# Attachment G

# Permit Compliance Report

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# Gude Landfill Remediation Design Permitting Compliance Report Montgomery County, Maryland

*Prepared for*

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

*Prepared by*

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January 2020
EA Project No. 15646.01

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Recycled Paper

# Gude Landfill Remediation Design
# Permitting Compliance Report
# Montgomery County, Maryland

*Prepared for*

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 14GP | 2014 General Permit for Stormwater Associated with Construction Activity |
| ACM | Assessment of Corrective Measures |
| the Authority | Northeast Maryland Waste Disposal Authority |
| CFR | Code of Federal Regulations |
| COMAR | Code of Maryland Regulations |
| the County | Montgomery County Department of Environmental Protection, Recycling and Resource Management Division |
| DPS | Department of Permitting Services |
| the Landfill | Gude Landfill |
| M-NCPPC | Maryland-National Capital Park and Planning Commission |
| MDE | Maryland Department of the Environment |
| NOI | Notice of Intent |
| the Remediation Design | Gude Landfill Remediation Project for Montgomery County, Maryland |

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# 1. INTRODUCTION

This Permitting Compliance Report was prepared for the Engineering, Bid Preparation, and Support Services for the Gude Landfill (the Landfill) Remediation Project for Montgomery County, Maryland (the Remediation Design), under the Northeast Maryland Waste Disposal Authority (the Authority) and the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division (the County).

The Landfill Remediation Design is for the recommended Corrective Measure Alternative, Toupee Capping and Additional Landfill Gas Collection, as approved by the Maryland Department of the Environment (MDE) on July 8, 2016.

## 1.1 PURPOSE

The purpose of this Permitting Compliance Report is to present the permits and approvals that are required for the project, the reviewing agencies for each permit, and a description of the permit application process with anticipated timelines. The required permits and approvals for the Remediation Design include:

- Maryland-National Capital Park and Planning Commission (M-NCPPC) Mandatory Referral,
- Montgomery County Department of Permitting Services (DPS) Sediment Control Permit and Stormwater Management Approval,
- MDE Solid Waste Program Approval, and
- 2014 General Permit for Stormwater Associated with Construction Activity (14GP).

Each of these permits or approvals is discussed in a separate section of this report. **Appendix A** provides the detailed written documentation and records for correspondence with all applicable federal, state, and local permitting agencies.

## 2. MARYLAND-NATIONAL CAPITAL PARK AND PLANNING COMMISSION MANDATORY REFERRAL

According to State law (Maryland LAND USE Code Ann. § 20-301 through 305), all federal, state, and local governments and public utilities are required to submit proposed projects involving construction of or impacts to any road, park, public ground, public building, or public utility in Montgomery County for a Mandatory Referral review by the Montgomery County Planning Board. The Mandatory Referral review process includes the following:

I. Preapplication Submission

- Determination of Type of Review

  — Determine if project is eligible for Mandatory Referral:
    - Exempt from Mandatory Referral Process
    - Subject to the Entitlement Process Instead of Mandatory Referral
    - Move Forward as a Mandatory Referral

  — If eligible for Mandatory Referral, determine what type of review is required:
    - Administrative Review by staff for minor projects
    - Full Planning Board Review

- Hold Pre-request Meeting
- Determine Submission Requirements

II. Public Hearing Notification

III. Planning Board Consideration and Recommendation

**Table 1** summarizes the reviewing agencies, permit application process, and anticipated timeline for the M-NCPPC Mandatory Referral.

**Table 1 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Maryland-National Capital Park and Planning Commission (M-NCPPC) Mandatory Referral**

| Reviewing Agencies | Permit Application Process | Anticipated Timeline[(a)] |
|---|---|---|
| Maryland-National Capital Park and Planning Commission | Pre-submission meeting | 1 day |
| | Draft application | 30 days |
| | Authority/County review | 15 days |
| | Final application and submittal to M-NCPPC | 15 days |
| | M-NCPPC review | 30 days |
| | Public Notice Period | 45 days |
| | Planning Board Hearing | 1 day |
| | Anticipated Total Duration | 137 days |
| (a) Timeline is presented in working days (Monday – Friday). | | |

# 3. MONTGOMERY COUNTY DEPARTMENT OF PERMITTING SERVICES

Permitting for sediment control and stormwater management is required per Montgomery County Code Chapter 19 because land-disturbance for this project will exceed five thousand (5,000) square feet and one hundred (100) cubic yards.

This will require an Engineered Plan Sediment Control Permit application, including a Stormwater Management Concept, Erosion and Sediment Control Plan with Stormwater Management design (plans and computations). The plans will be prepared and certified by a Professional Engineer.

The plans will be prepared in accordance with the 2011 Standards and Specifications for Soil Erosion and Sediment Control, the 2000 Maryland Stormwater Design Manual, and any other County DPS requirements.

A pre-application meeting will be held with DPS prior to submitting any applications to ensure all requirements are being met.

**Table 2** summarizes the reviewing agencies, permit application process, and anticipated timeline for the DPS Design Permit.

**Table 2 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Montgomery County Department of Permitting Services (DPS)**

| Reviewing Agencies | Permit Application Process | Anticipated Timeline[(a)] |
|---|---|---|
| Montgomery County Department of Permitting Services | 60% Design Draft Permit Application (to start during 60% Design) | 10 days |
| | Authority/County Review | 5 days |
| | 60% Final Permit Application to DPS | 5 days |
| | DPS Review | 15 days |
| | Draft Responses to DPS Comments (after receiving comments on 60% Design from Authority/County) | 15 days |
| | Authority/County Review | 5 days |
| | Final Responses to DPS Comments | 5 days |
| | 90% Design Draft Permit Application (to start during 90% Design) | 10 days |
| | Authority/County Review | 5 days |
| | 90% Final Permit Application to DPS | 5 days |
| | DPS Review | 15 days |
| | Draft Responses to DPS Comments (after receiving comments on 90% Design from Authority/County) | 15 days |
| | Authority/County Review | 5 days |
| | Final Responses to DPS Comments | 5 days |
| | 100% Draft Permit Application (to start during 100% Design) | 10 days |
| | Authority/County Review | 5 days |
| | 100% Final Permit Application to DPS | 5 days |
| | DPS Backcheck and Approval | 20 days |
| | Anticipated Total Duration | 160 days |
| (a) Timeline is presented in working days (Monday – Friday). | | |

# 4. MARYLAND DEPARTMENT OF THE ENVIRONMENT LAND ADMINISTRATION SOLID WASTE PROGRAM

MDE Land Administration Solid Waste Program approval will be required. A Consent Order, MDE Case No. CO-11-SW-036, was executed in 2013 between MDE and the County, which ordered the County to implement the MDE-approved corrective measures for the Landfill, per the approved Revised Assessment of Corrective Measures (ACM) Report incorporated by reference into the Consent Order. The Revised ACM was approved per MDE's letter dated July 8, 2016, including the recommended corrective measure of Toupee Capping and Additional Landfill Gas Collection.

**Table 3** summarizes the reviewing agencies, permit application process, and anticipated timeline for the MDE Solid Waste Program approval. Documents will be reviewed by MDE for compliance with the Code of Maryland Regulations (COMAR) 26.04.07.21 Sanitary Landfill – Closure and COMAR 26.04.07.22 Sanitary Landfills –Post Closure Monitoring and Maintenance.

**Table 3 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Maryland Department of the Environment (MDE) Land Administration Solid Waste Program**

| Reviewing Agencies | Permit Application Process | Anticipated Timeline[(a)] |
|---|---|---|
| Maryland Department of the Environment | 90% Design Submission to MDE | 45 days |
| | MDE Review | 15 days |
| | Draft Responses to MDE Comments | 15 days |
| | Authority/County Review of Draft Responses to MDE Comments | 5 days |
| | Final Responses to MDE Comments | 5 days |
| | 100% Design Submission to MDE | 20 days |
| | MDE Backcheck and Approval | 20 days |
| | Anticipated Total Duration | 125 days |
| (a) Timeline is presented in working days (Monday – Friday). | | |

# 5. NOTICE OF INTENT FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT 2014 GENERAL PERMIT FOR STORMWATER

This project will require coverage under the General Permit for Stormwater Associated with Construction Activity (14GP) issued by MDE because the project will disturb more than one (1) acre of land. To obtain coverage under the permit, a Notice of Intent (NOI) will be filed.

**Table 4** summarizes the reviewing agencies, permit application process, and anticipated timeline for the NOI for the MDE 14GP.

**Table 4 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Notice of Intent (NOI) for the Maryland Department of the Environment (MDE) 2014 General Permit for Stormwater**

| Reviewing Agencies | Permit Application Process | Anticipated Timeline[(a)] |
|---|---|---|
| Maryland Department of the Environment | Draft NOI | 10 days |
| | Authority/County Review | 10 days |
| | Final NOI Submission to MDE | 2 days |
| | Public Notification Period | 10 days |
| | MDE Approval | 10 days |
| | Anticipated Total Duration | 42 days |
| (a) Timeline is presented in working days (Monday – Friday). | | |

# Appendix A

# Written Documentation and Correspondence Records

# [Future Design Submittals]

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# Attachment H

# Stormwater Management Report

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# Gude Landfill Remediation Design
# Stormwater Management Report
# Montgomery County, Maryland

## Stormwater Concept Submission

*Prepared for*

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Division of Solid Waste Services
Montgomery County, Maryland

*Prepared by*

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December 2019
EA Project No. 15646.01

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# Gude Landfill Remediation Design
# Stormwater Management Report
# Montgomery County, Maryland

## Stormwater Concept Submission

*Prepared for*

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Division of Solid Waste Services
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December 2019
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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| cfs | Cubic feet per second |
| the County | Montgomery County Department of Environmental Protection, Division of Solid Waste Services |
| DA | Drainage Area |
| EA | EA Engineering, Science, and Technology, Inc., PBC |
| ESD | Environmental Site Design |
| HSG | Hydrologic soil group |
| the Landfill | Gude Landfill |
| LOD | Limit of Disturbance |
| M-NCPPC | Maryland-National Capital Park and Planning Commission |
| MDE | Maryland Department of the Environment |
| N/A | Not applicable |
| NRCS | Natural Resources Conservation Service |
| $Q_2$ | 2-Year peak flow |
| $Q_{10}$ | 10-Year peak flow |
| $Q_{100}$ | 100-Year peak flow |
| WRTP-5 | Water Resources Technical Policy 5 |

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# 1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has been contracted to provide engineering, permitting, and support services for developing a remediation design to address the remedial action objectives at the Gude Landfill ("the Landfill") in order to achieve compliance with the consent order for the Landfill (Maryland Department of the Environment [MDE] and Montgomery County 2013).

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. Refer to Figure 1 for a vicinity and location map. The site is accessed at two locations: East Gude Drive from the south-southwest and Southlawn Lane from the east-southeast.

The Landfill is currently owned and maintained by the Montgomery County Department of Environmental Protection, Division of Solid Waste Services (the County). The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres, of which approximately 140 acres were used for waste disposal. An additional 17 acres of waste disposal area were delineated in 2009 on Maryland-National Capital Park and Planning Commission (M-NCPPC) property, beyond the northeastern property boundary of the Landfill. A land exchange between the County and M-NCPPC on 21 October 2014 transferred ownership of this additional waste disposal area to the County in exchange for a similar area of land without waste, which was transferred to M-NCPPC.

Landfill capping was selected as a corrective measure for the upper surface of the Landfill, as well as portions of the side-slopes of the Landfill where placement of a closure capping system is feasible. EA's design includes the following major elements as part of the corrective measure:

- Erosion and sediment control,
- Existing waste reconfiguration and subgrade establishment,
- Landfill closure cap construction,
- Landfill gas management, and
- Stormwater management.

Stormwater management is necessary to mitigate the effects of development on the receiving stream system. The post-development ground surface, including impervious area, will be similar to the pre-development ground surface; however, the post-development ground surface slopes may be steeper than the pre-development slopes to promote drainage and minimize the potential for stormwater ponding on the Landfill cap.

A stormwater management design must ensure mitigation through practices described in the *2000 Maryland Stormwater Design Manual* as amended and with Montgomery County design requirements based on Chapter 19 of the Montgomery County Code. Environmental Site Design (ESD) features must be used to the maximum extent practicable to reduce stream pollution, erosion, and flooding. Pre-development runoff characteristics must be maintained as nearly as possible.

The approach to stormwater management is generally divided into quantity and quality control. This stormwater management report has been prepared to document the stormwater management design associated with the remediation design.

# 2. QUANTITY CONTROL

Stormwater quantity control must be provided to ensure that pre-development runoff characteristics are maintained as nearly as possible. EA analyzed the 2-year, 10-year, and 100-year storm events. The existing and proposed conditions hydrology was analyzed to establish runoff characteristics.

## 2.1 SOILS ANALYSIS

The Natural Resources Conservation Service (NRCS) Web Soil Survey was used to determine the soils onsite and in the vicinity and their properties. The NRCS Web Soil Survey report is included in Appendix A. The soils found throughout the project and in the vicinity have also been summarized in Table 1.

**Table 1 Soil Map Units and Soil Hydrologic Groups**

| Map Symbol | Soils Series | Hydrologic Soils Group |
|---|---|---|
| 1B | Gaila silt loan, 3 to 8 percent slopes | B |
| 1C | Gaila silt loam, 8 to 15 percent slopes | B |
| 2B | Glenelg silt loam, 3 to 8 percent slopes | B |
| 4B | Eliok silt loam, 3 to 8 percent slopes | C |
| 5A | Glenville silt loam, 0 to 3 percent slopes | C |
| 5B | Glenville silt loam, 3 to 8 percent slopes | C/D |
| 6A | Baile silt loam, 0 to 3 percent slopes | C/D |
| 16D | Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes | C |
| 17C | Ococoquan loam, 8 to 15 percent slopes | B |
| 54A | Hatboro silt loam, 0 to 3 percent slopes, frequently flooded | B/D |
| 100 | Dumps, refuse | N/A |
| 116D | Blocktown channery silt loam, 15 to 25 percent slopes, very rocky | D |
| 116E | Blocktown channery silt loam, 25 to 45 percent slopes, very rocky | D |

## 2.2 CURVE NUMBER DETERMINATION

The top of the Landfill consists of tall grasses with several dirt/gravel access roads. Runoff characteristics were determined by SCS Engineers in 1992 as part of developing the *Gude Landfill Post Closure Engineering Design and Management Tasks* plans. The SCS Engineers analysis considered the grassed areas to be “pasture.” Applicable drawings from the SCS Engineers plans are included in Appendix B.

EA’s analysis assumes the same land use category for the grassed areas as the SCS Engineers analysis. While there is no hydrologic soil group (HSG) rating for the soil within the footprint of the Landfill, the SCS Engineers analysis assumed HSG D soils. EA is maintaining this assumption.

## 2.3 EXISTING DRAINAGE AREA ANALYSIS

The hydrologic analyses contained within this report are based upon the methods outlined in the NRCS TR-55 Manual, WinTR-55 software, and the *2000 Maryland Stormwater Design Manual*.

The TR-55 hydrologic method computations and procedures were utilized to determine the weighted runoff curve number and time of concentration for the existing conditions of the site. Rainfall depths associated with Montgomery County from NOAA Atlas 14 were used for design. Drainage at the Landfill can be divided into 11 drainage areas (DAs), shown in the existing conditions drainage area map (Figure 2). Table 2 summarizes the existing conditions hydrology at the Landfill. Calculations are included in Appendix C.

**Table 2 Existing Conditions Hydrology Summary**

| | Existing | | | | | |
|---|---|---|---|---|---|---|
| **Drainage Area** | **Area (acres)** | **Runoff Curve Number** | **$Q_2$ (cfs)** | **$Q_{10}$ (cfs)** | **$Q_{100}$ (cfs)** | **Discharge Point** |
| DA-1A | 36.50 | 80 | 42.2 | 86.1 | 182.8 | Pond 3 Bypass |
| DA-1B | 15.69 | 81 | 22.6 | 45.0 | 93.9 | Pond 3 |
| DA-2 | 27.61 | 80 | 31.8 | 64.9 | 137.9 | Pond 1 |
| DA-3 | 12.68 | 80 | 14.8 | 30.2 | 64.1 | Sheet Flow |
| DA-4 | 9.10 | 78 | 9.1 | 19.3 | 42.5 | Pond 2 |
| DA-5 | 17.70 | 77 | 18.7 | 40.5 | 90.2 | M-NCPPC Pond |
| DA-6 | 15.19 | 67 | 9.2 | 26.8 | 72.1 | Southlawn Branch |
| DA-7 | 5.80 | 78 | 7.8 | 16.4 | 35.7 | Southlawn Branch |
| DA-8 | 3.88 | 80 | 5.4 | 10.9 | 23.2 | Southlawn Branch |
| DA-9 | 4.16 | 79 | 5.4 | 11.2 | 24.0 | Southlawn Branch |
| DA-10 | 0.99 | 80 | 1.3 | 2.6 | 5.6 | Southlawn Branch |
| DA-11 | 3.15 | 78 | 4.1 | 8.7 | 19.0 | Southlawn Branch |

Notes: cfs = cubic feet per second.
$Q_2$ = 2-Year peak flow.
$Q_{10}$ = 10-Year peak flow.
$Q_{100}$ = 100-Year peak flow.

## DA-1A and DA-1B

DA-1A consists of a 36.50-acre area while DA-1B is 15.69 acres. These drainage areas are located centrally at the site. Both DA-1A and DA-1B drain toward Pond 3, located on the east side of Incinerator Lane at the southern portion of the Landfill. According to a drawing developed by SCS Engineers in 2008, a stormwater bypass system was installed at Pond 3 to divert drainage from DA-1A into a 36-inch-diameter high-density polyethylene pipe and ultimately to the Southlawn Branch Stream. The stormwater bypass drawing is included in Appendix D. Pond 3 receives drainage from DA-1B and also discharges to Southlawn Branch.

## DA-2

DA-2 receives drainage from a 27.61-acre area on the western portion of the Landfill. Drainage from DA-2 is conveyed to Pond 1, which is located at the base of the Landfill in the southeast portion of the site. Based on discussion with the Department of Permitting Services, Pond 1 functions as a regional stormwater pond for Montgomery County and receives drainage from the commercial property to the west and a portion of East Gude Drive. Pond 1 discharges to Southlawn Branch to the south.

**DA-3**

DA-3 is an approximate 12.68-acre area located on the northwest portion of the Landfill. Drainage from a portion of the upper Landfill surface and the majority of the northwest slope is conveyed to a low spot and discharges by sheet flow to the northwest.

**DA-4**

DA-4 receives drainage from a 9.10-acre area located at the northeast portion of the site. Drainage is conveyed to a depressed area (Pond 2) and ultimately discharges to Crabbs Branch to the north. The topography in the vicinity of this pond is very steep.

**DA-5**

DA-5 is a 17.70-acre area located at the northeastern portion of the site, primarily consisting of the Landfill side slopes. Discharge from DA-5 is conveyed to M-NCPPC Pond, which discharges to Rock Creek to the east.

**DA-6**

DA-6 receives drainage from an approximate 15.19-acre area on the east portion of the Landfill. Discharge from DA-6 is conveyed to the south and ultimately Southlawn Branch.

**DA-7**

DA-7 receives drainage from an approximate 5.80-acre area on the southeast portion of the Landfill. Discharge from DA-7 is conveyed southeast to a stormdrain system and ultimately Southlawn Branch.

**DA-8**

DA-8 receives drainage from an approximate 3.88-acre area on the southern portion of the Landfill. Discharge from DA-8 is conveyed to southeast to a stormdrain system and ultimately Southlawn Branch.

**DA- 9**

DA- 9 is located at the southern portion of the Landfill and receives drainage from approximately 4.16 acres. The majority of this drainage area consists of the Landfill side slopes. Drainage from DA-9 is conveyed south to Sediment Basin B and ultimately Southlawn Branch.

**DA-10**

DA-10 receives drainage from an approximate 0.99-acre area on the southern portion of the Landfill. The majority of this drainage area consists of the Landfill side slopes. Discharge from DA-10 is conveyed overland and discharges offsite in a southernly direction to Southlawn Branch.

**DA-11**

DA-11 receives drainage from an approximate 3.15-acre area on the southern portion of the Landfill. The majority of this drainage area consists of the Landfill side slopes. Discharge from DA-11 enters a yard inlet, is conveyed through a culvert under an access road, and is ultimately discharged in a southernly direction to Southlawn Branch.

## 2.4 PROPOSED DRAINAGE AREA ANALYSIS

Drainage areas were delineated for the proposed grading plan and are identified in the proposed conditions drainage area map (Figure 3). Existing drainage patterns were maintained to the greatest extent possible. EA assumed HSG D soils for the cap conditions. The increase in discharge to DA-1B will be mitigated with an increase in the footprint of Pond 3, which is further discussed in Section 4.1. Table 3 summarizes the changes in peak discharges from existing conditions to proposed conditions at the Landfill.

**Table 3 Hydrology Comparison Summary**

| Drainage Area | Existing | | | Proposed | | | Discharge Point |
|---|---|---|---|---|---|---|---|
| | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) | |
| DA-1A | 42.2 | 86.1 | 182.8 | 36.8 | 75.3 | 160.3 | Pond 3 Bypass |
| DA-1B | 22.6 | 45.0 | 93.9 | 32.8 | 66.8 | 142.3 | Pond 3 |
| DA-2 | 31.8 | 64.9 | 137.9 | 29.1 | 59.1 | 125.1 | Pond 1 |
| DA-3 | 14.8 | 30.2 | 64.1 | 13.7 | 27.3 | 56.8 | Sheet Flow |
| DA-4 | 9.1 | 19.3 | 42.5 | 9.6 | 20.3 | 44.3 | Pond 2 |
| DA-5 | 18.7 | 40.5 | 90.2 | 17.1 | 38.7 | 89.2 | M-NCPPC Pond |
| DA-6 | 9.2 | 26.8 | 72.1 | 9.0 | 26.3 | 70.7 | Southlawn Branch |
| DA-7 | 7.8 | 16.4 | 35.7 | 7.8 | 16.4 | 35.7 | Southlawn Branch |
| DA-8 | 5.4 | 10.9 | 23.2 | 4.6 | 9.4 | 20.0 | Southlawn Branch |
| DA-9 | 5.4 | 11.2 | 24.0 | 5.2 | 10.8 | 23.3 | Southlawn Branch |
| DA-10 | 1.3 | 2.6 | 5.6 | 1.3 | 2.5 | 5.3 | Southlawn Branch |
| DA-11 | 4.1 | 8.7 | 19.0 | 4.1 | 8.6 | 18.8 | Southlawn Branch |

Notes: cfs = cubic feet per second.
$Q_2$ = 2-Year peak flow.
$Q_{10}$ = 10-Year peak flow.
$Q_{100}$ = 100-Year peak flow.

### DA-1A and DA-1B

DA 1-A (34.78 acres) and DA 1-B (28.82 acres) will drain to the same points of investigation as existing conditions. EA proposes to maintain a flow bypass to divert the same quantity or less of drainage as existing conditions. Since discharge to the existing flow bypass increases in the proposed conditions, some of the bypass drainage area is diverted to Pond 3. Pond 3 will be expanded to manage the additional drainage in proposed conditions. Additional discussion of the Pond 3 expansion is included in Section 4.1.

### DA-2

DA-2 (21.47 acres) discharges to Pond 1. Pond 1 is a regional stormwater pond that receives discharge from the commercial property to the west owned by EB Rockville, LLC and a portion of East Gude Drive. The design approach will decrease the size of DA-2. Discharge from DA-2 will not significantly change from existing conditions.

**DA-3**

DA-3 will decrease from 12.68 to 9.43 acres. Discharge from DA-3 is conveyed by sheet flow to the northwest in existing conditions. Under proposed conditions, the same method of conveyance is proposed, but the quantity of discharge is reduced.

**DA-4**

DA-4 will decrease from 9.10 to 8.01 acres. The decrease in drainage area limits proposed conditions discharges to quantities comparable to existing discharges.

**DA-5**

DA-5 will slightly increase in size from 17.70 to 17.94 ac. However, discharge will decrease from existing conditions.

**DA-9**

DA-9 will slightly increase in size from 4.16 to 4.24 ac. However, discharge will decrease from existing conditions.

**DA-11**

DA-11 will slightly increase in size from 3.15 to 3.18 ac. However, discharge will decrease from existing conditions.

**Drainage Areas 6, 7, 8, and 10**

DA-6 and DA-7 will slightly decrease from 15.19 ac. to 15.13 ac. and 5.80 ac. to 5.78 ac., respectively. DA-8 will decrease from 3.88 ac. to 3.34 ac. and DA-10 will decrease from 0.99 ac. to 0.84 ac. The decrease in drainage areas limit proposed conditions discharges to quantities below existing discharges. The ultimate manner of discharge does not change and no modifications are proposed.

# 3. QUALITY CONTROL

Stormwater quality control must be provided for any new impervious areas at the Landfill. The site is classified as new development because it has less than 40 percent impervious area. Stormwater quality will be addressed by implementing ESD to the maximum extent practicable. The Montgomery County Department of Permitting Services Water Resources Technical Policy 5 (WRTP-5) establishes design guidance for stormwater quality management. According to WRTP-5, ESD practices should modify the developed runoff conditions to be consistent with "woods in good condition" hydrology. A target ESD volume is determined based on new impervious area.

