)				0.250
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)				6.63
	Slope (%)				4.0
	Slope Length (ft)				285
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
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
WASTE TOP[2]	Thickness (in)	600	1200	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	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)			360	360
(Texture = 0)	Porosity (vol/vol)			0.5534	0.5534
	Field Capacity (vol/vol)			0.4945	0.4945
	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)	0.188	0.171	0.149	0.147
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)	8.55	5.67	3.82	3.16
	Slope (%)	2.5	2.5	2.5	2.5
	Slope Length (ft)	250	250	250	250
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0
	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)	45.34	45.34	45.34	45.72
RUNOFF	Average Annual (in)	1.71	2.14	2.14	1.84
EVAPOTRANSPIRATION	Average Annual (in)	28.90	28.78	28.78	28.56
LATERAL	Average Annual (cf/year)	15,978.5	38,549.8	25,384.5	12,002.0
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	234.8	383.8	133.1	97.1
LATERAL	Average Annual (cf/year)	1,597.8	3,855.0	2,538.5	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	23.5	38.4	13.3	
HEAD ON LINER	Average Annual (in)	0.002	0.009	0.009	0.005
	Peak Daily (in)	0.027	0.065	0.035	0.031

[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.

HELP MODEL OUTPUT FOR DEVELOPED AREA

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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:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\D\I50\DATA10.D10
OUTPUT DATA FILE:           C:\RO\D\I50\OUTPUT1.OUT


TIME:  39:10     DATE:  11/30/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - 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  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  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                      =      0.6483 VOL/VOL
  FIELD CAPACITY                =      0.5215 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.   =   8.55000019000     CM/SEC
  SLOPE                       =      2.50   PERCENT
  DRAINAGE LENGTH             =    250.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.
```

```
                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD
```

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

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.4270 VOL/VOL
  FIELD CAPACITY              =      0.4180 VOL/VOL
  WILTING POINT               =      0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC
```

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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
```

SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 800. FEET.

SCS RUNOFF CURVE NUMBER	=	84.90	
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	=	2.440	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.980	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.360	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	169.034	INCHES
TOTAL INITIAL WATER	=	169.034	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	58
END OF GROWING SEASON (JULIAN DATE)	=	331
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.084	0.204	0.099	0.214	0.198	0.283
	0.194	0.060	0.105	0.049	0.119	0.099
STD. DEVIATIONS	0.125	0.239	0.141	0.222	0.241	0.331
	0.341	0.151	0.159	0.064	0.061	0.234
EVAPOTRANSPIRATION						
TOTALS	1.662	2.185	2.817	3.226	3.799	3.421
	3.274	1.905	2.232	1.448	1.397	1.533
STD. DEVIATIONS	0.303	0.348	0.788	0.934	1.076	0.786

	1.623	1.414	1.081	0.863	0.499	0.120

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0339	0.0336	0.0339	0.0335	0.0351	0.0368
	0.0421	0.0392	0.0372	0.0357	0.0386	0.0406
STD. DEVIATIONS	0.0311	0.0347	0.0309	0.0299	0.0294	0.0312
	0.0347	0.0304	0.0274	0.0260	0.0297	0.0302

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.3051	0.3021	0.3051	0.3011	0.3163	0.3313
	0.3785	0.3531	0.3345	0.3215	0.3476	0.3654
STD. DEVIATIONS	0.2803	0.3127	0.2777	0.2693	0.2646	0.2808
	0.3123	0.2732	0.2470	0.2341	0.2676	0.2720

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0339	0.0336	0.0339	0.0335	0.0351	0.0368
	0.0421	0.0392	0.0372	0.0357	0.0386	0.0406
STD. DEVIATIONS	0.0311	0.0347	0.0309	0.0299	0.0294	0.0312
	0.0347	0.0304	0.0274	0.0260	0.0297	0.0302

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	0.0023	0.0024	0.0023	0.0023	0.0023	0.0025
	0.0028	0.0026	0.0026	0.0024	0.0027	0.0027
STD. DEVIATIONS	0.0021	0.0025	0.0021	0.0021	0.0020	0.0021
	0.0023	0.0020	0.0019	0.0017	0.0020	0.0020

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.34 (6.841)	164573.3	100.00
RUNOFF	1.707 (0.7186)	6195.81	3.765
EVAPOTRANSPIRATION	28.898 (3.5249)	104900.31	63.741
DRAINAGE RECIRCULATED INTO LAYER 2	0.44018 (0.35987)	1597.846	0.97090
LATERAL DRAINAGE COLLECTED FROM LAYER 4	3.96160 (3.23883)	14380.615	8.73812
DRAINAGE RECIRCULATED FROM LAYER 4	0.44018 (0.35987)	1597.846	0.97090
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.007	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.002 (0.002)		
CHANGE IN WATER STORAGE	10.770 (6.2510)	39095.65	23.756

****

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.056	3831.9832
DRAINAGE RECIRCULATED INTO LAYER 2	0.00647	23.48352
DRAINAGE COLLECTED FROM LAYER 4	0.05822	211.35173

```
DRAINAGE RECIRCULATED FROM LAYER  4        0.00647         23.48352

PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00002

AVERAGE HEAD ON TOP OF LAYER  5            0.013

MAXIMUM HEAD ON TOP OF LAYER  5            0.027

LOCATION OF MAXIMUM HEAD IN LAYER  4
      (DISTANCE FROM DRAIN)                0.7 FEET

SNOW WATER                                 3.53         12827.0205


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   28
    ----------------------------------------------------------------------
                  LAYER        (INCHES)       (VOL/VOL)
                  -----        --------       ---------
                    1            3.0321         0.2527

                    2          256.8777         0.4281

                    3            6.5721         0.2738

                    4            0.0055         0.0291

                    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              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\D\I100\DATA10.D10
OUTPUT DATA FILE:           C:\RO\D\I100\OUTPUT1.OUT


TIME:  17:12     DATE:  11/ 6/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - 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  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  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                     =      0.17   INCHES
  POROSITY                      =      0.8500 VOL/VOL
```

```
  FIELD CAPACITY              =     0.0100 VOL/VOL
  WILTING POINT               =     0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT  =     0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =   5.67000008000     CM/SEC
  SLOPE                       =     2.50   PERCENT
  DRAINAGE LENGTH             =    250.0   FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.



                          LAYER  5
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =     0.06   INCHES
  POROSITY                    =     0.0000 VOL/VOL
  FIELD CAPACITY              =     0.0000 VOL/VOL
  WILTING POINT               =     0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =     0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =     0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =     0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD



                          LAYER  6
                          --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =    24.00   INCHES
  POROSITY                    =     0.4270 VOL/VOL
  FIELD CAPACITY              =     0.4180 VOL/VOL
  WILTING POINT               =     0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =     0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC



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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
```

SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 4.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.60	
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	=	2.440	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.980	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.360	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	475.034	INCHES
TOTAL INITIAL WATER	=	475.034	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	58
END OF GROWING SEASON (JULIAN DATE)	=	331
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.098	0.245	0.126	0.281	0.245	0.354
	0.240	0.074	0.137	0.067	0.149	0.127
STD. DEVIATIONS	0.145	0.280	0.168	0.274	0.286	0.405
	0.409	0.178	0.202	0.088	0.076	0.287
EVAPOTRANSPIRATION						
TOTALS	1.662	2.184	2.805	3.178	3.753	3.411
	3.262	1.894	2.237	1.447	1.410	1.539
STD. DEVIATIONS	0.315	0.361	0.786	0.948	0.999	0.828

```
                         1.644    1.406    1.049    0.877    0.503    0.121

  LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
  -------------------------------------------
    TOTALS                0.0830   0.0855   0.0910   0.0850   0.0882   0.0884
                          0.0911   0.0918   0.0808   0.0944   0.0939   0.0889

    STD. DEVIATIONS       0.0272   0.0272   0.0264   0.0181   0.0197   0.0181
                          0.0205   0.0183   0.0185   0.0238   0.0208   0.0157

  LATERAL DRAINAGE COLLECTED FROM LAYER  4
  ----------------------------------------
    TOTALS                0.7471   0.7697   0.8188   0.7651   0.7937   0.7959
                          0.8196   0.8259   0.7268   0.8499   0.8455   0.7999

    STD. DEVIATIONS       0.2452   0.2452   0.2377   0.1630   0.1775   0.1629
                          0.1849   0.1651   0.1665   0.2142   0.1873   0.1409

  LATERAL DRAINAGE RECIRCULATED FROM LAYER  4
  -------------------------------------------
    TOTALS                0.0830   0.0855   0.0910   0.0850   0.0882   0.0884
                          0.0911   0.0918   0.0808   0.0944   0.0939   0.0889

    STD. DEVIATIONS       0.0272   0.0272   0.0264   0.0181   0.0197   0.0181
                          0.0205   0.0183   0.0185   0.0238   0.0208   0.0157

  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              0.0083   0.0094   0.0091   0.0088   0.0089   0.0092
                          0.0091   0.0092   0.0084   0.0095   0.0097   0.0089

    STD. DEVIATIONS       0.0027   0.0029   0.0027   0.0019   0.0020   0.0019
                          0.0021   0.0018   0.0019   0.0024   0.0022   0.0016

*******************************************************************************
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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.34	(6.841)	164573.3	100.00
RUNOFF	2.143	(0.8896)	7778.29	4.726
EVAPOTRANSPIRATION	28.783	(3.5398)	104483.09	63.487
DRAINAGE RECIRCULATED INTO LAYER 2	1.06198	(0.22124)	3854.977	2.34241
LATERAL DRAINAGE COLLECTED FROM LAYER 4	9.55779	(1.99112)	34694.793	21.08167
DRAINAGE RECIRCULATED FROM LAYER 4	1.06198	(0.22124)	3854.977	2.34241
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.009	(0.002)		
CHANGE IN WATER STORAGE	4.853	(5.5571)	17615.72	10.704

****

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.260	4572.7422
DRAINAGE RECIRCULATED INTO LAYER 2	0.01057	38.38216
DRAINAGE COLLECTED FROM LAYER 4	0.09516	345.43939

DRAINAGE RECIRCULATED FROM LAYER 4	0.01057	38.38216
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.033	
MAXIMUM HEAD ON TOP OF LAYER 5	0.065	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	3.2 FEET	
SNOW WATER	3.53	12827.0205
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3893	
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 28

LAYER	(INCHES)	(VOL/VOL)
1	3.0537	0.2545
2	503.5616	0.4196
3	6.6860	0.2786
4	0.0125	0.0733
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:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\D\I155\DATA10.D10
OUTPUT DATA FILE:           C:\RO\D\I155\OUTPUT1.OUT


TIME:  17:12     DATE:  11/ 6/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - Interim 155 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  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                     =    360.00   INCHES
  POROSITY                      =      0.5534 VOL/VOL
  FIELD CAPACITY                =      0.4945 VOL/VOL
  WILTING POINT                 =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                          LAYER  4
                          --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  10
  THICKNESS                     =     24.00   INCHES
  POROSITY                      =      0.3980 VOL/VOL
```

```
  FIELD CAPACITY              =      0.2440 VOL/VOL
  WILTING POINT               =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                         LAYER  5
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      0.15   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.   =   3.81999993000     CM/SEC
  SLOPE                       =      2.50   PERCENT
  DRAINAGE LENGTH             =    250.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                         LAYER  6
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD


                         LAYER  7
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
```

```
THICKNESS                      =     24.00   INCHES
POROSITY                       =      0.4270 VOL/VOL
FIELD CAPACITY                 =      0.4180 VOL/VOL
WILTING POINT                  =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

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

SCS RUNOFF CURVE NUMBER            =     85.60
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  =      2.440  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      3.980  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      1.360  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =    725.833  INCHES
TOTAL INITIAL WATER                =    725.833  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         SHREVEPORT           LOUISIANA

    STATION LATITUDE                        =  32.28 DEGREES
    MAXIMUM LEAF AREA INDEX                 =   2.00
    START OF GROWING SEASON (JULIAN DATE)   =     58
    END OF GROWING SEASON (JULIAN DATE)     =    331
    EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
    AVERAGE ANNUAL WIND SPEED               =   8.60 MPH
    AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  70.00 %
    AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  72.00 %
    AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  72.00 %
    AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85

```
RUNOFF
------
  TOTALS                 0.098    0.245    0.126    0.281    0.245    0.354
                         0.240    0.074    0.137    0.067    0.149    0.127

  STD. DEVIATIONS        0.145    0.280    0.168    0.274    0.286    0.405
                         0.409    0.178    0.202    0.088    0.076    0.287

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.662    2.184    2.805    3.178    3.753    3.411
                         3.262    1.894    2.237    1.447    1.410    1.539

  STD. DEVIATIONS        0.315    0.361    0.786    0.948    0.999    0.828
                         1.644    1.406    1.049    0.877    0.503    0.121

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                 0.0547   0.0543   0.0593   0.0578   0.0599   0.0588
                         0.0595   0.0598   0.0580   0.0593   0.0579   0.0600

  STD. DEVIATIONS        0.0129   0.0079   0.0084   0.0088   0.0084   0.0087
                         0.0089   0.0082   0.0079   0.0082   0.0084   0.0085

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.4920   0.4886   0.5339   0.5204   0.5387   0.5295
                         0.5356   0.5380   0.5219   0.5338   0.5213   0.5399

  STD. DEVIATIONS        0.1163   0.0710   0.0753   0.0795   0.0752   0.0784
                         0.0802   0.0737   0.0708   0.0736   0.0760   0.0764

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                 0.0547   0.0543   0.0593   0.0578   0.0599   0.0588
                         0.0595   0.0598   0.0580   0.0593   0.0579   0.0600

  STD. DEVIATIONS        0.0129   0.0079   0.0084   0.0088   0.0084   0.0087
                         0.0089   0.0082   0.0079   0.0082   0.0084   0.0085

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              0.0081   0.0089   0.0088   0.0089   0.0089   0.0091
                          0.0089   0.0089   0.0089   0.0088   0.0089   0.0089

    STD. DEVIATIONS       0.0019   0.0013   0.0012   0.0014   0.0012   0.0013
                          0.0013   0.0012   0.0012   0.0012   0.0013   0.0013

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   19 THROUGH   28
------------------------------------------------------------------------------
                                       INCHES           CU. FEET       PERCENT
                               -------------------   -------------   ---------
 PRECIPITATION                  45.34    (   6.841)     164573.3     100.00

 RUNOFF                          2.143   (  0.8896)       7778.29      4.726

 EVAPOTRANSPIRATION             28.783   (  3.5398)     104483.09     63.487

 DRAINAGE RECIRCULATED           0.69930 (  0.10015)      2538.452    1.54244
   INTO LAYER  2

 LATERAL DRAINAGE COLLECTED      6.29368 (  0.90131)     22846.064   13.88200
   FROM LAYER  5

 DRAINAGE RECIRCULATED           0.69930 (  0.10015)      2538.452    1.54244
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.009    0.00001
   LAYER  7

 AVERAGE HEAD ON TOP             0.009 (    0.001)
   OF LAYER  6

 CHANGE IN WATER STORAGE         8.117   (  4.7040)      29465.44     17.904

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

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

           PEAK DAILY VALUES FOR YEARS   19 THROUGH   28
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
      PRECIPITATION                               4.10         14883.000

      RUNOFF                                      1.260         4572.7422

      DRAINAGE RECIRCULATED INTO LAYER  2         0.00367         13.30604

      DRAINAGE COLLECTED FROM LAYER  5            0.03299        119.75438

      DRAINAGE RECIRCULATED FROM LAYER  5         0.00367         13.30604

      PERCOLATION/LEAKAGE THROUGH LAYER  7        0.000000         0.00002

      AVERAGE HEAD ON TOP OF LAYER  6             0.017

      MAXIMUM HEAD ON TOP OF LAYER  6             0.035

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)                 0.0 FEET

      SNOW WATER                                  3.53         12827.0205


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3893

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1360


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

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

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




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

FINAL WATER STORAGE AT END OF YEAR 28

LAYER	(INCHES)	(VOL/VOL)
1	3.0537	0.2545
2	646.6414	0.4311
3	140.4484	0.3901
4	6.6042	0.2752
5	0.0097	0.0648
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:\RO\30\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\30\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\30\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\30\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\D\C\DATA10.D10
OUTPUT DATA FILE:           C:\RO\D\C\OUTPUT1.OUT


TIME:  24:38     DATE:  11/10/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - Closed 155 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                   =      0.25   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.   =   6.63000011000     CM/SEC
  SLOPE                       =      4.00   PERCENT
  DRAINAGE LENGTH             =    180.0    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  10
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                          LAYER  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                   =    360.00   INCHES
POROSITY                    =      0.5534 VOL/VOL
FIELD CAPACITY              =      0.4945 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                        LAYER  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.   =   3.16000009000     CM/SEC
SLOPE                       =      2.50   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                        LAYER 10
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER 11
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC




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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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   =    736.450  INCHES
TOTAL INITIAL WATER                =    736.450  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR



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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

```
STATION LATITUDE                         =  32.28 DEGREES
MAXIMUM LEAF AREA INDEX                  =   4.50
START OF GROWING SEASON (JULIAN DATE)    =     58
END OF GROWING SEASON (JULIAN DATE)      =    331
EVAPORATIVE ZONE DEPTH                   =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED                =   8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.54	4.24	3.80	3.38	4.26	4.04
3.40	3.07	3.55	4.75	4.24	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA AND STATION LATITUDE = 32.28 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	4.06	3.66	3.91	3.61	4.07	4.22
	3.38	2.64	3.32	4.70	4.22	3.92
STD. DEVIATIONS	2.78	1.82	1.66	1.52	1.88	2.72
	1.70	2.24	1.86	2.59	1.43	2.47
RUNOFF						
TOTALS	0.162	0.146	0.063	0.034	0.117	0.276
	0.114	0.072	0.110	0.513	0.107	0.230
STD. DEVIATIONS	0.428	0.276	0.127	0.083	0.233	0.406
	0.237	0.174	0.228	0.834	0.088	0.475
EVAPOTRANSPIRATION						
TOTALS	1.730	2.131	2.966	3.241	3.405	3.076
	2.940	2.179	2.473	1.803	1.234	1.405
STD. DEVIATIONS	0.187	0.403	0.728	0.927	1.132	1.575
	1.317	1.424	1.146	0.873	0.226	0.202
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.4196	1.6307	1.0844	0.4815	0.6772	0.9315
	0.3962	0.3728	0.5029	1.9176	2.4589	2.3237
STD. DEVIATIONS	2.3570	1.3815	1.1689	0.5418	0.9091	1.1421
	0.5167	0.7152	0.7830	1.4816	1.2878	2.0416
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001
	0.0000	0.0000	0.0000	0.0002	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.2767	0.2600	0.2865	0.2746	0.2848	0.2742
	0.2822	0.2801	0.2691	0.2747	0.2673	0.2762
STD. DEVIATIONS	0.0674	0.0778	0.0843	0.0831	0.0812	0.0801

```
                          0.0764   0.0750   0.0719   0.0742   0.0678   0.0719

  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              0.0316   0.0291   0.0121   0.0037   0.0114   0.0183
                          0.0064   0.0064   0.0083   0.0553   0.0287   0.0399

    STD. DEVIATIONS       0.0445   0.0401   0.0170   0.0052   0.0275   0.0294
                          0.0136   0.0161   0.0177   0.0729   0.0165   0.0569

  DAILY AVERAGE HEAD ON TOP OF LAYER 10
  -------------------------------------
    AVERAGES              0.0050   0.0051   0.0052   0.0051   0.0051   0.0051
                          0.0051   0.0050   0.0050   0.0049   0.0050   0.0050

    STD. DEVIATIONS       0.0012   0.0016   0.0015   0.0015   0.0015   0.0015
                          0.0014   0.0014   0.0013   0.0013   0.0013   0.0013

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET      PERCENT
                                 -------------------   -------------   ---------
 PRECIPITATION                    45.72    (   8.166)     165946.7     100.00

 RUNOFF                            1.943   (  1.4253)       7054.32      4.251

 EVAPOTRANSPIRATION               28.583   (  3.6101)     103757.41     62.525

 LATERAL DRAINAGE COLLECTED       15.19686 (  5.20318)     55164.598   33.24236
   FROM LAYER  2
```

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00062 (	0.00030)	2.243	0.00135
AVERAGE HEAD ON TOP OF LAYER 3	0.021 (	0.011)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	3.30633 (	0.89061)	12001.985	7.23244
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 10	0.005 (	0.001)		
CHANGE IN WATER STORAGE	-3.315 (	0.9895)	-12031.64	-7.250

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	6.92	25119.600
RUNOFF	3.628	13168.5488
DRAINAGE COLLECTED FROM LAYER 2	2.08349	7563.06934
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000316	1.14858
AVERAGE HEAD ON TOP OF LAYER 3	4.598	
MAXIMUM HEAD ON TOP OF LAYER 3	7.622	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	30.5 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.02674	97.05990
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.015	

```
MAXIMUM HEAD ON TOP OF LAYER 10            0.031

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)                0.0 FEET

SNOW WATER                                 3.18         11547.1094


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3849

MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1360


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

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

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




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

              FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1            2.6644         0.2220

                2            0.0025         0.0100

                3            0.0000         0.0000

                4            7.6860         0.4270

                5            2.9280         0.2440

                6          498.4822         0.3323

                7          108.9168         0.3025

                8            6.0826         0.2534

                9            0.0044         0.0299
```

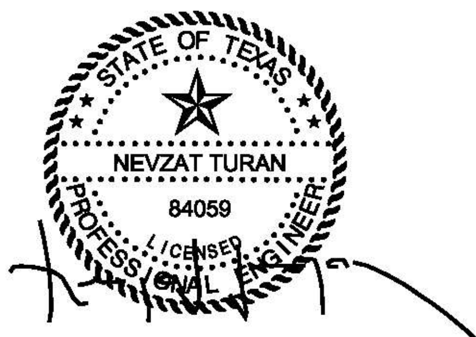
10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

****
****

APPENDIX IIIC-A.2

SUMMARY OF LEACHATE GENERATION MODEL FOR SIDESLOPES

Includes pages IIIC-A.2-1 through IIIC-A.2-99



05/20/2024

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.2-7. Double-sided geocomposite calculations, required properties, and HELP model summary sheet for the undeveloped sideslopes.
- Sheets IIIC-A.2-8 through IIIC-A.2-11. Double-sided geocomposite calculations, required properties, and HELP model summary sheet for the developed sideslopes.

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).

Required: Determine the minimum requirements of the 250-mil geocomposite leachate collection layer for Cells 10 through 12 sideslopes.

Method:

1. Determine the 250-mil geocomposite leachate collection layer thickness under the expected loading conditions.
2. Use HELP model to determine the minimum required hydraulic conductivity of the 250-mil geocomposite leachate collection layer at the expected loading conditions.
3. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
4. Compute the design transmissivity of the 250-mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses, the hydraulic conductivity, 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] (cm)
Active - 10'	10	2	49	720	0.248	0.630
Interim - 50'	50	3	49	2,795	0.236	0.599
Interim - 100'	100	3	57	6,045	0.214	0.544
Interim - 200'	200	3	71	14,545	0.164	0.416
Closed - 200'	200	5.5	71	14,833	0.162	0.412

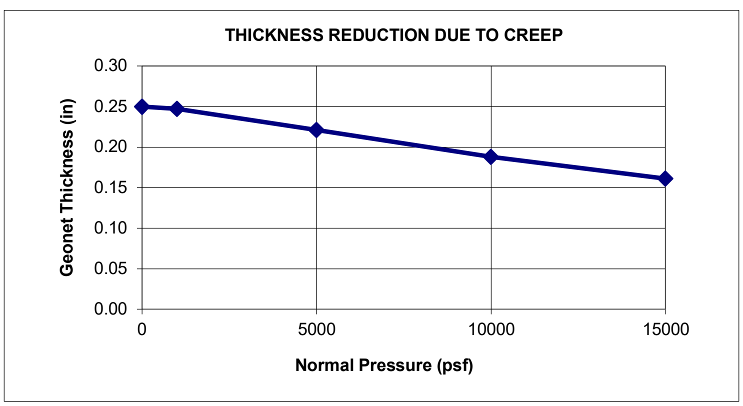
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[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. Use HELP model to determine the minimum required hydraulic conductivity of the 250-mil geocomposite leachate collection layer at the expected loading conditions. HELP model results are shown on Sheet IIIC-A.2-7

3. 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)	Closed
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.51	2.86

	Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Closed
Overall Factor of Safety to Account For Uncertainties	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]	2.20	3.15	3.96	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.

4. Compute the design transmissivity of the 250-mil geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses, the hydraulic conductivity, and the reduction factors.

Table 3 - Required Transmissivity for Subtitle D Areas

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (cm)	k[4] (cm/s)	T_{DES}[5] (m^2/s)	ORF[6]	T[7] (m^2/s)
Active - 10'	10	720	0.630	0.05	3.15E-06	2.20	6.94E-06
Interim - 50'	50	2,795	0.599	0.30	1.80E-05	3.15	5.65E-05
Interim - 100'	100	6,045	0.544	0.20	1.09E-05	3.96	4.31E-05
Interim - 200'	200	14,545	0.416	0.17	7.07E-06	5.02	3.55E-05
Closed - 200'	200	14,833	0.412	0.10	4.12E-06	5.72	2.36E-05

[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] k is obtained the HELP model design as shown on Sheet IIIC-A.2-7.

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

$$T_{DES} = (k * t)/100$$

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

[7] T is the design transmissivity value calculated using the following equation:

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

5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

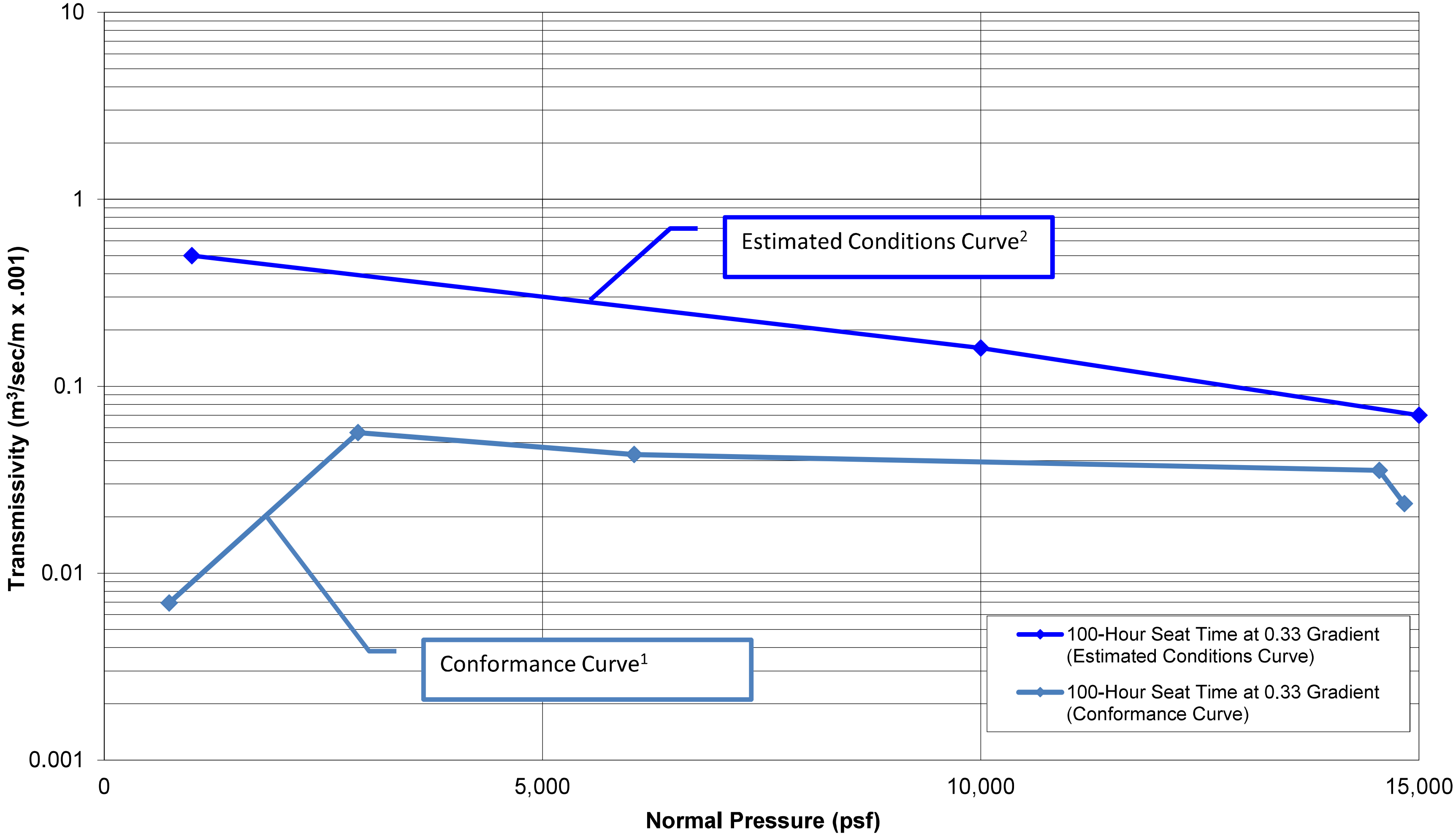
As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the conformance curve on the graph shown on Sheet IIIC-A.2-6 will provide a drainage layer that will maintain less than twelve inches of head on the liner system. The estimated conditions curve was developed based on engineering judgement and experience with similar geocomposite products at numerous MSW sites in Texas and is provided to verify the selected drainage geocomposite transmissivity provides greater conveyance than the specified transmissivity in these calculations.
The drainage geocomposite required transmissivity values will be measured at a gradient of 0.33 under normal pressures of 1,000, 10,000 and 14,833 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., 14,833 psf) with all the same assumptions as the first three tests.

Refer to the conformance curve plotted on Sheet IIIC-A.2-6 for the minimum transmissivity requirements.