New impervious areas include the net increase of proposed gravel access roads throughout the upper surface of the Landfill. The 0.86 ac. increase in impervious area is included in the overall 5.2 ac. impervious area within the 91.97 ac. limit of disturbance (LOD) associated with the remediation project. Considering the entire LOD, the target ESD volume is 19,502 cubic feet, based on a rainfall target $P_E$ of 1-inch. The ESD volume calculations are included in Appendix E.

The design will utilize disconnection of non-rooftop runoff for the gravel access roads and impervious area removal for some existing site roads. As the majority of the upper surface Landfill slopes are four percent or less, non-rooftop runoff disconnects (N-2) are anticipated to meet a portion (3,700 cubic feet) of the rainfall target $P_E$ of 1-inch (Appendix E).

No micro-scale practices are considered because MDE does not permit infiltration on the Landfill. The Landfill is defined as a "hotspot" per MDE Stormwater Management Guidelines; therefore, no recharge volume is required.

No structural stormwater storage is proposed because no standing water is permitted on the Landfill. The Landfill cap will extend to the property line and forested areas and it is not feasible to construct new features around the perimeter of the Landfill.

As the ESD volume is not fully met, the site is subject to channel protection volume ($CP_v$). All or a portion of the CPv may be met through modifications to Pond 3. Further analysis will be performed during future design stages.

In addition to the constraints outlined above, this is not a development project, but a remediation/maintenance project to further protect the environment. The physical character of the site will not be altered significantly by this project. The design intends to meet ESD to the maximum extent practicable.

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# 4. STORMWATER MANAGEMENT

## 4.1 EXPANSION OF POND 3

Based on the results presented in Table 3, runoff flow rates increase in DA-1B. Pond 3 receives drainage from this drainage area.

Modifications to Pond 3 will be required to manage discharge to pre-development conditions to the greatest extent possible. Using methods from the NRCS TR-55 Manual, EA calculated the approximate storage volume required for managing the increased runoff to existing conditions for the ten (10)-year storm. A conceptual expansion footprint of Pond 3 was estimated assuming a depth of two (2) feet. Pond 3 will be expanded to the west. Preliminary pond sizing calculations are included in Appendix F. Table 4 shows the required additional volume and acreage for the existing facility.

**Table 4 Estimated Additional Pond Capacity Requirements**

| Facility | Approximate Additional Storage Required (cubic feet) | Estimated Additional Footprint Required | |
|---|---|---|---|
| | | (square feet) | (acres) |
| Pond 3 | 87,295 | 43,647 | 1.00 |

## 4.2 NEW CONSTRUCTION OF NORTHWEST SLOPE DISCHARGE FACILITY

Drainage on the upper surface of the Landfill is conveyed primarily by a network of open channel swales. The swales convey drainage to the pond or to existing stormdrain networks along the perimeter of the Landfill. Stormwater runoff on the west and northwest slope will be conveyed by benches and downchutes to a swale at the base of the slope. A facility will be designed at the low point of the swale to discharge stormwater as sheet flow offsite.

## 4.3 INTEGRATION OF STORMWATER MANAGEMENT AND EROSION AND SEDIMENT CONTROL

The design will include a phased construction approach. Grading will be limited to twenty (20)-acre areas based on the limit imposed by the *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*, even though this limit has been subsequently increased beyond 20 ac. Phase boundaries will consider the drainage patterns. Proposed Pond 3 may be used as a sediment basin during construction. Further analysis will be required in future design stages.

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# 5. REFERENCES

Maryland Department of the Environment (MDE). 2011. *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*.

Maryland Department of the Environment (MDE) and Montgomery County. 2013. Consent Order (Gude Landfill). MDE Case Number CO-11-SW-036. 28 May.

Montgomery County Code. Chapter 19. Article II. *Stormwater Management*.

Montgomery County Department of Permitting Services. 2016. *Water Resources Technical Policy 5; Computation of Required ESD Volume*. January.

Natural Resources Conservation Service (NRCS). 1986. *Urban Hydrology for Small Watersheds; Technical Release 55*. June.

SCS Engineers. 1992. *Gude Landfill Post Closure Engineering Design and Management Tasks*. Drawings.

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# Figures

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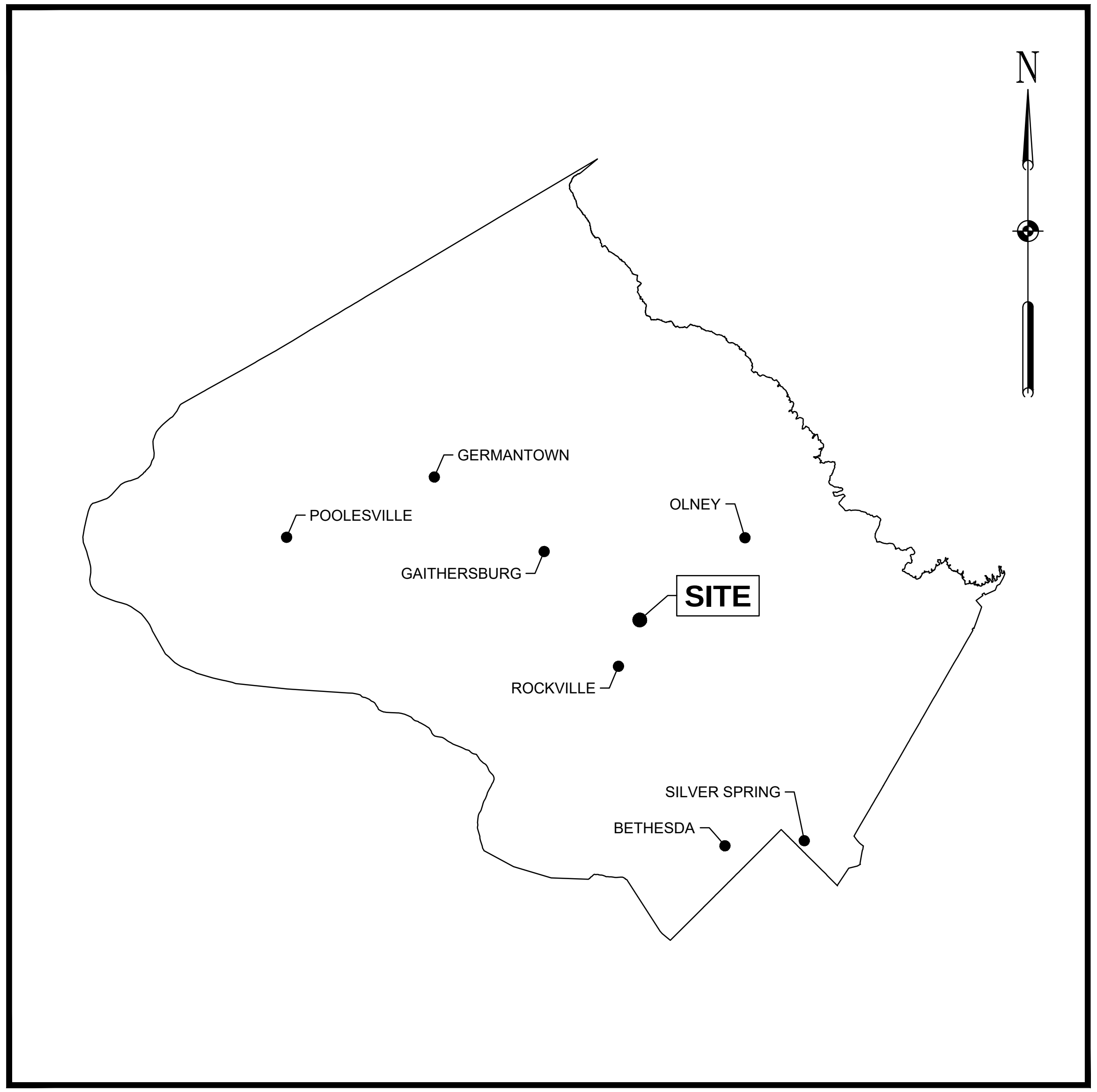
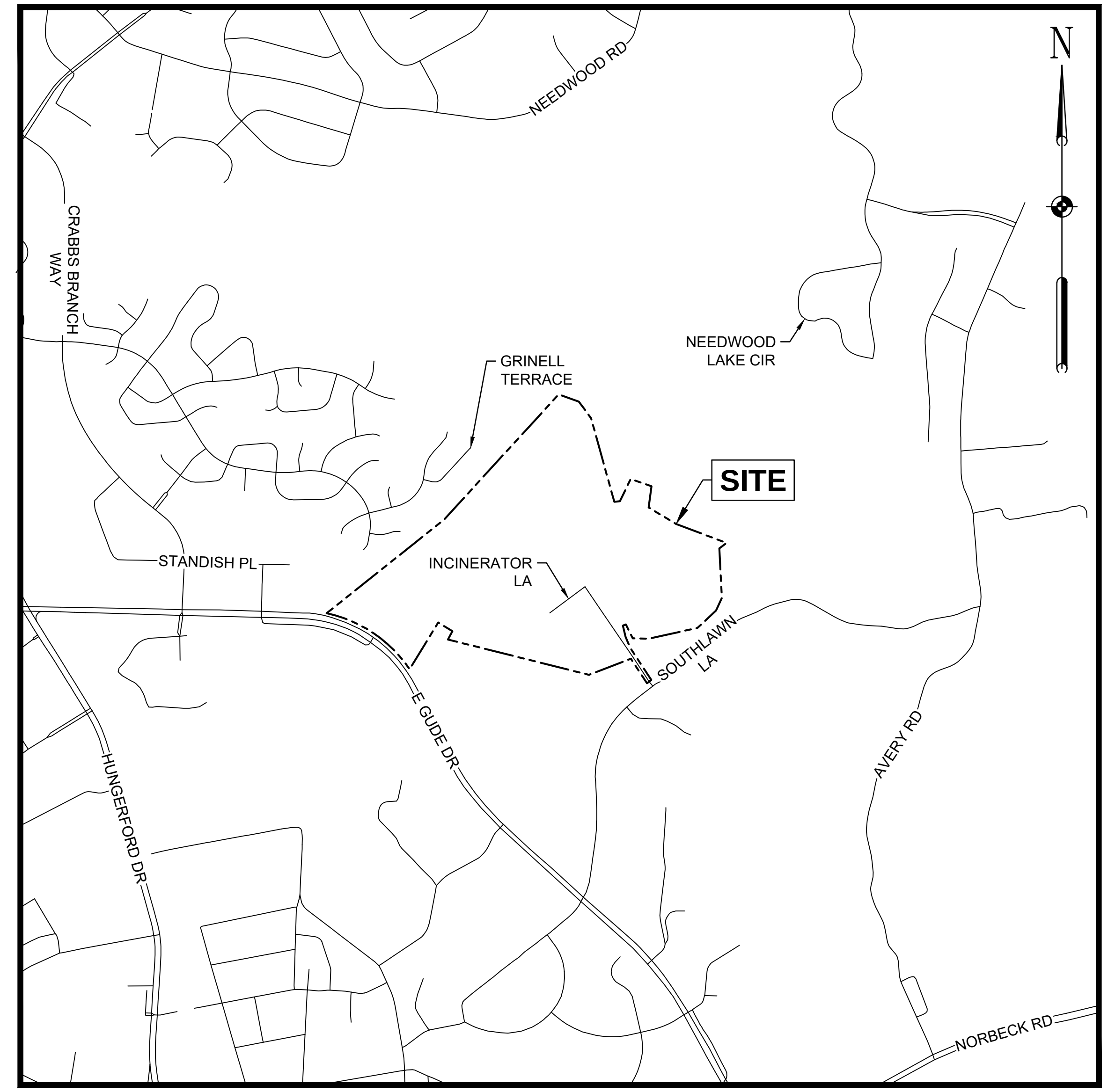



**LOCATION MAP - MONTGOMERY COUNTY, MARYLAND**
NOT TO SCALE




**VICINITY MAP**
SCALE: 1" = 2,000'

0 1000 2000 4000
GRAPHIC SCALE IN FEET

FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\SWM\FIGURE 1 - VICINITY AND LOCATION MAP.DWG [FIGURE 1] 4/30/19

| | | | | | | |
|---|---|---|---|---|---|---|
| **EA Engineering, Science, and Technology, Inc., PBC** Hunt Valley Center 225 Schilling Circle, Suite 400 Hunt Valley, Maryland 21031 (410) 584-7000 | PROJECT NUMBER: 1564601 | DESIGNED BY: KEF/SMB | DRAWN BY: SMB | FIGURE: 1 | **GUDE LANDFILL REMEDIATION DESIGN NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY** MONTGOMERY COUNTY, MARYLAND | **FIGURE 1 - LOCATION AND VICINITY MAP** |
| | DATE: DECEMBER 2019 | CHECKED BY: LJO | PROJECT MGR.: MJG | SHEET NUMBER: 1 OF 1 | | |

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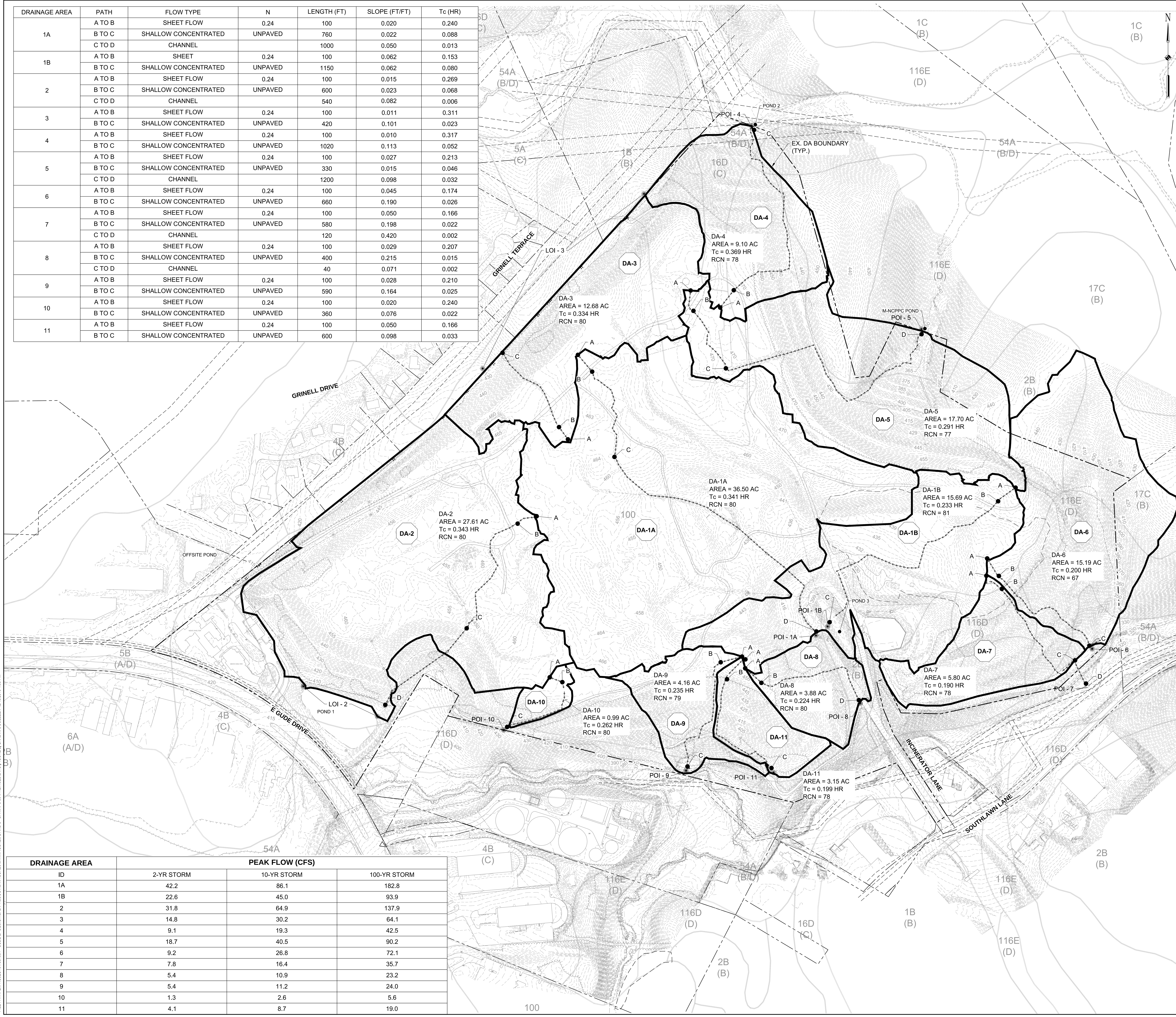
| DRAINAGE AREA | PATH | FLOW TYPE | N | LENGTH (FT) | SLOPE (FT/FT) | Tc (HR) |
|---|---|---|---|---|---|---|
| 1A | A TO B | SHEET FLOW | 0.24 | 100 | 0.020 | 0.240 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 760 | 0.022 | 0.088 |
| | C TO D | CHANNEL | | 1000 | 0.050 | 0.013 |
| 1B | A TO B | SHEET | 0.24 | 100 | 0.062 | 0.153 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 1150 | 0.062 | 0.080 |
| 2 | A TO B | SHEET FLOW | 0.24 | 100 | 0.015 | 0.269 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 600 | 0.023 | 0.068 |
| | C TO D | CHANNEL | | 540 | 0.082 | 0.006 |
| 3 | A TO B | SHEET FLOW | 0.24 | 100 | 0.011 | 0.311 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 420 | 0.101 | 0.023 |
| 4 | A TO B | SHEET FLOW | 0.24 | 100 | 0.010 | 0.317 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 1020 | 0.113 | 0.052 |
| 5 | A TO B | SHEET FLOW | 0.24 | 100 | 0.027 | 0.213 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 330 | 0.015 | 0.046 |
| | C TO D | CHANNEL | | 1200 | 0.098 | 0.032 |
| 6 | A TO B | SHEET FLOW | 0.24 | 100 | 0.045 | 0.174 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 660 | 0.190 | 0.026 |
| 7 | A TO B | SHEET FLOW | 0.24 | 100 | 0.050 | 0.166 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 580 | 0.198 | 0.022 |
| | C TO D | CHANNEL | | 120 | 0.420 | 0.002 |
| 8 | A TO B | SHEET FLOW | 0.24 | 100 | 0.029 | 0.207 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 400 | 0.215 | 0.015 |
| | C TO D | CHANNEL | | 40 | 0.071 | 0.002 |
| 9 | A TO B | SHEET FLOW | 0.24 | 100 | 0.028 | 0.210 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 590 | 0.164 | 0.025 |
| 10 | A TO B | SHEET FLOW | 0.24 | 100 | 0.020 | 0.240 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 360 | 0.076 | 0.022 |
| 11 | A TO B | SHEET FLOW | 0.24 | 100 | 0.050 | 0.166 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 600 | 0.098 | 0.033 |




| DRAINAGE AREA | PEAK FLOW (CFS) | | |
|---|---|---|---|
| ID | 2-YR STORM | 10-YR STORM | 100-YR STORM |
| 1A | 42.2 | 86.1 | 182.8 |
| 1B | 22.6 | 45.0 | 93.9 |
| 2 | 31.8 | 64.9 | 137.9 |
| 3 | 14.8 | 30.2 | 64.1 |
| 4 | 9.1 | 19.3 | 42.5 |
| 5 | 18.7 | 40.5 | 90.2 |
| 6 | 9.2 | 26.8 | 72.1 |
| 7 | 7.8 | 16.4 | 35.7 |
| 8 | 5.4 | 10.9 | 23.2 |
| 9 | 5.4 | 11.2 | 24.0 |
| 10 | 1.3 | 2.6 | 5.6 |
| 11 | 4.1 | 8.7 | 19.0 |

## LEGEND

DESCRIPTION | EXISTING | PROPOSED

BENCHMARK, PROPERTY BOUNDARY, PROPERTY MARKER, LIMIT OF FIELD RUN TOPOGRAPHY, CONTOUR, CONCRETE, FENCE, FENCE POST, GATE POST, SIGN, BOLLARD, MANHOLE - UNKNOWN, MONITORING WELL (MW), SOIL BORING / TEST PIT (SB / TP), TREE/BRUSH LINE, TREE, WETLAND, WETLAND BUFFER, EDGE OF WATER, FEMA FLOODPLAIN, STEEP SLOPE, SOIL BOUNDARY, SOIL CLASSIFICATION, STORM DRAIN STRUCTURE LABEL, STORM DRAIN PIPE, STORM DRAIN UTILITY MARKING, STORM DRAIN MANHOLE, STORM DRAIN INLET, SANITARY SEWER PIPE, SANITARY SEWER UTILITY MARKING, SANITARY SEWER MANHOLE, SANITARY SEWER CLEANOUT (CO), WATER PIPE (NA), WATER UTILITY MARKING, WATER MANHOLE, WATER METER, WATER VALVE (WV), WELL, FIRE HYDRANT, ELECTRIC LINE - UNDERGROUND (NA), ELECTRIC LINE UTILITY MARKING (UNDERGROUND), ELECTRIC LINE - OVERHEAD, ELECTRIC MANHOLE, ELECTRIC JUNCTION BOX, ELECTRIC TRANSFORMER, LIGHT POLE, UTILITY POLE, GUY WIRE, GUY POLE, GAS LINE (NA), GAS LINE UTILITY MARKING, GAS MANHOLE, GAS METER, GAS VALVE (GV), COMMUNICATIONS/CATV - UNDERGROUND (NA), COMMUNICATIONS/CATV - UTILITY MARKING, COMMUNICATIONS/CATV MANHOLE, COMMUNICATIONS/CATV PEDESTAL (C), TELEPHONE - UNDERGROUND (NA), TELEPHONE - UTILITY MARKING, TELEPHONE MANHOLE, TELEPHONE PEDESTAL (T)

0 100 200 400
GRAPHIC SCALE IN FEET

REVISIONS
NO. | DATE | BY | DESCRIPTION

DESIGN INFORMATION
DESIGNED BY: KEF / SMB
DRAWN BY: SMB
CHECKED BY: LJO/GAT
PROJECT MANAGER: MJG

PROFESSIONAL CERTIFICATION. I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 23402 EXPIRATION DATE: 8/25/2020

SEAL

# GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
MONTGOMERY COUNTY DEPARTMENT OF ENVIRONMENTAL PROTECTION
MONTGOMERY COUNTY, MARYLAND

## FIGURE 2: DRAINAGE AREA MAP - EXISTING CONDITIONS

EA Engineering, Science, and Technology, Inc., PBC
Hunt Valley Center
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

DATE: DECEMBER 2019
PROJECT NUMBER: 1564601

FIGURE 2
SHEET: - OF -

| DRAINAGE AREA | PATH | FLOW TYPE | N | LENGTH (FT) | SLOPE (FT/FT) | Tc (HR) |
|---|---|---|---|---|---|---|
| 1A | A TO B | SHEET FLOW | 0.24 | 100 | 0.009 | 0.330 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 391 | 0.036 | 0.035 |
| | C TO D | CHANNEL | | 1153 | 0.024 | 0.033 |
| | E TO F | | | 485 | 0.060 | 0.009 |
| 1B | A TO B | SHEET | 0.24 | 100 | 0.013 | 0.285 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 339 | 0.021 | 0.040 |
| | C TO D | CHANNEL | | 1331 | 0.034 | 0.028 |
| 2 | A TO B | SHEET | 0.24 | 100 | 0.040 | 0.182 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 78 | 0.056 | 0.006 |
| | C TO D | CHANNEL | | 771 | 0.130 | 0.007 |
| | E TO F | | | 1680 | 0.016 | 0.044 |
| 3 | A TO B | SHEET FLOW | 0.24 | 100 | 0.035 | 0.192 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 68 | 0.035 | 0.006 |
| | C TO D | CHANNEL | | 817 | 0.028 | 0.016 |
| | D TO E | | | 716 | 0.038 | 0.014 |
| 4 | A TO B | SHEET FLOW | 0.24 | 100 | 0.030 | 0.204 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 894 | 0.112 | 0.046 |
| 5 | A TO B | SHEET FLOW | 0.24 | 100 | 0.020 | 0.240 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 75 | 0.053 | 0.006 |
| | C TO D | CHANNEL | | 1265 | 0.090 | 0.035 |
| 6 | A TO B | SHEET FLOW | 0.24 | 100 | 0.040 | 0.182 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 660 | 0.190 | 0.026 |
| 7 | A TO B | SHEET FLOW | 0.24 | 100 | 0.050 | 0.166 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 540 | 0.194 | 0.021 |
| | C TO D | CHANNEL | | 120 | 0.420 | 0.002 |
| 8 | A TO B | SHEET FLOW | 0.24 | 100 | 0.030 | 0.204 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 500 | 0.215 | 0.019 |
| | C TO D | CHANNEL | | 40 | 0.071 | 0.002 |
| 9 | A TO B | SHEET FLOW | 0.24 | 100 | 0.020 | 0.240 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 590 | 0.164 | 0.025 |
| 10 | A TO B | SHEET FLOW | 0.24 | 100 | 0.045 | 0.174 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 281 | 0.091 | 0.016 |
| 11 | A TO B | SHEET FLOW | 0.24 | 100 | 0.042 | 0.178 |
| | B TO C | SHALLOW CONCENTRATED | UNPAVED | 621 | 0.100 | 0.034 |


| DRAINAGE AREA | PEAK FLOW (CFS) | | |
|---|---|---|---|
| ID | 2-YR STORM | 10-YR STORM | 100-YR STORM |
| 1A | 36.8 | 75.3 | 160.3 |
| 1B | 32.8 | 66.8 | 142.3 |
| 2 | 29.1 | 59.1 | 125.1 |
| 3 | 13.7 | 27.3 | 56.8 |
| 4 | 9.6 | 20.3 | 44.3 |
| 5 | 17.1 | 38.7 | 89.2 |
| 6 | 9.0 | 26.3 | 70.7 |
| 7 | 7.8 | 16.4 | 35.7 |
| 8 | 4.6 | 9.4 | 20.0 |
| 9 | 5.2 | 10.8 | 23.3 |
| 10 | 1.3 | 2.5 | 5.3 |
| 11 | 4.1 | 8.6 | 18.8 |