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.

TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE

6/8 oz/sy Polypropylene Geotextiles with 250-mil Drainage Net
(Soil/Geocomposite/Geomembrane)



[1] The transmissivity shall be greater than the Conformace Curve to be considered passing.

[2] These values are developed based on engineering judgement and experience with similar geocomposite products at numerous MSW sites in Texas and is provided to verify the selected drainage geocomposite transmissivity provides greater conveyance than the specified transmissivity in these calculations.

HELP VERSION 3.07 SUMMARY SHEET
UNDEVELOPED - CELLS 10-12 - SIDESLOPES

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	CLOSED (200 FT WASTE)
GENERAL	Case No.	1	2	3	4	6
INFORMATION	Output Page	IIIC-A.2-15	IIIC-A.2-23	IIIC-A.2-32	IIIC-A.2-41	IIIC-A.2-50
	No. of Years	1	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	80.3	84.9	85.6	85.6	80.8
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	0	70	80	90	100
	Maximum Leaf Area Index	0.0	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)					0.250
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)					6.63
	Slope (%)					5.0
	Slope Length (ft)					285
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
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
WASTE TOP[2]	Thickness (in)	120	600	1200	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6376	0.6483	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5185	0.5215	0.5156	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	0.2500	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	900
(Texture = 0)	Porosity (vol/vol)				0.5348	0.5348
	Field Capacity (vol/vol)				0.4892	0.4892
	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	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)	0.248	0.236	0.214	0.164	0.162
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)	0.05	0.30	0.20	0.17	0.10
	Slope (%)	33.0	33.0	33.0	33.0	33.0
	Slope Length (ft)	370	370	370	370	370
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0
	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)	56.27	45.34	45.34	45.34	45.72
RUNOFF	Average Annual (in)	0.00	1.67	2.14	2.41	1.94
EVAPOTRANSPIRATIO	Average Annual (in)	36.34	28.77	28.78	28.78	28.58
LATERAL	Average Annual (cf/year)	6,921.4	17,491.0	38,074.7	27,251.6	14,614.4
DRAINAGE COLLECTEI	Peak Daily (cf/day)	50.2	241.2	378.0	111.6	103.0
LATERAL	Average Annual (cf/year)		1,749.1	3,807.5	2,725.2	
DRAINAGE RECIRCULA	Peak Daily (cf/day)		24.1	37.8	11.2	
HEAD ON LINER	Average Annual (in)	0.023	0.010	0.031	0.027	0.024
	Peak Daily (in)	0.196	0.190	0.202	0.110	0.112

[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.

ROYAL OAKS LANDFILL
0120-076-11-106
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
DEVELOPED AREA - CELLS 1 THROUGH 9 SIDESLOPES

Required: Estimate the properties of the geocomposite leachate collection layer for the developed Subtitle D cells sideslope.

Note: The developed area was constructed 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] (cm)
Interim - 50'	50	3	49	2,795	0.189	0.479
Interim - 100'	100	3	57	6,045	0.171	0.435
Interim - 155'	155	3	65	10,420	0.149	0.377
Closed - 155'	155	5.5	65	10,708	0.147	0.374

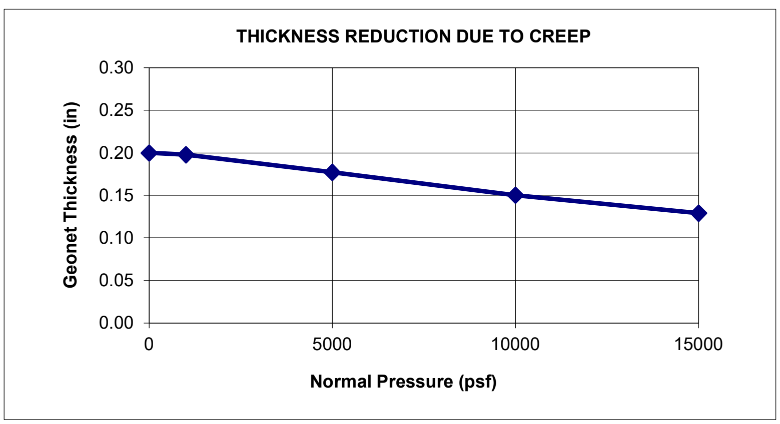
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[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: Interim (50' Waste)	Interim (100' Waste)	Interim (155' Waste)	Closed
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.3	1.5	1.8	2.0
RF_{BC}	Biological Clogging	1.1	1.2	1.2	1.3
Total Reduction Factor[2]		1.57	1.98	2.38	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		3.15	3.96	4.75	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 8 oz/sy geotextile is shown on Sheet IIIC-A.2-12. 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] (cm)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	2,795	0.479	1.13E-04	3.15	3.60E-05	0.75
Interim - 100'	100	6,045	0.435	7.25E-05	3.96	1.83E-05	0.42
Interim - 155'	155	10,420	0.377	4.83E-05	4.75	1.02E-05	0.27
Closed - 155'	155	10,708	0.374	4.72E-05	5.72	8.25E-06	0.22

[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.2-12.

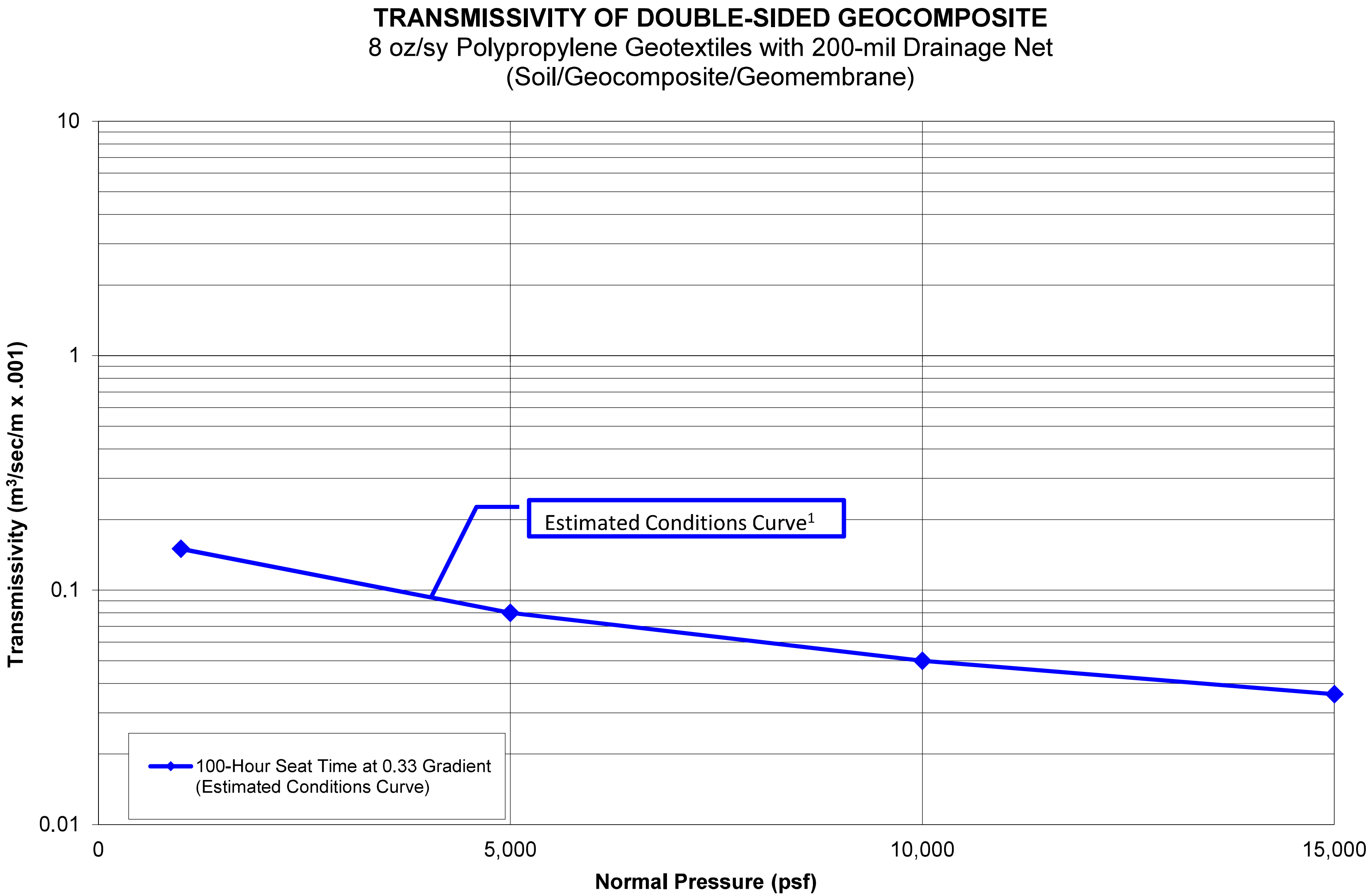
[5] ORF is the Overall Reduction Factor obtained from Table 2.

[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:

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



[1] These values are developed based on engineering judgement and experience with similar geocomposite products at numerous MSW sites in Texas and is provided to verify the selected drainage geocomposite transmissivity provides greater conveyance than the specified transmissivity in these calculations.

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (155 FT WASTE)	CLOSED (155 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4
	Output Page	IIIC-A.2-62	IIIC-A.2-71	IIIC-A.2-80	IIIC-A.2-89
	No. of Years	10	10	10	30
	Ground Cover	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	84.9	85.6	85.6	80.8
	Model Area (acre)	1	1	1	1
	Runoff Area (%)	70	80	80	100
	Maximum Leaf Area Index	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	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)				0.250
	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)				6.63
	Slope (%)				4.0
	Slope Length (ft)				285
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 = 10)	Thickness (in)	12	12	12	12
	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
WASTE TOP[2] (Texture = 0)	Thickness (in)	600	1200	1500	1500
	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	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] (Texture = 0)	Thickness (in)			360	360
	Porosity (vol/vol)			0.5534	0.5534
	Field Capacity (vol/vol)			0.4945	0.4945
	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 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)	0.188	0.171	0.149	0.147
	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)	0.75	0.42	0.27	0.22
	Slope (%)	33.0	33.0	33.0	33.0
	Slope Length (ft)	250	250	250	250
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	0	0	0	0
	Install. Defects (holes/acre)	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24
	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-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	45.34	45.34	45.34	45.72
RUNOFF	Average Annual (in)	1.74	2.14	2.14	1.83
EVAPOTRANSPIRATION	Average Annual (in)	29.01	28.78	28.78	28.56
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	14,844.2	38,306.8	25,398.8	11,984.0
	Peak Daily (cf/day)	172.3	381.8	123.4	95.5
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)	1,484.4	3,830.7	2,539.9	
	Peak Daily (cf/day)	17.2	38.2	12.3	
HEAD ON LINER	Average Annual (in)	0.002	0.010	0.011	0.006
	Peak Daily (in)	0.111	0.118	0.053	0.093

[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.

SIDESLOPE
HELP MODEL OUTPUT FOR UNDEVELOPED AREAS
(CELLS 10 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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\RO\1\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\1\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\1\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\1\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\US\A10\DATA10.D10
OUTPUT DATA FILE:           C:\RO\US\A10\OUTPUT1.OUT


TIME:   9:53     DATE:  12/ 4/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - 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.    =  0.500000007000E-01 CM/SEC
SLOPE                        =     33.00   PERCENT
DRAINAGE LENGTH              =    370.0    FEET


                        LAYER  4
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
```

```
   INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                          LAYER  5
                          --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #18 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
          A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER             =     80.30
FRACTION OF AREA ALLOWING RUNOFF    =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      2.500  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      6.376  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.770  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     46.106  INCHES
TOTAL INITIAL WATER                 =     46.106  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


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

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	58
END OF GROWING SEASON (JULIAN DATE)	=	331
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 19

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.82	5.12	5.51	2.78	4.62	2.12
	3.81	7.13	5.43	2.54	4.98	6.41
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	2.320	2.821	3.685	2.615	4.039	3.365
	3.014	3.652	4.334	1.724	2.683	2.091
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	0.0077	0.1051	0.1491	0.1488
	0.1648	0.1284	0.2448	0.3564	0.2657	0.3359
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   0.0011   0.0154   0.0211   0.0218
                           0.0233   0.0182   0.0358   0.0504   0.0388   0.0475

    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   19 THROUGH   19
-------------------------------------------------------------------------------
                                      INCHES           CU. FEET       PERCENT
                                -------------------  -------------   ---------
 PRECIPITATION                   56.27    (   0.000)     204260.0     100.00

 RUNOFF                           0.000   (  0.0000)          0.00      0.000

 EVAPOTRANSPIRATION              36.343   (  0.0000)    131925.47     64.587

 LATERAL DRAINAGE COLLECTED       1.90672 (  0.00000)      6921.384    3.38852
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)         0.007     0.00000
   LAYER  5

 AVERAGE HEAD ON TOP              0.023 (    0.000)
   OF LAYER  4

 CHANGE IN WATER STORAGE         18.020   (  0.0000)     65413.28     32.025
*******************************************************************************



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

             PEAK DAILY VALUES FOR YEARS   19 THROUGH   19
   ------------------------------------------------------------------------
                                                    (INCHES)     (CU. FT.)
                                                   ----------   -------------
     PRECIPITATION                                    2.73         9909.900
```

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.01383	50.22104
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 4	0.061	
MAXIMUM HEAD ON TOP OF LAYER 4	0.196	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.42	1525.7992

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4053

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 19

LAYER	(INCHES)	(VOL/VOL)
1	47.4061	0.3951
2	6.4204	0.2675
3	0.0522	0.2104
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:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\US\I50\DATA10.D10
OUTPUT DATA FILE:           C:\RO\US\I50\OUTPUT1.OUT


TIME:   9:52     DATE:  12/ 4/2023


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     TITLE:  Royal Oaks Landfill - Undeveloped Areas - 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  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  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                    =      0.6483 VOL/VOL
  FIELD CAPACITY              =      0.5215 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                   =      0.24   INCHES
  POROSITY                    =      0.8500 VOL/VOL
```

```
  FIELD CAPACITY              =      0.0100 VOL/VOL
  WILTING POINT               =      0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC
  SLOPE                       =     33.00   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  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD



                          LAYER  6
                          --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.4270 VOL/VOL
  FIELD CAPACITY              =      0.4180 VOL/VOL
  WILTING POINT               =      0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC



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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
```

SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 800. FEET.

SCS RUNOFF CURVE NUMBER	=	84.90	
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	=	2.440	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.980	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.360	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	169.034	INCHES
TOTAL INITIAL WATER	=	169.034	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	58	
END OF GROWING SEASON (JULIAN DATE)	=	331	
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.073	0.195	0.096	0.218	0.195	0.282
	0.191	0.057	0.105	0.050	0.108	0.103
STD. DEVIATIONS	0.111	0.229	0.137	0.220	0.235	0.335
	0.340	0.140	0.160	0.070	0.060	0.232
EVAPOTRANSPIRATION						
TOTALS	1.659	2.187	2.806	3.167	3.764	3.418
	3.250	1.890	2.230	1.445	1.410	1.541
STD. DEVIATIONS	0.312	0.361	0.785	0.955	1.013	0.822

```
                           1.657    1.401    1.043    0.874    0.504    0.120

 LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
 -------------------------------------------
   TOTALS                  0.0353   0.0326   0.0356   0.0403   0.0402   0.0404
                           0.0442   0.0418   0.0440   0.0404   0.0400   0.0471

   STD. DEVIATIONS         0.0310   0.0291   0.0308   0.0372   0.0337   0.0342
                           0.0372   0.0323   0.0344   0.0287   0.0307   0.0382

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                  0.3173   0.2936   0.3200   0.3625   0.3621   0.3639
                           0.3975   0.3763   0.3962   0.3635   0.3598   0.4239

   STD. DEVIATIONS         0.2789   0.2623   0.2770   0.3346   0.3031   0.3082
                           0.3348   0.2908   0.3092   0.2583   0.2760   0.3438

 LATERAL DRAINAGE RECIRCULATED FROM LAYER  4
 -------------------------------------------
   TOTALS                  0.0353   0.0326   0.0356   0.0403   0.0402   0.0404
                           0.0442   0.0418   0.0440   0.0404   0.0400   0.0471

   STD. DEVIATIONS         0.0310   0.0291   0.0308   0.0372   0.0337   0.0342
                           0.0372   0.0323   0.0344   0.0287   0.0307   0.0382

 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                0.0083   0.0084   0.0084   0.0098   0.0095   0.0099
                           0.0104   0.0099   0.0107   0.0095   0.0097   0.0111

   STD. DEVIATIONS         0.0073   0.0074   0.0073   0.0091   0.0079   0.0083
                           0.0088   0.0076   0.0084   0.0068   0.0075   0.0090

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

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.34	(6.841)	164573.3	100.00
RUNOFF	1.674	(0.7205)	6075.06	3.691
EVAPOTRANSPIRATION	28.768	(3.5104)	104426.44	63.453
DRAINAGE RECIRCULATED INTO LAYER 2	0.48184	(0.38906)	1749.095	1.06281
LATERAL DRAINAGE COLLECTED FROM LAYER 4	4.33660	(3.50152)	15741.859	9.56526
DRAINAGE RECIRCULATED FROM LAYER 4	0.48184	(0.38906)	1749.095	1.06281
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.007	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.010	(0.008)		
CHANGE IN WATER STORAGE	10.559	(6.5377)	38329.16	23.290

****

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.047	3799.3945
DRAINAGE RECIRCULATED INTO LAYER 2	0.00664	24.11605
DRAINAGE COLLECTED FROM LAYER 4	0.05979	217.04445

```
DRAINAGE RECIRCULATED FROM LAYER  4        0.00664         24.11605

PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00002

AVERAGE HEAD ON TOP OF LAYER  5            0.049

MAXIMUM HEAD ON TOP OF LAYER  5            0.190

LOCATION OF MAXIMUM HEAD IN LAYER  4
      (DISTANCE FROM DRAIN)                0.0 FEET

SNOW WATER                                 3.53         12827.0205


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3922

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   28
    ----------------------------------------------------------------------
                 LAYER        (INCHES)       (VOL/VOL)
                 -----        --------       ---------
                   1            3.0516         0.2543

                   2          254.7898         0.4246

                   3            6.5207         0.2717

                   4            0.0143         0.0605

                   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              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:       c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\RO\US\I100\DATA10.D10
OUTPUT DATA FILE:            C:\RO\US\I100\OUTPUT1.OUT


TIME:  17:31     DATE:  11/ 6/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - 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  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  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.   =  0.200000003000     CM/SEC
  SLOPE                       =     33.00   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  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD



                          LAYER  6
                          --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.4270 VOL/VOL
  FIELD CAPACITY              =      0.4180 VOL/VOL
  WILTING POINT               =      0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC



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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
```

SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 4.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.60	
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	=	2.440	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.980	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.360	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	475.034	INCHES
TOTAL INITIAL WATER	=	475.034	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	58	
END OF GROWING SEASON (JULIAN DATE)	=	331	
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.098	0.245	0.126	0.281	0.245	0.354
	0.240	0.074	0.137	0.067	0.149	0.127
STD. DEVIATIONS	0.145	0.280	0.168	0.274	0.286	0.405
	0.409	0.178	0.202	0.088	0.076	0.287
EVAPOTRANSPIRATION						
TOTALS	1.662	2.184	2.805	3.178	3.753	3.411
	3.262	1.894	2.237	1.447	1.410	1.539
STD. DEVIATIONS	0.315	0.361	0.786	0.948	0.999	0.828

	1.644	1.406	1.049	0.877	0.503	0.121

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0784	0.0799	0.0907	0.0842	0.0929	0.0901
	0.0887	0.0939	0.0828	0.0855	0.0840	0.0980
STD. DEVIATIONS	0.0255	0.0243	0.0259	0.0215	0.0158	0.0257
	0.0222	0.0222	0.0149	0.0221	0.0158	0.0160

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.7056	0.7189	0.8162	0.7575	0.8357	0.8106
	0.7979	0.8451	0.7451	0.7695	0.7563	0.8817
STD. DEVIATIONS	0.2292	0.2186	0.2332	0.1935	0.1418	0.2309
	0.1999	0.1997	0.1338	0.1992	0.1419	0.1437

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0784	0.0799	0.0907	0.0842	0.0929	0.0901
	0.0887	0.0939	0.0828	0.0855	0.0840	0.0980
STD. DEVIATIONS	0.0255	0.0243	0.0259	0.0215	0.0158	0.0257
	0.0222	0.0222	0.0149	0.0221	0.0158	0.0160

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	0.0277	0.0309	0.0321	0.0308	0.0328	0.0329
	0.0314	0.0332	0.0303	0.0302	0.0307	0.0347
STD. DEVIATIONS	0.0090	0.0091	0.0092	0.0079	0.0056	0.0094
	0.0079	0.0078	0.0054	0.0078	0.0058	0.0056

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.34	(6.841)	164573.3	100.00
RUNOFF	2.143	(0.8896)	7778.29	4.726
EVAPOTRANSPIRATION	28.783	(3.5398)	104483.09	63.487
DRAINAGE RECIRCULATED INTO LAYER 2	1.04889	(0.21026)	3807.469	2.31354
LATERAL DRAINAGE COLLECTED FROM LAYER 4	9.44001	(1.89233)	34267.227	20.82186
DRAINAGE RECIRCULATED FROM LAYER 4	1.04889	(0.21026)	3807.469	2.31354
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.031	(0.006)		
CHANGE IN WATER STORAGE	4.971	(5.3474)	18044.46	10.964

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.260	4572.7422
DRAINAGE RECIRCULATED INTO LAYER 2	0.01041	37.79585
DRAINAGE COLLECTED FROM LAYER 4	0.09371	340.16260

```
DRAINAGE RECIRCULATED FROM LAYER  4        0.01041         37.79585

PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00005

AVERAGE HEAD ON TOP OF LAYER  5            0.114

MAXIMUM HEAD ON TOP OF LAYER  5            0.202

LOCATION OF MAXIMUM HEAD IN LAYER  4
      (DISTANCE FROM DRAIN)                7.7 FEET

SNOW WATER                                 3.53         12827.0205


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3893

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   28
    ----------------------------------------------------------------------
                 LAYER        (INCHES)       (VOL/VOL)
                 -----        --------       ---------
                   1            3.0537         0.2545

                   2          504.8705         0.4207

                   3            6.5487         0.2729

                   4            0.0224         0.1049

                   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            **
**                                                                          **
**                                                                          **
******************************************************************************
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PRECIPITATION DATA FILE:    C:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\US\I200\DATA10.D10
OUTPUT DATA FILE:           C:\RO\US\I200\OUTPUT1.OUT


TIME:  33:59     DATE:  11/10/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - 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  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  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.    =  0.170000002000     CM/SEC
  SLOPE                        =     33.00   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  35
  THICKNESS                    =      0.06   INCHES
  POROSITY                     =      0.0000 VOL/VOL
  FIELD CAPACITY               =      0.0000 VOL/VOL
  WILTING POINT                =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY          =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS     =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  7
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
```

```
   THICKNESS                    =     24.00   INCHES
   POROSITY                     =      0.4270 VOL/VOL
   FIELD CAPACITY               =      0.4180 VOL/VOL
   WILTING POINT                =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC
```

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

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

SCS RUNOFF CURVE NUMBER              =     85.60
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    =      2.440  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      3.980  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.360  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    931.034  INCHES
TOTAL INITIAL WATER                  =    931.034  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA

     STATION LATITUDE                         =  32.28 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   2.00
     START OF GROWING SEASON (JULIAN DATE)    =     58
     END OF GROWING SEASON (JULIAN DATE)      =    331
     EVAPORATIVE ZONE DEPTH                   =  10.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   8.60 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  70.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  72.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85

```
RUNOFF
------
  TOTALS                   0.111    0.276    0.142    0.315    0.275    0.398
                           0.270    0.083    0.154    0.075    0.167    0.143

  STD. DEVIATIONS          0.163    0.314    0.189    0.307    0.320    0.456
                           0.460    0.199    0.227    0.098    0.085    0.323

EVAPOTRANSPIRATION
------------------
  TOTALS                   1.661    2.185    2.807    3.182    3.756    3.403
                           3.256    1.891    2.239    1.448    1.411    1.541

  STD. DEVIATIONS          0.316    0.357    0.785    0.954    1.002    0.823
                           1.630    1.409    1.050    0.874    0.504    0.121

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                   0.0593   0.0583   0.0645   0.0621   0.0646   0.0616
                           0.0642   0.0644   0.0620   0.0640   0.0613   0.0645

  STD. DEVIATIONS          0.0119   0.0060   0.0069   0.0060   0.0058   0.0049
                           0.0069   0.0045   0.0058   0.0051   0.0047   0.0063

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                   0.5337   0.5251   0.5801   0.5585   0.5817   0.5540
                           0.5775   0.5800   0.5580   0.5759   0.5520   0.5801

  STD. DEVIATIONS          0.1068   0.0542   0.0620   0.0542   0.0524   0.0443
                           0.0621   0.0404   0.0520   0.0455   0.0419   0.0565

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                   0.0593   0.0583   0.0645   0.0621   0.0646   0.0616
                           0.0642   0.0644   0.0620   0.0640   0.0613   0.0645

  STD. DEVIATIONS          0.0119   0.0060   0.0069   0.0060   0.0058   0.0049
                           0.0069   0.0045   0.0058   0.0051   0.0047   0.0063

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	0.0247	0.0266	0.0268	0.0267	0.0269	0.0265
	0.0267	0.0268	0.0267	0.0266	0.0264	0.0268
STD. DEVIATIONS	0.0049	0.0026	0.0029	0.0026	0.0024	0.0021
	0.0029	0.0019	0.0025	0.0021	0.0020	0.0026

***

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.34	(6.841)	164573.3	100.00
RUNOFF	2.408	(0.9980)	8742.70	5.312
EVAPOTRANSPIRATION	28.779	(3.5362)	104468.12	63.478
DRAINAGE RECIRCULATED INTO LAYER 2	0.75073	(0.05968)	2725.163	1.65590
LATERAL DRAINAGE COLLECTED FROM LAYER 5	6.75660	(0.53716)	24526.473	14.90307
DRAINAGE RECIRCULATED FROM LAYER 5	0.75073	(0.05968)	2725.163	1.65590
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.027	(0.002)		
CHANGE IN WATER STORAGE	7.393	(4.2890)	26835.83	16.306

***

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.417	5143.8730
DRAINAGE RECIRCULATED INTO LAYER 2	0.00307	11.16153
DRAINAGE COLLECTED FROM LAYER 5	0.02767	100.45375
DRAINAGE RECIRCULATED FROM LAYER 5	0.00307	11.16153
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.040	
MAXIMUM HEAD ON TOP OF LAYER 6	0.110	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.53	12827.0205

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3812

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

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

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

****

****

FINAL WATER STORAGE AT END OF YEAR 28

LAYER	(INCHES)	(VOL/VOL)
1	3.0531	0.2544
2	645.4828	0.4303
3	339.5151	0.3772
4	6.6346	0.2764
5	0.0280	0.1705
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:\RO\30\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\30\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\30\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\30\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\US\C\DATA10.D10
OUTPUT DATA FILE:           C:\RO\US\C\OUTPUT1.OUT


TIME:  24:37     DATE:  11/10/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - Closed 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  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                   =      0.25   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.   =   6.63000011000     CM/SEC
  SLOPE                       =      4.00   PERCENT
  DRAINAGE LENGTH             =    180.0    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  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                        LAYER  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                    =    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  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                   =      0.16   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000001000     CM/SEC
SLOPE                       =     33.00   PERCENT
DRAINAGE LENGTH             =    370.0    FEET


                        LAYER 10
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER 11
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC



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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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    =    941.650  INCHES
TOTAL INITIAL WATER                =    941.650  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR



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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

```
STATION LATITUDE                        =  32.28 DEGREES
MAXIMUM LEAF AREA INDEX                 =   4.50
START OF GROWING SEASON (JULIAN DATE)   =     58
END OF GROWING SEASON (JULIAN DATE)     =    331
EVAPORATIVE ZONE DEPTH                  =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED               =   8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.54	4.24	3.80	3.38	4.26	4.04
3.40	3.07	3.55	4.75	4.24	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA AND STATION LATITUDE = 32.28 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	4.06	3.66	3.91	3.61	4.07	4.22
	3.38	2.64	3.32	4.70	4.22	3.92
STD. DEVIATIONS	2.78	1.82	1.66	1.52	1.88	2.72
	1.70	2.24	1.86	2.59	1.43	2.47
RUNOFF						
TOTALS	0.162	0.146	0.063	0.034	0.117	0.276
	0.114	0.072	0.110	0.513	0.107	0.230
STD. DEVIATIONS	0.428	0.276	0.127	0.083	0.233	0.406
	0.237	0.174	0.228	0.834	0.088	0.475
EVAPOTRANSPIRATION						
TOTALS	1.730	2.131	2.966	3.241	3.405	3.076
	2.940	2.179	2.473	1.803	1.234	1.405
STD. DEVIATIONS	0.187	0.403	0.728	0.927	1.132	1.575
	1.317	1.424	1.146	0.873	0.226	0.202
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.4196	1.6307	1.0844	0.4815	0.6772	0.9315
	0.3962	0.3728	0.5029	1.9176	2.4589	2.3237
STD. DEVIATIONS	2.3570	1.3815	1.1689	0.5418	0.9091	1.1421
	0.5167	0.7152	0.7830	1.4816	1.2878	2.0416
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001
	0.0000	0.0000	0.0000	0.0002	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.3333	0.3177	0.3490	0.3362	0.3459	0.3314
	0.3428	0.3425	0.3280	0.3392	0.3251	0.3349
STD. DEVIATIONS	0.0989	0.1101	0.1238	0.1179	0.1205	0.1108

	0.1153	0.1110	0.1069	0.1125	0.1044	0.1069

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	0.0316	0.0291	0.0121	0.0037	0.0114	0.0183
	0.0064	0.0064	0.0083	0.0553	0.0287	0.0399
STD. DEVIATIONS	0.0445	0.0401	0.0170	0.0052	0.0275	0.0294
	0.0136	0.0161	0.0177	0.0729	0.0165	0.0569

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0236	0.0247	0.0247	0.0246	0.0245	0.0242
	0.0243	0.0242	0.0240	0.0240	0.0238	0.0237
STD. DEVIATIONS	0.0070	0.0086	0.0088	0.0086	0.0085	0.0081
	0.0082	0.0079	0.0078	0.0080	0.0076	0.0076

****

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.72 (8.166)	165946.7	100.00
RUNOFF	1.943 (1.4253)	7054.32	4.251
EVAPOTRANSPIRATION	28.583 (3.6101)	103757.41	62.525
LATERAL DRAINAGE COLLECTED FROM LAYER 2	15.19686 (5.20318)	55164.598	33.24236

```
 PERCOLATION/LEAKAGE THROUGH     0.00062 (  0.00030)        2.243     0.00135
   LAYER  4

 AVERAGE HEAD ON TOP             0.021 (    0.011)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED      4.02600 (  1.30952)    14614.370    8.80667
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.009     0.00001
   LAYER 11

 AVERAGE HEAD ON TOP             0.024 (    0.008)
   OF LAYER 10

 CHANGE IN WATER STORAGE        -4.034   (  1.3627)    -14644.02    -8.825

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



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

               PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                               6.92         25119.600

      RUNOFF                                      3.628        13168.5488

      DRAINAGE COLLECTED FROM LAYER  2            2.08349       7563.06934

      PERCOLATION/LEAKAGE THROUGH LAYER  4        0.000316         1.14858

      AVERAGE HEAD ON TOP OF LAYER  3             4.598

      MAXIMUM HEAD ON TOP OF LAYER  3             7.622

      LOCATION OF MAXIMUM HEAD IN LAYER  2
            (DISTANCE FROM DRAIN)                30.5 FEET

      DRAINAGE COLLECTED FROM LAYER  9            0.02837        102.99951

      PERCOLATION/LEAKAGE THROUGH LAYER 11        0.000000         0.00003

      AVERAGE HEAD ON TOP OF LAYER 10             0.062
```

```
MAXIMUM HEAD ON TOP OF LAYER 10           0.112

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)               0.0 FEET

SNOW WATER                                3.18         11547.1094


MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3849

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            2.6644         0.2220

                2            0.0025         0.0100

                3            0.0000         0.0000

                4            7.6860         0.4270

                5            2.9280         0.2440

                6          517.0857         0.3447

                7          273.8399         0.3043

                8            6.1529         0.2564

                9            0.0177         0.1090
```

10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

****
****

SIDESLOPE
HELP MODEL OUTPUT FOR UNDEVELOPED AREAS
(CELLS 1 THROUGH 9)

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\DS\I50\DATA10.D10
OUTPUT DATA FILE:           C:\RO\DS\I50\OUTPUT1.OUT


TIME:   9:52     DATE:  12/ 4/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - 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  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  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                     =      0.6483 VOL/VOL
  FIELD CAPACITY               =      0.5215 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.   =  0.750000000000     CM/SEC
  SLOPE                       =     33.00   PERCENT
  DRAINAGE LENGTH             =    250.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.
```

```
                           LAYER  5
                           --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD
```

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

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.4270 VOL/VOL
  FIELD CAPACITY              =      0.4180 VOL/VOL
  WILTING POINT               =      0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC
```

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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
```

SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 800. FEET.

SCS RUNOFF CURVE NUMBER	=	84.90	
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	=	2.440	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.980	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.360	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	169.034	INCHES
TOTAL INITIAL WATER	=	169.034	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
SHREVEPORT LOUISIANA

STATION LATITUDE	=	32.28	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	58	
END OF GROWING SEASON (JULIAN DATE)	=	331	
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.084	0.203	0.101	0.212	0.213	0.295
	0.201	0.062	0.106	0.048	0.118	0.097
STD. DEVIATIONS	0.125	0.235	0.144	0.211	0.260	0.346
	0.358	0.152	0.161	0.060	0.059	0.232
EVAPOTRANSPIRATION						
TOTALS	1.670	2.175	2.839	3.239	3.847	3.459
	3.286	1.892	2.234	1.450	1.395	1.530
STD. DEVIATIONS	0.292	0.371	0.795	0.936	1.039	0.827

	1.637	1.412	1.069	0.875	0.498	0.119

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0308	0.0291	0.0329	0.0328	0.0328	0.0346
	0.0347	0.0369	0.0358	0.0379	0.0339	0.0368
STD. DEVIATIONS	0.0280	0.0267	0.0302	0.0289	0.0274	0.0289
	0.0272	0.0282	0.0282	0.0313	0.0251	0.0265

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.2772	0.2617	0.2963	0.2949	0.2948	0.3115
	0.3127	0.3318	0.3222	0.3411	0.3052	0.3309
STD. DEVIATIONS	0.2522	0.2407	0.2722	0.2603	0.2465	0.2604
	0.2450	0.2538	0.2539	0.2815	0.2261	0.2386

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0308	0.0291	0.0329	0.0328	0.0328	0.0346
	0.0347	0.0369	0.0358	0.0379	0.0339	0.0368
STD. DEVIATIONS	0.0280	0.0267	0.0302	0.0289	0.0274	0.0289
	0.0272	0.0282	0.0282	0.0313	0.0251	0.0265

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0020	0.0020	0.0021	0.0022	0.0021	0.0023
	0.0022	0.0023	0.0024	0.0024	0.0022	0.0023
STD. DEVIATIONS	0.0018	0.0018	0.0019	0.0019	0.0017	0.0019
	0.0017	0.0018	0.0019	0.0020	0.0017	0.0017

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.34	(6.841)	164573.3	100.00
RUNOFF	1.740	(0.7408)	6315.96	3.838
EVAPOTRANSPIRATION	29.014	(3.5490)	105319.34	63.995
DRAINAGE RECIRCULATED INTO LAYER 2	0.40893	(0.33316)	1484.419	0.90198
LATERAL DRAINAGE COLLECTED FROM LAYER 4	3.68038	(2.99840)	13359.774	8.11783
DRAINAGE RECIRCULATED FROM LAYER 4	0.40893	(0.33316)	1484.419	0.90198
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.007	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.002	(0.002)		
CHANGE IN WATER STORAGE	10.903	(6.1158)	39577.43	24.049

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PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.111	4031.1228
DRAINAGE RECIRCULATED INTO LAYER 2	0.00475	17.22640
DRAINAGE COLLECTED FROM LAYER 4	0.04271	155.03761

DRAINAGE RECIRCULATED FROM LAYER 4	0.00475	17.22640
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.009	
MAXIMUM HEAD ON TOP OF LAYER 5	0.111	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.53	12827.0205

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3645
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 28

LAYER	(INCHES)	(VOL/VOL)
1	3.0552	0.2546
2	258.1118	0.4302
3	6.6444	0.2769
4	0.0032	0.0169
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:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\DS\I100\DATA10.D10
OUTPUT DATA FILE:           C:\RO\DS\I100\OUTPUT1.OUT


TIME:  11:18     DATE:  11/ 8/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - 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  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  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                   =      0.17   INCHES
  POROSITY                    =      0.8500 VOL/VOL
```

```
  FIELD CAPACITY              =      0.0100 VOL/VOL
  WILTING POINT               =      0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.419999987000     CM/SEC
  SLOPE                       =     33.00   PERCENT
  DRAINAGE LENGTH             =    250.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  6
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.4270 VOL/VOL
  FIELD CAPACITY              =      0.4180 VOL/VOL
  WILTING POINT               =      0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
```

```
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  500. FEET.

SCS RUNOFF CURVE NUMBER              =     85.60
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    =      2.440  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      3.980  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.360  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    475.034  INCHES
TOTAL INITIAL WATER                  =    475.034  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT           LOUISIANA

     STATION LATITUDE                         =  32.28 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   2.00
     START OF GROWING SEASON (JULIAN DATE)    =     58
     END OF GROWING SEASON (JULIAN DATE)      =    331
     EVAPORATIVE ZONE DEPTH                   =  10.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   8.60 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  70.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  72.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  72.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    SHREVEPORT         LOUISIANA

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  4.02        3.46        3.77        4.71        4.70        3.54
  3.56        2.52        3.29        2.63        3.77        3.87
```

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.098	0.245	0.126	0.281	0.245	0.354
	0.240	0.074	0.137	0.067	0.149	0.127
STD. DEVIATIONS	0.145	0.280	0.168	0.274	0.286	0.405
	0.409	0.178	0.202	0.088	0.076	0.287
EVAPOTRANSPIRATION						
TOTALS	1.662	2.184	2.805	3.178	3.753	3.411
	3.262	1.894	2.237	1.447	1.410	1.539
STD. DEVIATIONS	0.315	0.361	0.786	0.948	0.999	0.828

```
                         1.644    1.406    1.049    0.877    0.503    0.121

 LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
 -------------------------------------------
   TOTALS                0.0908   0.0787   0.0877   0.0888   0.0890   0.0883
                         0.0910   0.0897   0.0833   0.0927   0.0861   0.0893

   STD. DEVIATIONS       0.0321   0.0230   0.0183   0.0215   0.0164   0.0208
                         0.0209   0.0204   0.0156   0.0177   0.0215   0.0141

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                0.8175   0.7080   0.7897   0.7988   0.8008   0.7948
                         0.8186   0.8071   0.7496   0.8347   0.7746   0.8035

   STD. DEVIATIONS       0.2890   0.2071   0.1651   0.1939   0.1475   0.1876
                         0.1882   0.1840   0.1404   0.1589   0.1939   0.1272

 LATERAL DRAINAGE RECIRCULATED FROM LAYER  4
 -------------------------------------------
   TOTALS                0.0908   0.0787   0.0877   0.0888   0.0890   0.0883
                         0.0910   0.0897   0.0833   0.0927   0.0861   0.0893

   STD. DEVIATIONS       0.0321   0.0230   0.0183   0.0215   0.0164   0.0208
                         0.0209   0.0204   0.0156   0.0177   0.0215   0.0141

 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              0.0103   0.0098   0.0100   0.0104   0.0101   0.0104
                         0.0104   0.0102   0.0098   0.0106   0.0101   0.0102

   STD. DEVIATIONS       0.0037   0.0028   0.0021   0.0025   0.0019   0.0025
                         0.0024   0.0023   0.0018   0.0020   0.0025   0.0016

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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.34 (6.841)	164573.3	100.00
RUNOFF	2.143 (0.8896)	7778.29	4.726
EVAPOTRANSPIRATION	28.783 (3.5398)	104483.09	63.487
DRAINAGE RECIRCULATED INTO LAYER 2	1.05528 (0.20617)	3830.685	2.32765
LATERAL DRAINAGE COLLECTED FROM LAYER 4	9.49757 (1.85557)	34476.164	20.94882
DRAINAGE RECIRCULATED FROM LAYER 4	1.05528 (0.20617)	3830.685	2.32765
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.010 (0.002)		
CHANGE IN WATER STORAGE	4.914 (5.4571)	17836.31	10.838

****

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.260	4572.7422
DRAINAGE RECIRCULATED INTO LAYER 2	0.01052	38.18061
DRAINAGE COLLECTED FROM LAYER 4	0.09466	343.62543

DRAINAGE RECIRCULATED FROM LAYER 4	0.01052	38.18061
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.037	
MAXIMUM HEAD ON TOP OF LAYER 5	0.118	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.53	12827.0205

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3893
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

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

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

****

****

FINAL WATER STORAGE AT END OF YEAR 28

LAYER	(INCHES)	(VOL/VOL)
1	3.0537	0.2545
2	503.8755	0.4199
3	6.9906	0.2913
4	0.0017	0.0100
5	0.0000	0.0000
6	10.2480	0.4270

SNOW WATER 0.000

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\RO\10\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\DS\I155\DATA10.D10
OUTPUT DATA FILE:           C:\RO\DS\I155\OUTPUT1.OUT


TIME:  11:19     DATE:  11/ 8/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - Interim 155 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  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                   =    360.00   INCHES
  POROSITY                    =      0.5534 VOL/VOL
  FIELD CAPACITY              =      0.4945 VOL/VOL
  WILTING POINT               =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC



                          LAYER  4
                          --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  10
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.3980 VOL/VOL
```

```
          FIELD CAPACITY              =      0.2440 VOL/VOL
          WILTING POINT               =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                                LAYER  5
                                --------

                  TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   0
          THICKNESS                   =      0.15   INCHES
          POROSITY                    =      0.8500 VOL/VOL
          FIELD CAPACITY              =      0.0100 VOL/VOL
          WILTING POINT               =      0.0050 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.270000011000     CM/SEC
          SLOPE                       =     33.00   PERCENT
          DRAINAGE LENGTH             =    250.0    FEET
        NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
                 LAYER IS RECIRCULATED INTO LAYER #  2.


                                LAYER  6
                                --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
          THICKNESS                   =      0.06   INCHES
          POROSITY                    =      0.0000 VOL/VOL
          FIELD CAPACITY              =      0.0000 VOL/VOL
          WILTING POINT               =      0.0000 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
          FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
          FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
          FML PLACEMENT QUALITY       =  3 - GOOD


                                LAYER  7
                                --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER  16
```

```
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4270 VOL/VOL
FIELD CAPACITY               =      0.4180 VOL/VOL
WILTING POINT                =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

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

SCS RUNOFF CURVE NUMBER             =     85.60
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   =      2.440  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      3.980  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.360  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =    725.833  INCHES
TOTAL INITIAL WATER                 =    725.833  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         SHREVEPORT            LOUISIANA

    STATION LATITUDE                        =  32.28 DEGREES
    MAXIMUM LEAF AREA INDEX                 =   2.00
    START OF GROWING SEASON (JULIAN DATE)   =     58
    END OF GROWING SEASON (JULIAN DATE)     =    331
    EVAPORATIVE ZONE DEPTH                  =  10.0  INCHES
    AVERAGE ANNUAL WIND SPEED               =   8.60 MPH
    AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  70.00 %
    AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  72.00 %
    AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  72.00 %
    AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85

```
RUNOFF
------
  TOTALS                 0.098    0.245    0.126    0.281    0.245    0.354
                         0.240    0.074    0.137    0.067    0.149    0.127

  STD. DEVIATIONS        0.145    0.280    0.168    0.274    0.286    0.405
                         0.409    0.178    0.202    0.088    0.076    0.287

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.662    2.184    2.805    3.178    3.753    3.411
                         3.262    1.894    2.237    1.447    1.410    1.539

  STD. DEVIATIONS        0.315    0.361    0.786    0.948    0.999    0.828
                         1.644    1.406    1.049    0.877    0.503    0.121

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                 0.0556   0.0538   0.0588   0.0573   0.0601   0.0587
                         0.0597   0.0600   0.0582   0.0592   0.0579   0.0604

  STD. DEVIATIONS        0.0131   0.0082   0.0079   0.0084   0.0085   0.0086
                         0.0086   0.0074   0.0073   0.0085   0.0084   0.0090

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.5002   0.4844   0.5290   0.5158   0.5405   0.5285
                         0.5374   0.5397   0.5242   0.5329   0.5212   0.5434

  STD. DEVIATIONS        0.1181   0.0734   0.0710   0.0760   0.0762   0.0773
                         0.0773   0.0666   0.0656   0.0762   0.0757   0.0811

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                 0.0556   0.0538   0.0588   0.0573   0.0601   0.0587
                         0.0597   0.0600   0.0582   0.0592   0.0579   0.0604

  STD. DEVIATIONS        0.0131   0.0082   0.0079   0.0084   0.0085   0.0086
                         0.0086   0.0074   0.0073   0.0085   0.0084   0.0090

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	0.0098	0.0104	0.0104	0.0105	0.0106	0.0107
	0.0106	0.0106	0.0107	0.0105	0.0106	0.0107
STD. DEVIATIONS	0.0023	0.0015	0.0014	0.0015	0.0015	0.0016
	0.0015	0.0013	0.0013	0.0015	0.0015	0.0016

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.34 (6.841)	164573.3	100.00
RUNOFF	2.143 (0.8896)	7778.29	4.726
EVAPOTRANSPIRATION	28.783 (3.5398)	104483.09	63.487
DRAINAGE RECIRCULATED INTO LAYER 2	0.69969 (0.09780)	2539.883	1.54331
LATERAL DRAINAGE COLLECTED FROM LAYER 5	6.29723 (0.88023)	22858.943	13.88982
DRAINAGE RECIRCULATED FROM LAYER 5	0.69969 (0.09780)	2539.883	1.54331
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.011 (0.001)		
CHANGE IN WATER STORAGE	8.114 (4.6823)	29452.54	17.896

****

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

            PEAK DAILY VALUES FOR YEARS   19 THROUGH   28
   ------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
     PRECIPITATION                              4.10        14883.000

     RUNOFF                                     1.260        4572.7422

     DRAINAGE RECIRCULATED INTO LAYER  2        0.00340        12.34201

     DRAINAGE COLLECTED FROM LAYER  5           0.03060       111.07811

     DRAINAGE RECIRCULATED FROM LAYER  5        0.00340        12.34201

     PERCOLATION/LEAKAGE THROUGH LAYER  7       0.000000        0.00002

     AVERAGE HEAD ON TOP OF LAYER  6            0.019

     MAXIMUM HEAD ON TOP OF LAYER  6            0.053

     LOCATION OF MAXIMUM HEAD IN LAYER  5
           (DISTANCE FROM DRAIN)                0.0 FEET

     SNOW WATER                                 3.53        12827.0205


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3893

     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 28

LAYER	(INCHES)	(VOL/VOL)
1	3.0537	0.2545
2	646.7252	0.4312
3	140.3259	0.3898
4	6.6076	0.2753
5	0.0094	0.0630
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:\RO\30\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\30\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\30\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\30\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\DS\C\DATA10.D10
OUTPUT DATA FILE:           C:\RO\DS\C\OUTPUT1.OUT


TIME:  24:36     DATE:  11/10/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - Closed 155 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                   =      0.25   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.   =   6.63000011000     CM/SEC
  SLOPE                       =      4.00   PERCENT
  DRAINAGE LENGTH             =    180.0    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  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                         LAYER  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                    =    360.00   INCHES
POROSITY                     =      0.5534 VOL/VOL
FIELD CAPACITY               =      0.4945 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                        LAYER  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.   =  0.219999999000     CM/SEC
SLOPE                       =     33.00   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                        LAYER 10
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                  LAYER 11
                  --------

        TYPE 3 - BARRIER SOIL LINER
        MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.4270 VOL/VOL
FIELD CAPACITY              =      0.4180 VOL/VOL
WILTING POINT               =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
         AND A SLOPE LENGTH OF  180. 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   =    736.450  INCHES
TOTAL INITIAL WATER                =    736.450  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR


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

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         SHREVEPORT            LOUISIANA
```

```
STATION LATITUDE                         =  32.28 DEGREES
MAXIMUM LEAF AREA INDEX                  =   4.50
START OF GROWING SEASON (JULIAN DATE)    =     58
END OF GROWING SEASON (JULIAN DATE)      =    331
EVAPORATIVE ZONE DEPTH                   =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED                =   8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.54	4.24	3.80	3.38	4.26	4.04
3.40	3.07	3.55	4.75	4.24	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA AND STATION LATITUDE = 32.28 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                    4.06     3.66     3.91     3.61     4.07     4.22
                             3.38     2.64     3.32     4.70     4.22     3.92

   STD. DEVIATIONS           2.78     1.82     1.66     1.52     1.88     2.72
                             1.70     2.24     1.86     2.59     1.43     2.47

 RUNOFF
 ------
   TOTALS                    0.162    0.146    0.063    0.034    0.117    0.276
                             0.114    0.072    0.110    0.513    0.107    0.230

   STD. DEVIATIONS           0.428    0.276    0.127    0.083    0.233    0.406
                             0.237    0.174    0.228    0.834    0.088    0.475

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                    1.730    2.131    2.966    3.241    3.405    3.076
                             2.940    2.179    2.473    1.803    1.234    1.405

   STD. DEVIATIONS           0.187    0.403    0.728    0.927    1.132    1.575
                             1.317    1.424    1.146    0.873    0.226    0.202

 LATERAL DRAINAGE COLLECTED FROM LAYER  2
 ----------------------------------------
   TOTALS                    2.4196   1.6307   1.0844   0.4815   0.6772   0.9315
                             0.3962   0.3728   0.5029   1.9176   2.4589   2.3237

   STD. DEVIATIONS           2.3570   1.3815   1.1689   0.5418   0.9091   1.1421
                             0.5167   0.7152   0.7830   1.4816   1.2878   2.0416

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 ------------------------------------
   TOTALS                    0.0001   0.0001   0.0000   0.0000   0.0000   0.0000
                             0.0000   0.0000   0.0000   0.0001   0.0001   0.0001

   STD. DEVIATIONS           0.0001   0.0001   0.0000   0.0000   0.0001   0.0001
                             0.0000   0.0000   0.0000   0.0002   0.0000   0.0001

 LATERAL DRAINAGE COLLECTED FROM LAYER  9
 ----------------------------------------
   TOTALS                    0.2766   0.2601   0.2865   0.2747   0.2849   0.2742
                             0.2822   0.2801   0.2690   0.2747   0.2673   0.2761

   STD. DEVIATIONS           0.0674   0.0778   0.0844   0.0831   0.0813   0.0801
```

```
                        0.0763   0.0752   0.0718   0.0741   0.0679   0.0719

 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             0.0316   0.0291   0.0121   0.0037   0.0114   0.0183
                        0.0064   0.0064   0.0083   0.0553   0.0287   0.0399

   STD. DEVIATIONS      0.0445   0.0401   0.0170   0.0052   0.0275   0.0294
                        0.0136   0.0161   0.0177   0.0729   0.0165   0.0569

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   AVERAGES             0.0060   0.0062   0.0062   0.0062   0.0062   0.0062
                        0.0061   0.0061   0.0060   0.0060   0.0060   0.0060

   STD. DEVIATIONS      0.0015   0.0019   0.0018   0.0019   0.0018   0.0018
                        0.0017   0.0016   0.0016   0.0016   0.0015   0.0016

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                 -------------------  -------------  ---------
  PRECIPITATION                  45.72    (   8.166)     165946.7     100.00

  RUNOFF                          1.943   (  1.4253)       7054.32      4.251

  EVAPOTRANSPIRATION             28.583   (  3.6101)     103757.41     62.525

  LATERAL DRAINAGE COLLECTED     15.19686 (   5.20318)    55164.598   33.24236
    FROM LAYER  2
```

```
 PERCOLATION/LEAKAGE THROUGH     0.00062 (  0.00030)        2.243     0.00135
   LAYER  4

 AVERAGE HEAD ON TOP             0.021 (    0.011)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED      3.30631 (  0.89046)    12001.904    7.23239
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.009     0.00001
   LAYER 11

 AVERAGE HEAD ON TOP             0.006 (    0.002)
   OF LAYER 10

 CHANGE IN WATER STORAGE        -3.314   (  0.9893)    -12031.56    -7.250

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



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

              PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
      PRECIPITATION                                6.92         25119.600

      RUNOFF                                       3.628        13168.5488

      DRAINAGE COLLECTED FROM LAYER  2             2.08349       7563.06934

      PERCOLATION/LEAKAGE THROUGH LAYER  4         0.000316         1.14858

      AVERAGE HEAD ON TOP OF LAYER  3              4.598

      MAXIMUM HEAD ON TOP OF LAYER  3              7.622

      LOCATION OF MAXIMUM HEAD IN LAYER  2
            (DISTANCE FROM DRAIN)                 30.5 FEET

      DRAINAGE COLLECTED FROM LAYER  9             0.02630         95.46035

      PERCOLATION/LEAKAGE THROUGH LAYER 11         0.000000         0.00002

      AVERAGE HEAD ON TOP OF LAYER 10              0.018
```

```
MAXIMUM HEAD ON TOP OF LAYER 10           0.093

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)               0.0 FEET

SNOW WATER                                3.18         11547.1094


MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3849

MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1360


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

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

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




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

             FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1            2.6644         0.2220

                2            0.0025         0.0100

                3            0.0000         0.0000

                4            7.6860         0.4270

                5            2.9280         0.2440

                6          498.4822         0.3323

                7          108.9168         0.3025

                8            6.0826         0.2534

                9            0.0051         0.0344
```

10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

****
****

APPENDIX IIIC-B

LEACHATE COLLECTION SYSTEM DESIGN CALCULATIONS

Includes pages IIIC-B-1 through IIIC-B-64

STATE OF TEXAS

NEVZAT TURAN

84059

LICENSED

PROFESSIONAL ENGINEER

05/20/2024

CONTENTS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED PROFESSIONAL ENGINEER

05/20/2024

LEACHATE COLLECTION PIPE
CAPACITY CALCULATIONS

ROYAL OAKS LANDFILL
0120-076-11-106
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 cell 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 Cells:
From the HELP model results in Appendix IIIC-A.1 (highest leachate generation values used from all HELP runs for developed Cells).

CONDITION	PEAK cfd/ac	PEAK gpd/ac
Interim, 50' Waste	234.8	1,756.6
Interim, 100' Waste	383.8	2,871.0
Interim, 155' Waste	133.1	995.3

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

For the developed Cells the largest area draining to a leachate collection pipe is 8.7 acres (pipe in Cells 6-8).

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 3.5 ac
2. Interim condition, 100' waste over 3.9 ac
3. Interim condition, 155' waste over 1.3 ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Interim, 50' Waste	3.5	1,756.6	6,148.0	9.51E-03
Interim, 100' Waste	3.9	2,871.0	11,196.8	1.73E-02
Interim, 155' Waste	1.3	995.3	1,293.9	2.00E-03
Total =	8.7		18,638.7	2.88E-02

Undeveloped Cells:
From the HELP model results in Appendix IIIC-A (highest leachate generation values used from all HELP runs for undeveloped Cells including the developed area since portions of the developed area drain to the pipes in adjacent Subtitle D cells).

CONDITION	PEAK[1] cfd/ac	PEAK gpd/ac
Active, 10' Waste	47.6	356.4
Interim, 50' Waste	248.1	1,856.1
Interim, 100' Waste	313.0	2,341.3
Interim, 200' Waste	102.5	766.8

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

ROYAL OAKS LANDFILL
0120-076-11-106
LEACHATE COLLECTION PIPE
CAPACITY CALCULATIONS

For the undeveloped Cells, the largest area draining to a leachate collection pipe is 32.5 acres (pipe in Cell 12). The leachate from Cells 5 through 8 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 Cell 12.

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	7.0	ac
2. Interim condition, 50' waste over	8.4	ac
3. Interim condition, 100' waste over	10.4	ac
4. Interim condition, 200' waste over	6.7	ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Active, 10' Waste	7.0	356.4	2,494.7	3.86E-03
Interim, 50' Waste	8.4	1,856.1	15,591.2	2.41E-02
Interim, 100' Waste	10.4	2,341.3	24,349.6	3.77E-02
Interim, 200' Waste	6.7	766.8	5,137.4	7.95E-03
Total=	32.5		47,572.9	7.36E-02

Developed Cells Peak Leachate Production = 2.88E-02 cfs

Undeveloped Cells Peak Leachate Production = 7.36E-02 cfs

Determination of flow capacity (Q_{full}) for existing 6-inch ADS N-12 perforated pipe (Developed Areas):
*Use Developed Cells Peak Leachate Production

Determination of flow capacity (Q_{full}) for a 6-inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where:
A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions
S = Design slope of pipe
n = Manning's number

From Pipe Structural Stability Calculations:

ID =	6.00	in
=	0.500	ft
A =	0.196	sq ft
R =	0.125	ft
S[1] =	0.018	ft / ft

[1]The 1.8 percent slope was chosen as the minimum slope for the leachate collection pipes. Refer to Appendix IIIE-B.

n = Manning's number — n = 0.012

Q_{full} = 0.816 cfs

Compare Peak Q_{max} and Q_{full} for the 6" ADS N-12 pipe:

Q_{full} = 0.816 cfs >> Q_{max} = 0.0288 cfs

An ADS N-12 pipe with a nominal diameter of 6 inches exceeds flow capacity requirements.

Determination of flow capacity (Q_{full}) for proposed 6-inch SDR 17 perforated pipe (Undeveloped Area):
*Use Undeveloped Cells Peak Leachate Production

Determination of flow capacity (Q_{full}) for a 6-inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where:
A = Cross-sectional area of pipe, with d representing the inside diameter in feet

R = Hydraulic radius of pipe in feet under full flow conditions
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] = 0.015 ft / ft

[1]The 1.5 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} =	0.555	cfs

Compare Peak Q_{max} and Q_{full} for the 6" SDR 17 pipe:

Q_{full} =	0.555	cfs	>>	Q_{max} =	0.0736	cfs

An SDR 17 pipe with a nominal diameter of 6 inches exceeds flow capacity requirements.

B. Perforation configuration for a 6-inch 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

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 2.0 > 1.7 \quad \text{(acceptable)}$$

In Addition:

A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, the number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

LEACHATE COLLECTION PIPE STRUCTURAL STABILITY

ROYAL OAKS LANDFILL
0120-076-11-106
LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE
DEVELOPED AREAS

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-30 and IIIC-B-31 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.

7. www.ads-pipe.com

8. Advanced Drainage Systems, Inc. *Structural Performance of Corrugated PE Pipe Using the Burns and Richard Solution,* October 2003.