## LEGEND

DESCRIPTION / EXISTING / PROPOSED

BENCHMARK; PROPERTY BOUNDARY; PROPERTY MARKER; LIMIT OF FIELD RUN TOPOGRAPHY; CONTOUR; CONCRETE; FENCE; FENCE POST; GATE POST; SIGN; BOLLARD; MANHOLE - UNKNOWN; MONITORING WELL (MW); SOIL BORING / TEST PIT (SB / TP); TREE/BRUSH LINE; TREE; WETLAND; WETLAND BUFFER; EDGE OF WATER; FEMA FLOODPLAIN; STEEP SLOPE; SOIL BOUNDARY; SOIL CLASSIFICATION (SIB HSG B); STORM DRAIN STRUCTURE LABEL; STORM DRAIN PIPE; STORM DRAIN UTILITY MARKING; STORM DRAIN MANHOLE; STORM DRAIN INLET; SANITARY SEWER PIPE; SANITARY SEWER UTILITY MARKING; SANITARY SEWER MANHOLE; SANITARY SEWER CLEANOUT (CO); WATER PIPE (NA); WATER UTILITY MARKING; WATER MANHOLE; WATER METER; WATER VALVE (WV); WELL; FIRE HYDRANT; ELECTRIC LINE - UNDERGROUND (NA); ELECTRIC LINE UTILITY MARKING (UNDERGROUND); ELECTRIC LINE - OVERHEAD; ELECTRIC MANHOLE; ELECTRIC JUNCTION BOX; ELECTRIC TRANSFORMER; LIGHT POLE; UTILITY POLE; GUY WIRE; GUY POLE; GAS LINE (NA); GAS LINE UTILITY MARKING; GAS MANHOLE; GAS METER; GAS VALVE (GV); COMMUNICATIONS/CATV - UNDERGROUND (NA); COMMUNICATIONS/CATV - UTILITY MARKING; COMMUNICATIONS/CATV MANHOLE; COMMUNICATIONS/CATV PEDESTAL; TELEPHONE - UNDERGROUND (NA); TELEPHONE - UTILITY MARKING; TELEPHONE MANHOLE; TELEPHONE PEDESTAL

| CONCEPT SUMMARY TABLE | |
|---|---|
| GENERAL PROPERTY INFORMATION: | |
| SM # | 284828 (ORIGINAL SUBMISSION) |
| TYPE OF CONCEPT | SWM CONCEPT |
| MNCP&PC PROCESS/NO. | 420191540 |
| PROPERTY ADDRESS | 600 EAST GUDE DRIVE, ROCKVILLE, MARYLAND 20850 |
| PROPERTY LEGAL DESCRIPTION | LANDFILL |
| PROPERTY SIZE (AC./S.F.) | 162 AC./7,056,720 S.F. |
| TOTAL CONCEPT AREA (AC./S.F.) | 91.97 AC./4,006,213 S.F. |
| ZONING | INDUSTRIAL - CONDITIONAL USE (IHC) |
| WATERSHED AND STREAM CLASS | 021402060837 UPPER ROCK CREEK/USE IV STREAM |
| SPECIAL PROTECTION AREA | N/A |
| 100 YR FLOODPLAIN | OBTAINED FROM THE MONTGOMERY COUNTY PLANNING BOARD IN 2011 |
| EX. % IMPERVIOUS/REDEVELOPMENT OR NEW DEVELOPMENT | 4.7%/ NEW DEVELOPMENT |
| SWM SUMMARY | |
| TARGET $P_E$/PROPOSED $P_E$ | 1"/1" |
| TARGET $ESD_V$/PROVIDED $ESD_V$ | 19,502 CU. FT./3,700 CU. FT. |
| ESD MEASURES | TWENTY-FOUR (24) NON-ROOFTOP DISCONNECTIONS (N-2) |
| STRUCTURAL STORAGE REQUIRED/PROVIDED | 0 CU. FT. |
| STRUCTURAL MEASURES | N/A |
| WAIVER REQUEST/QL/QN/BOTH | N/A |
| PROVIDED $ESD_V$ + STRUCTURAL STORAGE PROVIDED + REQUESTED TO BE WAIVED | 3,700 CU. FT. |

0 100 200 400
GRAPHIC SCALE IN FEET

REVISIONS
NO. | DATE | BY | DESCRIPTION

DESIGN INFORMATION
DESIGNED BY: KEF / SMB
DRAWN BY: SMB
CHECKED BY: LJO/GAT
PROJECT MANAGER: MJG

PROFESSIONAL CERTIFICATION. I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 23402 EXPIRATION DATE: 8/25/2020

SEAL

# GUDE LANDFILL REMEDIATION DESIGN
## NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
## MONTGOMERY COUNTY DEPARTMENT OF ENVIRONMENTAL PROTECTION
MONTGOMERY COUNTY, MARYLAND

FIGURE 3: DRAINAGE AREA MAP - PROPOSED CONDITIONS


EA Engineering, Science, and Technology, Inc., PBC
Hunt Valley Center
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

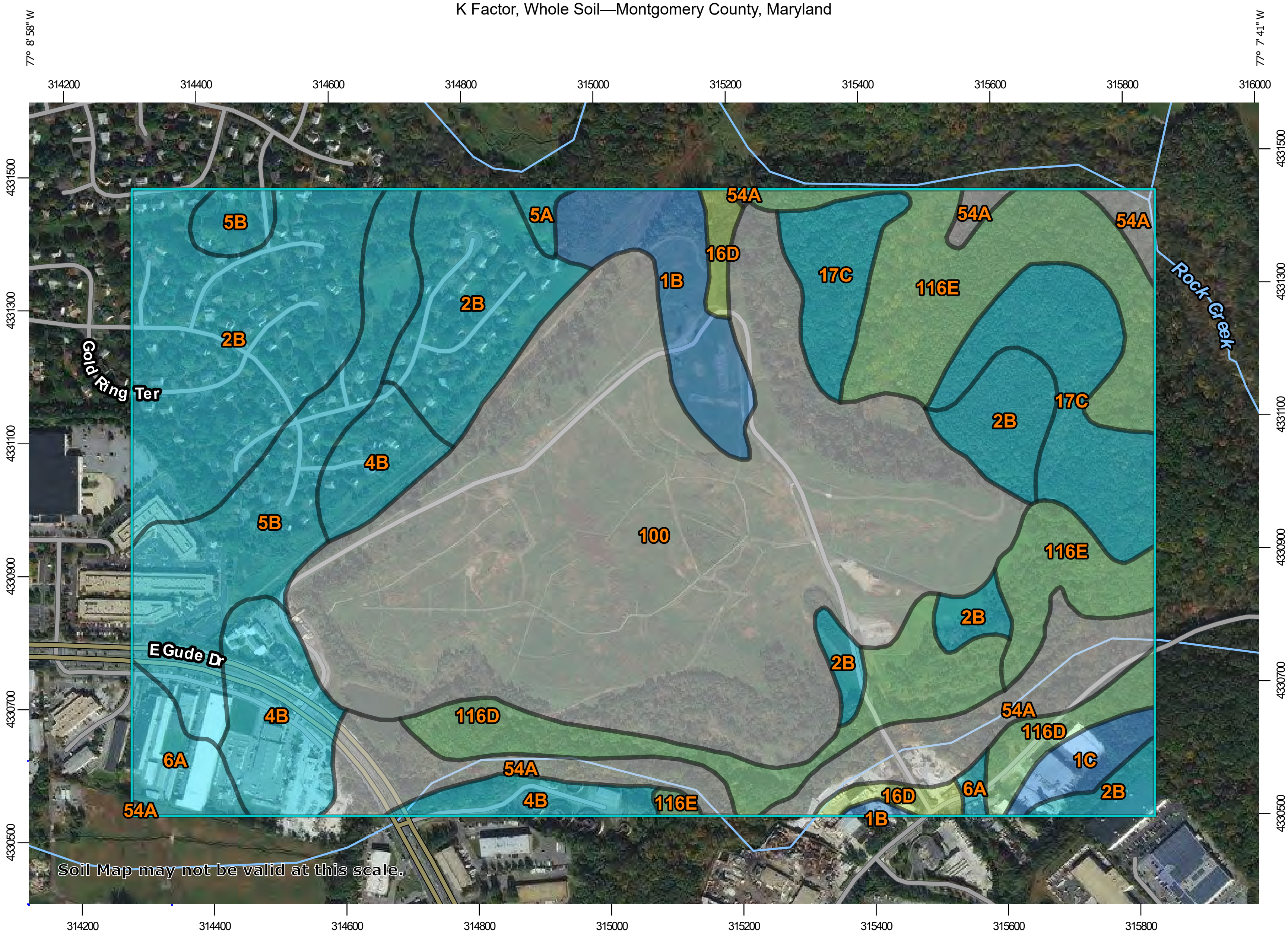

DATE: DECEMBER 2019
PROJECT NUMBER: 1564601

# FIGURE 3
SHEET: - OF -

# Appendix A

# Web Soil Survey

K Factor, Whole Soil—Montgomery County, Maryland




Map Scale: 1:8,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 100, 200, 400, 600

Feet: 0, 400, 800, 1600, 2400

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

## MAP LEGEND

**Area of Interest (AOI)**

Area of Interest (AOI)

**Soils**

**Soil Rating Polygons**

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
Not rated or not available

**Soil Rating Lines**

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
Not rated or not available

**Soil Rating Points**

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
Not rated or not available

**Water Features**

Streams and Canals

**Transportation**

Rails
Interstate Highways
US Routes
Major Roads
Local Roads

**Background**

Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Montgomery County, Maryland
Survey Area Data: Version 13, Sep 18, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 3, 2015—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

# K Factor, Whole Soil

| Map unit symbol | Map unit name | Rating | Acres in AOI | Percent of AOI |
|---|---|---|---|---|
| 1B | Gaila silt loam, 3 to 8 percent slopes | .43 | 12.9 | 3.6% |
| 1C | Gaila silt loam, 8 to 15 percent slopes | .43 | 3.9 | 1.1% |
| 2B | Glenelg silt loam, 3 to 8 percent slopes | .37 | 61.9 | 17.1% |
| 4B | Elioak silt loam, 3 to 8 percent slopes | .37 | 22.3 | 6.2% |
| 5A | Glenville silt loam, 0 to 3 percent slopes | .37 | 1.2 | 0.3% |
| 5B | Glenville silt loam, 3 to 8 percent slopes | .37 | 27.1 | 7.5% |
| 6A | Baile silt loam, 0 to 3 percent slopes | .37 | 6.5 | 1.8% |
| 16D | Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes | .24 | 3.8 | 1.0% |
| 17C | Occoquan loam, 8 to 15 percent slopes | .37 | 23.8 | 6.6% |
| 54A | Hatboro silt loam, 0 to 3 percent slopes, frequently flooded | | 24.9 | 6.9% |
| 100 | Dumps, refuse | | 121.9 | 33.7% |
| 116D | Blocktown channery silt loam, 15 to 25 percent slopes, very rocky | .28 | 19.9 | 5.5% |
| 116E | Blocktown channery silt loam, 25 to 45 percent slopes, very rocky | .28 | 31.6 | 8.7% |
| **Totals for Area of Interest** | | | **361.8** | **100.0%** |

## Description

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

## Rating Options

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff: None Specified*

*Tie-break Rule:* Higher

*Layer Options (Horizon Aggregation Method):* Surface Layer (Not applicable)

## Hydrologic Soil Group—Montgomery County, Maryland

## MAP LEGEND

**Area of Interest (AOI)**

- Area of Interest (AOI)

**Soils**

**Soil Rating Polygons**

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

**Soil Rating Lines**

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

**Soil Rating Points**

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

**Water Features**

- Streams and Canals

**Transportation**

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

**Background**

- Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Montgomery County, Maryland
Survey Area Data: Version 13, Sep 18, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 3, 2015—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

# Hydrologic Soil Group

| Map unit symbol | Map unit name | Rating | Acres in AOI | Percent of AOI |
|---|---|---|---|---|
| 1B | Gaila silt loam, 3 to 8 percent slopes | B | 12.9 | 3.6% |
| 1C | Gaila silt loam, 8 to 15 percent slopes | B | 3.9 | 1.1% |
| 2B | Glenelg silt loam, 3 to 8 percent slopes | B | 61.9 | 17.1% |
| 4B | Elioak silt loam, 3 to 8 percent slopes | C | 22.3 | 6.2% |
| 5A | Glenville silt loam, 0 to 3 percent slopes | C | 1.2 | 0.3% |
| 5B | Glenville silt loam, 3 to 8 percent slopes | C/D | 27.1 | 7.5% |
| 6A | Baile silt loam, 0 to 3 percent slopes | C/D | 6.5 | 1.8% |
| 16D | Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes | C | 3.8 | 1.0% |
| 17C | Occoquan loam, 8 to 15 percent slopes | B | 23.8 | 6.6% |
| 54A | Hatboro silt loam, 0 to 3 percent slopes, frequently flooded | B/D | 24.9 | 6.9% |
| 100 | Dumps, refuse | | 121.9 | 33.7% |
| 116D | Blocktown channery silt loam, 15 to 25 percent slopes, very rocky | D | 19.9 | 5.5% |
| 116E | Blocktown channery silt loam, 25 to 45 percent slopes, very rocky | D | 31.6 | 8.7% |
| **Totals for Area of Interest** | | | **361.8** | **100.0%** |

## Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

## Rating Options

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff: None Specified*

*Tie-break Rule:* Higher

# Appendix B

# SCS Engineers Plans

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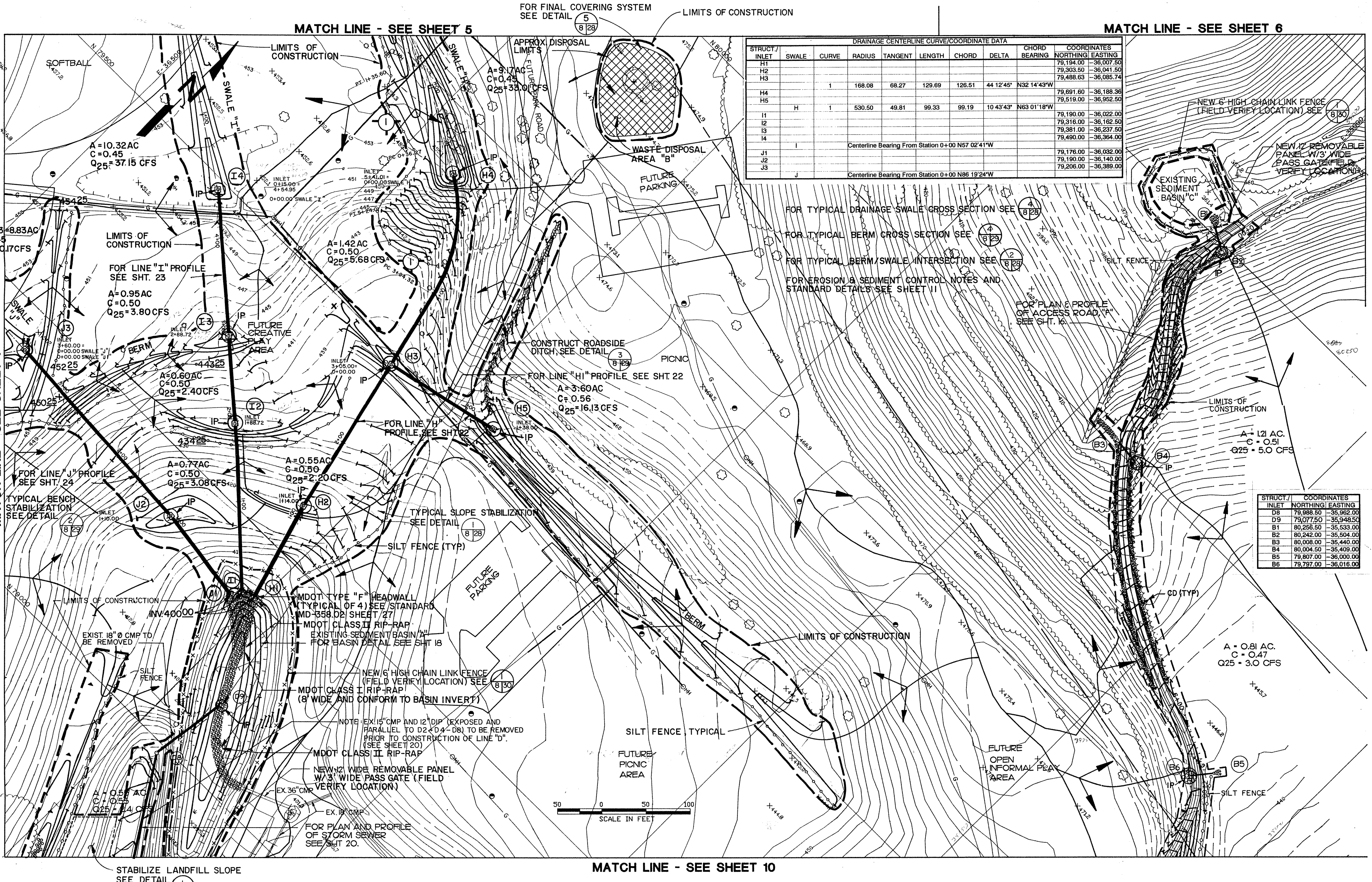



| DRAINAGE CENTERLINE CURVE/COORDINATE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STRUCT./ INLET | SWALE | CURVE | RADIUS | TANGENT | LENGTH | CHORD | DELTA | CHORD BEARING | COORDINATES NORTHING | EASTING |
| H1 | | | | | | | | | 79,194.00 | -36,007.50 |
| H2 | | | | | | | | | 79,303.50 | -36,041.50 |
| H3 | | | | | | | | | 79,488.63 | -36,085.74 |
| | | 1 | 168.08 | 68.27 | 129.69 | 126.51 | 44 12'45" | N32 14'43"W | | |
| H4 | | | | | | | | | 79,691.60 | -36,188.36 |
| H5 | | | | | | | | | 79,519.00 | -36,952.50 |
| | H | 1 | 530.50 | 49.81 | 99.33 | 99.19 | 10 43'43" | N63 01'18"W | | |
| I1 | | | | | | | | | 79,190.00 | -36,022.00 |
| I2 | | | | | | | | | 79,316.00 | -36,162.50 |
| I3 | | | | | | | | | 79,381.00 | -36,237.50 |
| I4 | | | | | | | | | 79,490.00 | -36,364.00 |
| | I | | Centerline Bearing From Station 0+00 N57 02'41"W | | | | | | | |
| J1 | | | | | | | | | 79,176.00 | -36,032.00 |
| J2 | | | | | | | | | 79,190.00 | -36,140.00 |
| J3 | | | | | | | | | 79,206.00 | -36,389.00 |
| | J | | Centerline Bearing From Station 0+00 N86 19'24"W | | | | | | | |

| STRUCT./ INLET | COORDINATES NORTHING | EASTING |
|---|---|---|
| D8 | 79,988.50 | -35,962.00 |
| D9 | 79,077.50 | -35,948.50 |
| B1 | 80,256.50 | -35,533.00 |
| B2 | 80,242.00 | -35,504.00 |
| B3 | 80,008.00 | -35,440.00 |
| B4 | 80,004.50 | -35,409.00 |
| B5 | 79,807.00 | -36,000.00 |
| B6 | 79,797.00 | -36,016.00 |

| NO. | REVISION | DATE |
|---|---|---|
| | | |

SHEET TITLE: SITE PLAN 6 SWM AND EROSION CONTROL

PROJECT TITLE: GUDE LANDFILL POST CLOSURE ENGINEERING DESIGN AND MANAGEMENT TASKS

CLIENT: MONTGOMERY COUNTY, MARYLAND

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
11260 ROGER BACON DRIVE - RESTON, VA. 22090
PH. (703) 471-6150 FAX. 703 471-6676

PROJ. NO. 0290136 | DWN. BY: E. CAZENAS | Q/A RVW BY:
DSN. BY: R. THOMAS | CHK. BY: P. MANDEVILLE | APP. BY: P. MANDEVILLE

CADD FILE: SHT6

DATE: 6-22-92

SCALE: 1" = 50'

## SEDIMENTATION BASIN A

****************** SUMMARY OF ROUTING COMPUTATIONS ************

Pond File: SEDA .PND
Inflow Hydrograph: SEDA2 .HYD
Outflow Hydrograph: SEDA-2 .HYD

Starting Pond W.S. Elevation = 389.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 45.00 cfs
Peak Outflow = 39.99 cfs
Peak Elevation = 393.00 ft

***** Summary of Approximate Peak Storage *****

Initial Storage = 0.00 ac-ft
Peak Storage From Storm = 0.44 ac-ft
Total Storage in Pond = 0.44 ac-ft

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
|---|---|---|---|---|---|---|
| 11.000 | 1.00 | ----- | 0.0 | 0.0 | 0.00 | 389.00 |
| 11.100 | 1.00 | 2.0 | -0.1 | 2.0 | 1.06 | 389.13 |
| 11.200 | 1.00 | 2.0 | -0.1 | 1.9 | 1.00 | 389.12 |
| 11.300 | 1.00 | 2.0 | -0.1 | 1.9 | 1.00 | 389.12 |
| 11.400 | 1.00 | 2.0 | -0.1 | 1.9 | 1.00 | 389.12 |
| 11.500 | 2.00 | 3.0 | -0.2 | 2.9 | 1.53 | 389.19 |
| 11.600 | 2.00 | 4.0 | -0.2 | 3.8 | 2.03 | 389.25 |
| 11.700 | 2.00 | 4.0 | -0.2 | 3.8 | 2.00 | 389.24 |
| 11.800 | 3.00 | 5.0 | -0.3 | 4.8 | 2.53 | 389.31 |
| 11.900 | 3.00 | 6.0 | -0.3 | 5.7 | 3.03 | 389.37 |
| 12.000 | 4.00 | 7.0 | -0.4 | 6.7 | 3.53 | 389.43 |
| 12.100 | 6.00 | 10.0 | -0.6 | 9.6 | 5.09 | 389.62 |
| 12.200 | 10.00 | 16.0 | -0.9 | 15.4 | 8.18 | 390.00 |
| 12.300 | 18.00 | 28.0 | 4.5 | 27.1 | 11.29 | 390.35 |
| 12.400 | 29.00 | 47.0 | 16.0 | 51.5 | 17.74 | 391.07 |
| 12.500 | 39.00 | 68.0 | 32.6 | 84.0 | 25.71 | 391.79 |
| 12.600 | 45.00 | 84.0 | 50.1 | 116.6 | 33.25 | 392.44 |
| 12.700 | 44.00 | 89.0 | 62.4 | 139.1 | 38.33 | 392.86 |
| 12.800 | 40.00 | 84.0 | 66.4 | 146.4 | 39.99 | 393.00 |
| 12.900 | 34.00 | 74.0 | 63.2 | 140.4 | 38.64 | 392.89 |
| 13.000 | 28.00 | 62.0 | 54.8 | 125.2 | 35.19 | 392.60 |

****************** SUMMARY OF ROUTING COMPUTATIONS ************

Pond File: SEDA .PND
Inflow Hydrograph: SEDA10 .HYD
Outflow Hydrograph: SEDA-10 .HYD

Starting Pond W.S. Elevation = 389.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 102.00 cfs
Peak Outflow = 73.70 cfs
Peak Elevation = 397.28 ft

***** Summary of Approximate Peak Storage *****

Initial Storage = 0.00 ac-ft
Peak Storage From Storm = 1.65 ac-ft
Total Storage in Pond = 1.65 ac-ft

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
|---|---|---|---|---|---|---|
| 11.000 | 3.00 | ----- | 0.0 | 0.0 | 0.00 | 389.00 |
| 11.100 | 3.00 | 6.0 | -0.4 | 6.0 | 3.18 | 389.39 |
| 11.200 | 4.00 | 7.0 | -0.4 | 6.6 | 3.52 | 389.43 |
| 11.300 | 4.00 | 8.0 | -0.5 | 7.6 | 4.03 | 389.49 |
| 11.400 | 5.00 | 9.0 | -0.5 | 8.5 | 4.53 | 389.55 |
| 11.500 | 5.00 | 10.0 | -0.6 | 9.5 | 5.03 | 389.61 |
| 11.600 | 6.00 | 11.0 | -0.6 | 10.4 | 5.53 | 389.67 |
| 11.700 | 7.00 | 13.0 | -0.8 | 12.4 | 6.56 | 389.80 |
| 11.800 | 8.00 | 15.0 | -0.9 | 14.2 | 7.56 | 389.92 |
| 11.900 | 9.00 | 17.0 | -0.6 | 16.1 | 8.38 | 390.02 |
| 12.000 | 11.00 | 20.0 | 0.9 | 19.4 | 9.24 | 390.12 |
| 12.100 | 16.00 | 27.0 | 4.9 | 27.9 | 11.51 | 390.38 |
| 12.200 | 28.00 | 44.0 | 14.7 | 48.9 | 17.10 | 391.01 |
| 12.300 | 47.00 | 75.0 | 35.5 | 89.7 | 27.10 | 391.92 |
| 12.400 | 71.00 | 118.0 | 71.3 | 153.5 | 41.10 | 393.11 |
| 12.500 | 91.00 | 162.0 | 127.9 | 233.3 | 52.65 | 394.33 |
| 12.600 | 102.00 | 193.0 | 199.6 | 320.9 | 60.68 | 395.54 |
| 12.700 | 99.00 | 201.0 | 265.5 | 400.6 | 67.53 | 396.50 |
| 12.800 | 89.00 | 188.0 | 308.4 | 453.5 | 72.54 | 397.09 |
| 12.900 | 75.00 | 164.0 | 325.0 | 472.4 | 73.70 | 397.28 |
| 13.000 | 61.00 | 136.0 | 315.0 | 461.0 | 73.00 | 397.17 |
| 13.100 | 51.00 | 112.0 | 286.6 | 427.0 | 70.21 | 396.80 |
| 13.200 | 41.00 | 92.0 | 248.0 | 378.6 | 65.31 | 396.26 |
| 13.300 | 36.00 | 77.0 | 203.1 | 325.0 | 60.95 | 395.59 |