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading:

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight =	190,500	lb
Tire pressure =	80	psi
Number of tires =	4	

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F =	47,625	lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

r =	13.8	in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

$$y = p\,(1 - ((r/z)^2+1)^{-3/2})$$

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Protective cover thickness (in)

z =	24	in

y =	27.8	psi

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L =	41.7	psi

P_D = (zw)/1728

Where: P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z =	24	in
w =	115	pcf

P_D =	1.60	psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T =	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.0	ft protective cover @	115	pcf =	230	psf	
3.5	ft final & intrm cover @	115	pcf =	402.5	psf	
155.0	ft solid waste/soil @	71	pcf =	11,005	psf	Highest waste column thickness
			Σ =	11,638	psf	over a 6" LCS pipe.

P_T =	80.8	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	80.8	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 = 80.8 psi

P_{DES1} =	107.8	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-30), 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-31), 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-31).

2c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\,2} \qquad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} \qquad (2)$$

Where:

- W_c = Load per unit length of conduit (lb/ft)
- γ = Unit weight of soil above conduit (pcf)
- B_c = Outer diameter of conduit (ft)
- H = Height of fill above conduit (ft)
- H_e = Height of plane of equal settlement above critical plane (ft)
- k = Lateral pressure ratio (earth pressure coefficient)
- μ = tan ϕ
- ϕ = Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p \left(\frac{H}{B_c}\right) \qquad (3)$$

Where:

- r_{sd} = Settlement ratio
- p = Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{\left(S_m + S_g\right) - \left(S_f + dc\right)}{S_m} \qquad (4)$$

Where:

- S_m = Compression deformation of soil column adjacent to conduit
- S_g = Settlement of natural ground adjacent to conduit
- S_f = Settlement of conduit into foundation material
- dc = Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \qquad (5)$$

Since the trench aggregate (PZB) is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and a the lower sign to a negative r_{sd}.

2d. Load analysis solution by trial and error

Step 1: Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.46

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} =	107.8	psi
D =	6.92	in
E_s =	3,000	psi

S_m =	0.249	in

Step 3: Calculate dc using Equation (5):

$$dc = S_m\,(1 - r_{sd})$$

dc =	0.364	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)

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LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE
DEVELOPED AREAS

DL =	2.5	(Ref 6)
k =	0.1	(Ref 6)
E =	31,000	psi (refer to chart 25 on page IIIC-B-32, based on PDES1 above)
t =	0.920	in (ADS N-12 HDPE pipe)
I =	0.065	in^4/in
r =	3.5	in
E' =	3,000	psi

$\boxed{W_c = 337 \text{ lb/in}}$

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 @	115	pcf =	633	psf
155.0	ft waste @	71	pcf =	11,005	psf
			Total =	11,638	psf

γ = 72.51 pcf (weighted average based on above table)
B_c = 6.92 in

$\boxed{C_c = 167.8 \text{ (unitless)}}$

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H = 155 ft
H/B_c = 268.8

Assume: H_e/B_c = 1.82

$k\mu$ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.38	
$-2k\mu$ =	-0.26	
$(H/B_c - H_e/B_c)$ =	267.0	
$e^{-2k\mu(He/Bc)}$ =	0.62	

Left-hand-side of equation (LHS) = 168
Right-hand-side of equation (RHS) = 168

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 =	268.8
H_e/B_c =	1.82
r_{sd} =	-0.46
LHS =	125
RHS =	125

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 =	337	lb/in
D =	6.9	in
P_{DES2} =	49	psi

B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR	= Standard dimension ratio	=	7.5	
S_Y	= compressive yield strength	=	2,000	psi
RD_{all}	= allowable ring deflection	=	5.0	%

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} = 49 psi

S_A = 158.9 psi
FS = 12.6

Compare calculated and suggested factor of safety: 12.6 > 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 = 29,000 psi for 50 years based on SA above (see chart page IIIC-B-32)
P_{DES2} = 49 psi

P_{cb} = 551.0 psi
FS = 11.3

Compare calculated and suggested factor of safety: 11.3 > 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} =	49	psi
E' =	3,000	psi

E_S =	1.6	%

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RD_{act}) is equal to soil strain.

RD_{act} = 1.6 %

Allowable ring deflection, RD_{all} = 5.00 %

$RD_{act} < RD_{all}$, 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.

ROYAL OAKS LANDFILL
0120-076-11-106
LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE
UNDEVELOPED AREAS

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-30 and IIIC-B-31 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.

7. www.ads-pipe.com

8. Advanced Drainage Systems, Inc. *Structural Performance of Corrugated PE Pipe Using the Burns and Richard Solution,* October 2003.

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

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LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE
UNDEVELOPED AREAS

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 @	115	pcf =	230	psf	
3.5	ft final & intrm cover @	115	pcf =	402.5	psf	
200.0	ft solid waste/soil @	71	pcf =	14,200	psf	Highest waste column thickness
			Σ =	14,833	psf	over a 6" LCS pipe.

P_T =	103.0	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	103.0	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

ROYAL OAKS LANDFILL
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LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE
UNDEVELOPED AREAS

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 =	103.0	psi
P_{DES1} =	137.3	psi

Adjust pipe stress determined above to account for effects of soil arching:

2. The design pipe stress is estimated by accounting for the soil structure interaction between the buried leachate collection pipe and its backfill to obtain a realistic loading condition on the pipe.

2a. For the burial conditions shown on Figure 1 (page IIIC-B-30), 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-31), 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-31).

2c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\,2} \qquad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} \qquad (2)$$

Where:
- W_c = Load per unit length of conduit (lb/ft)
- γ = Unit weight of soil above conduit (pcf)
- B_c = Outer diameter of conduit (ft)
- H = Height of fill above conduit (ft)
- H_e = Height of plane of equal settlement above critical plane (ft)
- k = Lateral pressure ratio (earth pressure coefficient)
- μ = tan ϕ
- ϕ = Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p\left(\frac{H}{B_c}\right) \qquad (3)$$

Where:
- r_{sd} = Settlement ratio
- p = Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{\left(S_m + S_g\right) - \left(S_f + dc\right)}{S_m} \qquad (4)$$

Where:
- S_m = Compression deformation of soil column adjacent to conduit
- S_g = Settlement of natural ground adjacent to conduit
- S_f = Settlement of conduit into foundation material
- dc = Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \qquad (5)$$

Since the trench aggregate (PZB) is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and a the lower sign to a negative r_{sd}.

2d. Load analysis solution by trial and error

Step 1: Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.66

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} =	137.3	psi
D =	6.625	in
E_s =	3,000	psi

S_m =	0.303	in

Step 3: Calculate dc using Equation (5):

$$dc = S_m\,(1 - r_{sd})$$

dc =	0.502	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 =	20,500	psi (refer to chart 25 on page IIIC-B-32, based on PDES1 above)
t =	0.390	in (SDR 17 pipe)
I =	0.005	in^4/in
r =	3.3	in
E' =	3,000	psi

W_c =	373	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 @	115	pcf =	633	psf
200.0	ft waste @	71	pcf =	14,200	psf
			Total =	14,833	psf

γ =	72.18	pcf (weighted average based on above table)
B_c =	6.625	in

C_c =	203.6	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	200	ft
H/B_c =	362.3	

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	
$(H/B_c - H_e/B_c)$ =	360.0	
$e^{-2k\mu(He/Bc)}$ =	0.56	

Left-hand-side of equation (LHS) = 204
Right-hand-side of equation (RHS) = 204

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 =	362.3
H_e/B_c =	2.23
r_{sd} =	-0.66
LHS =	238
RHS =	238

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 =	373	lb/in
D =	6.6	in
P_{DES2} =	56	psi

A summary table for the structural stability analysis is provided on page IIIC-B-29 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} = 56 psi

S_A = 450.8 psi
FS = 3.3

Compare calculated and suggested factor of safety: 3.3 > 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 = 20,000 psi for 50 years based on SA above (see chart page IIIC-B-32)
P_{DES2} = 56 psi

P_{cb} = 134.7 psi
FS = 2.4

Compare calculated and suggested factor of safety: 2.4 > 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} =	56	psi
E' =	3,000	psi

E_S =	1.9	%

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} = 1.9 %

Allowable ring deflection, RD_{all} = 4.20 %

$RD_{act} < RD_{all}$, design is acceptable

Note: An additional factor of safety is inherent to the design of the 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.

ROYAL OAKS LANDFILL
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LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE

Adjusted load to account for soil arching = 56 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	887.4	1.7	12,000	3,000	39.5	0.7	8.1	3,000	1.9	4.3
26.0	1,500	704.3	2.1	15,000	3,000	61.7	1.1	6.5	3,000	1.9	3.5
21.0	1,500	563.4	2.7	18,000	3,000	93.0	1.7	5.2	3,000	1.9	2.8
19.0	1,500	507.1	3.0	19,000	3,000	111.1	2.0	4.7	3,000	1.9	2.5
17.0 [1]	1,500	450.8	3.3	20,000	3,000	134.7	2.4	4.2	3,000	1.9	2.2
15.5	1,500	408.5	3.7	21,500	3,000	160.4	2.8	3.9	3,000	1.9	2.1
13.5	1,500	352.4	4.3	23,000	3,000	203.8	3.6	3.4	3,000	1.9	1.8
11.0	1,500	281.7	5.3	25,000	3,000	289.3	5.1	2.7	3,000	1.9	1.4

(grey box) 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-33), 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).

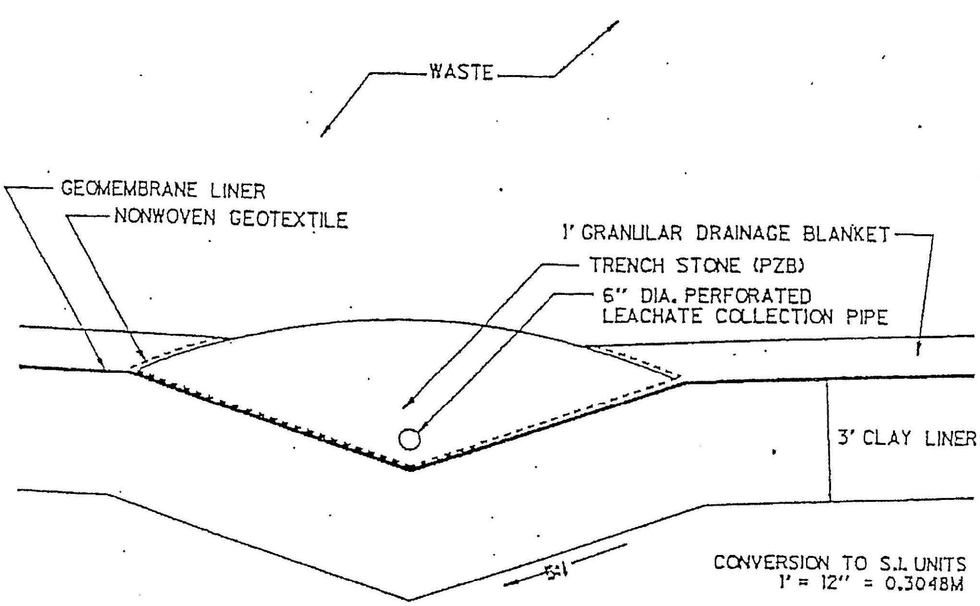


FIGURE 1: TYPICAL V-SHAPED TRENCH FOR LANDFILLS WITH COMPOSITE LINERS

/ol/users/jow/prgetrsn.dgn

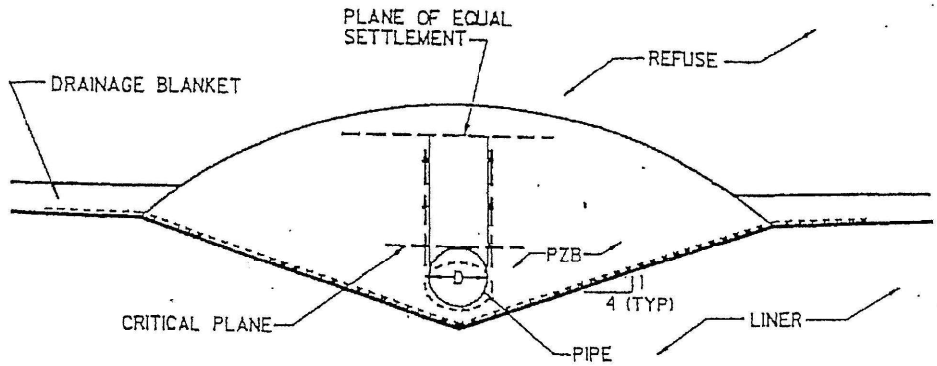


FIGURE 2: SETTLEMENT OF LEACHATE PIPE INDUCING SHEAR STRESSES IN PZB

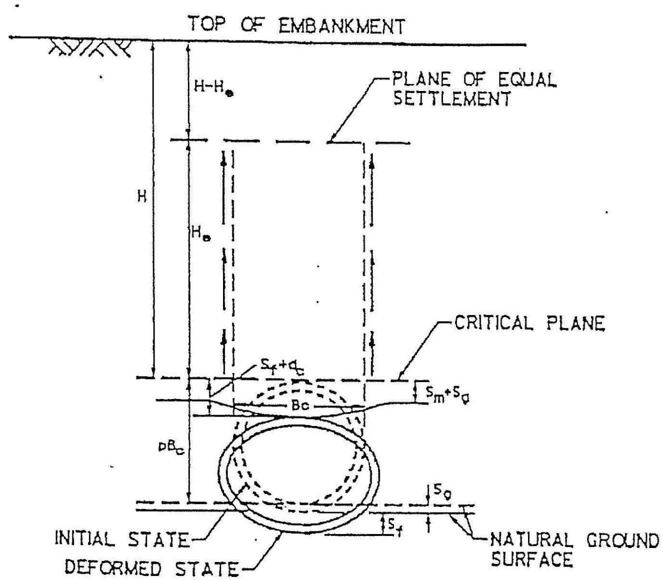


FIGURE 3: CASE OF AN INCOMPLETE DITCH CONDITION FOR A POSITIVE PROJECTING CONDUIT

/dl/users/jow/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 = 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 $P_t < P_{cb}$.

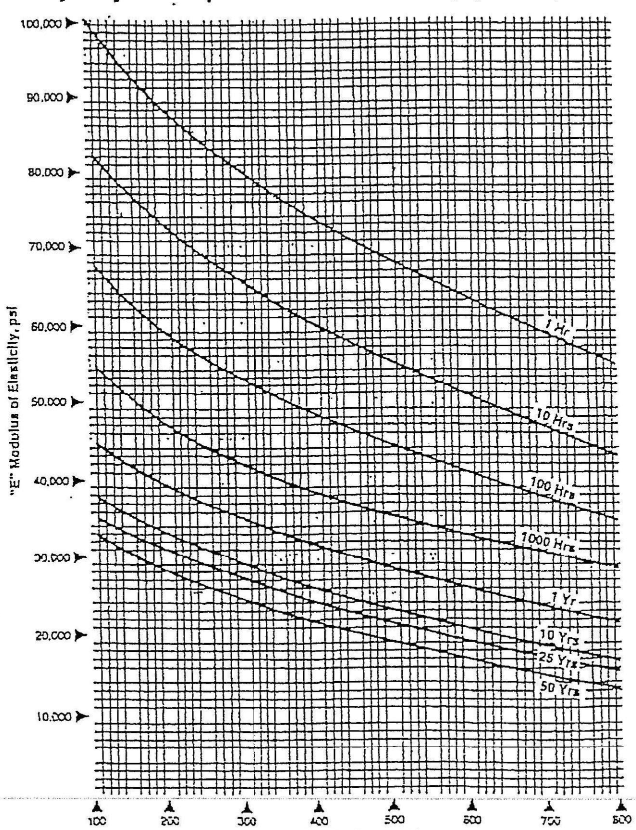
1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe.
2. Calculate the stress "S_A" in the pipe wall according to the formula:

$$S_A = \frac{(SDR - 1)\,P_t}{2}$$

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

LEACHATE GRADE ADS N-12 PRODUCT INFORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Inner Liner Thickness, Minimum	Minimum Pipe Stiffness @ 5% Deflection	Weight kg./6m (lbs./20 ft.)	Area mm^2/mm	"I" cm^4/cm	"C" mm
100 mm (4")	104 mm (4.10")	120 mm (4.78")	0.635 mm (0.025")	485 kN/m^2 70 psi	5.10 kg (11.24 lbs)	2.87 (0.113 in^2/in)	0.026 (0.0016 in^4/in)	3.56 (0.14 in)
150 mm (6")	152 mm (6.00")	176 mm (6.92")	0.635 mm (0.025")	450 kN/m^2 65 psi	9.90 kg (21.83 lbs)	3.63 (0.143 in^2/in)	0.062 (0.0038 in^4/in)	5.08 (0.20 in)
200 mm (8")	200 mm (7.90")	233 mm (9.11")	0.9 mm (0.035")	415 kN/m^2 60 psi	15.80 kg (34.83 lbs)	4.22 (0.166 in^2/in)	0.128 (0.0078 in^4/in)	6.35 (0.25 in)
250 mm (10")	251 mm (9.90")	287 mm (11.36")	0.6 mm (0.024")	345 kN/m^2 50 psi	20.50 kg (45.20 lbs)	3.48 (0.137 in^2/in)	0.134 (0.008 in^4/in)	7.88 (0.30 in)
300 mm (12")	308 mm (12.15")	367 mm (14.45")	0.9 mm (0.035")	345 kN/m^2 50 psi	28.96 kg (63.80 lbs)	5.50 (0.217 in^2/in)	0.574 (0.035 in^4/in)	10.92 (0.43 in)
375 mm (15")	380 mm (14.98")	448 mm (17.57")	1.0 mm (0.039")	290 kN/m^2 42 psi	42.00 kg (92.50 lbs)	6.91 (0.272 in^2/in)	0.901 (0.055 in^4/in)	13.21 (0.52 in)
450 mm (18")	459 mm (18.07")	536 mm (21.20")	1.3 mm (0.051")	275 kN/m^2 40 psi	58.38 kg (128.60 lbs)	6.93 (0.273 in^2/in)	1.327 (0.081 in^4/in)	14.48 (0.57 in)
600 mm (24")	612 mm (24.08")	719 mm (27.80")	1.5 mm (0.059")	235 kN/m^2 34 psi	101.97 kg (224.60 lbs)	8.23 (0.324 in^2/in)	2.245 (0.137 in^4/in)	18.80 (0.74 in)
750 mm (30")	762 mm (30.00")	892 mm (35.10")	1.5 mm (0.059")	195 kN/m^2 28 psi	139.97 kg (308.30 lbs)	9.60 (0.378 in^2/in)	4.539 (0.277 in^4/in)	21.84 (0.86 in)
900 mm (36")	914 mm (36.00")	1059 mm (41.70")	1.7 mm (0.067")	150 kN/m^2 22 psi	163.98 kg (361.20 lbs)	10.19 (0.401 in^2/in)	6.565 (0.400 in^4/in)	25.40 (1.00 in)

Date: December, 1999

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-30 and IIIC-B-31 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 @	115	pcf =	230	psf
3.5	ft final & intrm cover @	115	pcf =	402.5	psf
85	ft solid waste/soil @	71	pcf =	6,035	psf
			Σ =	6,668	psf

P_T =	46.3	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	46.3	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 =	46.3	psi
P_{DES1} =	61.7	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-30), 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-31), 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-31).

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

$$r_{sd} = \frac{\left(S_m + S_g\right) - \left(S_f + dc\right)}{S_m} \tag{4}$$

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} = -0.68

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} =	61.7	psi
D =	18	in
E_s =	3,000	psi

S_m =	0.370	in

Step 3: Calculate dc using Equation (5):

$dc = S_m (1 - r_{sd})$

dc =	0.621	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-32, based on PDES1 above)
t =	1.059	in (SDR 17 pipe)
I =	0.099	in^4/in
r =	9.0	in
E' =	3,000	psi

W_c =	466	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 @	115	pcf =	633	psf
85.0	ft waste/soil @	71	pcf =	6,035	psf
			Total =	6,668	psf

γ =	73.7	pcf (weighted average based on above table)
B_c =	18	in

C_c =	33.7	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	91	ft
H/B_c =	60.3	

Assume: H_e/B_c = 2.29

$k\mu$ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.45	
$-2k\mu$ =	-0.26	
$(H/B_c - H_e/B_c)$ =	58.0	
$e^{-2k\mu(He/Bc)}$ =	0.55	

Left-hand-side of equation (LHS) = 34
Right-hand-side of equation (RHS) = 34

<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 =	60.3
H_e/B_c =	2.290
r_{sd} =	-0.68
LHS =	41
RHS =	41

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 =	466	lb/in
D =	18.0	in

P_{DES2} =	26	psi

A summary table for the structural stability analysis is provided on page IIIC-B-45 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} = 26 psi

S_A =	207.0	psi
FS =	7.2	

Compare calculated and suggested factor of safety:	7.2	> 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 =	33,000	psi for 50 years based on SA above (see chart page IIIC-B-32)
P_{DES2} =	26	psi

P_{cb} =	173.0	psi
FS =	6.7	

Compare calculated and suggested factor of safety:	6.7	> 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} = 26 psi
E' = 3,000 psi

$\boxed{E_S = 0.9\ \%}$

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RDact) is equal to soil strain.

RD_{act} = 0.9 %

Allowable ring deflection, RD_{all} = 4.20 %

$\boxed{RD_{act} < RD_{all}\text{, design is acceptable}}$

ROYAL OAKS LANDFILL
0120-076-11-106
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
18"-DIA PIPE

Adjusted load to account for soil arching = 26 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	407.5	3.7	21,500	3,000	52.8	2.0	8.1	3,000	0.9	9.4
26.0	1,500	323.4	4.6	23,900	3,000	77.8	3.0	6.5	3,000	0.9	7.5
21.0	1,500	258.7	5.8	26,000	3,000	111.8	4.3	5.2	3,000	0.9	6.0
19.0	1,500	232.9	6.4	26,800	3,000	131.9	5.1	4.7	3,000	0.9	5.4
17.0 [1]	1,500	207.0	7.2	27,900	3,000	159.0	6.1	4.2	3,000	0.9	4.9
15.5	1,500	187.6	8.0	28,300	3,000	184.0	7.1	3.9	3,000	0.9	4.5
13.5	1,500	161.8	9.3	29,500	3,000	230.8	8.9	3.4	3,000	0.9	3.9
11.0	1,500	129.4	11.6	31,200	3,000	323.1	12.5	2.7	3,000	0.9	3.1

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-32), 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 areas from Sheet IIIC-B-52. The largest drainage area in the developed and the undeveloped areas are analyzed to provide for a conservative analysis. Sump details are provided in Appendix IIIA-A Liner and Final Cover System Details.
B. Determine geometry of sump and its corresponding storage capacity.
C. Assume pump size and determine the average pump cycle time.

REFERENCES:

1. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook* , 30 TAC 330.201, 1993.

2. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems* , Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

3. Phillips 66 Driscopipe, *System Design* , 1991.

4. Heisler, Sanford I., P.E., Wiley Engineer's Desk Reference, John Wiley & Sons, Inc., New York, 1998.

SOLUTION:

A. Average flow rate into sump

A.1 Determine the per acre flow rate for specific leachate collection sumps.

The following tables summarize the fill conditions that are likely to be present within each cell and have the greatest contribution of leachate into the LCS and sump system. The average flow rates (lateral drainage in the LCS layer) are shown for each condition.

Leachate sump drainage areas are shown on Sheet IIIC-B-52 Sump Drainage Areas.

Developed Area (Cells 1 through 4 and Cell 9)
From the HELP model results in Appendix IIIC-A.1:

For the developed area, the largest area draining to the sump is 14.8 acres (sump located in Cell 1). For each fill condition, the highest leachate generation rate from the HELP runs for developed area was used to be conservative.

Condition	Average cfy/ac	Average gpd/ac
Interim, 50' Waste	15,978.5	327.4
Interim, 100' Waste	38,549.8	790.0
Interim, 155' Waste	25,384.5	520.2
Closed, 155' Waste	12,002.0	246.0

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

Undeveloped Area (Cell 12)
From the HELP model results in Appendix IIIC-A:

For Cell 10, the largest area draining to the sump is 32.5 acres (sump located in Cell 10). The Cell 10 sump also recives leachate from developed Cells 5 through 8. For each fill condition, the highest leachate generation rate from the HELP runs for the undeveloped areas were used to be conservative.

Condition	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	6,779.5	138.9
Interim, 50' Waste	17,754.8	363.9
Interim, 100' Waste	38,081.1	780.4
Interim, 200' Waste	27,177.0	556.9
Closed, 200' Waste	14,614.1	299.5

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

Undeveloped Area (Cells 10 and 11)
From the HELP model results in Appendix IIIC-A:

For Cells 11 and 12, the area draining to the sump is 14.7 acres (sump located in Cell 11). For each fill condition, the highest leachate generation rate from the HELP runs for the undeveloped area was used to be conservative.

Condition	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	6,779.5	138.9
Interim, 50' Waste	17,754.8	363.9
Interim, 100' Waste	38,081.1	780.4
Interim, 200' Waste	27,177.0	556.9
Closed, 200' Waste	14,614.1	299.5

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

1. Sump for Developed Area

14.8 acres

Condition	Rate	Active		Inactive		Closed	
	(gpd/ac)	area (ac)	rate (gpd)	area (ac)	rate (gpd)	area (ac)	rate (gpd)
Interim, 50' Waste	327.4	3.0	982.3	0.0	0.0	0.0	0.0
Interim, 100' Waste	790.0	4.7	3,713.0	0.0	0.0	0.0	0.0
Interim, 155' Waste	520.2	3.9	2,028.8	14.8	7,699.1	0.0	0.0
Closed, 155' Waste	246.0	3.2	787.1	0.0	0.0	14.8	3,640.2
Total		14.8	7,511.3	14.8	7,699.1	14.8	3,640.2

2. Sump for Undeveloped Area Cell 12

32.5 acres

Condition	Rate	Active		Inactive		Closed	
	(gpd/ac)	area (ac)	rate (gpd)	area (ac)	rate (gpd)	area (ac)	rate (gpd)
Active, 10' Waste	138.9	4.8	666.9	0.0	0.0	0.0	0.0
Interim, 50' Waste	363.9	5.9	2,146.7	0.0	0.0	0.0	0.0
Interim, 100' Waste	780.4	8.0	6,243.2	0.0	0.0	0.0	0.0
Interim, 200' Waste	556.9	7.1	3,954.3	32.5	18,100.7	0.0	0.0
Closed, 200' Waste	299.5	6.7	2,006.6	0.0	0.0	32.5	9,733.4
Total		32.5	15,017.7	32.5	18,100.7	32.5	9,733.4

2. Sump for Undeveloped Area Cells 10 and 11

14.7 acres

Condition	Rate	Active		Inactive		Closed	
	(gpd/ac)	area (ac)	rate (gpd)	area (ac)	rate (gpd)	area (ac)	rate (gpd)
Active, 10' Waste	138.9	2.2	305.7	0.0	0.0	0.0	0.0
Interim, 50' Waste	363.9	3.6	1,309.9	0.0	0.0	0.0	0.0
Interim, 100' Waste	780.4	4.2	3,277.7	0.0	0.0	0.0	0.0
Interim, 200' Waste	556.9	3.4	1,893.6	14.7	8,187.1	0.0	0.0
Closed, 200' Waste	299.5	1.3	389.3	0.0	0.0	14.7	4,402.5
Total		14.7	7,176.1	14.7	8,187.1	14.7	4,402.5

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)
Dev. Area	7,511.3	1,004.2	2,869.1
Undev. Area (Cell 12)	15,017.7	2,007.7	5,736.3
Undev. Area (Cells 10 & 11)	7,176.1	959.4	2,741.1

2. Inactive with Intermediate Cover

	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Dev. Area	7,699.1	1,029.3	2,940.8
Undev. Area (Cell 12)	18,100.7	2,419.9	6,913.9
Undev. Area (Cells 10 & 11)	8,187.1	1,094.5	3,127.2

3. Closed

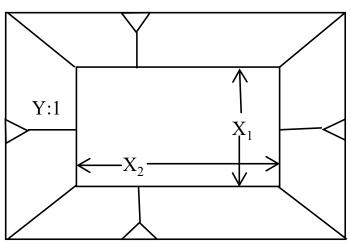
	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Dev. Area	3,640.2	486.7	1,390.4
Undev. Area (Cell 12)	9,733.4	1,301.3	3,717.9
Undev. Area (Cells 10 & 11)	4,402.5	588.6	1,681.6

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)
Dev. Cell 1	22	22	3	2	484	1,156	1,592
Undev. Area (Cell 12)	20	20	3	3	400	1,444	2,604
Undev. Area (Cells 10 & 11)	20	20	3	3	400	1,444	2,604

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)
Dev. Area	2,869.1	1,592	0.6
Undev. Area (Cell 12)	5,736.3	2,604	0.5
Undev. Area (Cells 10 & 11)	2,741.1	2,604	0.9

2. Inactive with Intermediate Cover

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Dev. Area	2,940.8	1,592	0.5
Undev. Area (Cell 12)	6,913.9	2,604	0.4
Undev. Area (Cells 10 & 11)	3,127.2	2,604	0.8

3. Closed

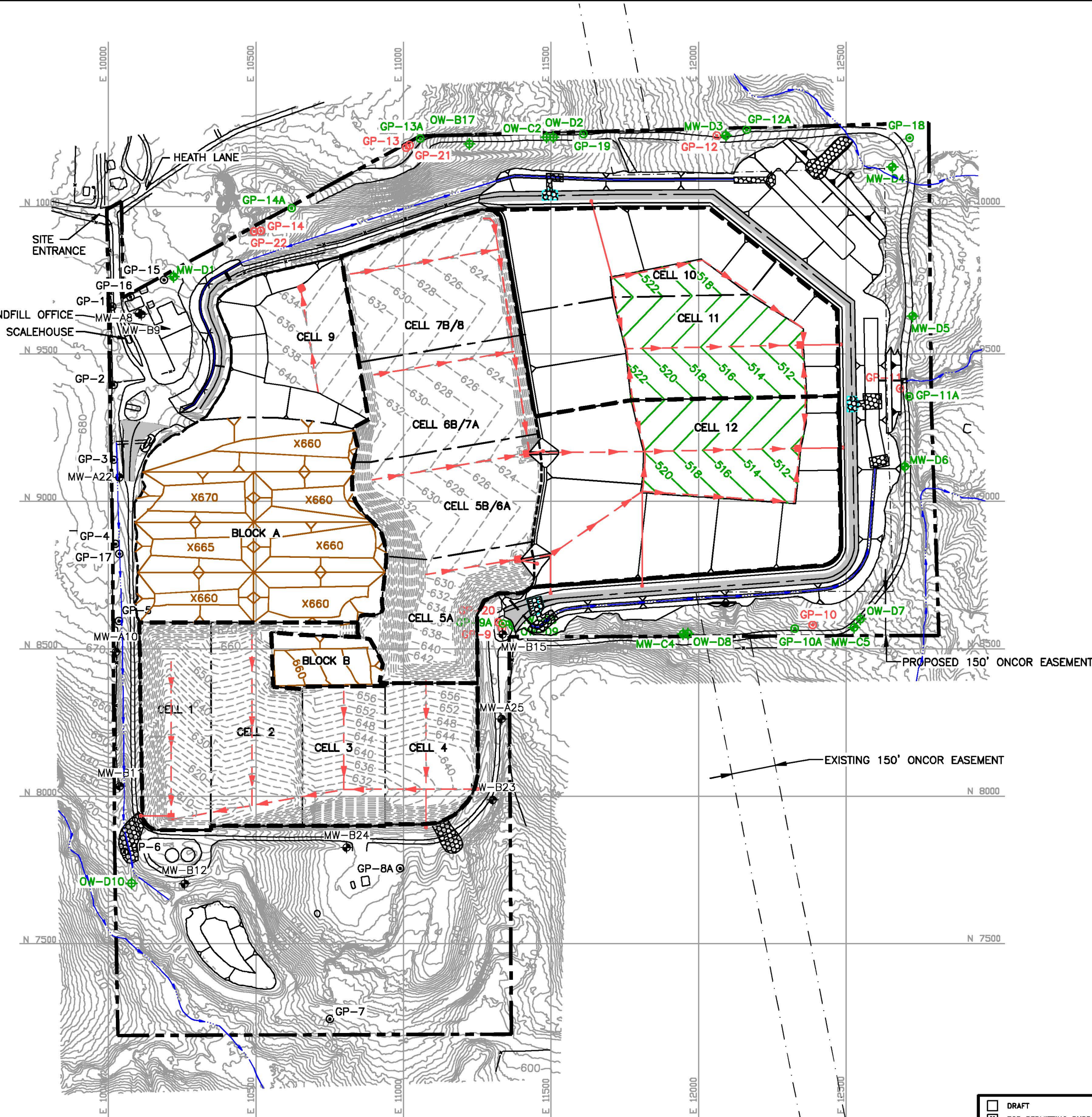
	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)	Storage (days)
Dev. Area	1,390.4	1,592	1.1
Undev. Area (Cell 12)	3,717.9	2,604	0.7
Undev. Area (Cells 10 & 11)	1,681.6	2,604	1.5

C. Estimated rate of leachate removal.

Submersible pump capacity - Cell 1 = 20 gpm
Submersible pump capacity - Cell 10 = 20 gpm
Submersible pump capacity - Cells 11 and 12 = 20 gpm

	Production (gpd)	Average Pump Time (min/day)	(hr/day)
Dev. Area			
-Active	7,511.3	375.6	6.3
-Inactive with Interm. Cover	7,699.1	385.0	6.4
-Closed	3,640.2	182.0	3.0
Undev. Area (Cell 12)			
-Active	7,699.1	385.0	6.4
-Inactive with Interm. Cover	18,100.7	905.0	15.1
-Closed	8,187.1	409.4	6.8
Undev. Area (Cells 10 & 11)			
-Active	7,176.1	358.8	6.0
-Inactive with Interm. Cover	8,187.1	409.4	6.8
-Closed	4,402.5	220.1	3.7

Average pump time is less than 24 hours per day, therefore the design is acceptable. A pump with less capacity may also be used if it can be determined that the actual leachate generation is less than the design flow.