****************** SUMMARY OF ROUTING COMPUTATIONS ************

Pond File: SEDA .PND
Inflow Hydrograph: SEDA25 .HYD
Outflow Hydrograph: SEDA-25 .HYD

Starting Pond W.S. Elevation = 389.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 123.00 cfs
Peak Outflow = 80.48 cfs
Peak Elevation = 398.83 ft

***** Summary of Approximate Peak Storage *****

Initial Storage = 0.00 ac-ft
Peak Storage From Storm = 2.26 ac-ft
Total Storage in Pond = 2.26 ac-ft

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
|---|---|---|---|---|---|---|
| 11.000 | 4.00 | ----- | 0.0 | 0.0 | 0.00 | 389.00 |
| 11.100 | 4.00 | 8.0 | -0.5 | 8.0 | 4.24 | 389.52 |
| 11.200 | 5.00 | 9.0 | -0.5 | 8.5 | 4.52 | 389.55 |
| 11.300 | 5.00 | 10.0 | -0.6 | 9.5 | 5.03 | 389.61 |
| 11.400 | 6.00 | 11.0 | -0.6 | 10.4 | 5.53 | 389.67 |
| 11.500 | 6.00 | 12.0 | -0.7 | 11.4 | 6.03 | 389.74 |
| 11.600 | 7.00 | 13.0 | -0.7 | 12.3 | 6.53 | 389.80 |
| 11.700 | 8.00 | 15.0 | -0.9 | 14.3 | 7.56 | 389.92 |
| 11.800 | 9.00 | 17.0 | -0.6 | 16.1 | 8.38 | 390.02 |
| 11.900 | 10.00 | 19.0 | 0.4 | 18.4 | 8.98 | 390.09 |
| 12.000 | 13.00 | 23.0 | 2.8 | 23.4 | 10.32 | 390.24 |
| 12.100 | 20.00 | 33.0 | 8.5 | 35.8 | 13.62 | 390.62 |
| 12.200 | 33.00 | 53.0 | 21.1 | 61.5 | 20.21 | 391.29 |
| 12.300 | 56.00 | 89.0 | 46.5 | 110.1 | 31.79 | 392.32 |
| 12.400 | 85.00 | 141.0 | 94.6 | 187.5 | 46.49 | 393.65 |
| 12.500 | 111.00 | 196.0 | 173.2 | 290.6 | 58.66 | 395.13 |
| 12.600 | 123.00 | 234.0 | 270.8 | 407.2 | 68.21 | 396.58 |
| 12.700 | 119.00 | 242.0 | 360.5 | 512.8 | 76.17 | 397.70 |
| 12.800 | 107.00 | 226.0 | 427.9 | 586.5 | 79.29 | 398.43 |
| 12.900 | 90.00 | 197.0 | 464.1 | 624.9 | 80.41 | 398.80 |
| 13.000 | 73.00 | 163.0 | 466.1 | 627.1 | 80.48 | 398.83 |
| 13.100 | 61.00 | 134.0 | 440.7 | 600.1 | 79.69 | 398.56 |
| 13.200 | 50.00 | 111.0 | 395.2 | 551.7 | 78.27 | 398.09 |
| 13.300 | 43.00 | 93.0 | 338.9 | 488.2 | 74.67 | 397.44 |
| 13.400 | 36.00 | 79.0 | 279.3 | 417.9 | 69.29 | 396.70 |

****************** SUMMARY OF ROUTING COMPUTATIONS ************

Pond File: SEDA .PND
Inflow Hydrograph: SEDA100 .HYD
Outflow Hydrograph: SEDA-100.HYD

Starting Pond W.S. Elevation = 389.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 170.00 cfs
Peak Outflow = 158.26 cfs
Peak Elevation = 400.24 ft

***** Summary of Approximate Peak Storage *****

Initial Storage = 0.00 ac-ft
Peak Storage From Storm = 2.89 ac-ft
Total Storage in Pond = 2.89 ac-ft

INFLOW HYDROGRAPH / ROUTING COMPUTATIONS

| TIME (hrs) | INFLOW (cfs) | I1+I2 (cfs) | 2S/t - O (cfs) | 2S/t + O (cfs) | OUTFLOW (cfs) | ELEVATION (ft) |
|---|---|---|---|---|---|---|
| 11.000 | 5.00 | ----- | 0.0 | 0.0 | 0.00 | 389.00 |
| 11.100 | 6.00 | 11.0 | -0.7 | 11.0 | 5.83 | 389.71 |
| 11.200 | 6.00 | 12.0 | -0.7 | 11.3 | 6.01 | 389.73 |
| 11.300 | 7.00 | 13.0 | -0.7 | 12.3 | 6.53 | 389.80 |
| 11.400 | 8.00 | 15.0 | -0.9 | 14.3 | 7.56 | 389.92 |
| 11.500 | 9.00 | 17.0 | -0.6 | 16.1 | 8.38 | 390.02 |
| 11.600 | 10.00 | 19.0 | 0.4 | 18.4 | 8.98 | 390.09 |
| 11.700 | 11.00 | 21.0 | 1.8 | 21.4 | 9.79 | 390.18 |
| 11.800 | 13.00 | 24.0 | 3.9 | 25.8 | 10.97 | 390.31 |
| 11.900 | 14.00 | 27.0 | 6.3 | 30.9 | 12.32 | 390.47 |
| 12.000 | 18.00 | 32.0 | 9.7 | 38.3 | 14.28 | 390.69 |
| 12.100 | 27.00 | 45.0 | 17.6 | 54.7 | 18.53 | 391.14 |
| 12.200 | 46.00 | 73.0 | 36.0 | 90.6 | 27.34 | 391.94 |
| 12.300 | 78.00 | 124.0 | 75.7 | 160.0 | 42.13 | 393.21 |
| 12.400 | 118.00 | 196.0 | 157.7 | 271.7 | 56.99 | 394.87 |
| 12.500 | 153.00 | 271.0 | 288.0 | 428.7 | 70.38 | 396.82 |
| 12.600 | 170.00 | 323.0 | 450.9 | 611.0 | 80.00 | 398.67 |
| 12.700 | 165.00 | 335.0 | 544.4 | 785.9 | 120.76 | 399.95 |
| 12.800 | 148.00 | 313.0 | 540.9 | 857.4 | 158.26 | 400.24 |
| 12.900 | 124.00 | 272.0 | 544.7 | 812.9 | 134.08 | 400.07 |
| 13.000 | 101.00 | 225.0 | 540.7 | 769.7 | 114.51 | 399.86 |
| 13.100 | 85.00 | 186.0 | 530.9 | 726.7 | 97.92 | 399.62 |
| 13.200 | 69.00 | 154.0 | 519.2 | 684.9 | 82.85 | 399.37 |
| 13.300 | 59.00 | 128.0 | 484.9 | 647.2 | 81.11 | 399.02 |
| 13.400 | 49.00 | 108.0 | 434.0 | 592.9 | 79.48 | 398.49 |
| 13.500 | 43.00 | 92.0 | 372.0 | 526.0 | 76.98 | 397.83 |

CALCULATED 06-24-1992 13:26:21
DISK FILE: SEDA .VOL

Planimeter scale: 1 inch = 30 ft.

| Elevation (ft) | Planimeter (sq.in.) | Area (acres) | A1+A2+sqr(A1*A2) (acres) | * Volume (acre-ft) | Volume Sum (acre-ft) |
|---|---|---|---|---|---|
| 389.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 390.00 | 4.02 | 0.08 | 0.08 | 0.03 | 0.03 |
| 391.00 | 5.82 | 0.12 | 0.30 | 0.10 | 0.13 |
| 392.00 | 7.61 | 0.16 | 0.41 | 0.14 | 0.27 |
| 393.00 | 9.58 | 0.20 | 0.53 | 0.18 | 0.44 |
| 394.00 | 11.55 | 0.24 | 0.65 | 0.22 | 0.66 |
| 395.00 | 13.32 | 0.28 | 0.77 | 0.26 | 0.92 |
| 396.00 | 15.11 | 0.31 | 0.88 | 0.29 | 1.21 |
| 397.00 | 17.05 | 0.35 | 1.00 | 0.33 | 1.54 |
| 398.00 | 19.03 | 0.39 | 1.12 | 0.37 | 1.92 |
| 399.00 | 20.59 | 0.43 | 1.23 | 0.41 | 2.33 |
| 399.40 | 21.50 | 0.44 | 1.30 | 0.17 | 2.50 |
| 400.00 | 22.59 | 0.47 | 1.37 | 0.27 | 2.77 |
| 401.00 | 24.54 | 0.51 | 1.46 | 0.49 | 3.26 |

$$IA = \left(\text{sq.rt}(Area1) + ((Ei-E1)/(E2-E1))*(\text{sq.rt}(Area2)-\text{sq.rt}(Area1))\right)^{2}$$

where: E1, E2 = Closest two elevations with planimeter data
Ei = Elevation at which to interpolate area
Area1,Area2 = Areas computed for E1, E2, respectively
IA = Interpolated area for Ei

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

### Tc COMPUTATIONS FOR: DA7

SHEET FLOW (Applicable to Tc only)

| | | | |
|---|---|---|---|
| Segment ID | | SF | |
| Surface description | | GRASS | |
| Manning's roughness coeff., n | | 0.2400 | |
| Flow length, L (total < or = 300) | ft | 300.0 | |
| Two-yr 24-hr rainfall, P2 | in | 3.200 | |
| Land slope, s | ft/ft | 0.0230 | |

$$T = \frac{.007 * (n*L)^{0.8}}{P2^{0.5} * s^{0.4}}$$ hrs 0.54 = 0.54

SHALLOW CONCENTRATED FLOW

| | | | |
|---|---|---|---|
| Segment ID | | SCF | SCF |
| Surface (paved or unpaved)? | | Unpaved | Unpaved |
| Flow length, L | ft | 360.0 | 240.0 |
| Watercourse slope, s | ft/ft | 0.0125 | 0.0300 |

$$Avg.V = Csf * (s)^{0.5}$$ ft/s 1.8039 2.7946

where: Unpaved Csf = 16.1345
Paved Csf = 20.3282

T = L / (3600*V) hrs 0.06 + 0.02 = 0.08

CHANNEL FLOW

| | | | |
|---|---|---|---|
| Segment ID | | CF | CF |
| Cross Sectional Flow Area, a | sq.ft | 7.91 | 5.69 |
| Wetted perimeter, Pw | ft | 15.15 | 6.72 |
| Hydraulic radius, r = a/Pw | ft | 0.522 | 0.847 |
| Channel slope, s | ft/ft | 0.0300 | 0.1300 |
| Manning's roughness coeff., n | | 0.0400 | 0.0095 |

$$V = \frac{1.49 * r^{2/3} * s^{1/2}}{n}$$ ft/s 4.1834 %50.6131

Flow length, L ft 530 450

T = L / (3600*V) hrs 0.04 + 0.00 = 0.04

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

TOTAL TIME (hrs) 0.66

GUDE LANDFILL SEDIMENTATION BASIN A
DRAINAGE AREA 7 POST DEVELOPED CONDITIONS

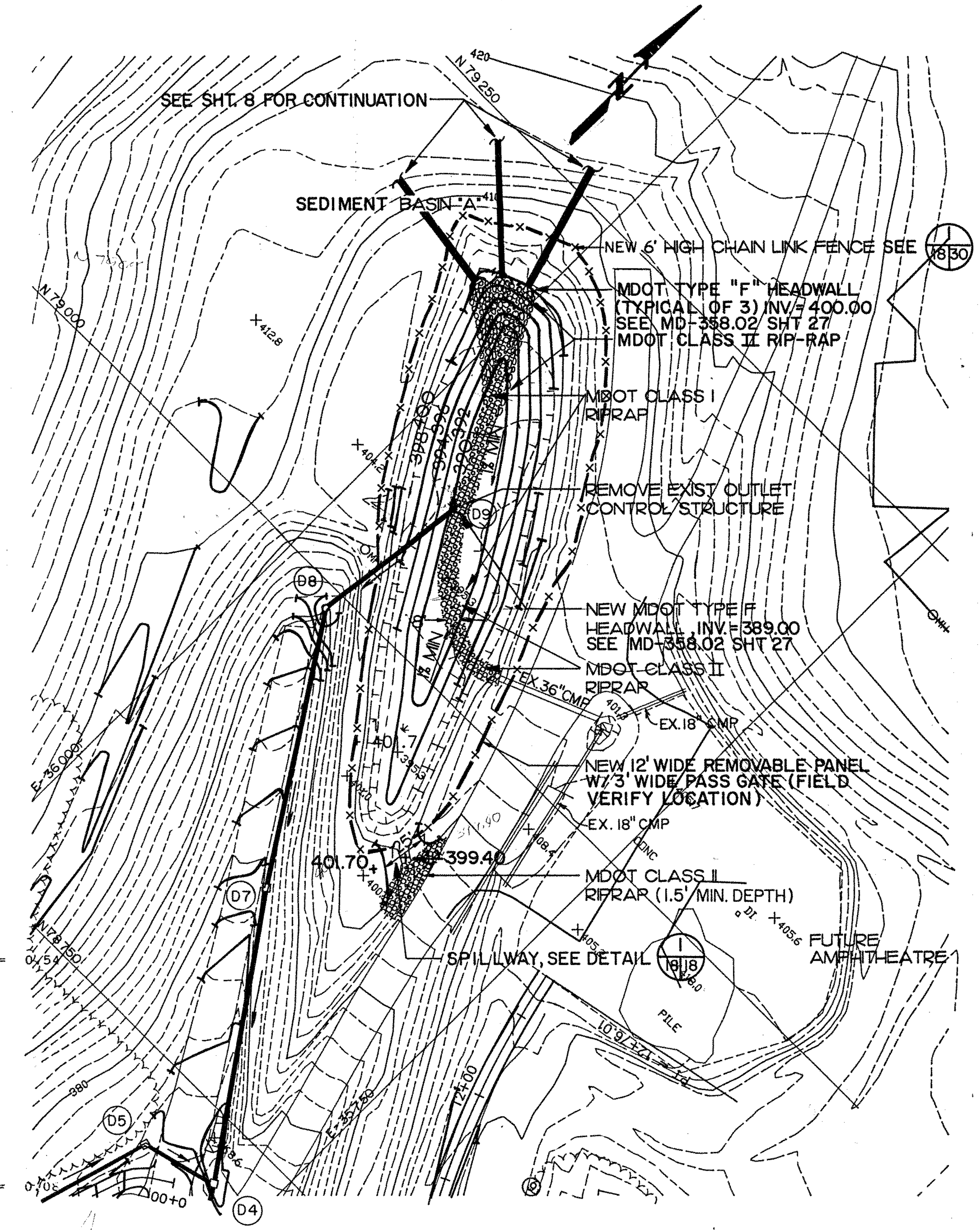
RUNOFF CURVE NUMBER DATA

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

Composite Area: DA7

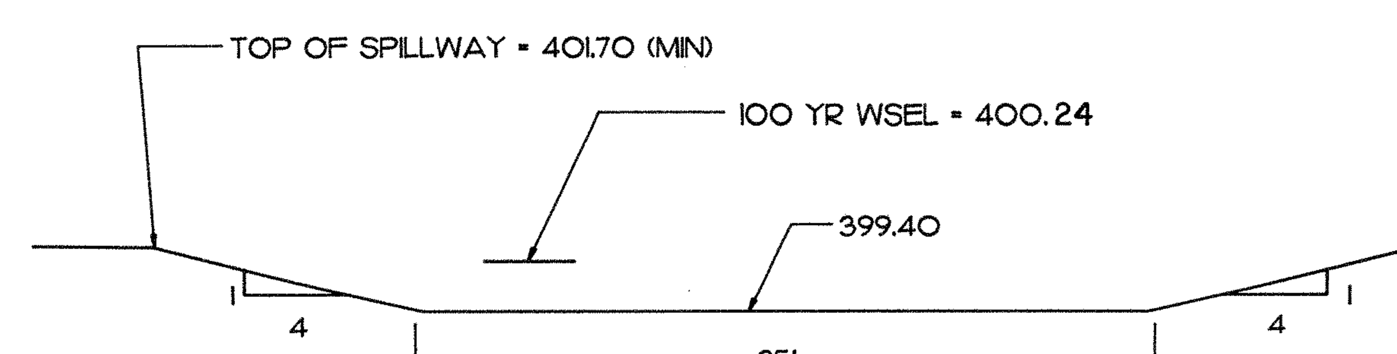
| SURFACE DESCRIPTION | AREA (acres) | CN | |
|---|---|---|---|
| GRAVEL ROAD D | 0.50 | 91 | |
| WOODED POOR D | 1.83 | 83 | |
| WOODED FAIR D | 0.59 | 79 | |
| PASTURE GOOD D | 48.28 | 80 | |
| IMPERVIOUS D | 0.50 | 98 | |
| COMPOSITE AREA ---> | 51.70 | 80.4 | ( 80 ) |

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::




SEDIMENTATION BASIN "A"

50 0 50 100
SCALE IN FEET




Q100 SPILLWAY = 3.367 X 25 X 0.84X = 70.71 CFS
V100 SPILLWAY = 70.71 CFS / 23.82 SF = 2.97 FT/SEC
USE GRASS LINED SPILLWAY V100 < 4.0 FT/SEC

**TYPICAL X-SECTION THROUGH SPILLWAY** 1/18
NO SCALE

SHEET TITLE: DETENTION BASIN "A"
PROJECT TITLE: GUDE LANDFILL POST CLOSURE ENGINEERING DESIGN AND MANAGEMENT TASKS
CLIENT: MONTGOMERY COUNTY, MARYLAND

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS
11260 ROGER BACON DRIVE - RESTON, VA. 22090
PH. (703) 471-6150 FAX 703 471-6676

PROJ. NO. 0290136 | DWN. BY: E. CAZENAS | Q/A RVW BY: P. MANDEVILLE
DSN. BY: R. THOMAS | CHK. BY: P. MANDEVILLE

NO. | REVISION | DATE

CADD FILE: BASIN
DATE: 6-22-92
SCALE: 1"=50'
SHEET NO. 18 of 30

# Appendix C

# TR-55 Calculations – Existing and Proposed

WinTR-55 Current Data Description

--- Identification Data ---

| | | | |
|---|---|---|---|
| User: | EA | Date: | 12/11/2019 |
| Project: | Gude | Units: | English |
| SubTitle: | DA-1A | Areal Units: | Acres |
| State: | Maryland | | |
| County: | Montgomery NOAA-C | | |

Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-1A EX | | Outlet | 36.5 | 80 | .341 |
| DA-1A PR | | Outlet | 34.78 | 80 | .407 |

Total area: 71.28 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-1A EX | 42.15 | 86.07 | 182.78 |
| DA-1A PR | 36.82 | 75.34 | 160.29 |
| REACHES | | | |
| OUTLET | 78.38 | 160.18 | 340.80 |

Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-1A EX | 42.15 | 86.07 | 182.78 |
| | 12.26 | 12.25 | 12.24 |
| DA-1A PR | 36.82 | 75.34 | 160.29 |
| | 12.29 | 12.28 | 12.30 |
| REACHES | | | |
| OUTLET | 78.38 | 160.18 | 340.80 |

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-1A EX | 36.50 | 0.341 | 80 | Outlet | |
| DA-1A PR | 34.78 | 0.407 | 80 | Outlet | |

Total Area: 71.28 (ac)

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-1A EX | | | | | | | |
| SHEET | 100 | 0.0200 | 0.240 | | | | 0.240 |
| SHALLOW | 760 | 0.0220 | 0.050 | | | | 0.088 |
| CHANNEL | 1000 | 0.0500 | 0.013 | 7.07 | 9.40 | 21.368 | 0.013 |
| | | | | | Time of Concentration | | .341 |
| DA-1A PR | | | | | | | |
| SHEET | 100 | 0.0090 | 0.240 | | | | 0.330 |
| SHALLOW | 391 | 0.0360 | 0.050 | | | | 0.035 |
| CHANNEL | 1153 | 0.0240 | 0.030 | 18.00 | 12.47 | 9.705 | 0.033 |
| CHANNEL | 485 | 0.0600 | 0.030 | 18.00 | 12.47 | 14.969 | 0.009 |
| | | | | | Time of Concentration | | .407 |

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-1A EX | Dirt (w/ right-of-way) | | D | .36 | 89 |
| | Pasture, grassland or range | (good) | D | 36.14 | 80 |
| | Total Area / Weighted Curve Number | | | 36.5 | 80 |
| | | | | ==== | == |
| DA-1A PR | Gravel (w/ right-of-way) | | D | 1.49 | 91 |
| | Pasture, grassland or range | (good) | D | 33.29 | 80 |
| | Total Area / Weighted Curve Number | | | 34.78 | 80 |
| | | | | ===== | == |

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA    Date: 12/11/2019
Project: Gude    Units: English
SubTitle: DA-1B    Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-1B EX | | Outlet | 15.69 | 81 | 0.233 |
| DA-1B PR | | Outlet | 28.82 | 80 | .353 |

Total area: 44.51 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

## Storm Data

### Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

DA-1B

Montgomery NOAA-C County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-1B EX | 22.61 | 44.98 | 93.88 |
| DA-1B PR | 32.75 | 66.75 | 142.26 |
| REACHES | | | |
| OUTLET | 53.34 | 108.12 | 229.00 |

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-1B EX | 22.61 | 44.98 | 93.88 |
| | 12.19 | 12.18 | 12.18 |
| DA-1B PR | 32.75 | 66.75 | 142.26 |
| | 12.27 | 12.27 | 12.26 |
| REACHES | | | |
| OUTLET | 53.34 | 108.12 | 229.00 |

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-1B EX | 15.69 | 0.233 | 81 | Outlet | |
| DA-1B PR | 28.82 | 0.353 | 80 | Outlet | |

Total Area: 44.51 (ac)

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-1B EX | | | | | | | |
| SHEET | 100 | 0.0620 | 0.240 | | | | 0.153 |
| SHALLOW | 1150 | 0.0616 | 0.050 | | | | 0.080 |
| | | | | Time of Concentration | | | 0.233 |
| | | | | | | | ======== |
| DA-1B PR | | | | | | | |
| SHEET | 100 | 0.0130 | 0.240 | | | | 0.285 |
| SHALLOW | 339 | 0.0210 | 0.050 | | | | 0.040 |
| CHANNEL | 1331 | 0.0340 | 0.013 | 3.14 | 6.30 | 13.204 | 0.028 |
| | | | | Time of Concentration | | | .353 |
| | | | | | | | ======== |

DA-1B

Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-1B EX | Paved parking lots, roofs, driveways | | D | .55 | 98 |
| | Dirt (w/ right-of-way) | | D | .62 | 89 |
| | Pasture, grassland or range | (good) | D | 14.33 | 80 |
| | Woods | (good) | D | .19 | 77 |
| | Total Area / Weighted Curve Number | | | 15.69 | 81 |
| | | | | ===== | == |
| DA-1B PR | Gravel (w/ right-of-way) | | D | 1.07 | 91 |
| | Pasture, grassland or range | (good) | D | 27.75 | 80 |
| | Total Area / Weighted Curve Number | | | 28.82 | 80 |
| | | | | ===== | == |

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WinTR-55 Current Data Description

--- Identification Data ---

| | | | |
|---|---|---|---|
| User: | EA | Date: | 12/12/2019 |
| Project: | Gude | Units: | English |
| SubTitle: | DA-2 | Areal Units: | Acres |
| State: | Maryland | | |
| County: | Montgomery NOAA-C | | |
| Filename: | P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des | | |

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-2 EX | | Outlet | 27.61 | 80 | .343 |
| DA-2 PR | | Outlet | 21.47 | 80 | .239 |

Total area: 49.08 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

DA-2

Montgomery NOAA-C County, Maryland

## Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-2 EX | 31.76 | 64.87 | 137.87 |
| DA-2 PR | 29.07 | 59.05 | 125.13 |
| REACHES | | | |
| OUTLET | 59.29 | 120.94 | 256.74 |

EA Gude

DA-2

Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-2 EX | 31.76 | 64.87 | 137.87 |
| | 12.25 | 12.26 | 12.24 |
| DA-2 PR | 29.07 | 59.05 | 125.13 |
| | 12.19 | 12.19 | 12.19 |
| REACHES | | | |
| OUTLET | 59.29 | 120.94 | 256.74 |

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-2 EX | 27.61 | 0.343 | 80 | Outlet | |
| DA-2 PR | 21.47 | 0.239 | 80 | Outlet | |