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SCALE IN FEET

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER
05/20/2024

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- CELL BOUNDARY
- EXISTING EASEMENT
- PROPOSED EASEMENT
- E 10500 SITE GRID
- 610 EXISTING CONTOUR (SEE NOTE 1)
- 516 TOP OF LINER CONTOUR
- 630 AS-BUILT TOP OF LINER
- X660 APPROXIMATE TOP OF PRE-SUBTITLE D LINER (SEE NOTE 8)
- CHANNEL CENTERLINE
- LEACHATE COLLECTION PIPE
- LEACHATE COLLECTION SUMP
- LEACHATE RISER PIPE
- SUMP DRAINAGE AREA
- MW-10 EXISTING GROUNDWATER MONITORING WELL
- MW-D1 PROPOSED GROUNDWATER MONITORING WELL
- OW-D7 PROPOSED OBSERVATION WELL
- GP-1 EXISTING GAS PROBE
- GP-10A PROPOSED GAS PROBE

NOTES:

1. EXISTING CONTOURS DEVELOPED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN NOVEMBER 10, 2022.
2. TOP OF PRE-SUBTITLE D LINER ARE APPROXIMATE AND WAS REPRODUCED FROM CROSS-SECTIONS INCLUDED IN THE 1983 PERMIT APPLICATION PREPARED BY STOKES & ASSOCIATES.

SUMP DRAINAGE AREAS

PHASE	AREA (ACRES)
CELL 1	14.8
CELL 10 AND 11	14.7
CELL 12	32.5

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 05/2024
FILE: 0120-76-11
CAD: B-52-SUMP DRAINAGE AREAS.DWG

DRAWN BY: RAA
DESIGN BY: JBM
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
PINE HILL FARMS LANDFILL TX, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
SUMP DRAINAGE AREAS

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

WWW.WCGRP.COM

SHEET IIIC-B-52

0:\0120\76\EXPANSION 2023\PART III\IIIC\B\B-52 SUMP DRAINAGE AREAS.dwg, byoung, 1:2

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 systems.

B. Geotextile "B" used as top component of drainage geocomposite. This is applicable to the liner 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.

5. GRI *GRI-GN4 Standard ,* October. 3, 2018, revised Nov. 23, 2020.

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-59, 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 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 cm/s) / 14.4

$\boxed{k_{allow} = 1.4\text{E-02 cm/s}}$

$k_{allow} >> k_{waste}$ (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 sec^{-1} as determined by ASTM D 4491.

Survivability:

Geotextile properties should be selected considering Class 2 survivability (IIIC-B-59).

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	>	310	lbs
Trapezoid tear	>	55	lbs
Permitivity	>=	0.2	sec^{-1}

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-59, 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 cm/s) / 14.4

$\boxed{k_{allow} = 1.4\text{E-02 cm/s}}$

$k_{allow} >> k_{protective\ cover}$ (1.2×10^{-4} cm/s).

Specification: Geotextile component of geocomposite permeability shall be equal to or greater than 0.2 sec^{-1} as determined by ASTM D 4491.

Survivability:

Geotextile properties should be selected considering Class 2 survivability (IIIC-B-59).

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	>	310	lbs
Trapezoid tear	>	55	lbs
Permitivity	>=	0.2	sec^{-1}

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.)

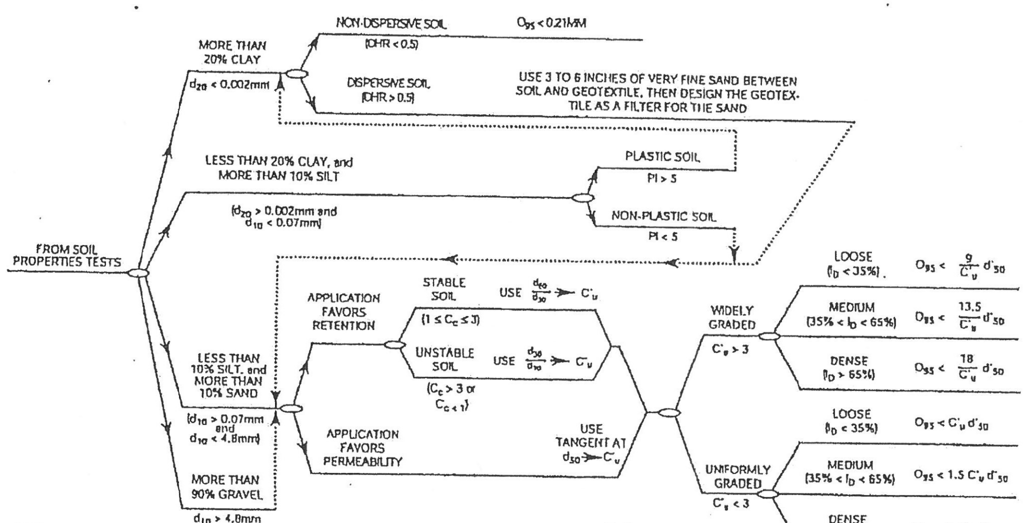
[c] As measured in accordance with ASTM D4632/D4632M.

[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



NOTES:

d_x = particle diameter of which size x percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremeties of a straight line drawn through the particle-size distribution, as directed above and d'_{50} is the midpoint of this line

$$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$$

I_D = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil
O_{95} = geotextile opening size

CHIMNEY DRAIN CALCULATIONS

ROYAL OAKS LANDFILL
0120-076-11-106
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.

Cells	**Peak Daily Generation Rate, q**		**Maximum Drainage Length, L[1]**	**Inflow Rate, Q_{req}**
	(cf/ac/day)	**(cfs/sf)**	**(ft)**	**(cfs)**
Developed Areas (Cells 1 through 9)	383.8	1.02E-07	500	5.10E-05
Undeveloped Areas (Cells 10 through 12)	313.0	8.32E-08	500	4.16E-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:

$$\boxed{Q_{req} = 5.10\text{E-}05 \text{ cfs}}$$

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. 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 = 4 ft

Q_{ult} = 2.62E-02 cfs

To determine the allowable drainage capacity of the geotextile, the following reduction factors are used:

Table 1 - Reduction Factors[1]

RF_{SCB} =	Reduction factor for soil clogging and blinding	2.0
RF_{CR} =	Reduction factor for creep reduction of void space	2.0
RF_{IN} =	Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} =	Reduction factor for chemical clogging	1.5
RF_{BC} =	Reduction factor for biological clogging	2.0
	Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 2.

$$Q_{allow} = Q_{ult} / ORF$$

where:

Q_{allow} = Allowable flow rate
Q_{ult} = Ultimate flow rate
ORF = Overall reduction factor from Table 1

Q_{allow} = 1.82E-03 cfs

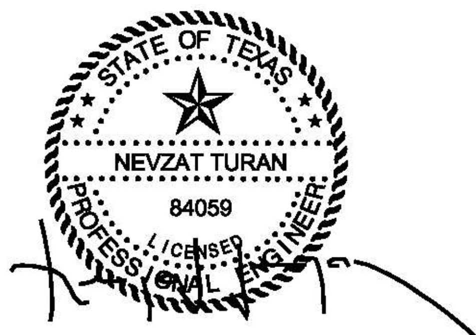
Q_{allow} = 1.82E-03 cfs >> Q_{req} = 5.10E-05 cfs

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

Includes pages IIIC-C-1 through IIIC-C-8



05/20/2024

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 Cherokee County is:

$R \approx$ 7.88 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 =		7.88	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.

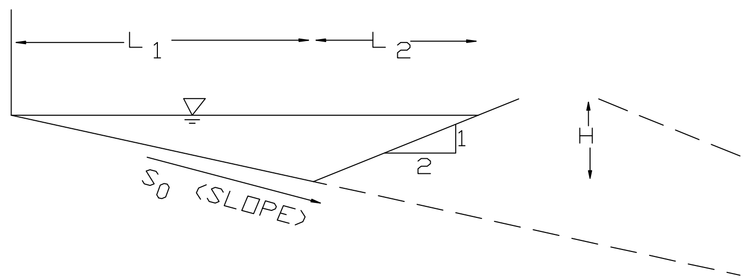
The volume contained by the berm is equal to the cross-sectional storage area multiplied by the width of the berm. The computed volume must be greater than the volume found in step 2.

$V_C = A_s W$

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 =	7.88	in
	$A_{stor} =$	0.25	ac	C =	0.5	
	A =	0.50	ac	W =	100	ft

Volume: $V_R =$ 7,151 cf

Height: H = 0.657 ft

2. Sloping water storage area:

Variables:						
	S_o =	1.00	%	R =	7.88	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 =	119.00	ft
L_2 =	2.38	ft
A_s =	72.2211	sf
V_C =	7,222	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 =	7.88	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 =	83.00	ft
L_2 =	3.32	ft
A_s =	71.6456	sf
V_C =	7,165	cf

V_C is larger than V_R; berm has adequate height. See Sheet IIIC-C-5 and page IIIC-C-8 for summary.

ROYAL OAKS LANDFILL
0120-076-11-106
CONTAINMENT BERM
CALCULATIONS SUMMARY

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	7,151	0	0.66	1.66						
			1	1.19	2.19	72.22	100	0.279	7,222	119.0	2.4
			2	1.66	2.66	71.65	100	0.198	7,165	83.0	3.3
1.0	0.50	14,302	0	0.66	1.66						
			1	1.68	2.68	143.94	100	0.393	14,394	168.0	3.4
			2	2.35	3.35	143.59	100	0.281	14,359	117.5	4.7
2.0	1.00	28,604	0	0.66	1.66						
			1	2.37	3.37	286.46	100	0.555	28,646	237.0	4.7
			2	3.32	4.32	286.58	100	0.396	28,658	166.0	6.6
4.0	2.00	57,209	0	0.66	1.66						
			1	3.35	4.35	572.35	100	0.784	57,235	335.0	6.7
			2	4.70	5.70	574.34	100	0.561	57,434	235.0	9.4

[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 1 for Cherokee County:

$Q = C\,I\,A$

Where: C= 0.5 (intermediate cover)
I = intensity in/hr
A = drainage area, ac

From Ref. 2, for
25-year storm event

t_c is assumed to be 10 min.

I = 8.59 in/hr

Diversion Berm Flow Rate Summary

Area(ac)	**Flow Rate (cfs)**
0.5	2.1
1	4.3
1.5	6.4
2	8.6
2.5	10.7
3	12.9

For 33H:1V Diversion Berm Area Slope

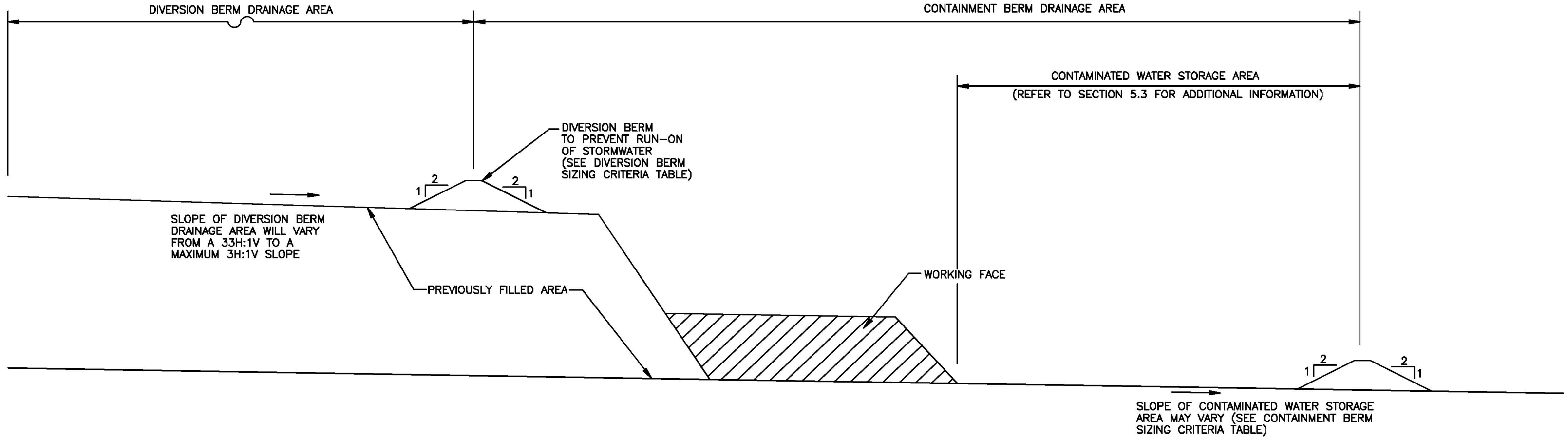
Drainage Area	Flow Rate (cfs)	Bottom Slope(ft/ft)	Manning's n	Side Slope (left)	Side Slope (right)	Bottom Width(ft)	Normal Depth(ft)	Flow Vel. (fps)	Froude Number	Velocity Head(ft)	Energy Head(ft)	Flow Area (sf)	Flow Top Width(ft)
0.5	2.1	0.01	0.03	2	33.0	0	0.29	1.38	0.636	0.03	0.32	1.52	10.30
1	4.3	0.01	0.03	2	33.0	0	0.39	1.65	0.664	0.04	0.43	2.60	13.49
1.5	6.4	0.01	0.03	2	33.0	0	0.45	1.83	0.680	0.05	0.50	3.51	15.66
2	8.6	0.01	0.03	2	33.0	0	0.50	1.96	0.693	0.06	0.56	4.38	17.50
2.5	10.7	0.01	0.03	2	33.0	0	0.54	2.07	0.702	0.07	0.61	5.16	19.00
3	12.9	0.01	0.03	2	33.0	0	0.58	2.17	0.710	0.07	0.66	5.94	20.39

Note: Calculations were performed using the HYDROCALC Hydraulics for Windows developed by Dodson and Associates (Version 1.2a, 1996).

For 3H:1V Diversion Berm Area Slope

Drainage Area	Flow Rate (cfs)	Bottom Slope(ft/ft)	Manning's n	Side Slope (left)	Side Slope (right)	Bottom Width(ft)	Normal Depth(ft)	Flow Vel. (fps)	Froude Number	Velocity Head(ft)	Energy Head(ft)	Flow Area (sf)	Flow Top Width(ft)
0.5	2.1	0.01	0.03	2	3	0	0.62	2.17	0.685	0.07	0.70	0.97	3.11
1	4.3	0.01	0.03	2	3	0	0.82	2.58	0.712	0.10	0.92	1.67	4.08
1.5	6.4	0.01	0.03	2	3	0	0.95	2.86	0.735	0.13	1.07	2.23	4.73
2	8.6	0.01	0.03	2	3	0	1.06	3.07	0.744	0.15	1.21	2.80	5.29
2.5	10.7	0.01	0.03	2	3	0	1.15	3.26	0.758	0.16	1.31	3.29	5.73
3	12.9	0.01	0.03	2	3	0	1.23	3.40	0.764	0.18	1.41	3.79	6.16

Note: Calculations were performed using the HYDROCALC Hydraulics for Windows developed by Dodson and Associates (Version 1.2a, 1996).



CONTAINMENT BERM SIZING CRITERIA *

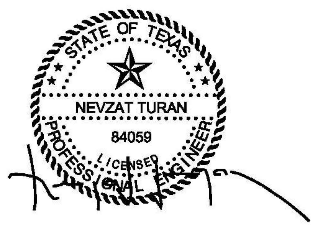
CONTAINMENT BERM DRAINAGE AREA (ACRES)	CONTAMINATED WATER STORAGE AREA (ACRES)	FLOOR SLOPE OF CONTAMINATED WATER STORAGE AREA	CALCULATED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)	REQUIRED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)
0.5	0.25	0 % 1 % 2 %	0.66 1.19 1.66	1.66 2.19 2.66
1.0	0.50	0 % 1 % 2 %	0.66 1.68 2.35	1.66 2.68 3.35
2.0	1.00	0 % 1 % 2 %	0.66 2.37 3.32	1.66 3.37 4.32
4.0	2.00	0 % 1 % 2 %	0.66 3.35 4.70	1.66 4.35 5.70

* CONTAINMENT BERM WILL BE SIZED USING THE ABOVE TABLE AS A GUIDLINE TO CONTAIN STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT. SUPPORTING CALCULATIONS ARE INCLUDED ON PAGES IIIC-C-2 THROUGH IIIC-C-5. NOTE THAT THE CRITERIA SET FORTH IN THE ABOVE TABLE IS BASED ON A MINIMUM DOWNSLOPE CONTAINMENT BERM LENGTH OF 100 FEET.

DIVERSION BERM SIZING CRITERIA *

DIVERSION BERM DRAINAGE AREA (ACRES)	MINIMUM 33%			MAXIMUM 3%		
	FLOW RATE (CFS)	FLOW DEPTH (FT)	REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)	FLOW RATE (CFS)	FLOW DEPTH (FT)	REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)
0.5	2.1	0.29	1.29	2.1	0.62	1.62
1	4.3	0.39	1.39	4.3	0.82	1.82
1.5	6.4	0.45	1.45	6.4	0.95	1.95
2	8.6	0.50	1.50	8.6	1.06	2.06
2.5	10.7	0.54	1.54	10.7	1.15	2.15
3	12.9	0.58	1.58	12.9	1.23	2.23

* 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.



05/20/2024

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☐ ISSUED FOR CONSTRUCTION

PREPARED FOR
PINE HILL FARMS LANDFILL TX, LP

DATE: 05/2024
FILE: 0120-76-11
CAD: IIIC-C-8 DVR BERM.DWG

DRAWN BY: RAA
DESIGN BY: JBM
REVIEWED BY: KDG

REVISIONS		
NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
LEACHATE AND CONTAMINATED WATER PLAN

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

WWW.WCGRP.COM

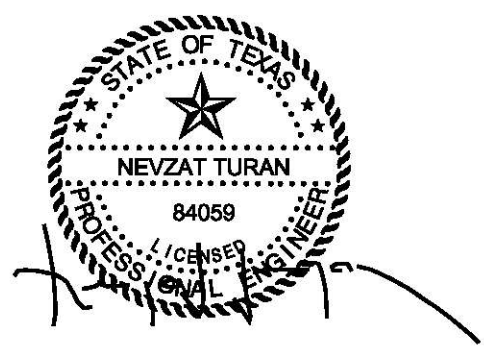
SHEET IIIC-C-8

O:\0120\76\EXPANSION 2023\PART III\IIIC\C\C-8 CONTAMINATED WATER PLAN.dwg, byoung, 1:2

APPENDIX IIIC-D

STORAGE TANK AND FORCEMAIN CAPACITY CALCULATIONS

Includes pages IIIC-D-1 through IIIC-D-11



05/20/2024

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	15,978.5	327.4
Interim, 100' Waste	38,549.8	790.0
Interim, 155' Waste	25,384.5	520.2
Closed, 155' Waste	12,002.0	246.0

[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	6,779.5	138.9
Interim, 50' Waste	17,754.8	363.9
Interim, 100' Waste	38,081.1	780.4
Interim, 200' Waste	27,177.0	556.9
Closed, 200' Waste	14,614.1	299.5

[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.

Assume the following fill scenarios:

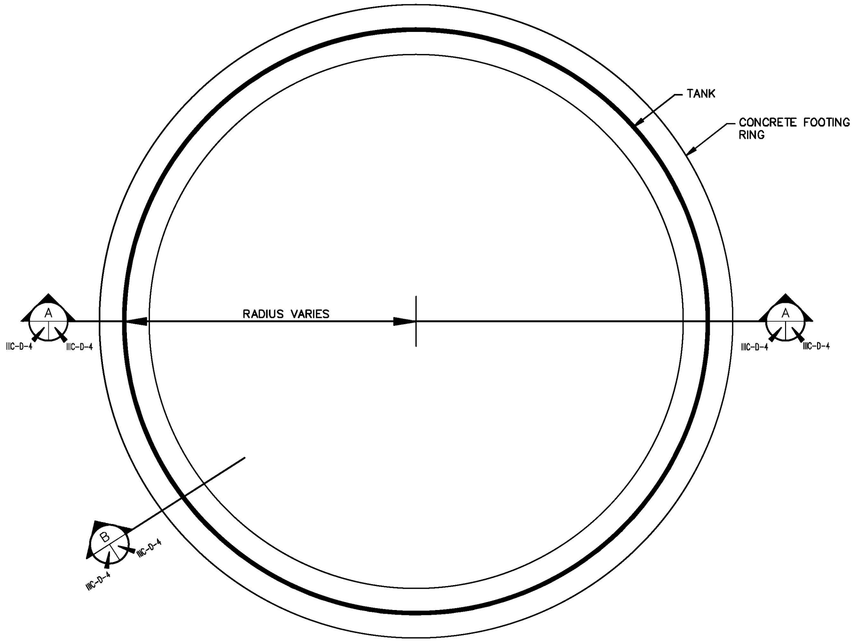
Condition	Storage Tanks			
	Developed Area Cells 1 through Cell 9 (41.5 acres)		Undeveloped Areas Cells 10 through 12 (28.6 acres)	
	(ac)	(gpd)	(ac)	(gpd)
Active, 10' Waste			1.9	264
Interim, 50 Waste	7.2	2,358	4.9	1,783
Interim, 100' Waste	17.4	13,746	10.4	8,116
Interim, 155' Waste	11.5	5,982		
Interim, 200' Waste			7.4	2,216
Closed	5.4	1,328	4.0	1,198
Total:	41.5	23,414	28.6	13,577
Total:			36,992	gpd

Leachate Storage Tank Management Plan

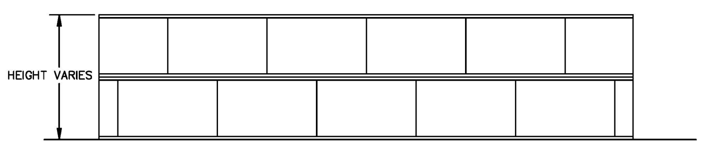
Tank Size	Leachate Generation, gallons per day	Management Plan
2-100,000 gallon tanks (200,000 gallons Total)	36,992	The 2-100,000 gallon storage tanks provides approximately 5.4 days of storage. Leachate will be discharged in accordance with Section 5.1 of Appendix IIIC.

2. **Design the secondary containment area for the leachate storage tank.**

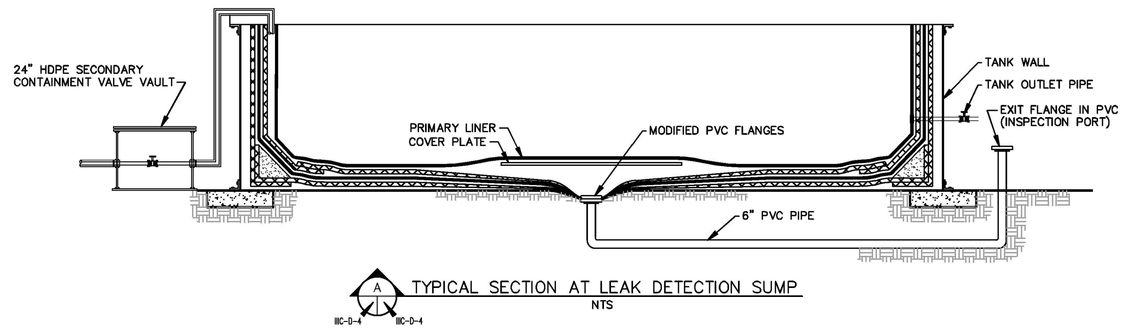
The storage tank(s) location are shown on Figure 4-1 in Appendix IIIC. The storage tank(s) is a double-walled steel tank that contains an inner tank ("storage vessel") consisting of a geomembrane liner. The secondary geomembrane liner, attached to the inner surface of the steel tank, collects any leachate that may infiltrate through the primary geomembrane liner.



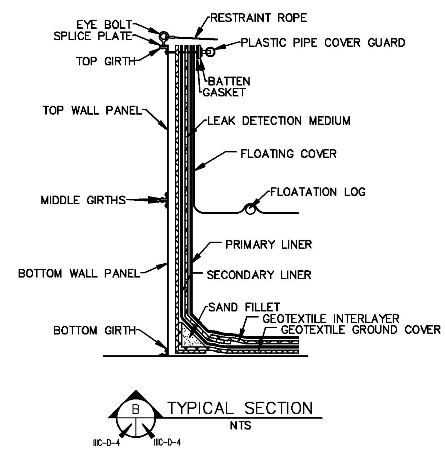
MODULAR TANK
PLAN
NTS



MODULAR TANK
ELEVATION
NTS



A TYPICAL SECTION AT LEAK DETECTION SUMP
NTS



B TYPICAL SECTION
NTS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER
05/20/2024

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: 05/2024
FILE: 0120-76-11
CAD: D-4-LEACHATE STORAGE TANK.DWG

DRAWN BY: RAA
DESIGN BY: JBM
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
PINE HILL FARMS LANDFILL TX, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE STORAGE TANK DETAILS

ROYAL OAKS LANDFILL
CHEROKEE COUNTY, TEXAS

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SHEET IIIC-D-4

0:\0120\76\EXPANSION 2023\PART III\IIIC\D\D-4 TANK DETAILS.dwg, byoung, 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] ac	AVERAGE ANNUAL FLOW cfy[2]	AVERAGE ANNUAL FLOW gpd/ac	TOTAL FLOW gpd	FLOW cfs
10' to 50' Waste	12.0	12,267	251	3,017	0.0047
50' to 100' Waste	27.0	27,918	572	15,447	0.0239
100' to 200' Waste	31.1	32,629	669	20,796	0.0322
Total =	70.1				0.0607

[1]Total limits of the Subtitle D area conveyed thorough the 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-8 and IIIC-A.1-7. The highest values for a given waste thickness have been used for demonstration purposes.