Total Area: 49.08 (ac)

## Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-2 EX | | | | | | | |
| SHEET | 100 | 0.0150 | 0.240 | | | | 0.269 |
| SHALLOW | 600 | 0.0233 | 0.050 | | | | 0.068 |
| CHANNEL | 540 | 0.0820 | 0.013 | 4.91 | 7.90 | 25.000 | 0.006 |
| | | | | | Time of Concentration | | .343 |
| DA-2 PR | | | | | | | |
| SHEET | 100 | 0.0400 | 0.240 | | | | 0.182 |
| SHALLOW | 78 | 0.0560 | 0.050 | | | | 0.006 |
| CHANNEL | 771 | 0.1300 | 0.013 | 4.91 | 7.90 | 30.595 | 0.007 |
| CHANNEL | 1680 | 0.0160 | 0.013 | 4.91 | 7.90 | 10.606 | 0.044 |
| | | | | | Time of Concentration | | .239 |

EA Gude

DA-2

Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-2 EX | Dirt (w/ right-of-way) | | D | .69 | 89 |
| | Pasture, grassland or range | (good) | D | 26.06 | 80 |
| | Woods | (good) | D | .86 | 77 |
| | Total Area / Weighted Curve Number | | | 27.61 | 80 |
| | | | | ===== | == |
| DA-2 PR | Gravel (w/ right-of-way) | | D | .98 | 91 |
| | Pasture, grassland or range | (good) | D | 19.63 | 80 |
| | Woods | (good) | D | .86 | 77 |
| | Total Area / Weighted Curve Number | | | 21.47 | 80 |
| | | | | ===== | == |

WinTR-55 Current Data Description

--- Identification Data ---

| | | | |
|---|---|---|---|
| User: | EA | Date: | 12/12/2019 |
| Project: | Gude | Units: | English |
| SubTitle: | DA-3 | Areal Units: | Acres |
| State: | Maryland | | |
| County: | Montgomery NOAA-C | | |

Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-3 EX | | Outlet | 12.68 | 80 | .334 |
| DA-3 PR | | Outlet | 9.43 | 81 | .228 |

Total area: 22.11 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

DA-3
Montgomery NOAA-C County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-3 EX | 14.77 | 30.15 | 64.06 |
| DA-3 PR | 13.68 | 27.31 | 56.82 |
| REACHES | | | |
| OUTLET | 27.61 | 55.86 | 117.88 |

Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-3 EX | 14.77<br>12.26 | 30.15<br>12.25 | 64.06<br>12.23 |
| DA-3 PR | 13.68<br>12.19 | 27.31<br>12.19 | 56.82<br>12.18 |
| REACHES | | | |
| OUTLET | 27.61 | 55.86 | 117.88 |

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-3 EX | 12.68 | 0.334 | 80 | Outlet | |
| DA-3 PR | 9.43 | 0.228 | 81 | Outlet | |

Total Area: 22.11 (ac)

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-3 EX | | | | | | | |
| SHEET | 100 | 0.0105 | 0.240 | | | | 0.311 |
| SHALLOW | 420 | 0.1010 | 0.050 | | | | 0.023 |
| | | | | | | Time of Concentration | .334 |
| DA-3 PR | | | | | | | |
| SHEET | 100 | 0.0350 | 0.240 | | | | 0.192 |
| SHALLOW | 68 | 0.0350 | 0.050 | | | | 0.006 |
| CHANNEL | 817 | 0.0280 | 0.022 | 18.00 | 12.47 | 14.184 | 0.016 |
| CHANNEL | 716 | 0.0380 | 0.013 | 3.14 | 6.30 | 14.206 | 0.014 |
| | | | | | | Time of Concentration | .228 |

EA Gude

DA-3

Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-3 EX | Paved parking lots, roofs, driveways | | D | .07 | 98 |
| | Dirt (w/ right-of-way) | | D | .25 | 89 |
| | Pasture, grassland or range | (good) | D | 10.74 | 80 |
| | Woods | (good) | D | 1.62 | 77 |
| | Total Area / Weighted Curve Number | | | 12.68 | 80 |
| | | | | ===== | == |
| DA-3 PR | Gravel (w/ right-of-way) | | D | .6 | 91 |
| | Pasture, grassland or range | (good) | D | 8.83 | 80 |
| | Total Area / Weighted Curve Number | | | 9.43 | 81 |
| | | | | ==== | == |

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WinTR-55 Current Data Description

--- Identification Data ---

| | | | |
|---|---|---|---|
| User: | EA | Date: | 12/13/2019 |
| Project: | Gude | Units: | English |
| SubTitle: | DA-4 | Areal Units: | Acres |
| State: | Maryland | | |
| County: | Montgomery NOAA-C | | |

Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-4 EX | | Outlet | 9.1 | 78 | 0.369 |
| DA-4 PR | | Outlet | 8.01 | 78 | .25 |

Total area: 17.11 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

DA-4

Montgomery NOAA-C County, Maryland

## Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-4 EX | 9.07 | 19.33 | 42.49 |
| DA-4 PR | 9.56 | 20.27 | 44.29 |
| REACHES | | | |
| OUTLET | 18.04 | 38.43 | 84.44 |

EA Gude
DA-4
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-4 EX | 9.07 | 19.33 | 42.49 |
| | 12.29 | 12.27 | 12.27 |
| DA-4 PR | 9.56 | 20.27 | 44.29 |
| | 12.21 | 12.20 | 12.19 |
| REACHES | | | |
| OUTLET | 18.04 | 38.43 | 84.44 |

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-4 EX | 9.10 | 0.369 | 78 | Outlet | |
| DA-4 PR | 8.01 | 0.250 | 78 | Outlet | |

Total Area: 17.11 (ac)

DA-4
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-4 EX | | | | | | | |
| SHEET | 100 | 0.0100 | 0.240 | | | | 0.317 |
| SHALLOW | 1020 | 0.1130 | 0.050 | | | | 0.052 |
| | | | | Time of Concentration | | | 0.369 |
| DA-4 PR | | | | | | | |
| SHEET | 100 | 0.0300 | 0.240 | | | | 0.204 |
| SHALLOW | 894 | 0.1120 | 0.050 | | | | 0.046 |
| | | | | Time of Concentration | | | .25 |

DA-4

Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-4 EX | Dirt (w/ right-of-way) | | D | .24 | 89 |
| | Pasture, grassland or range | (good) | D | 1.47 | 80 |
| | Woods | (good) | D | 7.39 | 77 |
| | Total Area / Weighted Curve Number | | | 9.1<br>=== | 78<br>== |
| DA-4 PR | Pasture, grassland or range | (good) | D | 1.46 | 80 |
| | Woods | (good) | D | 6.55 | 77 |
| | Total Area / Weighted Curve Number | | | 8.01<br>==== | 78<br>== |

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-5
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

Date: 12/9/2019
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-5 EX | | Outlet | 17.7 | 77 | .291 |
| DA-5 PR | | Outlet | 17.94 | 75 | .281 |

Total area: 35.64 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA Gude

DA-5

Montgomery NOAA-C County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-5 EX | 18.66 | 40.48 | 90.17 |
| DA-5 PR | 17.05 | 38.71 | 89.23 |
| REACHES | | | |
| OUTLET | 35.64 | 79.09 | 179.09 |

DA-5
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-5 EX | 18.66 | 40.48 | 90.17 |
| | 12.23 | 12.23 | 12.22 |
| DA-5 PR | 17.05 | 38.71 | 89.23 |
| | 12.22 | 12.22 | 12.21 |
| REACHES | | | |
| OUTLET | 35.64 | 79.09 | 179.09 |

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-5 EX | 17.70 | 0.291 | 77 | Outlet | |
| DA-5 PR | 17.94 | 0.281 | 75 | Outlet | |

Total Area: 35.64 (ac)

DA-5

Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-5 EX | | | | | | | |
| SHEET | 100 | 0.0270 | 0.240 | | | | 0.213 |
| SHALLOW | 330 | 0.0150 | 0.050 | | | | 0.046 |
| CHANNEL | 1200 | 0.0980 | 0.030 | 3.00 | 5.50 | 10.417 | 0.032 |
| | | | | | Time of Concentration | | .291 |
| DA-5 PR | | | | | | | |
| SHEET | 100 | 0.0200 | 0.240 | | | | 0.240 |
| SHALLOW | 75 | 0.0530 | 0.050 | | | | 0.006 |
| CHANNEL | 1265 | 0.0900 | 0.030 | 3.00 | 5.50 | 10.040 | 0.035 |
| | | | | | Time of Concentration | | .281 |

EA Gude

DA-5

Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-5 EX | Paved parking lots, roofs, driveways | | D | .28 | 98 |
| | Dirt (w/ right-of-way) | | D | .09 | 89 |
| | Pasture, grassland or range | (good) | C | 3.65 | 74 |
| | Woods | (good) | D | 13.68 | 77 |
| | Total Area / Weighted Curve Number | | | 17.7 | 77 |
| | | | | ==== | == |
| DA-5 PR | Gravel (w/ right-of-way) | | D | .12 | 91 |
| | Pasture, grassland or range | (good) | C | 14.97 | 74 |
| | Pasture, grassland or range | (good) | D | 2.85 | 80 |
| | Total Area / Weighted Curve Number | | | 17.94 | 75 |
| | | | | ===== | == |

WinTR-55 Current Data Description

--- Identification Data ---

| | | | |
|---|---|---|---|
| User: | EA | Date: | 12/10/2019 |
| Project: | Gude | Units: | English |
| SubTitle: | DA-6 | Areal Units: | Acres |
| State: | Maryland | | |
| County: | Montgomery NOAA-C | | |

Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-6 EX | | Outlet | 15.19 | 67 | .2 |
| DA-6 PR | | Outlet | 15.13 | 67 | .208 |

Total area: 30.32 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

DA-6
Montgomery NOAA-C County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-6 EX | 9.18 | 26.77 | 72.12 |
| DA-6 PR | 9.00 | 26.26 | 70.65 |
| REACHES | | | |
| OUTLET | 18.15 | 53.02 | 142.75 |

DA-6
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
| --- | --- | --- | --- |
| SUBAREAS | | | |
| DA-6 EX | 9.18 | 26.77 | 72.12 |
| | 12.18 | 12.18 | 12.17 |
| DA-6 PR | 9.00 | 26.26 | 70.65 |
| | 12.19 | 12.19 | 12.17 |
| REACHES | | | |
| OUTLET | 18.15 | 53.02 | 142.75 |

DA-6

Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-6 EX | 15.19 | 0.200 | 67 | Outlet | |
| DA-6 PR | 15.13 | 0.208 | 67 | Outlet | |

Total Area: 30.32 (ac)

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-6 EX | | | | | | | |
| SHEET | 100 | 0.0450 | 0.240 | | | | 0.174 |
| SHALLOW | 660 | 0.1900 | 0.050 | | | | 0.026 |
| | | | | | Time of Concentration | | .2 |
| DA-6 PR | | | | | | | |
| SHEET | 100 | 0.0400 | 0.240 | | | | 0.182 |
| SHALLOW | 660 | 0.1900 | 0.050 | | | | 0.026 |
| | | | | | Time of Concentration | | .208 |

EA Gude

DA-6

Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-6 EX | Dirt (w/ right-of-way) | | D | .03 | 89 |
| | Pasture, grassland or range | (good) | D | 1.96 | 80 |
| | Woods | (good) | B | 7.44 | 55 |
| | Woods | (good) | D | 5.76 | 77 |
| | Total Area / Weighted Curve Number | | | 15.19 | 67 |
| | | | | ===== | == |
| DA-6 PR | Gravel (w/ right-of-way) | | D | .12 | 91 |
| | Pasture, grassland or range | (good) | D | 1.81 | 80 |
| | Woods | (good) | B | 7.44 | 55 |
| | Woods | (good) | D | 5.76 | 77 |
| | Total Area / Weighted Curve Number | | | 15.13 | 67 |
| | | | | ===== | == |

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-7
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

Date: 12/10/2019
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-7 EX | | Outlet | 5.8 | 78 | .19 |
| DA-7 PR | | Outlet | 5.78 | 78 | .189 |

Total area: 11.58 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA Gude

DA-7

Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Gude
DA-7
Montgomery NOAA-C County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-7 EX | 7.77 | 16.38 | 35.70 |
| DA-7 PR | 7.76 | 16.35 | 35.65 |
| REACHES | | | |
| OUTLET | 15.53 | 32.71 | 71.34 |

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-7 EX | 7.77 | 16.38 | 35.70 |
| | 12.17 | 12.17 | 12.16 |
| DA-7 PR | 7.76 | 16.35 | 35.65 |
| | 12.17 | 12.17 | 12.16 |
| REACHES | | | |
| OUTLET | 15.53 | 32.71 | 71.34 |

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-7 EX | 5.80 | 0.190 | 78 | Outlet | |
| DA-7 PR | 5.78 | 0.189 | 78 | Outlet | |

Total Area: 11.58 (ac)

DA-7

Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-7 EX | | | | | | | |
| SHEET | 100 | 0.0500 | 0.240 | | | | 0.166 |
| SHALLOW | 580 | 0.1980 | 0.050 | | | | 0.022 |
| CHANNEL | 120 | 0.4200 | 0.011 | 0.10 | 1.00 | 16.667 | 0.002 |
| | | | | | Time of Concentration | | .19 |
| DA-7 PR | | | | | | | |
| SHEET | 100 | 0.0500 | 0.240 | | | | 0.166 |
| SHALLOW | 540 | 0.1940 | 0.050 | | | | 0.021 |
| CHANNEL | 120 | 0.4200 | 0.011 | 0.10 | 1.00 | 16.667 | 0.002 |
| | | | | | Time of Concentration | | .189 |

DA-7

Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-7 EX | Pasture, grassland or range | (good) | D | 1.16 | 80 |
| | Woods | (good) | D | 4.64 | 77 |
| | Total Area / Weighted Curve Number | | | 5.8 | 78 |
| | | | | === | == |
| DA-7 PR | Pasture, grassland or range | (good) | D | 1.14 | 80 |
| | Woods | (good) | D | 4.64 | 77 |
| | Total Area / Weighted Curve Number | | | 5.78 | 78 |
| | | | | ==== | == |

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WinTR-55 Current Data Description

--- Identification Data ---

| | | | |
|---|---|---|---|
| User: | EA | Date: | 12/10/2019 |
| Project: | Gude | Units: | English |
| SubTitle: | DA-8 | Areal Units: | Acres |
| State: | Maryland | | |
| County: | Montgomery NOAA-C | | |

Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-8 EX | | Outlet | 3.88 | 80 | .224 |
| DA-8 PR | | Outlet | 3.34 | 80 | .225 |

Total area: 7.22 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

## Storm Data

### Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

DA-8

Montgomery NOAA-C County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-8 EX | 5.40 | 10.94 | 23.19 |
| DA-8 PR | 4.64 | 9.44 | 19.97 |
| REACHES | | | |
| OUTLET | 10.04 | 20.34 | 43.13 |

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-8 EX | 5.40 | 10.94 | 23.19 |
| | 12.19 | 12.18 | 12.18 |
| DA-8 PR | 4.64 | 9.44 | 19.97 |
| | 12.18 | 12.19 | 12.18 |
| REACHES | | | |
| OUTLET | 10.04 | 20.34 | 43.13 |

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-8 EX | 3.88 | 0.224 | 80 | Outlet | |
| DA-8 PR | 3.34 | 0.225 | 80 | Outlet | |

Total Area: 7.22 (ac)

## Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-8 EX | | | | | | | |
| SHEET | 100 | 0.0290 | 0.240 | | | | 0.207 |
| SHALLOW | 400 | 0.2150 | 0.050 | | | | 0.015 |
| CHANNEL | 40 | 0.0710 | 0.030 | 0.90 | 3.50 | 5.556 | 0.002 |
| | | | | | Time of Concentration | | .224 |
| DA-8 PR | | | | | | | |
| SHEET | 100 | 0.0300 | 0.240 | | | | 0.204 |
| SHALLOW | 500 | 0.2150 | 0.050 | | | | 0.019 |
| CHANNEL | 40 | 0.0710 | 0.030 | 0.80 | 2.90 | 5.556 | 0.002 |
| | | | | | Time of Concentration | | .225 |

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-8 EX | Pasture, grassland or range | (good) | D | 3.88 | 80 |
| | Total Area / Weighted Curve Number | | | 3.88 | 80 |
| | | | | ==== | == |
| DA-8 PR | Pasture, grassland or range | (good) | D | 3.34 | 80 |
| | Total Area / Weighted Curve Number | | | 3.34 | 80 |
| | | | | ==== | == |

# WinTR-55 Current Data Description

## --- Identification Data ---

| | | | |
|---|---|---|---|
| User: | EA | Date: | 12/13/2019 |
| Project: | Gude | Units: | English |
| SubTitle: | DA-9 | Areal Units: | Acres |
| State: | Maryland | | |
| County: | Montgomery NOAA-C | | |

Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

## --- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-9 EX | | Outlet | 4.16 | 79 | .235 |
| DA-9 PR | | Outlet | 4.24 | 79 | .265 |

Total area: 8.40 (ac)

## --- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Gude
DA-9
Montgomery NOAA-C County, Maryland

## Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-9 EX | 5.39 | 11.15 | 24.03 |
| DA-9 PR | 5.21 | 10.81 | 23.34 |
| REACHES | | | |
| OUTLET | 10.56 | 21.92 | 47.17 |

EA Gude

DA-9

Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-9 EX | 5.39 | 11.15 | 24.03 |
| | 12.19 | 12.20 | 12.19 |
| DA-9 PR | 5.21 | 10.81 | 23.34 |
| | 12.21 | 12.21 | 12.20 |
| REACHES | | | |
| OUTLET | 10.56 | 21.92 | 47.17 |

Gude
DA-9
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-9 EX | 4.16 | 0.235 | 79 | Outlet | |
| DA-9 PR | 4.24 | 0.265 | 79 | Outlet | |

Total Area: 8.40 (ac)

DA-9

Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-9 EX | | | | | | | |
| SHEET | 100 | 0.0280 | 0.240 | | | | 0.210 |
| SHALLOW | 590 | 0.1640 | 0.050 | | | | 0.025 |
| | | | | | Time of Concentration | | .235 |
| DA-9 PR | | | | | | | |
| SHEET | 100 | 0.0200 | 0.240 | | | | 0.240 |
| SHALLOW | 590 | 0.1640 | 0.050 | | | | 0.025 |
| | | | | | Time of Concentration | | .265 |

## Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-9 EX | Dirt (w/ right-of-way) | | D | .23 | 89 |
| | Pasture, grassland or range | (good) | D | 1.85 | 80 |
| | Woods | (good) | D | 2.08 | 77 |
| | Total Area / Weighted Curve Number | | | 4.16 | 79 |
| | | | | ==== | == |
| DA-9 PR | Gravel (w/ right-of-way) | | D | .15 | 91 |
| | Pasture, grassland or range | (good) | D | 2.01 | 80 |
| | Woods | (good) | D | 2.08 | 77 |
| | Total Area / Weighted Curve Number | | | 4.24 | 79 |
| | | | | ==== | == |

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-10
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

Date: 12/10/2019
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-10 | | Outlet | 0.99 | 80 | .262 |
| DA-10 PR | | Outlet | 0.84 | 80 | .19 |

Total area: 1.83 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

DA-10

Montgomery NOAA-C County, Maryland

## Storm Data

### Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

## Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-10 | 1.29 | 2.62 | 5.57 |
| DA-10 PR | 1.25 | 2.53 | 5.34 |
| REACHES | | | |
| OUTLET | 2.49 | 5.07 | 10.73 |

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-10 | 1.29 | 2.62 | 5.57 |
| | 12.21 | 12.21 | 12.20 |
| DA-10 PR | 1.25 | 2.53 | 5.34 |
| | 12.17 | 12.17 | 12.16 |
| REACHES | | | |
| OUTLET | 2.49 | 5.07 | 10.73 |

EA Gude

DA-10

Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-10 | .99 | 0.262 | 80 | Outlet | |
| DA-10 PR | .84 | 0.190 | 80 | Outlet | |

Total Area: 1.83 (ac)

Gude
DA-10
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-10 | | | | | | | |
| SHEET | 100 | 0.0200 | 0.240 | | | | 0.240 |
| SHALLOW | 360 | 0.0760 | 0.050 | | | | 0.022 |
| | | | | | Time of Concentration | | .262 |
| DA-10 PR | | | | | | | |
| SHEET | 100 | 0.0450 | 0.240 | | | | 0.174 |
| SHALLOW | 281 | 0.0910 | 0.050 | | | | 0.016 |
| | | | | | Time of Concentration | | .19 |

DA-10
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-10 | Pasture, grassland or range | (good) | D | .88 | 80 |
| | Woods | (good) | D | .11 | 77 |
| | Total Area / Weighted Curve Number | | | .99 | 80 |
| | | | | === | == |
| DA-10 PR | Pasture, grassland or range | (good) | D | .75 | 80 |
| | Woods | (good) | D | .087 | 77 |
| | Total Area / Weighted Curve Number | | | .84 | 80 |
| | | | | === | == |

WinTR-55 Current Data Description

--- Identification Data ---

| | | | |
|---|---|---|---|
| User: | EA | Date: | 12/10/2019 |
| Project: | | Units: | English |
| SubTitle: | | Areal Units: | Acres |
| State: | Maryland | | |
| County: | Montgomery NOAA-C | | |
| Filename: | P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des | | |

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| DA-11 EX | | Outlet | 3.15 | 78 | .199 |
| DA-11 PR | | Outlet | 3.18 | 78 | .212 |

Total area: 6.33 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.14 | 4.13 | 4.82 | 6.19 | 7.1 | 8.32 | 2.6 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

Montgomery NOAA-C County, Maryland

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| DA-11 EX | 4.14 | 8.73 | 19.04 |
| DA-11 PR | 4.07 | 8.60 | 18.77 |
| REACHES | | | |
| OUTLET | 8.20 | 17.31 | 37.79 |

EA

Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 10-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
| --- | --- | --- | --- |
| SUBAREAS | | | |
| DA-11 EX | 4.14 | 8.73 | 19.04 |
| | 12.17 | 12.17 | 12.16 |
| DA-11 PR | 4.07 | 8.60 | 18.77 |
| | 12.19 | 12.18 | 12.17 |
| REACHES | | | |
| OUTLET | 8.20 | 17.31 | 37.79 |

EA

Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| DA-11 EX | 3.15 | 0.199 | 78 | Outlet | |
| DA-11 PR | 3.18 | 0.212 | 78 | Outlet | |

Total Area: 6.33 (ac)

Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| DA-11 EX | | | | | | | |
| SHEET | 100 | 0.0500 | 0.240 | | | | 0.166 |
| SHALLOW | 600 | 0.0980 | 0.050 | | | | 0.033 |
| | | | | Time of Concentration | | | .199 |
| DA-11 PR | | | | | | | |
| SHEET | 100 | 0.0420 | 0.240 | | | | 0.178 |
| SHALLOW | 621 | 0.1000 | 0.050 | | | | 0.034 |
| | | | | Time of Concentration | | | .212 |

Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| DA-11 EX | Pasture, grassland or range | (good) | D | .88 | 80 |
| | Woods | (good) | D | 2.27 | 77 |
| | Total Area / Weighted Curve Number | | | 3.15 | 78 |
| | | | | ==== | == |
| DA-11 PR | Gravel (w/ right-of-way) | | D | .012 | 91 |
| | Pasture, grassland or range | (good) | D | .868 | 80 |
| | Woods | (good) | D | 2.3 | 77 |
| | Total Area / Weighted Curve Number | | | 3.18 | 78 |
| | | | | ==== | == |

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# Appendix D

# Stormwater Bypass Drawing

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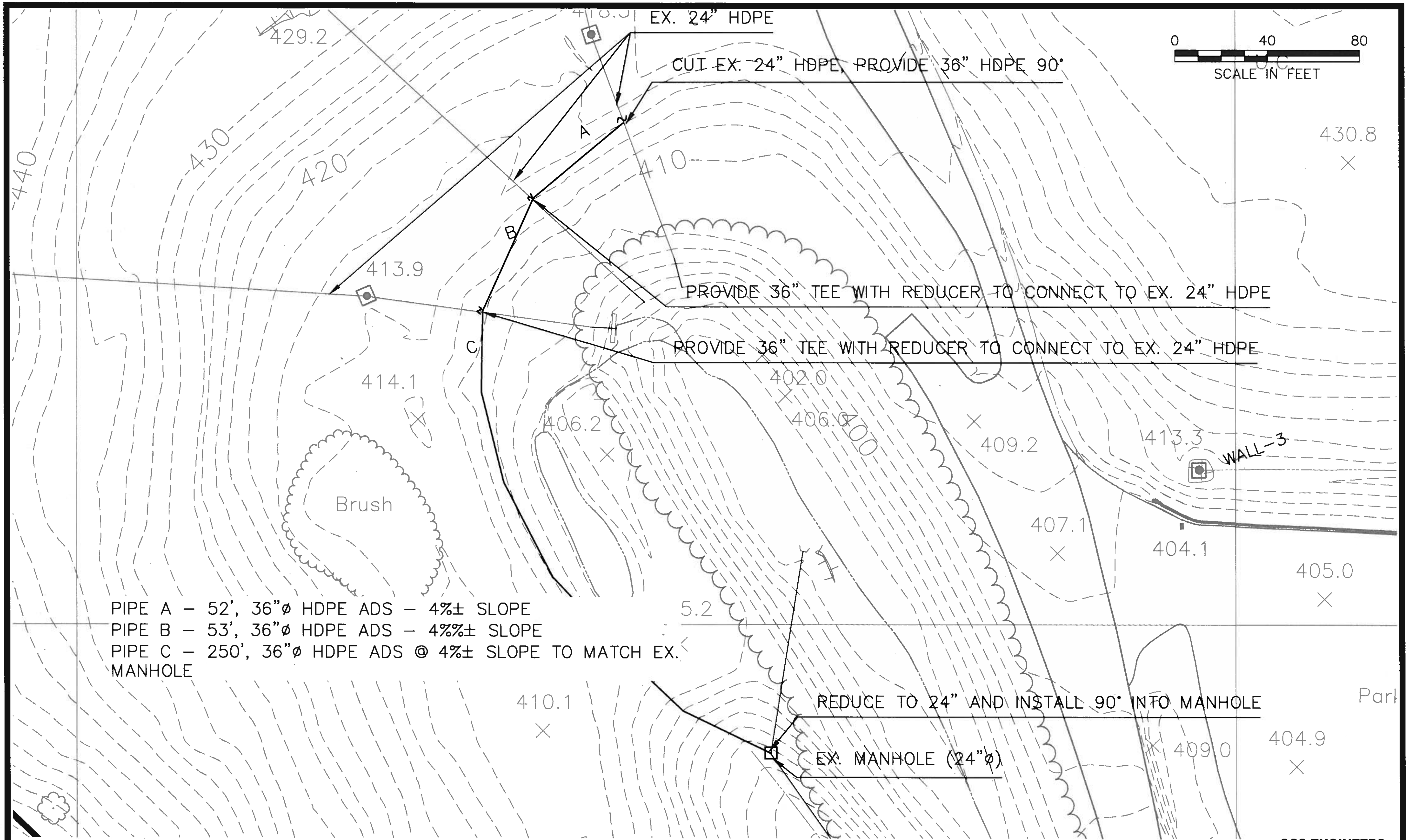
DRAWN BY: SMS DATE: 4/4/08 FILE NAME: 02203039.13\ROUGH GRADING




ROUGH GRADING STORMWATER MANAGEMENT DIVERSION

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# Appendix E

# ESD Volume Calculations

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
225 Schilling Circle, Suite 400, Hunt Valley, MD 21031

# Environmental Site Design

| | | | |
|---|---|---|---|
| By: | CAG | Project Name: | Gude Landfill |
| Date: | 12/10/2019 | Project Number: | |
| Checked: | KEF/MP | Maryland County: | Montgomery |
| Date: | | Study Area Limits: | Limit of Disturbance |
| Sheet: | of | POI/LOI Number: | |

Location:

Limit of Disturbance: 4006105 sq. ft. = 91.97 ac.

Impervious Area: 37462 sq. ft. = 0.86 ac.

Impervious percentage (%I) = 0.9%

Use %I = **5%**

-user defined fields

**ESD DESIGN**

Treatment based on new impervious area within the entire LOD

Determine ESD Implementation Goals

Determine Target $P_E$ Using Table 5.3: See next page for Table 5.3

Determine Percent Impervious (I) for each HSG:

| HSG | Impervious Area (ac) | Pervious Area (ac) | Total Area (ac) | Percent Imp |
|---|---|---|---|---|
| A | 0.00 | 0.00 | 0.00 | 0.0% |
| B | 0.00 | 0.00 | 0.00 | 0.0% |
| C | 0.00 | 0.00 | 0.00 | 0.0% |
| D | 5.20 | 86.77 | 91.97 | 5.7% |
| Total | 5.20 | 86.77 | 91.97 | 5.7% |

Determine $P_E$ from Table 5.3:

Using %I = **5%** and A soils $P_E$ = 1.0 in.

Using %I = **5%** and B soils $P_E$ = 1.0 in.

Using %I = **5%** and C soils $P_E$ = 1.0 in.

Using %I = **5%** and D soils $P_E$ = 1.0 in.

Composite $P_E$ =

$((\%I_{A\ soils} * P_{E\text{-}A\ soils})+(\%I_{B\ soils} * P_{E\text{-}B\ soils})+(\%I_{C\ soils} * P_{E\text{-}C\ soils})+(\%I_{D\ soils} * P_{E\text{-}D\ soils}))/\%I_{total}$ =

Composite $P_E$ = 1.00 in.

Watershed Specific $P_{E\ Req.}$ = 1.00 inches of rainfall as the target for ESD implementation

Watershed Maximum $P_E$ = **3.20** inches (1-yr- 24 hour storm) Table 2.2

Compute $Q_E$:

$Q_E = P_E \times R_V$

$R_V = 0.05 + (0.009)(I) =$ 0.06

$Q_E$ = 0.06 inches

Min. 1 inch $ESD_{v\ Req.} = (P_E)(R_v)(A)/12 =$ 19,502 $ft^3$

**Site Specific $ESD_{v\ Req.} = (P_E)(R_v)(A)/12 =$ 19,502 $ft^3$**

Max Maximum $ESD_v = (\text{Max } P_E)(R_v)(A)/12 =$ 62,406 $ft^3$

**Table 5.3** Runoff Curve Number Reductions used for Environmental Site Design (continued)

| Hydrologic Soil Group C | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **%I** | **RCN*** | **$P_E$ = 1"** | **1.2"** | **1.4"** | **1.6"** | **1.8"** | **2.0"** | **2.2"** | **2.4"** | **2.6"** |
| 0% | 74 | | | | | | | | | |
| 5% | 75 | | | | | | | | | |
| 10% | 76 | | | | | | | | | |
| 15% | 78 | | | | | | | | | |
| 20% | 79 | **70** | | | | | | | | |
| 25% | 80 | 72 | **70** | **70** | | | | | | |
| 30% | 81 | 73 | 72 | 71 | | | | | | |
| 35% | 82 | 74 | 73 | 72 | **70** | | | | | |
| 40% | 84 | 77 | 75 | 73 | 71 | | | | | |
| 45% | 85 | 78 | 76 | 74 | 71 | | | | | |
| 50% | 86 | 78 | 76 | 74 | 71 | | | | | |
| 55% | 86 | 78 | 76 | 74 | 71 | **70** | | | | |
| 60% | 88 | 80 | 78 | 76 | 73 | 71 | | | | |
| 65% | 90 | 82 | 80 | 77 | 75 | 72 | | | | |
| 70% | 91 | 82 | 80 | 78 | 75 | 72 | | | | |
| 75% | 92 | 83 | 81 | 79 | 75 | 72 | | | | |
| 80% | 93 | 84 | 82 | 79 | 76 | 72 | | | | |
| 85% | 94 | 85 | 82 | 79 | 76 | 72 | | | | |
| 90% | 95 | 86 | 83 | 80 | 77 | 73 | **70** | | | |
| 95% | 97 | 88 | 85 | 82 | 79 | 75 | 71 | | | |
| 100% | 98 | 89 | 86 | 83 | 80 | 76 | 72 | **70** | | |

| Hydrologic Soil Group D | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **%I** | **RCN*** | **$P_E$ = 1"** | **1.2"** | **1.4"** | **1.6"** | **1.8"** | **2.0"** | **2.2"** | **2.4"** | **2.6"** |
| 0% | 80 | | | | | | | | | |
| 5% | 81 | | | | | | | | | |
| 10% | 82 | | | | | | | | | |
| 15% | 83 | | | | | | | | | |
| 20% | 84 | **77** | | | | | | | | |
| 25% | 85 | 78 | | | | | | | | |
| 30% | 85 | 78 | **77** | **77** | | | | | | |
| 35% | 86 | 79 | 78 | 78 | | | | | | |
| 40% | 87 | 82 | 81 | 79 | **77** | | | | | |
| 45% | 88 | 82 | 81 | 79 | 78 | | | | | |
| 50% | 89 | 83 | 82 | 80 | 78 | | | | | |
| 55% | 90 | 84 | 82 | 80 | 78 | | | | | |
| 60% | 91 | 85 | 83 | 81 | 78 | | | | | |
| 65% | 92 | 85 | 83 | 81 | 78 | | | | | |
| 70% | 93 | 86 | 84 | 81 | 78 | | | | | |
| 75% | 94 | 86 | 84 | 81 | 78 | | | | | |
| 80% | 94 | 86 | 84 | 82 | 79 | | | | | |
| 85% | 95 | 86 | 84 | 82 | 79 | | | | | |
| 90% | 96 | 87 | 84 | 82 | 79 | **77** | | | | |
| 95% | 97 | 88 | 85 | 82 | 80 | 78 | | | | |
| 100% | 98 | 89 | 86 | 83 | 80 | 78 | **77** | | | |

**$Cp_v$ Addressed (RCN = Woods in Good Condition)**

**RCN Applied to $Cp_v$ Calculations**

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*Water Quality Calculation for Redevelopment Only*

| | |
|---|---|
| Required Treatment Area (acres) | 0.00 |
| Runoff Coefficient, Rv | 0.95 |

| | |
|---|---|
| **Water Quality Volume, WQv (cf)** | **0** |

### Step 4: Calculate Environmental Site Design (ESD) Rainfall Target, $P_E$

| | |
|---|---|
| **Development Category (for ESD)** | **New Development** |

| | |
|---|---|
| % Soil Type A | 0% |
| % Soil Type B | 0% |
| % Soil Type C | 0% |
| % Soil Type D | 100% |

| | |
|---|---|
| Pre-Developed Condition, $RCN_{woods}$ | 77 |

| | |
|---|---|
| Soil Type A ESD Rainfall Target, $P_E$ (in) | 0.00 |
| Soil Type B ESD Rainfall Target, $P_E$ (in) | 0.00 |
| Soil Type C ESD Rainfall Target, $P_E$ (in) | 0.00 |
| Soil Type D ESD Rainfall Target, $P_E$ (in) | 1.00 |

| | |
|---|---|
| Maximum $P_E$ (in) | 1 |

| | |
|---|---|
| **Site ESD Rainfall Target, $P_E$ (in)** | 1.00 |

| | |
|---|---|
| ESD Runoff Depth, $Q_E$ (in) | 0.21 |

| | |
|---|---|
| **ESD Runoff Volume, ESDv (cf)** | **3,700** |

| | |
|---|---|
| **Total Treatment Volume (cf)** | **3,700** |

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| *Nonstructural Practices* | $P_E$ Credit Description | Contributing Drainage Area (sf) | % Impervious Cover | Direct WQv or ESDv Received by Practice (cf) | WQv or ESDv from Up-Gradient Practices (cf) | Practice Specific Parameter(s) | | $P_E$ Credit (in) | WQV or ESDv credit (cf) | Runoff Volume Remaining (cf) | Down-Gradient Practice |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Disconnection of Non-Rooftop Runoff (C/D Soils) | Up to 1 inch credit provided based upon disconnection and contributing flow lengths. | 213,880 | 100% | 16,932 | 0 | Disconnection Length (ft): 10 | Contributing Length (ft) (Impervious): 7.5 | 1.00 | 16,932.17 | 0 | Disconnection of Rooftop Runoff (A/B Soils) |
| Disconnection of Non-Rooftop Runoff (C/D Soils) | Up to 1 inch credit provided based upon disconnection and contributing flow lengths. | | 100% | 0 | 0 | Disconnection Length (ft) | Contributing Length (ft) (Impervious) | 0.00 | 0.00 | 0 | |
| Disconnection of Non-Rooftop Runoff (C/D Soils) | Up to 1 inch credit provided based upon disconnection and contributing flow lengths. | | 100% | 0 | 0 | Disconnection Length (ft) | Contributing Length (ft) (Impervious) | 0.00 | 0.00 | 0 | |
| Total | | 213,880 | | 16,932 | 0 | | | 1 | 16,932 | 0 | |

### Step 5: Select Nonstructural Practices to Treat the ESD Rainfall Target

| *Nonstructural Practices* | $P_E$ Credit Description | Contributing Drainage Area (sf) | Direct WQv or ESDv Received by Practice (cf) | WQv or ESDv from Up-Gradient Practices (cf) | $P_E$ Credit (in) | WQV or ESDv credit (cf) | Runoff Volume Remaining (cf) |
|---|---|---|---|---|---|---|---|
| Disconnection of Rooftop Runoff (A/B Soils) | Up to 1 inch credit provided based upon disconnection flow length. | 0 | 0 | 0 | 0.00 | 0 | 0 |
| Disconnection of Rooftop Runoff (C/D Soils) | Up to 1 inch credit provided based upon disconnection flow length. | 0 | 0 | 0 | 0.00 | 0 | 0 |
| Disconnection of Non-Rooftop Runoff (A/B Soils) | Up to 1 inch credit provided based upon disconnection and contributing flow lengths. | 0 | 0 | 0 | 0 | 0 | 0 |
| Disconnection of Non-Rooftop Runoff (C/D Soils) | Up to 1 inch credit provided based upon disconnection and contributing flow lengths. | 213,880 | 16,932 | 0 | 1 | 16,932 | 0 |
| Sheetflow to Conservation Areas (A/B Soils) | Up to 1 inch credit provided based upon conservation area width. | 0 | 0 | 0 | 0 | 0 | 0 |
| Sheetflow to Conservation Areas (C/D Soils) | Up to 1 inch credit provided based upon conservation area width. | 0 | 0 | 0 | 0 | 0 | 0 |

# Appendix F

# Preliminary Pond Sizing Calculations

**OBJECTIVE:**

The hydrologic analyses contained within this report are based upon the methods outlined in the NRCS TR-55 Manual (Small Watershed Hydrology Win-TR-55 User Guide, issued January 2009), WinTR-55 software, and the *2000 Maryland Stormwater Design Manual*. The appropriate TR-55 computations and procedures were utilized to determine the weighted runoff curve number and time of concentration for the existing conditions of the site. A composite curve number was computed, for each drainage area (DA). Based on these results, runoff volumes increase in the majority of the drainage areas.

Modifications to Pond 3 will be required to manage discharge to pre-development conditions to the greatest extent possible. Using methods from the NRCS TR-55 Manual, EA calculated the approximate storage volume required for managing the increased runoff to existing conditions for the ten (10)-year storm. An expansion footprint was estimated assuming a depth of two (2) feet.

**PROCEDURE:**

Natural Resources Conservation Service (NRCS). 1986. *Urban Hydrology for Small Watersheds; Technical Release 55*. June.

USDA Urban Hydrology for Small Watersheds TR-55, chapter 6: Storage Volume for Detention Basins was used as guidance.

1) $Q = \dfrac{(P-I_a)^2}{(P-I_a)+S}$

where:

$Q$ = runoff (in.)
$P$ = rainfall (in.)
$S$ = potential maximum retention after runoff begins (in.)
$I_a$ = initial abstraction (in.)

2) $V_r = 53.33(Q)(A_m)$

where:

$V_r$ = runoff volume (acre-ft)
$Q$ = runoff (in.)
Am = drainage area ($mi^2$)
53.33 = conversion factor from in-$mi^2$ to acre-ft

3) $\dfrac{\text{Peak outflow discharge}}{\text{Peak inflow discharge}} = \dfrac{q_o}{q_i}$

4) Refer to Figure 6-1 to calculate storage volume required ($V_s$) for Type II rainfall.

**CONCLUSION:**

Results from the storage volume calculation are in the following table:

**Table 1 Estimated Additional Pond Capacity Requirements**

| Facility | Approximate Additional Storage Required (cubic feet) | Estimated Additional Footprint Required (square feet) | Estimated Additional Footprint Required (acres) |
|---|---|---|---|
| Pond 3 | 87,295 | 43,647 | 1.00 |

See attached calculations

**Pond 3 Storage Volume Estimation**

| | | | |
|---|---|---|---|
| S = | 2.5 | | |
| P = | 5.1 | in | 10-yr storm |
| | | | |
| $A_m$ = | 0.045 | sq. mi | |
| Q = | 2.980 | in | |
| $q_o$ = | 28.3 | cfs | Assume: predevelopment discharge rates |
| $q_i$ = | 66.75 | cfs | |
| $q_o/q_i$ = | 0.42397 | | |
| $V_s/V_r$ = | 0.28 | | Figure 6-1 |
| $V_r$ = | 7.157 | acre-ft | |
| $V_s$ = | 2.004 | acre-ft | |
| $V_s$ = | 87295 | cf | |
| Assume 2-ft Depth | | | |
| $A_s$ = | 43647 | $ft^2$ | |
| $A_s$ = | 1.00 | AC | |
| Assume rectangle with L = 2*W | | | |
| W = | 148 | ft2 | |
| L = | 295 | ft2 | |

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# Chapter 6 Storage Volume for Detention Basins

As rural areas become urbanized, the resulting increases in peak discharges can adversely affect downstream flood plains. Increasingly, planners, developers, and the public want these downstream areas to be protected. Many local governments are adopting ordinances to control the type of development and its allowable impacts on the watershed. One of the most common controls requires that postdevelopment discharges do not exceed present-condition discharges for one or more storm frequencies at specified points along a channel.

This chapter discusses ways to manage peak discharges by delaying runoff. It also presents a procedure for estimating the storage capacity required to maintain the peaks within a specified level.

Efforts to reduce the effects of increased runoff from urban areas have been innovative and diverse. Many methods have been used effectively, such as infiltration trenches, porous pavement, rooftop storage, and cisterns. But these solutions can be expensive or require site conditions that cannot be provided.

The detention basin is the most widely used measure for controlling peak discharge. It is generally the least expensive and most reliable of the measures that have been considered. It can be designed to fit a wide variety of sites and can accommodate multiple-outlet spillways to meet requirements for multifrequency control of outflow. Measures other than a detention basin may be preferred in some locations; their omission here is not intended to discourage their use. Any device selected, however, should be assessed as to its function, maintenance needs, and impart.

## Estimating the effect of storage

When a detention basin is installed, hydrologic routing procedures can be used to estimate the effect on hydrographs. Both the TR-20 (SCS 1983) and DAMS2 (SCS 1982) computer programs provide accurate methods of analysis. Programmable calculator and computer programs are available for routing hydrographs through dams.

This chapter contains a manual method for quick estimates if the effects of temporary detention on peak discharges. The method is based on average storage and routing effects for many structures.

Figure 6-1 relates two ratios: peak outflow to peak inflow discharge ($q_o/q_i$) and storage volume runoff volume ($V_s/V_r$) for all rainfall distributions.

The relationships in figure 6-1 were determined on the basis of single stage outflow devices. Some were controlled by pipe flow, others by weir flow. Verification runs were made using multiple stage outflow devices, and the variance was similar to that in the base data. The method can therefore be used for both single- and multiple-stage outflow devices. The only constraints are that (1) each stage requires a design storm and a computation of the storage required for it and (2) the discharge if the upper stage(s) includes the discharge of the lower stage(s).

The brevity of the procedure allows the planner to examine many combinations of detention basins. When combined with the Tabular Hydrograph method, the procedure's usefulness is increased. Its principal use is to develop preliminary indications of storage adequacy and to allocate control to a group of detention basins. It is also adequate, however, for final design of small detention basins.

## Input requirements and procedures

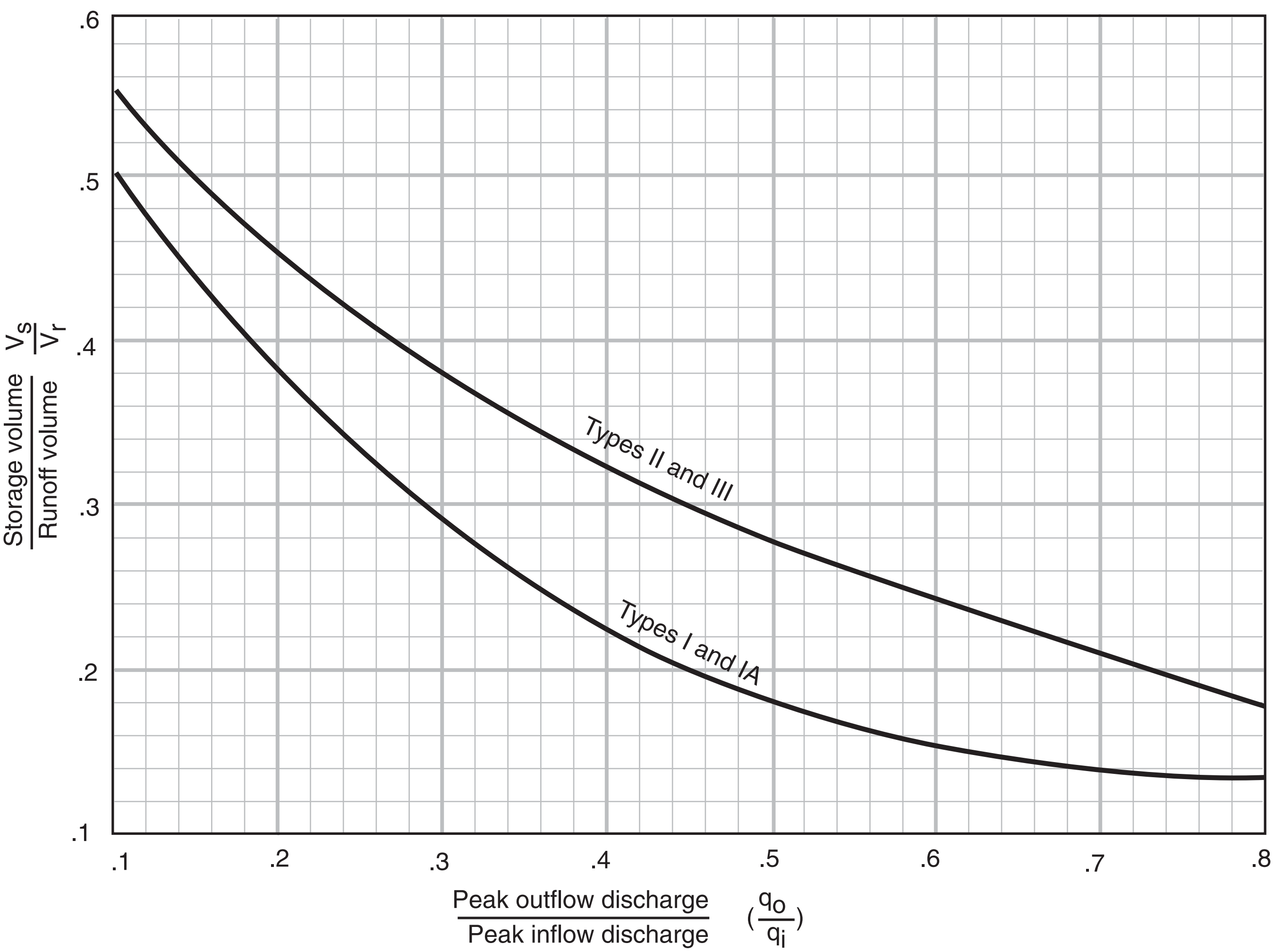
Use figure 6-1 estimate storage volume ($V_s$) required or peak outflow discharge ($q_o$). The most frequent application is to estimate $V_s$, for which the required inputs are runoff volume ($V_r$), $q_o$, and peak inflow discharge ($q_i$). To estimate $q_o$, the required inputs are $V_r$, $V_s$, and $q_i$.

## Estimating $V_s$

Use worksheet 6a to estimate $V_s$, storage volume required, by the following procedure.

1. Determine $q_o$. Many factors may dictate the selection of peak outflow discharge. The most common is to limit downstream discharges to a desired level, such as predevelopment discharge. Another factor may be that the outflow device has already been selected.
2. Estimate $q_i$ by procedures in chapters 4 or 5. Do not use peak discharges developed by other procedure. When using the Tabular Hydrograph method to estimate $q_i$ for a subarea, only use peak discharge associated with $T_t = 0$.

Figure 6-1 Approximate detention basin routing for rainfall types I, IA, II, and III



3. Compute $q_o/q_i$ and determine $V_s/V_r$ from figure 6-1.
4. Q (in inches) was determined when computing $q_i$ in step 2, but now it must be converted to the units in which $V_s$ is to be expressed—most likely, acre-feet or cubic feet. The most common conversion of Q to $V_r$ is expressed in acre-feet:

$$V_r = 53.33Q(A_m) \qquad \text{[eq. 6-1]}$$

where
$V_r$ = runoff volume (acre-ft)
Q = runoff (in)
$A_m$ = drainage area ($mi^2$), and
53.33 = conversion factor from in-$mi^2$ to acre-ft.

5. Use the results of steps 3 to 4 to compute $V_s$:

$$V_s = V_r\left(\frac{V_s}{V_i}\right) \qquad \text{[eq. 6-2]}$$

where
$V_s$ = storage volume required (acre-ft).

6. The stage in the detention basin corresponding to $V_s$ must be equal to the stage used to generate $q_o$. In most situations a minor modification of the outflow device can be made. If the device has been preselected. repeat the calculations with a modified $q_o$ value.

### Estimating $q_o$

Use worksheet 6b to estimate $q_o$, required peak outflow discharge, by the following procedure.

1. Determine $V_s$. If the maximum stage in the detention basin is constrained, set $V_s$ by the maximum permissible stage.
2. Compute Q (in inches) by the procedures in chapter 2, and convert it to the same units as $V_s$ (see step 4 in "estimating $V_s$").
3. Compute $V_s/V_r$ and determine $q_o/q_i$ from figure 6-1.
4. Estimate $q_i$ by the procedures in chapters 4 or 5. Do not use discharges developed by any other method. When using Tabular method to estimate $q_i$ for a subarea, use only the peak discharge associated with $T_t = 0$.
5. From steps 3 to 4, compute $q_o$:

$$q_o = q_i\left(\frac{q_o}{q_i}\right) \qquad \text{[eq. 6-3]}$$

6. Proportion the outflow device so that the stage at $q_o$ is equal to the stage corresponding to $V_s$. If $q_o$ cannot be calibrated except in discrete steps (i.e., pipe sizes), repeat the procedure until the stages for $q_o$ and $V_s$ are approximately equal.