Total maximum leachate production = Q = 0.0607 cubic feet per second (cfs)
Q = 27 gallons per minute (gpm)
Q = 39,260 gallons per day (gpd)

Required capacity of leachate forcemain pipe =	39,260	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} = $(P - \Delta h) / (L/100)$

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 =	620	ft-msl
Elevation at the high point of forcemain =	655	ft-msl
Δh =	35	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 = 15.17 psi

Pipe Strength Available for Friction Loss = P - Δh

Pipe Strength for Friction Loss = 144.83 psi

L= 6,100 ft

(Note: Forcemain length is assumed to be the total length encompassing the eastern side of the facility (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 - 15.17)/(6,100/100)

ΔP_{100} = 2.37 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)

$Q = [(\Delta P_{100} C^{1.85} D^{4.86})/452]^{(1/1.85)}$

$Q = [(2.37*155^{1.85}*2.864^{4.86})/452]^{(1/1.85)}$

Q = 144 gpm
Q = 207,472 gpd

The above calculated value reflects the maximum capacity of the pipe, which is greater than the required capacity (i.e., 207,472 gpd > 39,260 gpd).

C. Calculate the maximum pressure experienced by the forcemain pipe.

Calculate head loss in the 3-inch diameter forcemain using the following equation from Ref. 1:

$$\Delta P_{100} = \frac{452 * Q^{1.85}}{C^{1.85} * D^{4.86}}$$

Q =	27	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} = 0.11 psi

Total head loss ($\Sigma\Delta P$) = ΔP_{100} * (L/100) = 0.11 psi x (6100/100)

$\Sigma\Delta P$= 6.66 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.=	7.99	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} = 7.99 psi + 15.17 psi

P=	23.16	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 =	27	gpm (from Step A)
D =	2.864	inches

V=	1.36	fps

E. Conclusion.

The pipe capacity (144 gpm) is not exceeded by the expected flow of 27 gpm.

The forcemain can withstand 160 psi, and the maximum pressure calculated as 23.16 psi; therefore, the pipe strength is acceptable.

The calculated velocity of the 3-inch forcemain for 27 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 27 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

Effective: 3-1-94

Chart 4

Table of "C" Values for "Hazen and Williams Formula"

Constant	Type of Pipe
155	Driscopipe
140	New steel pipe or tubing Glass tubing Asbestos cement
130	Copper tubing Ordinary brass pipe Cast iron – new Cast iron – tar coated but new Cast iron – fully cement lined
125	Steel pipe – old
120	Wood stave pipe Concrete pipe New wrought iron pipe Four to six years old cast iron pipe
110	Ten to twelve years old cast iron pipe Vitrified pipe Spiral riveted steel, flow with lap Galvanized steel
100	Spiral riveted steel, flow against lap Thirteen to twenty years old cast iron pipe Galvanized steel – over 5 years old Cast iron – tar coated over 10 years old
90	Twenty-six to thirty-year old cast iron pipe
60	Corrugated steel pipe

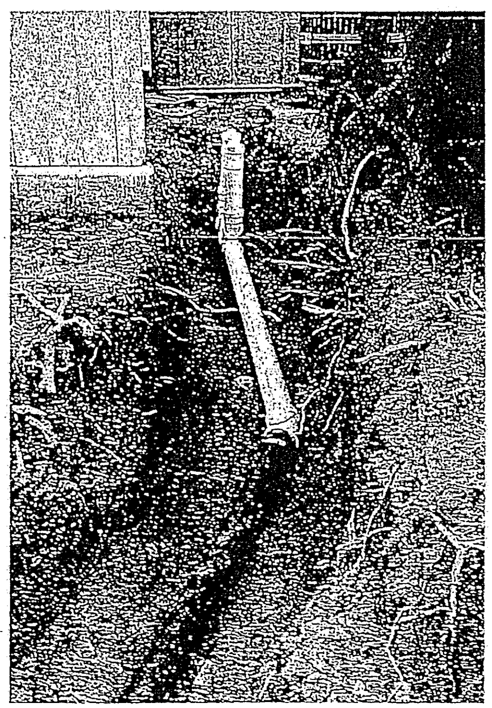
Fitting Pressure Drop: Listed below in Chart 5 are various common piping system components and the associated pressure loss through the fitting expressed as an equivalent length of straight pipe in terms of diameters. The inside diameter (in feet) multiplied by the equivalent length diameters gives the equivalent length (in feet) of pipe. This equivalent length of pipe is added to the total footage of the piping system when calculating the total system pressure drop.

These equivalent lengths should be considered an approximation suitable for most installations.

Chart 5

Fabricated Fitting	Equiv. Length
Running Tee	20 D
Branch Tee	50 D
90° Fab, Ell	30 D
60° Fab, Ell	25 D
45° Fab, Ell	18 D
45° Fab, Wye	60 D
Conventional Globe Valve (Full Open)	350 D
Conventional Angle Valve (Full Open)	180 D
Conventional Wedge Gate Valve (Full Open)	15 D
Butterfly Valve (Full Open)	40 D
Conventional Swing Check Valve	100D

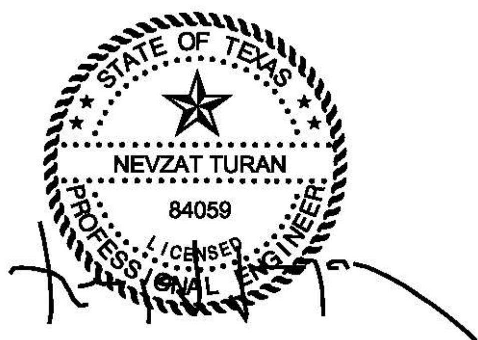
(See Appendix for further data on resistance of valves and fittings to flow).



APPENDIX IIIC-E

SITE LEACHATE GENERATION INFORMATION

Includes pages IIIC-E-1 through IIIC-E-79



05/20/2024

CONTENTS

This appendix includes the following leachate generation information.

- Sheet IIIC-E-2. Summary table listing the leachate generation information for 2018 to 2022 for the Royal Oaks Landfill.
- Sheets IIIC-E-3 through IIIC-E-4. Summary of leachate generation volume over the life of the site using actual leachate generation rate information.
- Sheets IIIC-E-5 through IIIC-E-7. Summary of leachate generation over the life of the site using the HELP analysis included in Appendices IIIC-A, IIIC-A.1 and IIIC-E.
- Sheets IIIC-E-8 through IIIC-E-9. Leachate depth on liner calculations for the actual leachate generation rates.
- Sheets IIIC-E-10 through IIIC-E-11. HELP summary sheets for the postclosure cases.

This information is summarized in Section 6 of Appendix IIIC.

ROYAL OAKS LANDFILL
0120-076-11-106
LEACHATE GENERATION SUMMARY TABLE

Purpose: Summarize the leachate information for the Royal Oaks Landfill. The leachate generation information was provided by Republic site personnel.

Leachate Generation Summary

Year	Annual Rainfall[1] (in)	Lined Area (acres)	Leachate Generated (gal/year)	Leachate Generated (gal/ac/year)
2018	60.6	30.8	499,384	16,214
2019	42.8	30.8	710,819	23,079
2020	52.4	36.3	722,719	19,910
2021	47.7	36.3	772,770	21,288
2022	39.4	41.5	674,510	16,253
Average	48.6	NA	676,040	19,349

[1] The rainfall data provided by NOAA from the Jacksonville, Texas Weather Station.

ROYAL OAKS LANDFILL
0120-076-11-106
LEACHATE GENERATION VOLUMES
USING ACTUAL LEACHATE GENERATION INFORMATION

Required: Estimate the leachate volume generated over the life of the site and the postclosure period using leachate generation information from Royal Oaks 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 Royal Oaks Landfill obtained from Republic site personnel.

Procedure:

1. Determine the approximate cell development sequence.
2. Estimate the leachate generation volume of each stage of development.

Solution:

1. **Determine the approximate cell development sequence.**

   The approximate cell development sequence is shown on Table IIIC-E-2. Leachate generation volumes will be compared for the following years.

   2022
   2025
   2030
   2035
   2041
   2041 through 2050 - First 10 years of postclosure period
   2051 through 2060 - Second 10 years of postclosure period
   2061 through 2070 - 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	Cells Developed	Lined Area (acres)	Leachate Generation Rate (gallons/acre)	Total Leachate Generated (gallons)	Source of Information
2022	Cells 1 through 9	41.5	19,349	802,972	Leachate generation information from Royal Oaks Landfill (average of 2018 to 2022) was used on a per acre basis to estimate the leachate generation rate.
2025	Cells 1 through 10A/11A	48.3	19,349	934,543	
2030	Cells 1 through 12A	62.2	19,349	1,203,490	
2035	Cells 1 through 12B	70.1	19,349	1,356,345	
2041	Cells 1 through 12	70.1	19,349	1,356,345	
SITE CLOSURE IN 2041					
2041 through 2050	All Sectors	70.1	1,935	135,635	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.
2051 through 2060	All Sectors	70.1	387	27,127	
2061 through 2070	All Sectors	70.1	387	27,127	

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 cell development sequence established on Table IIIC-E-3 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	Cell Development	Lined Area (acres)	Total Leachate Generated Average (gal/year)	Total Leachate Generated Peak (gal/year)	Source of Information
2022	Cells 1 through 9	41.5	11,967,451	43,491,268	Cells 1-9 assume a 100-foot waste column thickness to determine the average and peak leachate generation rate.
2025	Cells 1 through 10A/11A	48.3	12,858,915	47,901,256	Cells 1-9 assume a 100-foot waste column thickness; and Cell 10A/11A assumes a 50-foot waste column thickness to determine the average and peak leachate generation rate.
2030	Cells 1 through 12A	62.2	16,513,564	60,057,320	Cells 1-9 assume a 100-foot waste column thickness; Cell 10A/11A, and 10B/11B assumes a 100-foot waste column thickness; and Cell 12A assumes a 50-foot waste column thickness to determine the average and peak leachate generation rate.
2035	Cells 1 through 12B	70.1	16,033,700	41,175,354	Cells 1-9 assume a 155-foot waste column thickness; and Cell 10A/11A, 10B/11B, 12A, and 12B assumes a 100-foot waste column thickness to determine the average and peak leachate generation rate.
2041	Cells 1 through 12	70.1	13,698,188	23,437,173	Cells 1-9 assume a 155-foot waste column thickness; and Cell 10A/11A, 10B/11B, 12A, and 12B assumes a 200-foot waste column thickness to determine the average and peak leachate generation rate.
SITE CLOSURE IN 2041					
2041 through 2050	All Cells	70.1	4,288,202	6,169,676	All Cells 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 2041 to 2050.
2051 through 2060	All Cells	70.1	3,680,115	5,202,293	All Cells 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 2041-2050 were input as the initial moisture contents in the HELP run for years 2051 to 2060.
2061 through 2071	All Cells	70.1	2,365,635	5,065,114	All Cells 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 2051-2060 were input as the initial moisture contents in the HELP run for years 2061 to 2071.

Table IIIC-E-3[1]
Summary of Leachate Generation Rates

Developed Area (Cells 1 Through 9)				
	Average (cf/year/acre)	**Average (gal/year/acre)**	**Peak (cf/day/acre)**	**Peak (gal/day/acre)**
Interim 50 ft	15,711.9	117,533.2	189.3	1,416.0
Interim 100 ft	38,549.8	288,372.3	383.8	2,871.2
Interim 155 ft	25,384.5	189,889.4	133.1	995.4
Closed	12,002.0	89,781.1	97.1	726.1
Postclosure (First 10 Years)	7,533.3	56,353.0	32.2	241.2
Postclosure (Second 10 Years)	6,442.8	48,195.8	27.1	202.7
Postclosure (Third 10 Years)	2,894.2	21,650.1	28.1	210.3
Undeveloped Area (Cells 10-12)				
	Average (cf/year/acre)	**Average (gal/year/acre)**	**Peak (cf/day/acre)**	**Peak (gal/day/acre)**
Active	6,784.8	50,753.7	47.8	357.2
Interim 50 ft	17,525.2	131,097.7	237.5	1,776.8
Interim 100 ft	38,109.7	285,080.1	334.2	2,500.1
Interim 200 ft	27,193.1	203,418.8	107.1	800.8
Closed	14,614.1	109,321.2	101.9	762.3
Postclosure (First 10 Years)	9,112.5	68,166.2	32.2	241.0
Postclosure (Second 10 Years)	7,852.5	58,740.8	27.3	204.2
Postclosure (Third 10 Years)	6,857.7	51,299.2	24.1	180.1

[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 - Cells 1 through 9 (200 mil geocomposite)

β=	1.43	°
tanβ=	0.025	
$\tan^2\beta$=	0.0006	
cosβ=	1.00	
L=	250	ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_1 (in/s)	T_{max} (in)
Interim 50 ft	19,349	2.26E-08	3.35	0.0008
Interim 100 ft	19,349	2.26E-08	2.23	0.0012
Interim 155 ft	19,349	2.26E-08	1.51	0.0018
Closed	19,349	2.26E-08	1.24	0.0022
Postclosure (First 10 Years)	1,935	2.26E-09	1.24	0.0002
Postclosure (Second 10 Years)	387	4.52E-10	1.24	0.0000
Postclosure (Third 10 Years)	387	4.52E-10	1.24	0.0000

Undeveloped Areas - Cells 10 through 12 (250 mil geocomposite)

β=	1.43	°
tanβ=	0.025	
$\tan^2\beta$=	0.0006	
cosβ=	1.00	
L=	250	ft

Condition	q_h (gal/acre/year)	q_h (in/s)	k_1 (in/s)	T_{max} (in)
Active 10 ft	19,349	2.26E-08	0.09	0.0313
Interim 50 ft	19,349	2.26E-08	0.48	0.0056
Interim 100 ft	19,349	2.26E-08	0.69	0.0039
Interim 200 ft	19,349	2.26E-08	0.28	0.0098
Closed	19,349	2.26E-08	0.28	0.0098
Postclosure (First 10 Years)	1,935	2.26E-09	0.28	0.0010
Postclosure (Second 10 Years)	387	4.52E-10	0.28	0.0002
Postclosure (Third 10 Years)	387	4.52E-10	0.28	0.0002

		POST-CLOSURE 2041-2050	POST-CLOSURE 2051-2060	POST-CLOSURE 2061-2071
GENERAL	Case No.	1	2	3
INFORMATION	Output Page	IIIC-E-13	IIIC-E-24	IIIC-E-35
	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)	0.250	0.250	0.250
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)	6.63	6.63	6.63
	Slope (%)	4.0	4.0	4.0
	Slope Length (ft)	180	180	180
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)	0.3980	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
WASTE TOP[2]	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)	0.3323	0.3209	0.3112
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)	360	360	360
(Texture = 0)	Porosity (vol/vol)	0.5534	0.5534	0.5534
	Field Capacity (vol/vol)	0.4945	0.4945	0.4945
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3025	0.2925	0.2839
	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)	0.2534	0.2506	0.2480
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.147	0.147	0.147
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)	3.16	3.16	3.16
	Slope (%)	2.5	2.5	2.5
	Slope Length (ft)	250	250	250
FLEXIBLE	Thickness (in)	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0
	Placement Quality	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	45.34	45.34	45.34
RUNOFF	Average Annual (in)	1.33	1.33	1.33
EVAPOTRANSPIRATION	Average Annual (in)	30.07	30.07	30.07
LATERAL	Average Annual (cf/year)	7,533.3	6,442.8	2,894.2
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	32.2	27.1	28.1
HEAD ON LINER	Average Annual (in)	0.003	0.003	0.001
	Peak Daily (in)	0.013	0.001	0.009

[1] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids i Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		POST-CLOSURE 2041-2050	POST-CLOSURE 2051-2060	POST-CLOSURE 2061-2071
GENERAL	Case No.	1	2	3
INFORMATION	Output Page	IIIC-E-47	IIIC-E-58	IIIC-E-69
	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)	0.250	0.250	0.250
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)	6.63	6.63	6.63
	Slope (%)	4.0	4.0	4.0
	Slope Length (ft)	180	180	180
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)	0.3980	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
WASTE TOP[2]	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)	0.3447	0.3337	0.3242
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)	900	900	900
(Texture = 0)	Porosity (vol/vol)	0.5348	0.5348	0.5348
	Field Capacity (vol/vol)	0.4892	0.4892	0.4892
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3043	0.2948	0.2867
	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)	0.2564	0.2537	0.2512
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.162	0.162	0.162
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	0.87	0.87	0.87
	Slope (%)	2.0	2.0	2.0
	Slope Length (ft)	250	250	250
FLEXIBLE	Thickness (in)	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0
	Placement Quality	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	45.34	45.34	45.34
RUNOFF	Average Annual (in)	1.33	1.33	1.33
EVAPOTRANSPIRATION	Average Annual (in)	30.07	30.07	30.07
LATERAL	Average Annual (cf/year)	9,112.5	7,852.5	6,857.7
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	32.2	27.3	24.1
HEAD ON LINER	Average Annual (in)	0.017	0.015	0.013
	Peak Daily (in)	0.045	0.038	0.033

[1] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp

POST-CLOSURE

HELP MODEL OUTPUT FOR DEVELOPED AREAS

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\RO\10C\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10C\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10C\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10C\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\D\C10\DATA10.D10
OUTPUT DATA FILE:           C:\RO\D\C10\OUTPUT1.OUT


TIME:  11:29     DATE:  11/15/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - Closed 10YR-155 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                     =      0.25   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.     =   6.63000011000     CM/SEC
  SLOPE                         =      4.00   PERCENT
  DRAINAGE LENGTH               =    180.0    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  10
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC



                        LAYER  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  =      0.3323 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC



                        LAYER  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    360.00   INCHES
POROSITY                    =      0.5534 VOL/VOL
FIELD CAPACITY              =      0.4945 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.3025 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  =      0.2534 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.   =   3.16000009000     CM/SEC
SLOPE                       =      2.50   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                       LAYER 10
                       --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                         LAYER 11
                         --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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    =    637.226  INCHES
TOTAL INITIAL WATER                 =    637.226  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

```
STATION LATITUDE                          =  32.28 DEGREES
MAXIMUM LEAF AREA INDEX                   =   4.50
START OF GROWING SEASON (JULIAN DATE)     =     58
END OF GROWING SEASON (JULIAN DATE)       =    331
EVAPORATIVE ZONE DEPTH                    =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED                 =   8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.062	0.177	0.067	0.153	0.167	0.230
	0.162	0.042	0.074	0.024	0.078	0.094
STD. DEVIATIONS	0.098	0.228	0.124	0.190	0.237	0.303
	0.379	0.113	0.131	0.033	0.045	0.231
EVAPOTRANSPIRATION						
TOTALS	1.710	2.184	2.981	3.588	4.122	3.801
	3.582	1.969	2.381	1.406	1.047	1.304
STD. DEVIATIONS	0.210	0.243	0.831	0.939	1.167	0.612
	1.813	1.515	1.194	0.865	0.330	0.111
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7055	1.7641	1.3620	1.5837	0.9083	0.7742
	0.4328	0.3415	0.4655	0.3695	2.2414	1.9836
STD. DEVIATIONS	1.9678	1.1552	1.0848	1.5086	1.0112	0.7110
	0.7056	0.7335	0.7277	0.4474	0.7845	1.9572
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.1755	0.1618	0.1768	0.1700	0.1782	0.1700
	0.1756	0.1762	0.1701	0.1762	0.1692	0.1755
STD. DEVIATIONS	0.0114	0.0091	0.0094	0.0082	0.0108	0.0099

```
                            0.0112   0.0108   0.0089   0.0096   0.0106   0.0096

  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                0.0194   0.0271   0.0131   0.0214   0.0121   0.0146
                            0.0074   0.0044   0.0061   0.0035   0.0246   0.0230

    STD. DEVIATIONS         0.0235   0.0265   0.0135   0.0213   0.0177   0.0213
                            0.0190   0.0100   0.0097   0.0052   0.0073   0.0306

  DAILY AVERAGE HEAD ON TOP OF LAYER 10
  -------------------------------------
    AVERAGES                0.0032   0.0032   0.0032   0.0032   0.0032   0.0032
                            0.0032   0.0032   0.0032   0.0032   0.0032   0.0032

    STD. DEVIATIONS         0.0002   0.0002   0.0002   0.0002   0.0002   0.0002
                            0.0002   0.0002   0.0002   0.0002   0.0002   0.0002

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



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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   19 THROUGH   28
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET       PERCENT
                                -------------------   -------------   ---------
 PRECIPITATION                   45.34    (   6.841)     164573.3     100.00

 RUNOFF                           1.330   (  0.6931)       4827.82      2.934

 EVAPOTRANSPIRATION              30.074   (  3.6386)     109169.79     66.335

 LATERAL DRAINAGE COLLECTED      13.93206 (  3.58906)     50573.391   30.73001
   FROM LAYER  2
```

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00045 (	0.00016)	1.646	0.00100
AVERAGE HEAD ON TOP OF LAYER 3	0.015 (	0.006)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	2.07529 (	0.11131)	7533.296	4.57747
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 10	0.003 (	0.000)		
CHANGE IN WATER STORAGE	-2.075 (	1.7630)	-7530.99	-4.576

****

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.200	4355.8101
DRAINAGE COLLECTED FROM LAYER 2	1.44075	5229.92627
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000100	0.36376
AVERAGE HEAD ON TOP OF LAYER 3	1.384	
MAXIMUM HEAD ON TOP OF LAYER 3	1.791	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	11.3 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00888	32.24805
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.005	

MAXIMUM HEAD ON TOP OF LAYER 10 0.013

LOCATION OF MAXIMUM HEAD IN LAYER 9
(DISTANCE FROM DRAIN) 0.0 FEET

SNOW WATER 3.53 12827.0205

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3211

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 28

LAYER	(INCHES)	(VOL/VOL)
1	2.9262	0.2439
2	0.0061	0.0245
3	0.0000	0.0000
4	7.6860	0.4270
5	2.9280	0.2440
6	481.3590	0.3209
7	105.3056	0.2925
8	6.0150	0.2506
9	0.0050	0.0341

10	0.0000	0.0000
11	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:\RO\10C\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10C\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10C\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10C\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\D\C20\DATA10.D10
OUTPUT DATA FILE:           C:\RO\D\C20\OUTPUT1.OUT


TIME:  11:30     DATE:  11/15/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - Closed 20YR-155 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                  =      0.25   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.  =   6.63000011000     CM/SEC
  SLOPE                      =      4.00   PERCENT
  DRAINAGE LENGTH            =    180.0    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  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                        LAYER  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   =      0.3209 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                        LAYER  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    360.00   INCHES
POROSITY                     =      0.5534 VOL/VOL
FIELD CAPACITY               =      0.4945 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.2925 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  =      0.2506 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.   =   3.16000009000     CM/SEC
SLOPE                       =      2.50   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                        LAYER 10
                        --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER 11
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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   =    616.458  INCHES
TOTAL INITIAL WATER                =    616.458  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR


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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

STATION LATITUDE = 32.28 DEGREES
MAXIMUM LEAF AREA INDEX = 4.50
START OF GROWING SEASON (JULIAN DATE) = 58
END OF GROWING SEASON (JULIAN DATE) = 331
EVAPORATIVE ZONE DEPTH = 12.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

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

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                3.00     4.01     4.21     5.33     4.86     5.06
                          3.89     2.22     3.25     2.21     3.88     3.42

    STD. DEVIATIONS       1.93     1.49     1.24     2.54     2.06     1.75
                          2.35     2.15     2.00     0.96     0.84     2.85

  RUNOFF
  ------
    TOTALS                0.062    0.177    0.067    0.153    0.167    0.230
                          0.162    0.042    0.074    0.024    0.078    0.094

    STD. DEVIATIONS       0.098    0.228    0.124    0.190    0.237    0.303
                          0.379    0.113    0.131    0.033    0.045    0.231

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                1.710    2.184    2.981    3.588    4.122    3.801
                          3.582    1.969    2.381    1.406    1.047    1.304

    STD. DEVIATIONS       0.210    0.243    0.831    0.939    1.167    0.612
                          1.813    1.515    1.194    0.865    0.330    0.111

  LATERAL DRAINAGE COLLECTED FROM LAYER  2
  ----------------------------------------
    TOTALS                1.7055   1.7641   1.3620   1.5837   0.9083   0.7742
                          0.4328   0.3415   0.4655   0.3695   2.2414   1.9836

    STD. DEVIATIONS       1.9678   1.1552   1.0848   1.5086   1.0112   0.7110
                          0.7056   0.7335   0.7277   0.4474   0.7845   1.9572

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                0.0001   0.0001   0.0000   0.0001   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0001   0.0001

    STD. DEVIATIONS       0.0001   0.0001   0.0000   0.0001   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0001

  LATERAL DRAINAGE COLLECTED FROM LAYER  9
  ----------------------------------------
    TOTALS                0.1497   0.1381   0.1515   0.1482   0.1506   0.1453
                          0.1511   0.1498   0.1462   0.1506   0.1439   0.1498

    STD. DEVIATIONS       0.0077   0.0079   0.0073   0.0066   0.0079   0.0061
```

```
                         0.0082   0.0092   0.0065   0.0083   0.0066   0.0072

  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             0.0194   0.0271   0.0131   0.0214   0.0121   0.0146
                         0.0074   0.0044   0.0061   0.0035   0.0246   0.0230

    STD. DEVIATIONS      0.0235   0.0265   0.0135   0.0213   0.0177   0.0213
                         0.0190   0.0100   0.0097   0.0052   0.0073   0.0306

  DAILY AVERAGE HEAD ON TOP OF LAYER 10
  -------------------------------------
    AVERAGES             0.0027   0.0027   0.0027   0.0028   0.0027   0.0027
                         0.0027   0.0027   0.0027   0.0027   0.0027   0.0027

    STD. DEVIATIONS      0.0001   0.0002   0.0001   0.0001   0.0001   0.0001
                         0.0001   0.0002   0.0001   0.0001   0.0001   0.0001

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   19 THROUGH   28
-------------------------------------------------------------------------------
                                 INCHES             CU. FEET       PERCENT
                            -------------------   -------------   ---------
 PRECIPITATION                45.34    (   6.841)     164573.3     100.00

 RUNOFF                        1.330   (  0.6931)       4827.82      2.934

 EVAPOTRANSPIRATION           30.074   (  3.6386)     109169.79     66.335

 LATERAL DRAINAGE COLLECTED   13.93206 (  3.58906)     50573.391   30.73001
   FROM LAYER  2
```

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00045 (	0.00016)	1.646	0.00100
AVERAGE HEAD ON TOP OF LAYER 3	0.015 (	0.006)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	1.77489 (	0.07941)	6442.846	3.91488
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 10	0.003 (	0.000)		
CHANGE IN WATER STORAGE	-1.774 (	1.7565)	-6440.55	-3.913

****

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.200	4355.8101
DRAINAGE COLLECTED FROM LAYER 2	1.44075	5229.92627
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000100	0.36376
AVERAGE HEAD ON TOP OF LAYER 3	1.384	
MAXIMUM HEAD ON TOP OF LAYER 3	1.791	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	11.3 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00747	27.09875
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.004	

```
MAXIMUM HEAD ON TOP OF LAYER 10            0.001

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)              205.1 FEET

SNOW WATER                                 3.53         12827.0205


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3211

MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1360

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

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

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




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

             FINAL WATER STORAGE AT END OF YEAR   28
    ----------------------------------------------------------------------
              LAYER        (INCHES)       (VOL/VOL)
              -----        --------       ---------
                1            2.9262         0.2439

                2            0.0061         0.0245

                3            0.0000         0.0000

                4            7.6860         0.4270

                5            2.9280         0.2440

                6          466.7536         0.3112

                7          102.2132         0.2839

                8            5.9516         0.2480

                9            0.0031         0.0208
```

10	0.0000	0.0000
11	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:\RO\10C\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10C\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10C\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10C\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\D\C30\DATA10.D10
OUTPUT DATA FILE:           C:\RO\D\C30\OUTPUT1.OUT


TIME:  11:34     DATE:  11/15/2023


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

     TITLE:  Royal Oaks Landfill - Developed Areas - Closed 30YR-155 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                     =      0.25   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.   =   6.63000011000     CM/SEC
  SLOPE                         =      4.00   PERCENT
  DRAINAGE LENGTH               =    180.0    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  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                        LAYER  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   =      0.3112 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                        LAYER  7
                        --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    360.00   INCHES
POROSITY                     =      0.5534 VOL/VOL
FIELD CAPACITY               =      0.4945 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.2839 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  =      0.2480 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.   =   3.16000009000     CM/SEC
SLOPE                       =      2.50   PERCENT
DRAINAGE LENGTH             =    250.0    FEET
```

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

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER 11
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC




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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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    =    598.750  INCHES
TOTAL INITIAL WATER                 =    598.750  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR




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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

STATION LATITUDE = 32.28 DEGREES
MAXIMUM LEAF AREA INDEX = 4.50
START OF GROWING SEASON (JULIAN DATE) = 58
END OF GROWING SEASON (JULIAN DATE) = 331
EVAPORATIVE ZONE DEPTH = 12.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.062	0.177	0.067	0.153	0.167	0.230
	0.162	0.042	0.074	0.024	0.078	0.094
STD. DEVIATIONS	0.098	0.228	0.124	0.190	0.237	0.303
	0.379	0.113	0.131	0.033	0.045	0.231
EVAPOTRANSPIRATION						
TOTALS	1.710	2.184	2.981	3.588	4.122	3.801
	3.582	1.969	2.381	1.406	1.047	1.304
STD. DEVIATIONS	0.210	0.243	0.831	0.939	1.167	0.612
	1.813	1.515	1.194	0.865	0.330	0.111
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7055	1.7641	1.3620	1.5837	0.9083	0.7742
	0.4328	0.3415	0.4655	0.3695	2.2414	1.9836
STD. DEVIATIONS	1.9678	1.1552	1.0848	1.5086	1.0112	0.7110
	0.7056	0.7335	0.7277	0.4474	0.7845	1.9572
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.0753	0.0614	0.0672	0.0654	0.0654	0.0654
	0.0671	0.0667	0.0652	0.0672	0.0642	0.0668
STD. DEVIATIONS	0.0655	0.0648	0.0708	0.0689	0.0690	0.0690

	0.0708	0.0703	0.0688	0.0709	0.0677	0.0704

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	0.0194	0.0271	0.0131	0.0214	0.0121	0.0146
	0.0074	0.0044	0.0061	0.0035	0.0246	0.0230
STD. DEVIATIONS	0.0235	0.0265	0.0135	0.0213	0.0177	0.0213
	0.0190	0.0100	0.0097	0.0052	0.0073	0.0306

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0014	0.0012	0.0012	0.0012	0.0012	0.0012
	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
STD. DEVIATIONS	0.0012	0.0013	0.0013	0.0013	0.0012	0.0013
	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.34	(6.841)	164573.3	100.00
RUNOFF	1.330	(0.6931)	4827.82	2.934
EVAPOTRANSPIRATION	30.074	(3.6386)	109169.79	66.335
LATERAL DRAINAGE COLLECTED FROM LAYER 2	13.93206	(3.58906)	50573.391	30.73001

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00045 (	0.00016)	1.646	0.00100
AVERAGE HEAD ON TOP OF LAYER 3	0.015 (	0.006)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.79730 (	0.81932)	2894.195	1.75861
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.006	0.00000
AVERAGE HEAD ON TOP OF LAYER 10	0.001 (	0.001)		
CHANGE IN WATER STORAGE	-0.797 (	1.9782)	-2891.93	-1.757

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PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.200	4355.8101
DRAINAGE COLLECTED FROM LAYER 2	1.44075	5229.92627
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000100	0.36376
AVERAGE HEAD ON TOP OF LAYER 3	1.384	
MAXIMUM HEAD ON TOP OF LAYER 3	1.791	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	11.3 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00774	28.11188
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.004	