## Limitations

- This routing method is less accurate as the $q_o/q_i$ ratio approaches the limits shown in figure 6-1. The curves in figure 6-1 depend on the relationship between available storage, outflow device, inflow volume, and shape of the inflow hydrograph. When storage volume ($V_s$) required is small, the shape of the outflow hydrograph is sensitive to the rate of the inflow hydrograph. Conversely, when $V_s$ is large, the inflow hydrograph shape has little effect on the outflow hydrograph. In such instances, the outflow hydrograph is controlled by the hydraulics of the outflow device and the procedure therefore yields consistent results. When the peak outflow discharge ($q_o$) approaches the peak flow discharge ($q_i$) parameters that affect the rate of rise of a hydrograph, such as rainfall volume, curve number, and time of concentration, become especially significant.
- The procedure should not be used to perform final design if an error in storage of 25 percent cannot be tolerated. Figure 6-1 is biased to prevent undersizing of outflow devices, but it may significantly overestimate the required storage capacity. More detailed hydrograph development and routing will often pay for itself through reduced construction costs.

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# Attachment I

# Geosynthetics Calculations

## OBJECTIVE:

Determine the required transmissivity and thickness of the geocomposite drainage layer based on the maximum rainfall intensity and maximum permeability of the vegetative support soil. Consider combinations of geocomposites and vegetative support soil permeabilities to optimize the design.

Evaluate three scenarios. Refer to the attached figure for the locations. Scenario A represents the longest length possible (90 horizontal feet) of the steepest slope (3H:1V) on the landfill. Scenario B represents a longer length (100 horizontal feet) of a slightly less steep slope (4H:1V) on the landfill. Scenario C represents a two-slope scenario on the northwest slope of the landfill. Drainage from the geocomposites will be conveyed to downchutes at benches.

## PROCEDURE:

Giroud, J.P., J.G. Zornberg, and J.F. Beech, 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", Geosynthetics International, Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp 453-489.

1) Utilize the design method developed by Giroud et al. to evaluate the multiple slope configurations on the west side of the landfill. The multiple slope analysis considers flow through a flatter slope before reaching a steeper slope. For a single slope scenarios, use the equation for the upper slope only.

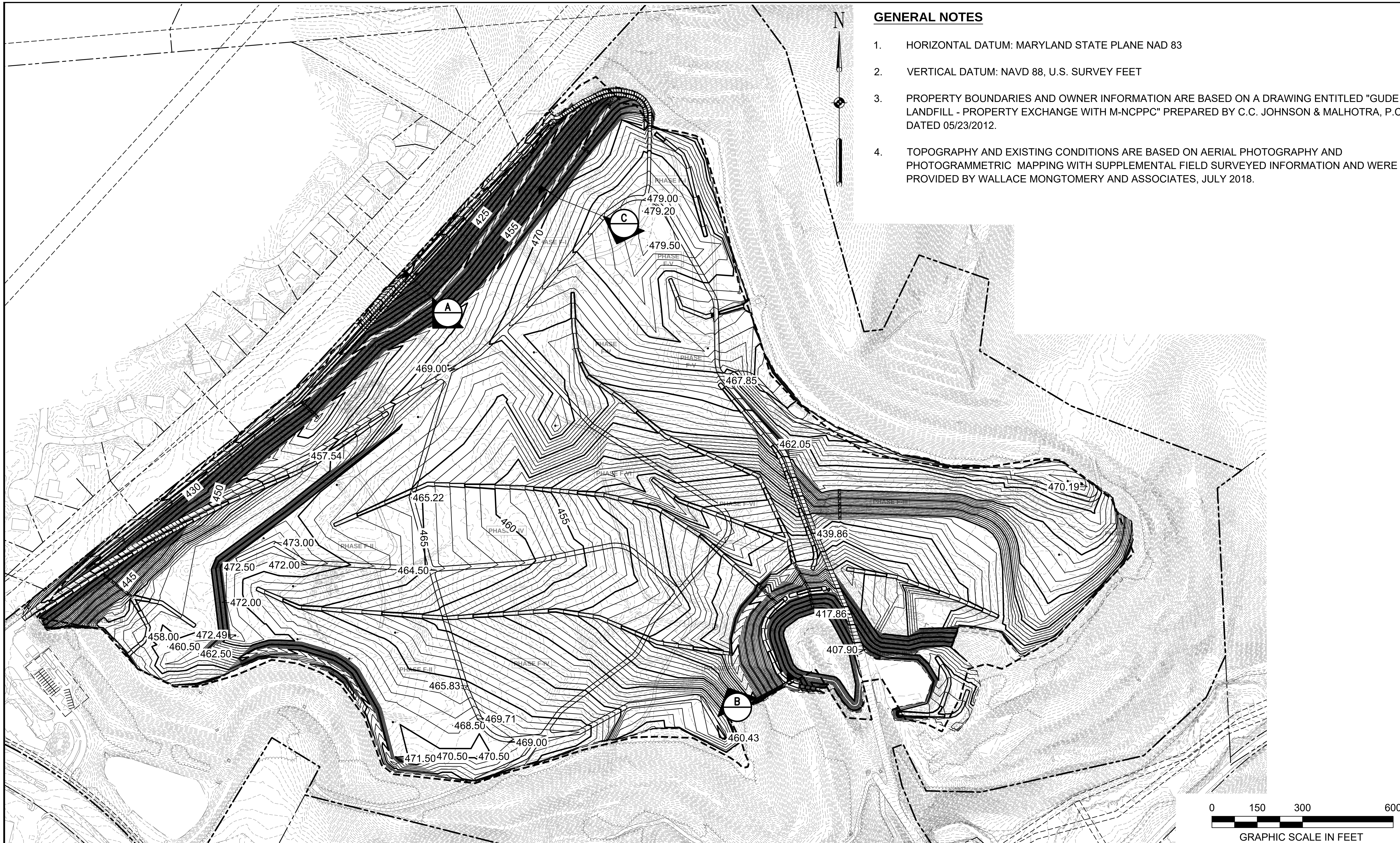
The design method calculates the maximum liquid thickness in the upper and lower slopes. If the liquid thickness is contained within the geocomposite, there is no head in the overlying soil material and the design is acceptable.

Both the standard and the alternate closure cap section are based on a drainage layer providing a minimum 7.5 x $10^{-4}$ $m^2$/sec transmittivity.

2) Calculations are shown on the attached sheet, which also further describes the equations. A design factor of safety of 1.5 was used.

## CONCLUSION:

A 300-mil or thicker geocomposite or the 50 mil LLDPE Agru MicroDrain geomembrane (or equivalent) with a minimum ultimate transmissivity of 7.0 x $10^{-4}$ $m^2$/sec is adequate if the vegetative support soil has a maximum permeability of 1 x $10^{-4}$ cm/sec.




## GENERAL NOTES

1. HORIZONTAL DATUM: MARYLAND STATE PLANE NAD 83
2. VERTICAL DATUM: NAVD 88, U.S. SURVEY FEET
3. PROPERTY BOUNDARIES AND OWNER INFORMATION ARE BASED ON A DRAWING ENTITLED "GUDE LANDFILL - PROPERTY EXCHANGE WITH M-NCPPC" PREPARED BY C.C. JOHNSON & MALHOTRA, P.C., DATED 05/23/2012.
4. TOPOGRAPHY AND EXISTING CONDITIONS ARE BASED ON AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRIC MAPPING WITH SUPPLEMENTAL FIELD SURVEYED INFORMATION AND WERE PROVIDED BY WALLACE MONGTOMERY AND ASSOCIATES, JULY 2018.

FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\1564601 - GEOCOMPOSITE CAPACITY CALC FIGURE.DWG [02] 11/6/18

EA Engineering, Science, and Technology, Inc., PBC
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(410) 584-7000

| PROJECT NUMBER: | DESIGNED BY: | DRAWN BY: | FIGURE: |
|---|---|---|---|
| 1564601 | KEF | SMB | 1 |
| DATE: | CHECKED BY: | PROJECT MGR.: | SHEET NUMBER: |
| JANUARY 2020 | GAT | MJG | - |

**GUDE LANDFILL REMEDIATION DESIGN**
**NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY**
**BASIS OF DESIGN REPORT**
MONTGOMERY COUNTY, MARYLAND

**FIGURE 1: GEOCOMPOSITE CALCULATION FIGURE**

## GUDE LANDFILL REMEDIATION DESIGN

## GEOCOMPOSITE CAPACITY ANALYSIS
### Scenario A: One Slope Scenario: 3:1 Slope

| | | | |
|---|---|---|---|
| liquid impingement rate, $q_h$ = | 1.0E-04 | cm/sec | (min of design storm or barrier layer permeability) |
| **GEOCOMPOSITE PROPERTIES** | | | |
| ultimate transmissivity, $\Theta$ = | 7.5E-04 | $m^2$/sec | |
| geocomposite thickness, t = | 300 | mil | RF Ranges for Landfill Caps |
| reduction factor for elastic deformation, $RF_{in}$ = | 1.1 | | 1.0 to 1.2 |
| reduction factor for creep deformation, $RF_{cr}$ = | 1.3 | | 1.1 to 1.4 |
| reduction factor for chemical clogging $RF_{cc}$ = | 1.1 | | 1.0 to 1.2 |
| reduction factor for biological clogging $RF_{bc}$ = | 1.4 | | 1.2 to 1.5 |
| reduction factor for root penetration, $RF_{rp}$ = | 1.0 | | -- |
| design factor of safety, FS = | 1.5 | | |
| allowable hydraulic conductivity, k = | 3.0E+00 | cm/sec | |
| **CALCULATION** | | | |
| slope, z = | 3 | H:1V | |
| slope, $\beta$ = | 18.43 | ° | |
| length of slope, L = | 90 | ft | |
| characteristic parameter, $\lambda$ = | 0.000302 | | |
| modifying factor, j = | 0.998363 | | |
| max. liquid thickness, $t_{max}$ = | 0.11 | in | |
| max. liquid thickness, $t_{max}$ = | 114.62 | mil | Acceptable - liquid thickness is less than geocomposite thickne |

**MAX. LIQUID THICKNESS IN SLOPE:**

$$\boxed{t_{\max} = \frac{q_h \; L_{up}}{k \sin \beta}}$$

WHERE:
$t_{max}$ = maximum liquid thickness
$q_h$ = liquid impingement rate
$L_{up}$ = length of slope
k = hydraulic conductivity of geocomposite
$\beta$ = slope

REFERENCE: Giroud, J.P., J.G. Zornberg, and J.F. Beech, 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", *Geosynthetics International* , Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp 453-489.

**GUDE LANDFILL REMEDIATION DESIGN**

**GEOCOMPOSITE CAPACITY ANALYSIS**
**Scenario B: One Slope Scenario: 4:1 Slope**

| | | | |
|---|---|---|---|
| liquid impingement rate, $q_h$ = | 1.0E-04 | cm/sec | (min of design storm or barrier layer permeability) |
| **GEOCOMPOSITE PROPERTIES** | | | |
| ultimate transmissivity, Θ = | 7.5E-04 | $m^2$/sec | |
| geocomposite thickness, t = | 300 | mil | RF Ranges for Landfill Caps |
| reduction factor for elastic deformation, $RF_{in}$ = | 1.1 | | 1.0 to 1.2 |
| reduction factor for creep deformation, $RF_{cr}$ = | 1.3 | | 1.1 to 1.4 |
| reduction factor for chemical clogging $RF_{cc}$ = | 1.1 | | 1.0 to 1.2 |
| reduction factor for biological clogging $RF_{bc}$ = | 1.4 | | 1.2 to 1.5 |
| reduction factor for root penetration, $RF_{rp}$ = | 1.0 | | -- |
| design factor of safety, FS = | 1.5 | | |
| allowable hydraulic conductivity, k = | 3.0E+00 | cm/sec | |
| **CALCULATION** | | | |
| slope, z = | 4 | H:1V | |
| slope, β = | 14.04 | ° | |
| length of slope, L = | 100 | ft | |
| characteristic parameter, λ = | 0.000537 | | |
| modifying factor, j = | 0.996948 | | |
| max. liquid thickness, $t_{max}$ = | 0.17 | in | |
| max. liquid thickness, $t_{max}$ = | 166.05 | mil | Acceptable - liquid thickness is less than geocomposite thickne |

**MAX. LIQUID THICKNESS IN SLOPE:**

$$\boxed{t_{\max} = \frac{q_h \, L_{up}}{k \sin \beta}}$$

WHERE:
$t_{max}$ = maximum liquid thickness
$q_h$ = liquid impingement rate
$L_{up}$ = length of slope
k = hydraulic conductivity of geocomposite
β = slope

REFERENCE: Giroud, J.P., J.G. Zornberg, and J.F. Beech, 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", *Geosynthetics International* , Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp 453-489.

**GUDE LANDFILL REMEDIATION DESIGN**

**GEOCOMPOSITE CAPACITY ANALYSIS**
**Scenario C: Two Slope Scenario**

| | | | |
|---|---|---|---|
| liquid impingement rate, $q_h$ = | 1.0E-04 | cm/sec | (min of design storm or barrier layer permeability) |
| **GEOCOMPOSITE PROPERTIES** | | | |
| ultimate transmissivity, $\Theta$ = | 7.5E-04 | $m^2$/sec | |
| geocomposite thickness, t = | 300 | mil | RF Ranges for Landfill Caps |
| reduction factor for elastic deformation, $RF_{in}$ = | 1.1 | | 1.0 to 1.2 |
| reduction factor for creep deformation, $RF_{cr}$ = | 1.3 | | 1.1 to 1.4 |
| reduction factor for chemical clogging $RF_{cc}$ = | 1.1 | | 1.0 to 1.2 |
| reduction factor for biological clogging $RF_{bc}$ = | 1.4 | | 1.2 to 1.5 |
| reduction factor for root penetration, $RF_{rp}$ = | 1.0 | | -- |
| design factor of safety, FS = | 1.5 | | |
| allowable hydraulic conductivity, k = | 3.0E+00 | cm/sec | |

| **UPPER SLOPE (FLATTER)** | | | **LOWER SLOPE (STEEPER)** | | |
|---|---|---|---|---|---|
| slope, z = | 4 | % | slope, z = | 3 | H:1V |
| slope, $\beta$ = | 2.29 | ° | slope, $\beta$ = | 18.43 | ° |
| length of slope, L = | 165 | ft | length of slope, L = | 30 | ft |
| characteristic parameter, $\lambda$ = | 0.020976 | | characteristic parameter, $\lambda$ = | 0.000302 | |
| modifying factor, j = | 0.948653 | | modifying factor, j = | 0.998363 | |
| max. liquid thickness, $t_{max}$ = | 1.66 | in | max. liquid thickness, $t_{max}$ = | 0.25 | in |
| max. liquid thickness, $t_{max}$ = | 1662.62 | mil | max. liquid thickness, $t_{max}$ = | 248.35 | mil |

**MAX. LIQUID THICKNESS IN UPPER SLOPE:**

$$\boxed{t_{\max} = \frac{q_h\, L_{up}}{k \sin \beta}}$$

WHERE:
$t_{max}$ = maximum liquid thickness
$q_h$ = liquid impingement rate
$L_{up}$ = length of upper slope
k = hydraulic conductivity of geocomposite
$\beta$ = upper slope

**MAX. LIQUID THICKNESS IN LOWER SLOPE:**

$$\boxed{t_{\max} = \frac{q_h\, \left(L_{up} + L_{down}\right)}{k \sin \beta}}$$

WHERE:
$t_{max}$ = maximum liquid thickness
$q_h$ = liquid impingement rate
$L_{up}$ = length of upper slope
$L_{down}$ = length of lower slope
k = hydraulic conductivity of geocomposite
$\beta$ = lower slope

REFERENCE: Giroud, J.P., J.G. Zornberg, and J.F. Beech, 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", *Geosynthetics International* , Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp 453-489.

| | | | | | |
|---|---|---|---|---|---|
| Project | Gude Landfill Remediation Design | | | Project No. | 15646.01 |
| Subject | Vegetative Support Soil Requirements | | | Sheet No. | 1 of 1 |
| | Based on Geotextile Filter | | | Drawing No. | |
| Computed by | KEF | Date | 1/6/2020 | Checked by | GAT |
| | | | | Date | 1/7/2020 |

**OBJECTIVE:**

Determine the requirements for the vegetative support soil material based on the apparent opening size (AOS) of the geotextile component of the geocomposite drainage collection layer. Specify a vegetative support soil material which will minimize clogging of the geotextile and piping into the drainage layer.

Koerner, R.M. (1998). *Designing With Geosynthetics, Fourth Edition*. Prentice Hall. Upper Saddle River, NJ.

Carroll, R.G., Jr. (1983). "Geotextile Filter Criteria," *Engineering Fabrics in Transportation Construction*. TRR 916, TBR, Washington, D.C.

GSE FabriNet HF

**PROCEDURE:**

Use Carroll's criteria to determine the smallest acceptable $d_{85}$ for the vegetative support soil.

$$d_{85} \geq \frac{O_{95}}{2}$$

where:

$O_{95}$ = apparent opening size of geotextile (AOS)

$d_{85}$ = grain size which 85% of the barrier protection soil is smaller than (mm)

$$d_{85} \geq \frac{O_{95}}{2} \geq \frac{0.177\ mm}{2} \geq 0.089\ mm$$

**RESULTS:**

Therefore, the $d_{85}$ of the vegetative support soil must be > 0.089 mm.

| | | | |
|---|---|---|---|
| Project | Gude Landfill Remediation Design | Project No. | 15646.01 |
| Subject | Veneer Stability Over Closure Cap | Sheet No. | 1 of 2 |
| | | Drawing No. | |
| Computed by KEF | Date 12/04/2019 | Checked by GAT | Date 1/7/2020 |

**OBJECTIVE:**

Analyze cap stability by calculating the required peak friction angle between all cap components to achieve a factor of safety of 1.5 for cap stability.

**PROCEDURE**

Use methodology presented by the Environmental Protection Agency (EPA) in *Stability of Lined Slopes at Landfills and Surface Impoundments* (1990). Calculate the factor of safety based on infinite slope and finite slope theory. Finite slope theory considers the buttressing effect of the toe of the landfill and results in a higher factor of safety.

The interfaces are evaluated on longest and steepest slopes of the landfill, which are the 3H:1V slopes on the northwest side of the landfill. This provides a conservative estimate of the minimum required interface friction angles to achieve a factor of safety of 1.5.

See attached sheets for veneer stability calculations.

**CONCLUSIONS:**

**A peak friction angle of 27° will exceed a minimum finite slope factor of safety of 1.5 and will be specified.** Based on manufacturer's data, this is an achievable peak interface friction angle for the specified cap components.

**GUDE LANDFILL REMEDIATION DESIGN**
**VENEER STABILITY CALCULATION**

| | | | |
|---|---|---|---|
| interface cohesion, $c$ = | 0 | psf | |
| interface friction angle, $\phi$ = | 27 | ° | |
| slope, $z$ = | 3 | H:1V | |
| slope, $\beta$ = | 18.43 | ° | |
| length of slope, $L$ = | 90 | ft | |
| unit weight of soil, $\gamma$ = | 120 | pcf | |
| depth of soil, $D$ = | 2 | ft | |
| pore pressure, $\mu$ = | 0.25 | in. water | |
| | 1.3 | psf | |
| toe soil cohesion, $c_s$ = | 0 | psf | Silty sand |
| toe soil friction angle, $\phi_s$ = | 28 | ° | Silty sand |
| weight of toe, $W_T$ = | 720 | lb/ft | |

**INFINITE SLOPE FACTOR OF SAFETY:**

$$\boxed{F.S. = \frac{(\gamma D \cos\beta - \mu)\tan\phi + c}{\gamma D \sin\beta}}$$

**F.S. = 1.52**

Reference: Stability of Lined Slopes at Landfills and Surface Impoundments, August 1990 (Equation 5).

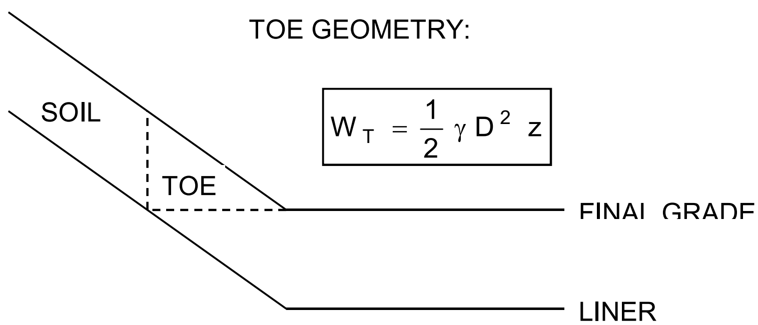
**FINITE SLOPE FACTOR OF SAFETY:**

$$\boxed{F.S. = \frac{(\gamma D\cos\beta - \mu)\, L\tan\phi + c\,L + \dfrac{W_T\tan\phi_s + c_s L}{\cos\beta - \sin\beta\tan\phi}}{\gamma D L \sin\beta}}$$

**F.S. = 1.59**

TOE GEOMETRY:

$$\boxed{W_T = \frac{1}{2}\gamma D^2 z}$$




Reference: Stability of Lined Slopes at Landfills and Surface Impoundments, August 1990 (Equation 9).

## OBJECTIVE:

Determine the required mass per unit area of the cushion geotextile to provide a minimum factor of safety of 3.0 for the puncture resistance of the proposed geomembrane liner for the Gude Landfill closure cap. It is imperative that the geomembrane not be punctured when installing the closure cap as this will cause unacceptable material transfer between the landfill and the exterior environment.

## PROCEDURE:

The required mass per unit area is calculated using the method presented in Koerner and is based on a 1.0 mm thick (40 mil) LLDPE geomembrane. The method uses the design by function approach.

Koerner, R.M. (2012), *Designing with Geosynthetics*, 6th Edition, Prentice Hall Publishing Co., Englewood Cliffs, NJ.

$$FS = \frac{P_{allow}}{P_{act}}$$

$$P_{allow} = \left(50 + 0.00045\frac{M}{H^2}\right)\left[\frac{1}{MF_s * MF_{PD} * MF_A}\right]\left[\frac{1}{RF_{CR} * RF_{CBD}}\right]$$

$$P_{act} = \gamma * d + P_{eqp}$$

Where:

| | |
|---|---|
| FS | = Factor of safety against geomembrane puncture |
| $P_{allow}$ | = Allowable pressure based on geotextile and site specific conditions (kPa) |
| $P_{act}$ | = Actual pressure due to the landfill contents or surface (kPa) |
| M | = Geotextile mass per unit area (g/m$^2$) |
| H | = Height of the protrusion above the liner (m) |
| $MF_S$ | = Modification factor for protrusion shape |
| $MF_{PD}$ | = Modification factor for packing density |
| $MF_A$ | = Modification factor for arching in solids |
| $RF_{CR}$ | = Reduction factor for long-term creep |
| $RF_{CBD}$ | = Reduction factor for long-term chemical/biological degradation |
| $\gamma$ | = Unit weight of material on top of geomembrane (kN/m$^3$) |
| d | = depth of material on top of geomembrane (m) |
| $P_{eqp}$ | = Pressure from equipment (kPa) |

Assumptions / Inputs:

M = 8 oz/sy (271 g/m$^2$)
H = 0.025 m
$MF_S$ = 0.5 (subrounded)
$MF_{PD}$ = 0.67 (Dense, 25mm)
$MF_A$ = 0.75 (Geostatic, shallow)
$RF_{CR}$ = 1.5 (maximum reduction factor)
$RF_{CBD}$ = 1.1 (mild leachate)
$\gamma$ = 120 lb/ft$^3$ (18.85 kN/m$^3$)
d = 2 ft (0.6096 m)
$P_{eqp}$ = 8 psi (55.2 kPa)

Solved:

$$FS = \frac{P_{allow}}{P_{act}} = 10.3$$

**CONCLUSIONS:**

**A 8 oz/sy geotextile will provide a factor of safety greater than 3.0 against puncturing the geomembrane. The load proposed to be applied to the geomembrane does not subject the geomembrane to puncture risk.**

**GUDE LANDFILL REMEDIATION DESIGN**
**GEOMEMBRANE PUNCTURE RESISTANCE**

This calculation apply to geotextiles placed under geomembranes.

$$FS = \frac{p_{allow}}{p_{act}} \qquad p_{allow} = \left(50 + 0.00045\frac{M}{H^2}\right)\left[\frac{1}{MF_S \times MF_{PD} \times MF_A}\right]\left[\frac{1}{RF_{CR} \times RF_{CBD}}\right]$$

| | | | |
|---|---|---|---|
| geotextile mass per unit area, M = | 8 | oz/sy | |
| | 271 | g/m2 | |
| protrusion height, H = | 1 | in | |
| | 0.025 | m | |
| modification factor for protrusion shape, $MF_S$ = | 0.5 | | subrounded |
| modification factor for packing density, $MF_{PD}$ = | 0.67 | | dense, 25mm |
| modification factor for arching in solids, $MF_A$ = | 0.75 | | geostatic, shallow |
| reduction factor for long-term creep, $RF_{CR}$ = | 1.5 | | |
| reduction factor for long-term degradation, $RF_{CBD}$ = | 1.1 | | mild leachate |
| allowable pressure, $p_{allow}$ = | 577 | kPa | |
| | 84 | psi | |
| unit weight of material on top of geomembrane, γ = | 120 | pcf | |
| depth of material on top of geomembrane, d = | 2 | ft | |
| pressure from equipment, $P_{eqp}$ = | 8 | psi | assume 8 psi ground pressure from equipme |
| actual pressure, $p_{act}$ = | 8.14 | psi | |
| factor of safety for puncture, FS = | 10.28 | | |

Reference: Koerner, R., Designing with Geosynthetics, Sixth Edition (Equations 5.33 and 5.34).