```
MAXIMUM HEAD ON TOP OF LAYER 10           0.009

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)               0.0 FEET

SNOW WATER                                3.53         12827.0205


MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3211

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   28
    ----------------------------------------------------------------------
               LAYER        (INCHES)       (VOL/VOL)
               -----        --------       ---------
                 1            2.9262         0.2439

                 2            0.0061         0.0245

                 3            0.0000         0.0000

                 4            7.6860         0.4270

                 5            2.9280         0.2440

                 6          460.3550         0.3069

                 7          100.7765         0.2799

                 8            5.8560         0.2440

                 9            0.0015         0.0100
```

10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

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****

POST-CLOSURE

HELP MODEL OUTPUT FOR UNDEVELOPED AREAS

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\RO\10C\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10C\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10C\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10C\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\U\C10\DATA10.D10
OUTPUT DATA FILE:           C:\RO\U\C10\OUTPUT1.OUT


TIME:  11:23     DATE:  11/15/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - Closed 10YR-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  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                   =      0.25   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.   =   6.63000011000     CM/SEC
  SLOPE                       =      4.00   PERCENT
  DRAINAGE LENGTH             =    180.0    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  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                         LAYER  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   =      0.3447 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                         LAYER  7
                         --------

          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  =      0.3043 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  =      0.2564 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  9
                        --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.16   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.699999988000     CM/SEC
SLOPE                       =      2.50   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                        LAYER 10
                        --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                         LAYER 11
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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   =    820.868  INCHES
TOTAL INITIAL WATER                =    820.868  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR


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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

STATION LATITUDE	=	32.28 DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50
START OF GROWING SEASON (JULIAN DATE)	=	58
END OF GROWING SEASON (JULIAN DATE)	=	331
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SHREVEPORT LOUISIANA
AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.062	0.177	0.067	0.153	0.167	0.230
	0.162	0.042	0.074	0.024	0.078	0.094
STD. DEVIATIONS	0.098	0.228	0.124	0.190	0.237	0.303
	0.379	0.113	0.131	0.033	0.045	0.231
EVAPOTRANSPIRATION						
TOTALS	1.710	2.184	2.981	3.588	4.122	3.801
	3.582	1.969	2.381	1.406	1.047	1.304
STD. DEVIATIONS	0.210	0.243	0.831	0.939	1.167	0.612
	1.813	1.515	1.194	0.865	0.330	0.111
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7055	1.7641	1.3620	1.5837	0.9083	0.7742
	0.4328	0.3415	0.4655	0.3695	2.2414	1.9836
STD. DEVIATIONS	1.9678	1.1552	1.0848	1.5086	1.0112	0.7110
	0.7056	0.7335	0.7277	0.4474	0.7845	1.9572
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.2112	0.1942	0.2168	0.2076	0.2140	0.2053
	0.2137	0.2144	0.2056	0.2129	0.2039	0.2105
STD. DEVIATIONS	0.0122	0.0116	0.0105	0.0085	0.0112	0.0110

	0.0122	0.0109	0.0105	0.0101	0.0089	0.0122

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	0.0194	0.0271	0.0131	0.0214	0.0121	0.0146
	0.0074	0.0044	0.0061	0.0035	0.0246	0.0230
STD. DEVIATIONS	0.0235	0.0265	0.0135	0.0213	0.0177	0.0213
	0.0190	0.0100	0.0097	0.0052	0.0073	0.0306

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0172	0.0173	0.0176	0.0175	0.0174	0.0173
	0.0174	0.0174	0.0173	0.0173	0.0171	0.0171
STD. DEVIATIONS	0.0010	0.0010	0.0009	0.0007	0.0009	0.0009
	0.0010	0.0009	0.0009	0.0008	0.0008	0.0010

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 19 THROUGH 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.34 (6.841)	164573.3	100.00
RUNOFF	1.330 (0.6931)	4827.82	2.934
EVAPOTRANSPIRATION	30.074 (3.6386)	109169.79	66.335
LATERAL DRAINAGE COLLECTED FROM LAYER 2	13.93206 (3.58906)	50573.391	30.73001

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00045 (	0.00016)	1.646	0.00100
AVERAGE HEAD ON TOP OF LAYER 3	0.015 (	0.006)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	2.51033 (	0.11649)	9112.498	5.53705
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 10	0.017 (	0.001)		
CHANGE IN WATER STORAGE	-2.510 (	1.7631)	-9110.23	-5.536

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PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.200	4355.8101
DRAINAGE COLLECTED FROM LAYER 2	1.44075	5229.92627
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000100	0.36376
AVERAGE HEAD ON TOP OF LAYER 3	1.384	
MAXIMUM HEAD ON TOP OF LAYER 3	1.791	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	11.3 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00887	32.21462
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.022	

```
MAXIMUM HEAD ON TOP OF LAYER 10            0.044

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)                4.8 FEET

SNOW WATER                                 3.53         12827.0205


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3211

MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1360


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

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

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




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

                FINAL WATER STORAGE AT END OF YEAR   28
    ----------------------------------------------------------------------
                LAYER        (INCHES)       (VOL/VOL)
                -----        --------       ---------
                  1            2.9262         0.2439

                  2            0.0061         0.0245

                  3            0.0000         0.0000

                  4            7.6860         0.4270

                  5            2.9280         0.2440

                  6          500.5185         0.3337

                  7          265.3527         0.2948

                  8            6.0900         0.2537

                  9            0.0153         0.0942
```

10	0.0000	0.0000
11	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:\RO\10C\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10C\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10C\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10C\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\U\C20\DATA10.D10
OUTPUT DATA FILE:           C:\RO\U\C20\OUTPUT1.OUT


TIME:  11:26     DATE:  11/15/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - Closed 20YR-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  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                   =      0.25   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.   =   6.63000011000     CM/SEC
  SLOPE                       =      4.00   PERCENT
  DRAINAGE LENGTH             =    180.0    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  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                         LAYER  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   =      0.3337 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                         LAYER  7
                         --------

          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  =      0.2948 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  =      0.2537 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC




                        LAYER  9
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.16   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.699999988000     CM/SEC
SLOPE                       =      2.50   PERCENT
DRAINAGE LENGTH             =    250.0    FEET




                        LAYER 10
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
   FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER 11
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     24.00   INCHES
   POROSITY                    =      0.4270 VOL/VOL
   FIELD CAPACITY              =      0.4180 VOL/VOL
   WILTING POINT               =      0.3670 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC




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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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     =    795.753  INCHES
TOTAL INITIAL WATER                  =    795.753  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR




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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

```
STATION LATITUDE                         =  32.28 DEGREES
MAXIMUM LEAF AREA INDEX                  =   4.50
START OF GROWING SEASON (JULIAN DATE)    =     58
END OF GROWING SEASON (JULIAN DATE)      =    331
EVAPORATIVE ZONE DEPTH                   =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED                =   8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.062	0.177	0.067	0.153	0.167	0.230
	0.162	0.042	0.074	0.024	0.078	0.094
STD. DEVIATIONS	0.098	0.228	0.124	0.190	0.237	0.303
	0.379	0.113	0.131	0.033	0.045	0.231
EVAPOTRANSPIRATION						
TOTALS	1.710	2.184	2.981	3.588	4.122	3.801
	3.582	1.969	2.381	1.406	1.047	1.304
STD. DEVIATIONS	0.210	0.243	0.831	0.939	1.167	0.612
	1.813	1.515	1.194	0.865	0.330	0.111
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7055	1.7641	1.3620	1.5837	0.9083	0.7742
	0.4328	0.3415	0.4655	0.3695	2.2414	1.9836
STD. DEVIATIONS	1.9678	1.1552	1.0848	1.5086	1.0112	0.7110
	0.7056	0.7335	0.7277	0.4474	0.7845	1.9572
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.1826	0.1656	0.1811	0.1802	0.1835	0.1764
	0.1831	0.1843	0.1779	0.1842	0.1788	0.1855
STD. DEVIATIONS	0.0101	0.0073	0.0085	0.0108	0.0094	0.0070

```
                             0.0073   0.0098   0.0078   0.0111   0.0127   0.0090

  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                 0.0194   0.0271   0.0131   0.0214   0.0121   0.0146
                             0.0074   0.0044   0.0061   0.0035   0.0246   0.0230

    STD. DEVIATIONS          0.0235   0.0265   0.0135   0.0213   0.0177   0.0213
                             0.0190   0.0100   0.0097   0.0052   0.0073   0.0306

  DAILY AVERAGE HEAD ON TOP OF LAYER 10
  -------------------------------------
    AVERAGES                 0.0149   0.0148   0.0147   0.0151   0.0149   0.0148
                             0.0149   0.0150   0.0150   0.0150   0.0150   0.0151

    STD. DEVIATIONS          0.0008   0.0006   0.0007   0.0009   0.0008   0.0006
                             0.0006   0.0008   0.0007   0.0009   0.0011   0.0007

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



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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   19 THROUGH   28
-------------------------------------------------------------------------------
                                        INCHES            CU. FEET      PERCENT
                                  -------------------   -------------   ---------
 PRECIPITATION                     45.34    (   6.841)     164573.3     100.00

 RUNOFF                             1.330   (  0.6931)       4827.82      2.934

 EVAPOTRANSPIRATION                30.074   (  3.6386)     109169.79     66.335

 LATERAL DRAINAGE COLLECTED        13.93206 (  3.58906)     50573.391   30.73001
   FROM LAYER  2
```

```
 PERCOLATION/LEAKAGE THROUGH     0.00045 (  0.00016)         1.646     0.00100
   LAYER  4

 AVERAGE HEAD ON TOP             0.015 (    0.006)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED      2.16323 (  0.09422)      7852.509    4.77144
   FROM LAYER  9

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.009     0.00001
   LAYER 11

 AVERAGE HEAD ON TOP             0.015 (    0.001)
   OF LAYER 10

 CHANGE IN WATER STORAGE        -2.163   (  1.7668)      -7850.16     -4.770

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



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

               PEAK DAILY VALUES FOR YEARS   19 THROUGH   28
   ------------------------------------------------------------------------
                                                      (INCHES)      (CU. FT.)
                                                     ----------   -------------
      PRECIPITATION                                    4.10        14883.000

      RUNOFF                                           1.200        4355.8101

      DRAINAGE COLLECTED FROM LAYER  2                 1.44075      5229.92627

      PERCOLATION/LEAKAGE THROUGH LAYER  4             0.000100        0.36376

      AVERAGE HEAD ON TOP OF LAYER  3                  1.384

      MAXIMUM HEAD ON TOP OF LAYER  3                  1.791

      LOCATION OF MAXIMUM HEAD IN LAYER  2
            (DISTANCE FROM DRAIN)                     11.3 FEET

      DRAINAGE COLLECTED FROM LAYER  9                 0.00752         27.29831

      PERCOLATION/LEAKAGE THROUGH LAYER 11             0.000000        0.00002

      AVERAGE HEAD ON TOP OF LAYER 10                  0.019
```

```
MAXIMUM HEAD ON TOP OF LAYER 10            0.037

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)                0.0 FEET

SNOW WATER                                 3.53         12827.0205


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3211

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   28
    ----------------------------------------------------------------------
```

LAYER	(INCHES)	(VOL/VOL)
1	2.9262	0.2439
2	0.0061	0.0245
3	0.0000	0.0000
4	7.6860	0.4270
5	2.9280	0.2440
6	486.2332	0.3242
7	258.0591	0.2867
8	6.0281	0.2512
9	0.0124	0.0763

10	0.0000	0.0000
11	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:\RO\10C\DATA4.D4
TEMPERATURE DATA FILE:      c:\RO\10C\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\RO\10C\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\RO\10C\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\RO\U\C30\DATA10.D10
OUTPUT DATA FILE:           C:\RO\U\C30\OUTPUT1.OUT


TIME:  11:28     DATE:  11/15/2023


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

     TITLE:  Royal Oaks Landfill - Undeveloped Areas - Closed 30YR-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  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                  =      0.25   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.  =   6.63000011000     CM/SEC
  SLOPE                      =      4.00   PERCENT
  DRAINAGE LENGTH            =    180.0    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  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                        LAYER  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   =      0.3242 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                        LAYER  7
                        --------

          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  =      0.2867 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  =      0.2512 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  9
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.16   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.699999988000     CM/SEC
SLOPE                       =      2.50   PERCENT
DRAINAGE LENGTH             =    250.0    FEET


                        LAYER 10
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
```

```
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD
```

LAYER 11

```
              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.4270 VOL/VOL
  FIELD CAPACITY              =      0.4180 VOL/VOL
  WILTING POINT               =      0.3670 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.4270 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000001000E-06 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

```
 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  4.%
          AND A SLOPE LENGTH OF  180. 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    =    774.153  INCHES
TOTAL INITIAL WATER                 =    774.153  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          SHREVEPORT            LOUISIANA
```

```
STATION LATITUDE                          =  32.28 DEGREES
MAXIMUM LEAF AREA INDEX                   =   4.50
START OF GROWING SEASON (JULIAN DATE)     =     58
END OF GROWING SEASON (JULIAN DATE)       =    331
EVAPORATIVE ZONE DEPTH                    =  12.0  INCHES
AVERAGE ANNUAL WIND SPEED                 =   8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	56.70	64.10	72.20	79.10
82.80	82.40	76.60	66.40	55.80	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SHREVEPORT LOUISIANA AND STATION LATITUDE = 32.28 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 19 THROUGH 28

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	4.01	4.21	5.33	4.86	5.06
	3.89	2.22	3.25	2.21	3.88	3.42
STD. DEVIATIONS	1.93	1.49	1.24	2.54	2.06	1.75
	2.35	2.15	2.00	0.96	0.84	2.85
RUNOFF						
TOTALS	0.062	0.177	0.067	0.153	0.167	0.230
	0.162	0.042	0.074	0.024	0.078	0.094
STD. DEVIATIONS	0.098	0.228	0.124	0.190	0.237	0.303
	0.379	0.113	0.131	0.033	0.045	0.231
EVAPOTRANSPIRATION						
TOTALS	1.710	2.184	2.981	3.588	4.122	3.801
	3.582	1.969	2.381	1.406	1.047	1.304
STD. DEVIATIONS	0.210	0.243	0.831	0.939	1.167	0.612
	1.813	1.515	1.194	0.865	0.330	0.111
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7055	1.7641	1.3620	1.5837	0.9083	0.7742
	0.4328	0.3415	0.4655	0.3695	2.2414	1.9836
STD. DEVIATIONS	1.9678	1.1552	1.0848	1.5086	1.0112	0.7110
	0.7056	0.7335	0.7277	0.4474	0.7845	1.9572
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 9						
TOTALS	0.1582	0.1456	0.1627	0.1559	0.1602	0.1554
	0.1601	0.1602	0.1553	0.1601	0.1551	0.1604
STD. DEVIATIONS	0.0087	0.0063	0.0047	0.0060	0.0043	0.0060

```
                              0.0063   0.0081   0.0063   0.0081   0.0062   0.0074

 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                   0.0194   0.0271   0.0131   0.0214   0.0121   0.0146
                              0.0074   0.0044   0.0061   0.0035   0.0246   0.0230

   STD. DEVIATIONS            0.0235   0.0265   0.0135   0.0213   0.0177   0.0213
                              0.0190   0.0100   0.0097   0.0052   0.0073   0.0306

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   AVERAGES                   0.0129   0.0130   0.0132   0.0131   0.0130   0.0131
                              0.0130   0.0130   0.0131   0.0130   0.0130   0.0130

   STD. DEVIATIONS            0.0007   0.0006   0.0004   0.0005   0.0004   0.0005
                              0.0005   0.0007   0.0005   0.0007   0.0005   0.0006

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   19 THROUGH   28
-------------------------------------------------------------------------------
                                      INCHES           CU. FEET      PERCENT
                                ------------------   -------------   ---------
 PRECIPITATION                   45.34    (   6.841)     164573.3     100.00

 RUNOFF                           1.330   (  0.6931)       4827.82      2.934

 EVAPOTRANSPIRATION              30.074   (  3.6386)     109169.79     66.335

 LATERAL DRAINAGE COLLECTED      13.93206 (  3.58906)     50573.391   30.73001
   FROM LAYER  2
```

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00045 (	0.00016)	1.646	0.00100
AVERAGE HEAD ON TOP OF LAYER 3	0.015 (	0.006)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	1.88917 (	0.05825)	6857.705	4.16696
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 10	0.013 (	0.000)		
CHANGE IN WATER STORAGE	-1.889 (	1.7621)	-6855.41	-4.166

****

****

PEAK DAILY VALUES FOR YEARS 19 THROUGH 28

	(INCHES)	(CU. FT.)
PRECIPITATION	4.10	14883.000
RUNOFF	1.200	4355.8101
DRAINAGE COLLECTED FROM LAYER 2	1.44075	5229.92627
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000100	0.36376
AVERAGE HEAD ON TOP OF LAYER 3	1.384	
MAXIMUM HEAD ON TOP OF LAYER 3	1.791	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	11.3 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00663	24.07152
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.017	

MAXIMUM HEAD ON TOP OF LAYER 10	0.034	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.53	12827.0205
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3211	
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 28

LAYER	(INCHES)	(VOL/VOL)
1	2.9262	0.2439
2	0.0061	0.0245
3	0.0000	0.0000
4	7.6860	0.4270
5	2.9280	0.2440
6	473.7916	0.3159
7	251.6866	0.2797
8	5.9819	0.2492
9	0.0131	0.0810

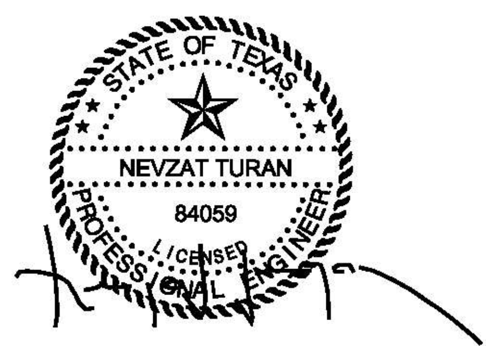
10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

****
****

APPENDIX IIIC-F

CITY OF JACKSONVILLE INDUSTRIAL WASTEWATER DISCHARGE PERMIT

Includes pages IIIC-F-1 through IIIC-F-24



05/20/2024

City of Jacksonville
Industrial Wastewater Discharge Permit

Permit No. 090

In accordance with all of the terms of the City of Jacksonville Industrial Waste Ordinances, and also with any applicable provisions of Federal or State law or regulation, permission is hereby granted to:

ROYAL OAKS LANDFILL

Heath Lane

Jacksonville, Texas 75766

to discharge industrial wastewater into the sanitary sewer of the City of Jacksonville at a point located at Heath Lane, Jacksonville, TX.

This permit is granted in accordance with the application filed on June 30, 2023, in the office of the Manager of Water Quality and with the effluent limitations, monitoring requirements and other conditions set forth in the following.

This permit shall become effective on the date issued, and shall expire at midnight on July 31, 2026, or upon 30 days written notice by the City of Jacksonville.

Date Issued: July 31, 2023

Christina Lyles

Christina Lyles
Pretreatment Coordinator

X

Recieved By

X 7-28-23

Date

PART I - STANDARD CONDITIONS

A. General Conditions and Definitions

1. Severability

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

2. Duty to Comply

The permittee must comply with all conditions of this permit. Failure to comply with the requirements of this permit may be grounds for administrative action or enforcement proceedings including civil or criminal penalties, injunctive relief, and summary abatements.

3. Permit Modification

This permit may be modified for good causes including, but not limited to, the following:

a. To incorporate any new or revised Federal, State, or local pretreatment standards or requirements;

b. Material or substantial alterations or additions to the discharger's operation processes, or discharge volume or character which were not considered in drafting the effective permit;

c. A change in any condition in either the industrial user or the POTW that requires either a temporary or permanent reduction or elimination of the authorized discharge;

d. Information indicating the permitted discharge poses a threat to the City's collection and treatment systems, plant or associated personnel, or the receiving waters;

e. Violation of any terms or conditions of the permit;

f. Misrepresentation or failure to disclose fully all relevant facts in the permit application or in any required reporting;

g. Revision of, or a grant of variance from, such categorical standards pursuant to 40 CFR 403.13 (as applicable);

h. To correct typographical or other errors in the permit;

i. Upon request of the permittee, provided such request does not create a violation of any applicable requirements, standards, laws, or rule and regulations.

The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

5. Permit Termination

This permit may be terminated for the following reasons:

a. Falsifying self-monitoring reports;

b. Tampering with monitoring equipment;

c. Refusing to allow timely access to the facility premises and records.

6. Property Rights

The issuance of this permit does not convey any property rights of any sort, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any violation of Federal, State, or local laws or regulations.

7. Limitation on Permit Transfer

Permits may be reassigned or transferred to a new owner and/or operator with prior approval of the Manager of Water Quality or his delegated representative upon meeting the following conditions:

a. The permittee must give at least thirty (30) days advance notice to the City;

b. The notice must include a written certification by the new owner which:

    i. States that the new owner has no immediate intent to change the facility's operations and processes;
    ii. Identifies the specific date on which the transfer is to occur; and
    iii. Acknowledges full responsibility for complying with the existing permit.

c. A copy of the permit will be provided to a new owner in the event of an approved permit transfer, according to 40 CFR 403.8(f)(1)(iii)(B).

8. Duty to Reapply

If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must submit an application for a new permit at least 90 days before the expiration date of this permit.

9. Continuation of Expired Permits

An expired permit will continue to be effective and enforceable until the permit is reissued if:

a. The permittee has submitted a complete permit application at least ninety (90) days prior to the expiration date of the user's existing permit; and

b. The failure to reissue the permit prior to expiration of the previous permit is not due to any act or failure to act on the part of the permittee.

10. Dilution

The permittee shall not increase the use of potable or process water, or in any way, attempt to dilute an effluent as a partial or complete substitute for adequate treatment to achieve compliance with the limitations contained in this permit.

11. Act of God

In an action brought in municipal or State court, if the permittee can establish that an event that would otherwise be a violation of a pretreatment ordinance or permit issued under the ordinance was caused solely by an Act of God, war, strike, riot, or other catastrophe, the event is not a violation of the ordinance or permit.

B. Definitions

1. Daily Maximum - The maximum allowable discharge of pollutant during a calendar day. Where daily maximum limitations are expressed in units of mass, the daily discharge is the total mass discharged over the course of the day. Where daily maximum limitations are expressed in terms of a concentration, the daily discharge is the arithmetic average measurement of the pollutant concentration derived from all measurements taken that day. Discharges in excess of the Daily Maximum Limit are in violation of this permit.

2. Sampling points – Location (outfall #) where process water sampling takes place. If the Industry has only one (1) sampling location or point, the most stringent limit between categorical standard (or using combined wastestream formula) and local limit shall be used.

3. Composite Sample - A sample that is collected over time, formed either by continuous sampling or by mixing discrete samples. The sample may be composited either as a time composite sample: composed of discrete sample aliquots collected in one container at constant time intervals providing representative samples irrespective of stream flow; or as a flow proportional composite sample: collected either as a constant sample volume at time intervals proportional to stream flow, or collected by increasing the volume of each aliquot as the flow increases while maintaining a constant time interval between the aliquots. The sampling time duration will be specified (i.e., 8-hour, 12-hour, or 24-hour). Composite samples shall contain a minimum of four (4) discrete sample aliquots.

4. Grab Sample - An individual sample collected in less than 15 minutes, without regard for flow or time.

5. Instantaneous Maximum Concentration - The maximum concentration allowed in any single grab sample.

6. Significant Noncompliance: For the purpose of this program, an Industrial User is in Significant Noncompliance if its violation meets one or more of the following criteria:

   a) Chronic violations of wastewater discharge limits, defined here as those in which sixty-six percent (66%) or more of all measurements, including instantaneous limits, taken during a six month period exceed (by any magnitude) a numeric Pretreatment Standard or Requirement, including instantaneous limits, as defined by 40 CFR 403.3(l);

   b) Technical review criteria (TRC) violations, defined here as those in which thirty-three percent (33%) or more of all of the measurements, including instantaneous limits, for each pollutant parameter taken during a six month period equal or exceed the product of the numeric Pretreatment Standard or Requirement including instantaneous limits, as defined by 40 CFR 403.3(l) multiplied by the applicable TRC (=1.4 Fats, oil, and grease, and 1.2 for all other pollutants except pH.); *

   c) Any other violation of a pretreatment effluent limit (Daily maximum or longer term average including instantaneous limits or narrative standard) that the control authority determines has caused, alone or in combination with other discharges, interference or pass through (including endangering the health of the POTW personnel or the general public);

   d) Any discharge of a pollutant that has caused imminent endangerment to human health, welfare or to the environment or has resulted in the POTW's exercise of its emergency authority to halt or prevent such a discharge;

   e) Failure to meet, within ninety days after the schedule date, a compliance schedule milestone contained in a local control mechanism or enforcement order for starting construction, completing construction, or attaining final compliance;

   f) Failure to provide, within 30 days after the due date, required reports such as baseline monitoring reports, 90-day compliance reports, periodic self-monitoring reports, and reports on compliance with compliance schedules;

   g) Failure to accurately report noncompliance;

   h) Any other violation or group of violations which may include a violation of Best management Practices, which the COJ determines will adversely affect the operation or implementation of the local pretreatment program.

   *-NOTE: BOD, COD, AND TSS EXCEEDENCE IS CONTROLLED BY SURCHARGE FOR EXCESSIVE STRENGTH.

7. Cooling Water -

a. Uncontaminated: Water used for cooling purposes only, which has no direct contact with any raw material, intermediate, or final product, and which does not contain a level of contaminants detectable higher than that of the intake water.

b. Contaminated: Water used for cooling purposes only, which may become contaminated either through the use of water treatment chemicals used for corrosion inhibitors or biocides, or by direct contact with process materials and/or wastewater.

8. Monthly Average - The arithmetic mean of the values for effluent samples collected during a calendar month or specified 30 day period (as opposed to a rolling 30 day window).

9. Weekly Average - The arithmetic mean of the values for effluent samples collected over a period of seven consecutive days.

10. Bi-Weekly - Once every other week.

11. Bi-Monthly - Once every other month.

12. Bypass - Means the intentional diversion of wastes from any portion of a treatment facility.

13. Slug Discharge – any discharge of a non-routine, episodic nature, including but not limited to an accidental spill or a non-customary batch discharge, which has a reasonable potential to cause interference or pass through, or in any other way violate the POTW's regulations, local limits, or permit conditions.

C. General Prohibitive Standards

The permittee shall comply with all general prohibitive discharge standards in the Industrial Waste Ordinance. Namely, the industrial user shall not discharge wastewater to the sewer system:

a. Pollutants which create a fire or explosive hazard in the municipal wastewater collection system and POTW, including, but not limited to, waste streams with a close-cup flashpoint of less then 140°F (60°C) using the test methods specified in 40 CFR 261.21.

b. Any wastewater having a pH less than 5.5 or more than 9.5, or otherwise causing corrosive structural damage to the POTW or equipment, or endangering City personnel.

c. Solid or viscous substances in amounts which will cause obstruction of the flow to or within the POTW resulting in interference, but in no case solids greater than 0.5 inches in any dimension.

d. Any wastewater containing pollutants, including oxygen demanding pollutants (BOD_5, COD, etc.), released in a discharge at a flow rate and/or pollutant concentration which, either singly or by interaction with other pollutants, will cause pass through or interference with the POTW or any wastewater treatment or sludge process; or which will constitute a hazard to human or animal life.

e. Any wastewater having a temperature greater than 150°F (65°C), or which will inhibit biological activity in the treatment plant resulting in interference, but in no case wastewater which causes the water temperature at the introduction into the treatment plant to exceed 104°F (40°C).

f. Petroleum oil, nonbiodegradable cutting oil, or products of mineral oil origin in amounts that will cause interference or pass through. Any discharge of such oil is limited to 100 mg/l.

g. Any discharge of fats, oils, or greases of animal or vegetable origin in a concentration greater than 100 mg/l.

h. Any pollutants which result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity that may cause acute worker health and safety problems.

i. Any trucked or hauled pollutants, except at discharge points designated by the ACM in accordance with Section 30-69E.

j. Any noxious or malodorous liquids, gases, solids, or other wastewater which, either singly or by interaction with other wastes, are sufficient to create a public nuisance, a hazard to life, or to prevent entry into the sewers for maintenance and repair.

k. Any wastewater which imparts color that cannot be removed by the treatment process, such as, but not limited to, dye wastes or vegetable tanning solutions, and which consequently imparts color to the treatment plant's effluent thereby violating the City's NPDES permit. Color (in combination with turbidity) shall not cause the treatment plant effluent to reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonably established norm for aquatic life.

l. Any wastewater containing any radioactive wastes or isotopes except as specifically approved by the ACM in compliance with applicable State or Federal regulations.

m. Any wastewater causing the effluent from the treatment plant to fail a toxicity test.

n. Any wastes containing detergents, surface active agents, or other substances which cause excessive foaming in the POTW.

o. Storm water, surface water, ground water, artesian well water, roof runoff, subsurface drainage, swimming pool drainage, condensate, deionized water, non-contact cooling water, and unpolluted industrial wastewater, unless specifically authorized by the Water Quality Manager.

D. Operation and Maintenance of Pollution Controls

1. Proper Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes but is not limited to: effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process control, including appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit.

2. Duty to Halt or Reduce Activity

Upon reduction of efficiency of operation, or loss or failure of all or part of the treatment facility, the permittee shall, to the extent necessary to maintain compliance with its permit, control its production or discharges (or both) until operation of the treatment facility is restored or an alternative method of treatment is provided. This requirement applies, for example, when the primary source of power of the treatment facility fails or is reduced. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

3. Bypass of Treatment Facilities

Bypass is prohibited unless it is unavoidable to prevent loss of life, personal injury, or severe property damage, or no feasible alternatives exist. The permittee may allow bypass to occur which does not cause effluent limitations to be exceeded, but only if it is also for essential maintenance to assure efficient operation.

4. Notification by bypass:

   a. Anticipated bypass - If the permittee knows in advance of the need for a bypass, it shall submit prior written notice, at least ten days before the date of the bypass, to the City of Jacksonville.

   b. Unanticipated bypass - The permittee shall immediately notify the City of Jacksonville, and then submit a written notice to the City within 5 days. This report shall specify:

      i. A description of the bypass, and its cause, including its duration;

      ii. Whether the bypass has been corrected; and

      iii. The steps being taken or to be taken to reduce, eliminate and prevent a recurrence of the bypass.

5. Removed Substances

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewater shall be disposed of in accordance with Section 405 of the Clean Water Act and Subtitles C and D of the Resource Conservation and Recovery Act.

6. Slug Control

A slug discharge is any discharge of a nonroutine, episodic nature, including but not limited to an accidental spill or a noncustomary batch discharge, which has a reasonable potential to cause interference or pass through , or in any other way violate the City's regulations, local limits or permit conditions.

If determined to be necessary, a Slug Control Plan may be required to be prepared by the Industrial User. The minimum requirements to be included in the plan follows:

- Description of discharge practices, including non-routine batch discharges.
- Description of stored chemicals.
- Telephone notice: Procedure for <u>immediately</u> notifying the City of Jacksonville's Chief Wastewater Operator via telephone of any slug discharges, non-routine discharges or accidental discharges, including any discharge which would violate a prohibition under 40 CFR Part 403.5(b). The notification procedure must include provisions for including the time and location of the discharge, type, concentration and volume of the pollutant discharged and corrective actions proposed and/or taken.
- Written notice: Procedure for follow-up written notification to the City of Jacksonville's Pretreatment Department within five days. The notification procedure must include provision of a detailed report describing the cause, time and location of the discharge, the type, concentration and volume of the pollutant discharged, any hazards which may be posed to life or property and the measures taken or to be taken to prevent similar occurrences from happening in the future.
- Procedures to prevent adverse impact from any accidental or slug discharge.

<u>E. Monitoring and Records</u>

1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge. All samples shall be taken at the monitoring points specified in this permit (see PART VI) and, unless otherwise specified, before the effluent joins or is diluted by any other waste stream, body of water or substance. All equipment used for sampling and analysis must be routinely calibrated, inspected and maintained to ensure its accuracy. Monitoring points shall not be changed without notification to, and the approval of, the Manager of Water Quality.

2. Flow Measurements

If flow measurement is required by this permit, the appropriate flow measurement devices and methods consistent with approved scientific practices shall be selected and used to ensure the accuracy and reliability of measurements of the volume of monitored discharges. The devices shall be installed, calibrated, and maintained to ensure that the accuracy of the measurements is consistent with the accepted capability of that type of device. All automatic flow measuring and/or totalizing meters required by this permit for measuring permit limited flows shall be accurately calibrated by a trained person. Such person shall verify in writing that the device is operating properly and giving accurate results. Copies of the verification shall be kept at the plant site for at least three years. Devices selected shall be capable of measuring flows with a maximum deviation of less than 10 percent from true discharge rates throughout the range of expected discharge volumes.

3. Resampling due to Violation of Effluent Limits

If a monitoring event reveals an exceedance of an effluent discharge limit for a single parameter or multiple parameters, the permittee shall resample for that parameter or parameters and submit the reports on the parameter(s) to the City of Jacksonville within thirty (30) days of the permittee becoming aware of the violation. If the required sampling frequency for this parameter is equal to or more frequent than monthly, the permittee may submit the results of the following monitoring period for the resampling requirement, on the approval of the Manager of Water Quality. If approved, the results for the following monitoring period must be submitted within thirty (30) days of the permittee becoming aware of the violation.

When the City of Jacksonville performs sampling for the permitee, the City is required to repeat sampling and analysis within 30 days of becoming aware of the violation.

4. Inspection and Entry

The permittee shall allow duly authorized employees of the City of Jacksonville, or an authorized representative, upon the presentation of proper credentials and other documents as may be required by law, to:

a. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

b. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit;

d. Sample or monitor, for the purposes of assuring permit compliance, and substances or parameters at any locations; and

e. Inspect any production, manufacturing, fabricating, or storage area where pollutants, regulated under the permit, could originate, be stored, or be discharged to the sewer system.

The City of Jacksonville fully acknowledges the right-of-entry for federal and state representatives by laws independent of this permit.

5. Retention of Records

The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, to including documentation of compliance with BMPs (if applicable) for a period of at least three years from the date of the sample, measurement, report or application.

This period may be extended by request of the City of Jacksonville at any time.

All records that pertain to matters that are the subject of special orders or any other enforcement or litigation activities brought by the City of Jacksonville shall be retained and preserved by the permittee until all enforcement activities have concluded and all periods of limitation with respect to any and all appeals have expired.

6. Falsifying Information

Knowingly making any false statement on any report or other document required by this permit or knowingly rendering any monitoring device or method inaccurate is a crime and may result in the imposition of criminal sanctions and/or civil penalties. In accordance with Ordinance 960, "...ANY PERSON WHO VIOLATES OR FAILS TO COMPLY WITH ANY PROVISION OF THIS ORDINANCE SHALL BE GUILTY OF A MISDEMEANOR PUNISHABLE BY A FINE NOT TO EXCEED $2000.00 FOR EACH ACT OF VIOLATION AND FOR EACH DAY OF CONTINUED VIOLATION OF THIS ORDINANCE." (See Section 2)

F. Additional Reporting Requirements

1. 24-Hour Notice for Self-Monitoring effluent violation

The permittee shall give notice to the City of Jacksonville within 24 hours of becoming aware of an effluent violation discovered through self-monitoring.

2. Slug Discharges

The permittee shall give notice to the City of Jacksonville immediately of any slug discharge, including the time and nature of the pollutants discharged to the POTW. The permittee shall then follow up with written notification within five (5) days. The permittee shall also immediately notify the POTW of any changes at its facility affecting the potential of a slug discharge.

3. Planning Changes

The permittee shall give notice to the City of Jacksonville 90 days prior to any facility expansion, production increase, or process modification which results in new or substantially increased discharges or a change in the nature of the discharge.

4. Anticipated Noncompliance

The permittee shall give advance notice to the City of Jacksonville of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

5. Duty to Provide Information

The permittee shall furnish to the City of Jacksonville within 45 days any information which the City may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also, upon request, furnish to the City of Jacksonville within 45 days copies of any records required to be kept by this permit.

6. Signatory Requirements

All applicants, reports, or information submitted to the City of Jacksonville must contain the following certification statement and be signed as required in Sections (a), (b), (c), or (d) below:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

a. by a responsible corporate office, if the Industrial User submitting the reports is a corporation. For the purpose of this paragraph, a responsible corporate office means:

    i. a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy - or decision - making functions for the corporation; or

ii. the manager of one or more manufacturing, production, or operation facilities if authority to sign documents has been assigned or delegated to the manager in accordance with corporation procedures.

b. by a general partner or proprietor if the Industrial User submitting the reports is a partnership or sole proprietorship respectively.

c. The principal executive officer or director having responsibility for the overall operation of the discharging facility if the Industrial User submitting the reports is a Federal, State, or local governmental entity, or their agents.

d. By a duly authorized representative of the individual designated in paragraph (a), (b), or (c) of this section if:

i. the authorization is made in writing by the individual described in paragraph (a), (b), or (c);

ii. the authorization specifies either an individual or a position having responsibility for the overall operation of the facility from which the Industrial Discharge originates, such as the position of plant manager, operator of a well, or a well field superintendent, or a position of equivalent responsibility, or having overall responsibility for environmental matters for the company; and

iii. The written authorization is submitted to the City.

e. If an authorization under paragraph (d) of this section is no longer accurate because a different individual or position has responsibility for the environmental matters for the company, a new authorization satisfying the requirements of paragraph (d) of this section must be submitted to the City prior to or together with any reports to be signed by an authorized representative.

PART II - EFFLUENT LIMITATIONS

During the period starting on the date the permit was issued until July 31, 2026, the permittee is authorized to discharge wastewater to the City of Jacksonville sewer system from the outfall(s) listed below.

Outfall	Description
#001	At pump station next to holding tank at the SW corner of the landfill

B. During the period starting on the date the permit was issued until July 31, 2026, the wastewater discharge from Outfall #1* shall not exceed the following effluent limitations.

OUTFALL #1 CATEGORICAL EFFLUENT LIMITATIONS

Parameter	Daily maximum (mg/L)	Monthly average (mg/L)
Cadmium (Total)	0.11	0.07
Chromium (Total)	2.77	1.80
Copper (Total)	3.38	2.17
Lead (Total)	0.69	0.45
Nickel (Total)	3.98	2.50
Silver (Total)	0.43	0.25
Zinc (Total)	2.61	1.55
Cyanide (Total)	1.20	0.68
Total Toxic Organics (TTO)*		

* The abbreviation TTO means total toxic organics, which is the summation of all quantifiable values greater than 0.01 milligram per liter (mg/L) for the following toxic organics:

Acenaphthene	Bis (2-chloroethoxy) methane	Toluene
Acrolein	Methylene chloride	Trichloroethylene
Acrylonitrile	Methyl chloride	Vinyl chloride
Benzene	Methyl bromide	Aldrin
Benzidine	Bromoform	Dieldrin
Carbon tetrachloride	Dichlorobromomethane	Chlordane
Chlorobenzene	Chlorodibromomethane	4,4-DDT
1,2,4-Trichlorobenzene	Hexachlorobutadiene	4,4-DDE (p,p-DDX)
Hexachlorobenzene	Hexachlorocyclopentadiene	4,4-DDD (p,p-TDE)
1,2,-Dichloroethane	Isophorone	Alpha-endosulfan
1,1,1-Trichloroethane	Naphthalene	Beta-endosulfan
Hexachloroethane	Nitrobenzene	Endosulfan sulfate
1,1-Dichloroethane	2-Nitrophenol	Endrin
1,1,2-Trichloroethane	4-Nitrophenol	Endrin aldehyde
1,1,2,2-Tetrachloroethane	2,4-Dinitrophenol	Heptachlor
Chloroethane	4,6-Dinitro-o-cresol	Heptachlor epoxide
Bis (2-chloroethyl) ether	N-nitrosodimethylamine	Alpha-BHC
2-Chloroethyl vinyl ether	N-nitrosodiphenylamine	Beta-BHC
2-Chloronaphthalene	N-nitrosodi-n-propylamine	Gamma-BHC
2,4,6-Trichlorophenol	Pentachlorophenol	Delta-BHC
Parachlorometa cresol	Phenol	PCB-1242 (Arochlor 1242)

Chloroform
2-Chlorophenol
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3-Dichlorobenzidine
1,1-Dichloroethylene
1,2-Trans-dichloroethylene
2,4-Dichlorophenol
1,2-Dichloropropane

Bis (2-ethylhexyl) phthalate
Butyl benzyl phthalate
Di-n-butyl phthalate
Di-n-octyl phthalate
Diethyl phthalate
Dimethyl phthalate
Benzo(a)Anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(k)fluoranthene

PCB-1254 (Arochlor 1254)
PCB-1221 (Arochlor 1221)
PCB-1232 (Arochlor 1232)
PCB-1248 (Arochlor 1248)
PCB-1260 (Arochlor 1260)
PCB-1016 (Arochlor 1016)
Toxaphene
2,3,7,8-Tetrachlorodibenzo-p-dioxin

1,3-Dichloropropylene
2,4-Dimethylphenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
1,2-Diphenylhydrazine
Ethylbenzene
Fluoranthene
4-Chlorophenyl phenyl ether
4-Bromophenyl phenyl ether
Bis (2-chloroisopropyl) ether

Chrysene
Acenaphthylene
Anthracene
Benzo(ghi)perylene
Fluorene
Phenanthrene
Dibenzo(a,h)anthracene
Indeno(1,2,3-cd) pyrene
Pyrene
Tetrachloroethylene

During the period starting on the date the permit was issued until July 31, 2026, the wastewater discharge from Categorical Outfall #1 shall not exceed the following effluent limitations in accordance with the categorical pretreatment standards of the <u>Landfill Point Source Category (40 CFR Part 445.3)</u>, and is only applicable to production based categorical standards:

Parameter	Production Based Daily Max. (mg/L)
Pentachlorophenol *	(0.032)(21.1)y
Trichlorophenol *	(0.010)(21.1)y

y = wastewater discharged in kilo-gallon per ton of product.

* If the permittee does not use chlorophenolic-containing biocides, it may certify to that effect in lieu of testing. See PART VII for details.

C. During the period starting on the date the permit was issued until July 31, 2026, the effluent from outfall 001 will be of domestic, and noncategorical wastewaters and must comply with the local limits listed below as per Section 21-42

LOCAL EFFLUENT LIMITATIONS

Parameter	Daily Max. (mg/L)
Arsenic	1.74
Cadmium	0.10
Chromium	8.79
Copper	1.43
Cyanide	0.59
Lead	0.26
Mercury**	0.00
Nickel	5.43
Selenium	0.069
Silver	0.26
Zinc	3.01
Total Suspended Solids (TSS) ***	Report
Biochemical Oxygen Demand (BOD) ***	Report
Chemical Oxygen Demand (COD) ***	Report
Flow	Report
pH	5.5-9.5
Oil and Grease	100

* Local Effluent Limitations Applicable
**Compliance will be determined at or below minimum analytical level (MAL).
***The City of Jacksonville reserves the right to surcharge the permittee in accordance to Ordinance 1407 in conjunction with, but not in lieu of, any administrative action imposed.

D. All discharges shall comply with all other applicable laws, regulations, standards, and requirements of the City of Jacksonville and any other applicable Federal and/or State laws, regulations, standards, and requirements, including any such laws, regulations, standards, and requirements that become effective during the term of this permit.

Federal categorical pretreatment standards. The National Categorical Pretreatment Standards found at 40 CFR, Subchapter N, Parts 405-471 are hereby incorporated. Pollutants shall not be discharged into the collection system by any manner as to violate the general pretreatment standards. When wastewater subject to a categorical pretreatment standard is mixed with wastewater not regulated by the same standard, the CA shall impose an alternate limit in accordance with 40 CFR 403.6(e).

E. According to Ordinance 1407, "...Should it be determined by the Water Quality Manager that an industrial user's waste stream does not require that the wastewater collection system, treatment, or other disposal facilities of the City of Jacksonville be improved, expanded, or enlarged in order to treat the waste due to excess volume or character, then the user charge shall consist of a base charge plus a surcharge to distribute operation and maintenance costs and bond service to each user in proportion to his contribution to the total wastewater loading of the treatment plant. The surcharge shall be levied when: (1) the five-day BOD and/or TSS concentrations exceed the Normal Wastewater Discharge level of 700 mg/l, and/or (2) the COD concentrations exceed the normal discharge level of 2,000 mg/l. This shall be calculated according to the following formula."

$$Cs = (0.007B + 0.004S + 0.002D)\ Vu$$

Where: Cs= Surcharge, in dollars for wastewater in excessive concentrations.
B = Concentration of BOD, in mg/l from an industrial user in excess of 700 mg/l.
S = Concentration of TSS, in mg/l from an industrial user in excess of 700mg/l.
D = Concentration of COD, in mg/l in excess of 2,000 mg/l.
Vu= Volume of wastewater from an industrial user, expressed in thousand gallons.

PART III - MONITORING REQUIREMENTS

A. During the period starting on the date the permit was issued until July 31, 2026, the permittee shall monitor Outfall #1[1] for the following parameters, at the indicated frequency:

Parameter	Frequency [3]	Sample Type
Arsenic	Semiannually	24-hour time-weighted composite [2]
Cadmium	Semiannually	24-hour time-weighted composite [2]
Chromium	Semiannually	24-hour time-weighted composite [2]
Copper	Semiannually	24-hour time-weighted composite [2]
Lead	Semiannually	24-hour time-weighted composite [2]
Mercury	Semiannually	24-hour time-weighted composite [2]
Nickel	Semiannually	24-hour time-weighted composite [2]
Selenium	Semiannually	24-hour time-weighted composite [2]
Silver	Semiannually	24-hour time-weighted composite [2]
Zinc	Semiannually	24-hour time-weighted composite [2]
Total Suspended Solids (TSS)	Semiannually	24-hour time-weighted composite [2]
Biochemical Oxygen Demand (BOD)	Semiannually	24-hour time-weighted composite [2]
Chemical Oxygen Demand (COD)	Semiannually	24-hour time-weighted composite [2]
pH	Semiannually	Grab
Oil and Grease	Semiannually	4 grabs

B. During the period starting on the date the permit was issued until July 31, 2026, the permittee shall monitor Categorical Outfall #1[1] for the following parameters, at the indicated frequency:

Parameter	Frequency [3]	Sample Type
Pentachlorophenol [4]	Semiannually	4-part grab
Trichlorophenol [4]	Semiannually	4-part grab

1. See PART VI for sampling location.
2. Composite samples shall contain a minimum of four (4) discrete sample aliquots.
3. If the sample frequency is indicated as monthly, a minimum of one sampling event must occur between the first and last day of the month, inclusively. If N/A, the industry is not required to sample for this parameter unless the permit issuer determines it to be present in significant quantity. If the sample period is listed as Quarterly, at least one sampling event must occur between the periods listed below:

From the first day of:	to	The last day of:
December	to	May
June	to	November

4. The permittee may, in lieu of testing for pentachlorophenol and trichlorophenol, submit certification that no chlorophenolic-containing biocides are used in their processes. See Part VII.

C. All sampling and analysis required by this permit, including the handling and preservation of collected samples, shall be performed in accordance with 40 CFR Part 136 and amendments thereto, otherwise approved by the EPA or as specified in this permit.

1. The permittee must not discharge wastewater containing any of the following substances from any of the outfalls:

   a) Fats, oil, or greases of animal or vegetable origin in concentrations greater than 100 mg/L

   b) Petroleum oil, nonbiodegradable cutting oil, or products of mineral oil origin, in amounts that will cause interference or pass through

   c) Pollutants that create a fire or explosive hazard in the POTW, including but not limited to waste streams with a closed-cup flashpoint of less than 140 degrees Fahrenheit (60 degrees Centigrade) using the methods specified at 40 CFR 261.21

   d) Wastewater that has a temperature greater than 150° F (65° C), or will inhibit biological activity in the treatment plant resulting in interference, but in no case wastewater that causes the temperature at the introduction into the treatment plant to exceed 104 degrees Fahrenheit (40 degrees Celsius)

   e) Solids or viscous substances in amounts that will cause obstruction of flow in the POTW, resulting in interference [but in no case solids greater than 0.5 inches in any dimension.

f) Pollutants, including oxygen-demanding pollutants (e.g., BOD), released in a discharge at a flow rate and/or concentration that, singly or by interaction with other pollutants, will cause interference with the POTW. For the purpose of this section, the term interference has the same definition as that in the City of Jacksonville's ordinance Section 21-38

g) Wastewater having a pH of less than 5.5 or more than 9.5, or otherwise causing corrosive structural damage to the POTW or equipment.

h) Pollutants that result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity that might cause acute worker health and safety problems.

D. All discharges must comply with all other applicable laws, regulations, standards, and requirements contained in DIVISION 2. , Subdivision A and any applicable state and federal pretreatment laws, regulations, standards, and requirements, including any such laws, regulations, standards, or requirements that might become effective during the term of this permit.

PART IV - REPORTING REQUIREMENTS

Monitoring Reports

A. Monitoring information required by this permit shall be summarized and submitted on an Industrial User Self-Monitoring Report Form, supplied by the City, at the frequency stated in the monitoring requirements. The reports shall be submitted to the Manager of Water Quality, City of Jacksonville. Reporting periods shall end on the last day of the month of the reporting period. The Industrial User Self-Monitoring Report shall be submitted no later than the 15th day following the end of the reporting period. The reporting period shall begin on signature date of permit. The report shall indicate the nature and concentration of all pollutants in the effluent for which the sampling and analyses were performed during the calendar month preceding the submission of the report. The following information must be included on each report:

a. the date, time, and exact location of sampling;

b. the name of company and/or individual(s) performing the sampling;

c. the dates the analyses were performed;

d. the name of the company and/or individuals performing the analyses;

e. type of sample (grab, sample-composite, flow-weighted composite);

f. the results of all required analyses

g. chain of custody form

h. analytical method numbers

i. flow measurement

B. If the permittee monitors a pollutant more frequently than required by this permit using test procedures identified in PART II.B above, the results of such monitoring shall be included in any calculations of actual daily maximum or monthly average pollutant discharge, and the results shall be reported in the monthly report submitted to the City of Jacksonville. Such increased monitoring frequency shall also be indicated in the permittee's self-monitoring reports.

C. Best Management Practices: The City of Jacksonville may develop Best Management Practices to implement 40 CFR 403.5(c)(1), (c)(2), and (c)(4). Such BMPs shall be considered local limits and pretreatment standards. If applicable, documentation and reporting of compliance with BMPs and their applicable Categorical Standards will be listed here.

Certification Statements

The permittee is required to sign and submit the following certification statement with all monitoring reports:

> I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. If the permittee monitors any pollutant more frequently than required by this permit, using test procedures prescribed in 40 CFR Part 136 or amendments thereto, or otherwise approved by the U.S. Environmental Protection Agency (EPA) or as specified in this permit, the results of such monitoring must be included in any calculations of actual daily maximum or monthly average pollutant discharge, and results must be reported in the monthly report submitted to the City of Jacksonville. Such an increased monitoring frequency must also be indicated in the monthly report.

B. Automatic Resampling

If the results of the permittee's wastewater analysis indicate that a violation of this permit has occurred, the permittee must do the following:

1. Inform the City of Jacksonville of the violation within 24 hours, and

2. Repeat the sampling and pollutant analysis and submit, in writing, the results of this second analysis within 30 days of becoming aware of the first violation.

C. Accidental Discharge Report

1. The permittee must notify the City of Jacksonville immediately upon the occurrence of spills, including accidental discharges, discharges of a nonroutine, episodic nature, a noncustomary batch discharge, slug loads or slug discharges that might cause potential problems for the POTW or spills that might enter the public sewer. During normal

business hours the City of Jacksonville should be notified by telephone at 903-589-3510. At all other times, the City of Jacksonville should be notified by telephone at 903-721-2254. The notification must include location of discharge; date and time of discharge; type of waste, including concentration and volume; and corrective actions taken. The permittee's notification of accidental releases in accordance with this section does not relieve it of other reporting requirements that arise under local, state, or federal laws.

Within 5 days following an accidental discharge, the permittee shall submit to the City of Jacksonville a detailed written report. The report must specify the following:

a) Description and cause of the upset, slug load, or accidental discharge; the cause thereof; and the impact on the permittee's compliance status. The description should also include location of discharge and type, concentration, and volume of waste.

b) Duration of noncompliance, including exact dates and times of noncompliance and, if the noncompliance is continuing, the time by which compliance is reasonably expected to occur.

c) All steps taken or to be taken to reduce, eliminate, and/or prevent recurrence of such an upset, slug load, accidental discharge, or other conditions of noncompliance.

D. Notification of the Discharge of Hazardous Waste

(Note to the permit writer: The municipality may choose to prohibit the discharge of hazardous wastes.)

1. Any permittee who begins discharging hazardous waste must notify, in writing, the POTW, the EPA Regional Waste Management Division Director, and state hazardous waste authorities of any discharge into the POTW of a substance that, if otherwise disposed of, would be a hazardous waste under 40 CFR Part 261. Such notification must include the name of the hazardous waste as set forth in 40 CFR Part 261, the EPA hazardous waste number, and the type of discharge (continuous, batch, or other). If the permittee discharges more than 100 kilograms of such waste per calendar month to the POTW, the notification also must contain the following information to the extent such information is known and readily available to the permittee: an identification of the hazardous constituents contained in the wastes, an estimation of the mass and concentration of such constituents in the wastestream discharged during that calendar month, and an estimation of the mass of constituents in the wastestream expected to be discharged during the following 12 months. All notifications must take place no later than 180 days after the discharge begins. Any notification under this paragraph must be submitted only once for each hazardous waste discharged. However, notifications of changed conditions must be submitted under section 21-71 of the ordinance. The notification requirement in this section does not apply to pollutants already reported by permittee subject to categorical pretreatment standards.

2. Dischargers are exempt from the requirements of paragraph a above, during a calendar month in which they discharge no more than 15 kilograms of hazardous wastes, unless the wastes are acute hazardous wastes as specified in 40 CFR 261.30(d) and 261.33(e).

Discharge of more than 15 kilograms of nonacute hazardous wastes in a calendar month, or of any quantity of acute hazardous wastes as specified in 40 CFR 261.30(d) and 261.33(e), requires a one-time notification. Subsequent months during which the permittee discharges more than such quantities of any hazardous waste do not require additional notification.

3. If any new regulations are made under section 3001 of Resource Conservation and Recovery Act identifying additional characteristics of hazardous waste or listing any additional substance as a hazardous waste, the permittee must notify the City of Jacksonville Pretreatment Coordinator, the EPA Regional Waste Management Waste Division Director, and state hazardous waste authorities of the discharge of such substance within 90 days of the effective date of such regulations.

4. If any notification is made under this section, the permittee must certify that it has a program in place to reduce the volume and toxicity of hazardous wastes generated to the degree it has determined to be economically practical.

5. This provision does not create a right to discharge any substance not otherwise permitted to be discharged by this ordinance, a permit issued under the ordinance, or any applicable federal or state law.

E. All reports required by this permit must be submitted to the City of Jacksonville at the following address:

City of Jacksonville
Pretreatment Program
1220 South Bolton Street
Jacksonville, TX 75766

Attention: Larry Burney, Pretreatment Coordinator

PART V – SLUG DISCHARGE CONTROL REQUIREMENTS

If necessary, the permittee is required to submit and implement a slug discharge control plan within 90 days of the effective date of this permit. The slug discharge control plan must include, at a minimum, the following:

a) Description of discharge practices, including nonroutine batch discharges

b) Description of stored chemicals

c) Procedures for immediately notifying the City of Jacksonville of slug discharges, including any discharge that would violate a prohibition under 40 CFR 403.5(b), with procedures for follow-up, written notification within 5 days

d) Procedures to prevent adverse impact from accidental spills, including inspection and maintenance of storage areas, handling and transfer of materials, loading and unloading operations, control of plant site runoff, worker training, building of containment structures or equipment, measures for containing toxic organic pollutants, and measures and equipment for emergency response.

PART VI – SPECIAL CONDITIONS

SECTION 1 – ADDITIONAL/SPECIAL MONITORING REQUIREMENTS.

Examples:

a) One-time monitoring for specific pollutants to verify absence (e.g., "The permittee must submit by [date] sampling data for pentachlorophenol and trichlorophenol")

b) Biomonitoring or other toxicity to determine the toxicity of the discharge

c) Development of sludge disposal plan

d) Additional monitoring of pollutants that are limited in the permit in response to noncompliance

SECTION 2 - COMPLIANCE SCHEDULE

A. The permittee must accomplish the following tasks in the designated time period:

	Event	No Later Than
1.	Submit new wastewater pretreatment plant design submission	N/A
2.	Order equipment and materials	N/A
3.	Develop, and submit a copy to the City of Jacksonville, a slug discharge control plan to eliminate or minimize the accidental spill or slug discharge of pollutants into the sewer system	N/A
4.	Implement the slug loading control plan	N/A
5.	Complete installation of wastewater pretreatment plant	N/A
6.	Obtain full pretreatment plant operational status and achieve full compliance	N/A

B. Compliance Schedule Reporting

No later than 14 days following each date in the above schedule, the permittee must submit to the City of Jacksonville a report including, at a minimum, whether it complied with the increment of progress to be met on such date and, if not, the date on which it expects to comply with the increment of progress, the reasons for delay, and the steps being taken to return the project to the schedule established.

PART VII – STANDARD CONDITIONS

[Note: For a list of standard conditions that may be placed in industrial user permits, see Appendix F.]

PART VIII - REOPENER CLAUSE

A. This permit may be reopened and modified to incorporate any new or revised Federal, State, or local pretreatment standards or requirements.

B. This permit may be reopened and modified to incorporate any new or revised requirements contained in a National Categorical Pretreatment Standard promulgated for Landfill Point Source Category (40 CFR Part 445.3), if applicable.