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# Attachment J

# Condensate Quantity And Quality Evaluation Technical Memorandum

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Fax: 410-771-1625
www.eaest.com

14 November 2019

**TECHNICAL MEMORANDUM**

**TO**: Northeast Maryland Waste Disposal Authority and the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division

**FROM**: Laura Jo Oakes, P.E., BCEE, EA Project Engineer

**SUBJECT**: Remediation Design – Condensate Quantity and Quality Evaluation
Gude Landfill, Montgomery County, Maryland
EA Project No. 15646.01

## 1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has evaluated the quantity and characterized the quality of existing condensate generated at Gude Landfill (the Landfill), as part of the design for the Maryland Department of the Environment-approved corrective measure alternative, toupee capping and additional landfill gas (LFG) collection. This Technical Memorandum presents the summary of the quality and estimated quantity of condensate generated from the Landfill as part of the redesign and improvements to the LFG management system.

## 2. BACKGROUND

Gude Landfill is currently owned and maintained by the Montgomery County Department of Environmental Protection (the County). The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres, of which approximately 140 acres were used for waste disposal. The site is located at 600 East Gude Drive in Rockville, Maryland. The site is bordered to the east by industrial operations, to the south by Gude Drive, to the west by the community of Derwood, and to the north by Maryland-National Capital Park and Planning Commission land.

### 2.1 EXISTING CONDENSATE MANAGEMENT

As LFG is extracted from the Landfill and transported through the LFG collection system, it gradually cools and condensate is formed. The LFG condensate primarily consists of water and typically contains minimal quantities of volatile and miscible compounds. LFG condensate can have similar composition to leachate. Condensate sumps within the system are utilized for the collection of condensate, which are periodically pumped out, as necessary. It is EA's understanding that condensate is currently managed with the use of three sumps, several condensate traps, and at least one self-draining condensate trap that currently drains back to the Landfill. Additionally, there is a condensate knockout located at the blower skid that drains to a below-grade condensate sump within the fenced area for the enclosed flares. A site plan depicting the existing condensate sumps is included as **Figure 1**.

Based on information provided by APTIM (previously CB&I) and reviewed as-built documentation, the following sumps are utilized to manage condensate:

1. Flare Sump – is located close to the plant where the condensate drains to the sump by gravity from the flare and knockout.

2. Inlet Sump – a sump is located at the inlet to the LFG plant that is below grade with a pneumatic pump.

3. Sump A – located between the Inlet Sump and Sump B, has an estimated depth of 16.5 feet. Based on APTIM's inspections throughout the years, this sump has historically not contained condensate.

4. Sump B – is located near the center of the existing well field with an estimated depth of 12 feet. APTIM noted that the connections to the sump are below grade and include a valve with an extended stem for operations.

## 2.2 PROPOSED CONDENSATE MANAGEMENT

As part of the improvements to the LFG collection system, the existing condensate sumps, traps, and drains are to be disconnected and abandoned along with the existing above-grade LFG collection system; however, a condensate sump located at the LFG blower skid will remain. Based on the slope of the finished grade, condensate drains are proposed to be installed at the potential low points of the proposed LFG collection system. The proposed condensate drains would increase the overall efficiency and reliability of the LFG collection system since there would be less chance of condensate accumulation in the LFG collection piping. Moreover, there would be less likelihood for system downtime for maintenance and/or other issues associated with pumping stations that would be required throughout the Landfill. Since this facility is adjacent to a residential community, minimal interruptions to operation of the LFG collection system is a priority to the County. Condensate sumps with conveyance pumps within the Landfill are not proposed due to the frequency of low spots and overall management that would be required via a series of below grade sumps with conveyance pumps and piping under the toupee cap at an unmanned landfill. Additionally, settlement across the Landfill may vary and would significantly impact the infrastructure associated with condensate sumps and the associated electrical service that would need to be installed across the site. Design and operational considerations for electrical requirements of the pumps would also be required. Currently there is no electrical service planned for the site and the addition of a permanent electrical service and transmission of electric across the site would be significant in relation to both cost and design. Another consideration is that due to the average estimated depth of waste (50 feet) according to the temporary piezometers (installed in the Landfill as part of the Assessment of Corrective Measures [ACM]) construction logs, it is anticipated that due to the capped condition, condensate from the proposed drains would likely percolate slowly and may become perched within the existing waste mass. The detail drawing of the proposed condensate drains and a schedule will be provided as part of the 60% design submittal.

# 3. CONDENSATE QUANTITY

## 3.1 CONDENSATE GENERATION

As part of the condensate quantity determination, EA performed the calculation of condensate generation using Antoine's equation. The calculation is provided in **Attachment A**. To estimate LFG production to be used for condensate generation calculation, EA used the U.S. Environmental Protection Agency (EPA) LFG Emissions Model (LandGEM) and compared that to recent data. The average LFG collection observed from November 2017 to April 2018 was 507 standard cubic feet per minute. The average LFG volume collected from the Landfill was estimated to be 485 standard cubic feet per minute according to the LandGEM model for the years 2017 and 2018 based on 75% collection efficiency. Since the LandGEM model confirmed the most recent landfill gas volume data, an LFG production value of 507 standard cubic feet per minute was utilized for the design basis. Based on the estimated total LFG production from the Landfill, the total volume of condensate produced per minute is estimated to be 0.264 gallon per minute or 380 gallons per day (**Attachment A)**. Currently, the volume of condensate removed from the existing sumps varies, but during the period of January through April 2019 the monthly volume pumped out for disposal ranged from 700 to 2,200 gallons.

## 3.2 LEACHATE GENERATION COMPARISON

The Hydrologic Evaluation of Landfill Performance (HELP) model was used as part of the ACM report preparation to estimate the average annual leachate generation volume which infiltrates (percolates) through the bottom of the waste as leachate (ACM 2016). The average annual leachate volume was calculated over the entire 140 acres of original Landfill footprint, including portions of the Landfill that will remain uncapped. Based on the estimated volume of condensate generation and leachate generation, it appears that the total volume of condensate generated comprises only 0.9% of the total leachate generation from the Landfill. Additionally, a portion of the total condensate generated will still be collected and managed at the blower skid. Therefore, based on the volume of condensate generated, the percolation of condensate via drains back into the waste mass is not a significant potential source of contamination to the groundwater and is an appropriate approach to minimize the maintenance associated with the installation of sumps within the proposed toupee cap. For further information, refer to the HELP model results included as **Attachment B**.

# 4. CONDENSATE QUALITY

In order to evaluate and characterize the quality of condensate, EA performed a condensate sample collection event on March 5, 2019. During the sampling event, two condensate samples were collected from condensate sumps located at the Flare facility and within the Landfill (Sump B) and analyzed for general water quality parameters, total metals, and volatile organic compounds (VOCs).

## 4.1 SAMPLE COLLECTION

Condensate samples from two condensate sumps were obtained during the sampling event and analyzed in accordance with the parameters identified in the Landfill's Groundwater and Surface Water Monitoring Plan.

Samples were collected from each condensate sump using grab sampling methodology. Each sample was obtained using a clean and non-preservative long-handled polytetrafluoroethylene dip sampler, which was used to collect the sample from the sampling location and then transfer it into the proper sample container. The first sample aliquot was used to fill the volatile organics parameter vials. Samples for volatile organics were collected in a manner that minimized aeration and the containers were free of bubbles and headspace. The remaining sample was transferred to the sample containers. Containers that held preservative were not filled to overflowing and were mixed after filling by upending. Each pre-labeled container was then placed in a cooler containing ice and a sample entry made on the chain-of-custody form.

During the sampling event, a trip blank was prepared and delivered to the laboratory accompanying the field samples. The trip blank was analyzed for VOCs. The trip blank was prepared prior to field sampling by the laboratory, sealed and labeled, and never opened during any sampling activities. Trip blanks were collected to identify potential contamination during shipping and handling of samples.

## 4.2 SAMPLE ANALYSIS

The samples were analyzed by Maryland Spectral Services, Inc. located in Baltimore, Maryland. The laboratory performed the following methods: EPA 9045D, EPA 180.1, EPA 8260B, EPA 3010A/6020A, EPA 410.4, USGS I-3765-85, and SM 2320B. All analytical results below practical quantitation limits are reported with a "J" qualifier, and non-detect analytical results are identified with a "U" qualifier. Laboratory reports are included as **Attachment C**.

## 4.3 CONDENSATE ANALYTICAL RESULTS

A complete summary of detected analytes of the condensate samples, as well as the range of results from the most recent groundwater sampling event for comparison, is presented in **Table 1**.

As shown in **Table 1**, none of the measured general water quality parameters had maximum contaminant level (MCL) exceedances at any of the condensate sump locations. Additionally, all general water quality parameters at both condensate sumps were within the range of Fall 2018 groundwater water quality parameters with one exception—the pH value of the condensate collected from Sump B.

There was an MCL exceedance for antimony reported at both condensate sumps during the sampling event. Antimony exceeded the MCL at concentrations of 0.0317 and 0.0796 milligram per liter (mg/L) in the Flare Sump, which had a pH of 7.05, and Sump B, which had a pH of 7.76, respectively. All other metals remained within the range of Fall 2018 groundwater metal results.

Antimony is a natural constituent of soil and also comes from anthropogenic sources such as municipal waste. In the neutral pH range, antimony is retained in soil through the process of adsorption and can also sorb onto clay minerals, oxides, and hydroxides in the soil (Agency for Toxic Substances and Disease Registry 2017). Since, antimony is not typically found in groundwater at the site it can be assumed that it is not mobile in groundwater at the site and, therefore, the presence of it within the condensate is not a concern.

No VOCs were detected above the MCLs for the samples collected from both condensate sumps. Four VOCs were detected above practical quantitation limits in both condensate sumps: 1,4-dicholorobenzene was detected at concentrations of 2.2 and 5.5 micrograms per liter (µg/L) in the Flare Sump and Sump B, respectively; acetone was detected at concentrations of 82.4 and 621 µg/L in the Flare Sump and Sump B, respectively; m&p-xylene was detected at concentrations of 1.9 and 5.7 µg/L in the Flare Sump and Sump B, respectively; o-xylene was detected at concentrations of 1.1 and 2.6 µg/L in the Flare Sump and Sump B, respectively. Cis-1,2-dichlororethene was detected only in the Flare Sump at a concentration of 1.0 µg/L. 2-Butanone, 2-hexanone, 4-methyl-2-pentanone, and ethylbenzene were detected only in Sump B at concentrations of 727, 5.4, 29.0, and 1.1 µg/L, respectively. Among the VOCs detected at the condensate sumps, acetone, m&p-xylene, and o-xylene exceeded the range of Fall 2018 groundwater VOC results. In addition, the condensate sample collected from Sump B exceeded the groundwater range for 2-butanone, 2-hexanone, and 4-methyl-2-pentanone. Based on the analytical results, the range of VOC concentrations are unlikely to significantly impact groundwater.

**Table 1 Summary of Condensate and Groundwater Analytical Results**

| | | Sampling Location | Flare Sump | Sump B (Field Sump) | Groundwater Results |
|---|---|---|---|---|---|
| | | **Sampling date** | **3/5/2019** | **3/5/2019** | **Fall 2018** |
| **Parameters** | **Units** | **MCL** | **Results** | **Results** | **Range (min–max)** |
| **General Parameters** | | | | | |
| Alkalinity | mg/L | -- | 112 | 196 | 8.8–1,050 |
| Ammonia Nitrogen | mg/L | -- | 0.95 | 3.07 | 0.202–23.7 |
| Chemical Oxygen Demand | mg/L | -- | 37.8 | 67.2 | 10.2–142 |
| Chloride | mg/L | -- | 157 | 154 | 2.51–607 |
| Hardness | mg/L | -- | 130 | 586 | 11.8–832 |
| Nitrate | mg/L | 10 | 1.1 | 0.4 | 0.205–5.81 |
| pH | SU | -- | 7.05 | 7.76 | 4.84–7.36 |
| Specific Conductivity | µS/cm | -- | 782 | 1240 | 31.4–2,710 |
| Sulfate, total | mg/L | -- | 28.5 | 63.1 | 2.6–240 |
| Total Dissolved Solids | mg/L | -- | 432 | 756 | 26–1,840 |
| Total Suspended Solids | mg/L | -- | 4.3 | 3.5 | -- |
| Turbidity | NTU | -- | 8.69 | 17.4 | 0.0–149.8 |
| **Inorganics** | | | | | |
| Antimony, total | mg/L | 0.006 | **0.0317** | **0.0796** | 0.002U–0.005U |
| Arsenic, total | mg/L | 0.01 | 0.00331 | 0.00422 | 0.00201–0.035 |
| Barium, total | mg/L | 2 | 0.0242 | 0.0608 | 0.00381–0.605 |
| Calcium, total | mg/L | -- | 34.8 | 119 | 2.54–178 |
| Chromium, total | mg/L | 0.1 | 0.00527 | 0.001 U | 0.00205–0.0276 |
| Cobalt, total | mg/L | -- | 0.001 U | 0.0146 | 0.00223–0.786 |
| Copper, total | mg/L | -- | 0.011 | 0.001 U | 0.00211–0.0488 |
| Iron, total | mg/L | -- | 1.09 | 1.48 | 0.0645–91.2 |
| Magnesium, total | mg/L | -- | 10.5 | 69.9 | 1.32–116 |

**Table 1 Summary of Condensate and Groundwater Analytical Results**

| | | Sampling Location | Flare Sump | Sump B (Field Sump) | Groundwater Results |
|---|---|---|---|---|---|
| | | Sampling date | 3/5/2019 | 3/5/2019 | Fall 2018 |
| **Parameters** | **Units** | **MCL** | **Results** | **Results** | **Range (min–max)** |
| Manganese, total | mg/L | -- | 0.0459 | 12.9 | 0.00686–24 |
| Nickel, total | mg/L | -- | 0.00805 | 0.00608 | 0.00223–0.0875 |
| Potassium, total | mg/L | -- | 3.69 | 0.278 | 0.675–58.4 |
| Sodium, total | mg/L | -- | 99.7 | 20.5 | 3.36–462 |
| **VOCs** | | | | | |
| 1,4-Dichlorobenzene | µg/L | 75 | 2.2 | 5.5 | 1.01–17.7 |
| 2-Butanone | µg/L | -- | 5 U | 727 | 5U |
| 2-Hexanone | µg/L | -- | 5 U | 5.4 | 5U |
| 4-Methyl-2-Pentanone | µg/L | -- | 5 U | 29.0 | 5U |
| Acetone | µg/L | -- | 82.4 | 621 | 5U–14.5 |
| cis-1,2-Dichloroethene | µg/L | 70 | 1.0 | 1 U | 1.29–80 |
| Ethylbenzene | µg/L | 700 | 1 U | 1.1 | 1U |
| m&p-Xylene | µg/L | 10,000 | 1.9 | 5.7 | 2U |
| o-Xylene | µg/L | 10,000 | 1.1 | 2.6 | 1U |
| Toluene | µg/L | 1,000 | 1 U | 2.2 | 1.74–12.4 |

Note: µS/cm = Microsiemens per centimeter.
NTU = Nephelometric turbidity units.
SU = Standard Units.
U = The compound was analyzed for but not detected. The associated value is the compound reporting limit.

## 5. CONCLUSIONS

Based on the condensate quantity and quality analyses performed, the following can be concluded:

- In comparison to the total leachate volume estimated to be generated following installation of the toupee cap, the volume of condensate generated is estimated as approximately 0.9% of the total combined volume.

- The quality of the condensate generated from the Landfill had no MCL exceedances except for antimony and is generally within the range of the groundwater results observed during the most recent sampling event.

- The volume of condensate generated can be appropriately managed by the proposed condensate drains and the sump located at the blower skid.

## 6. REFERENCES

Agency for Toxic Substances and Disease Registry. 2017. *Toxicological Profile for Antimony and Compounds.* Draft for Public Comment. April. https://www.atsdr.cdc.gov/toxprofiles/tp23.pdf. Accessed on 13 April 2019.

**Figure**



**Table**



**Attachments**

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**Figure**

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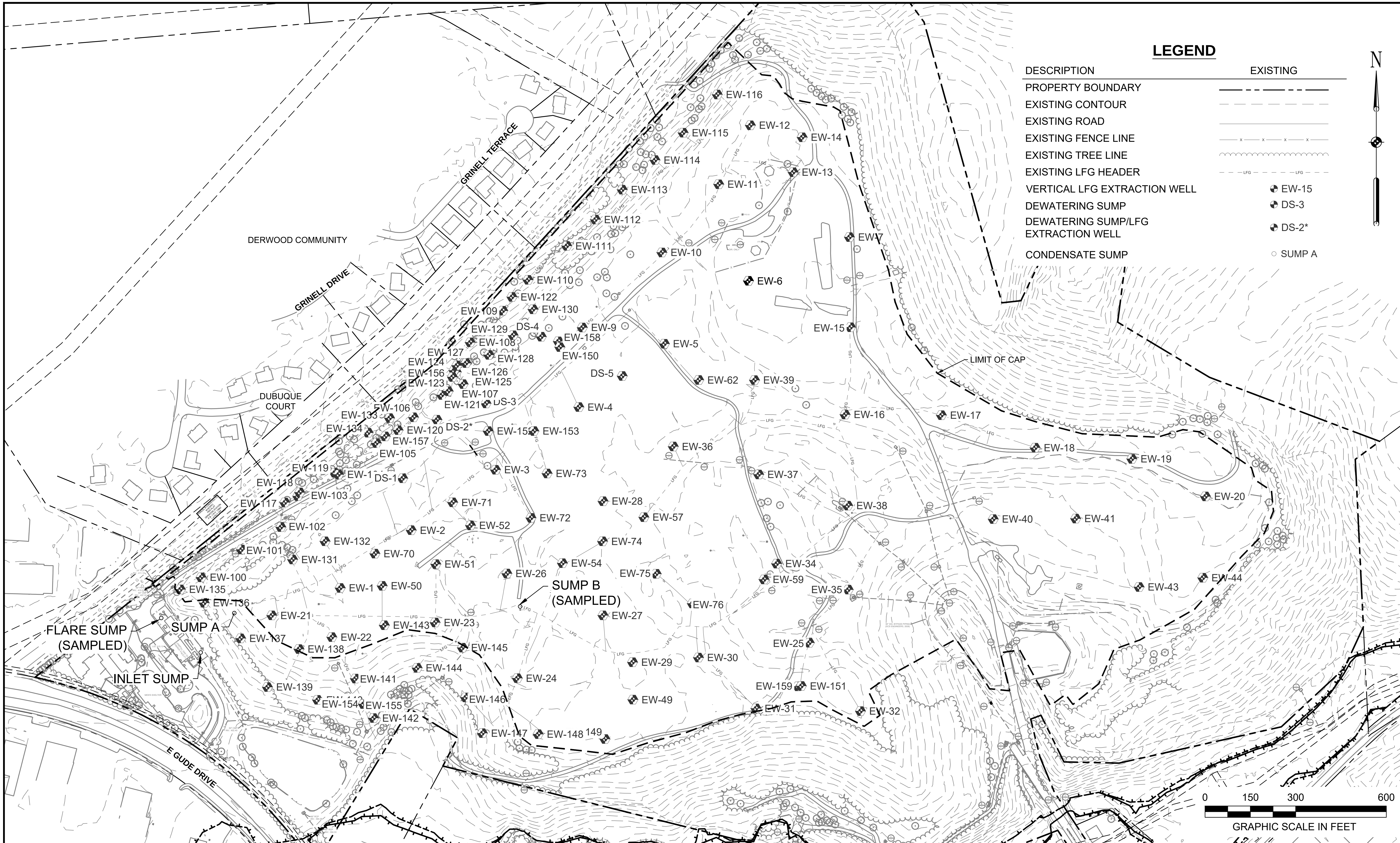


FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\LANDFILL GAS\1564601 - FIGURE CONDENSATE SUMP LOCATION TM.DWG [11X17 CONDENSATE TM] 12/20/16

| EA Engineering, Science, and Technology, Inc., PBC<br>Hunt Valley Center<br>225 Schilling Circle, Suite 400<br>Hunt Valley, Maryland 21031<br>(410) 584-7000 | PROJECT NUMBER: 1564601 | DESIGNED BY: - | DRAWN BY: SS | FIGURE: 1 | GUDE LANDFILL REMEDIATION DESIGN<br>NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY<br>MONTGOMERY COUNTY, MARYLAND | FIGURE 1: LOCATION OF EXISTING CONDENSATE SUMPS |
|---|---|---|---|---|---|---|
| | DATE: APRIL 2019 | CHECKED BY: GAT | PROJECT MGR.: MJG | SHEET NUMBER: - | | |

# Attachment A

# Condensate Quantity Calculation

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*References:*
LANDTEC. Landfill Gas System Engineering Design: A Practical Approach. 1994

LFG Extraction Wells Operational Data, APTIM, March 2019

**CONDENSATE ESTIMATION**

**OBJECTIVE:**
Estimate the quantity of condensate production in the LFG collection system.

**PROCEDURE:**
Use Antoine's Equation to determine a conservative estimate of condensate produced within the system.

**A. Antoine's Equation**—Use Antoine's equation to provide a conservative estimate for LFG production.

$$V_{cond} = 5{,}694 * {10^{\beta}}/{P_s}$$

where:

| | | |
|---|---|---|
| $V_{cond}$ | = | Volume of condensate (water) produced (gallons per million cubic foot of LFG) |
| β | = | 6.32-(3081/(T+385)) |
| T | = | Maximum gas temperature (degrees Fahrenheit [°F]) = Assume average initial temperature of gas at 110 °F |
| $P_{atm}$ | = | Atmospheric pressure (in. w.c.) |
| $P_{vac}$ | = | Vacuum pressure (in. w.c.) |
| | = | 30 in. w.c (based on the operational data) |
| $P_s$ | = | System pressure (psia) |
| | = | $(P_{atm} – P_{vac})/27.7$ |
| | = | 13.671 psia |

$$V_{cond} = 521.3 \frac{gal}{MMcf LFG}$$

**Solution:** Total gas production from the landfill is estimated at 507 scfm; therefore, the Total Volume of condensate produced per minute is estimated at 0.264 gallon per minute or 380 gallons per day.

# Attachment B

# HELP Model Results (ACM 2016)

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# Appendix B

# Infiltration Testing Summary Report and HELP Model Results – 2016

Contents:

Infiltration Testing Summary Report

HELP Model Results

# Infiltration Testing Summary Report

**Soil and Land Use Technology, Inc. (SaLUT-TLB)**
530 McCormick Drive, Suite S • Glen Burnie, MD 21061 (443) 577-1600
www.SaLUTinc.com

November 20, 2015

Ms. Laura Jo Oakes, PE
EA Engineering, Science and Technology, Inc.
225 Schilling Circle, Suite 400
Hunt Valley, MD 21031

Re: Gude Landfill Double Ring Infiltration Testing
Montgomery County, MD.
SaLUT Summary Report

Dear Ms. Oakes,

In accordance with our proposal dated October 15, 2015, Soil and Land Use Technology, Inc. (SaLUT) has completed the double ring infiltration testing at the Gude Landfill located in Montgomery County, Maryland as shown in Figure A-1 in Appendix A. The purpose of this testing was to evaluate the infiltration rate in the top two (2) feet of the existing soil cover. The specific scope of our services on this project consisted of preparing the surface at six (6) test locations, installing double rings below the surface, providing water and obtaining water level readings for up to 8 hours, and submitting our findings in a summary report.

The field exploration consisted of six (6) double ring infiltration tests, conducted on November 5, 2015 through November 10, 2015. A test location plan showing all six (6) test locations and a sketch of each individual location is included in Appendix A. The ground surface at each test location was prepared by clearing away any grass or vegetation using a skid loader. The infiltration test locations were located just outside of previously disturbed areas as observed by new growth of grass and straw mulch, and as shown on test location sketch in Appendix A. Approximate dimensions from the existing well and edge of the access road are shown on the location sketches. After the ground surface was prepared, the double infiltration test rings were installed at each location to a maximum depth of 6-inches below the ground surface. The diameter of the inner and outer rings were 12-inches and 24-inches, respectfully. Several double ring infiltration test were conducted simultaneously at various locations. Water was brought to the site and was manually added during the infiltration test using a graduated cylinder. Water level readings were recorded at 15 minute intervals for the first hour, 30 minute intervals for the second hour and one hour intervals for the following 6 hours, totaling 8 hours. All six (6) double ring infiltration test were terminated after 8 hours. After the test was completed, the double rings were removed from the test locations.

The incremental infiltration velocity was calculated for the inner ring and annular space in accordance with ASTM D 3385. Results of the infiltration testing are summarized in Table-1. The infiltration test logs are included in Appendix B.

| Table 1: Average Incremental Infiltration Velocity | | |
|---|---|---|
| Test Location | Inner Ring ($V_{IR, AVG}$) (in/hr) | Annular Space ($V_{A, AVG}$) (in/hr) |
| I-1 | 0.34 | 0.35 |
| I-2 | 0 | 0.13 |
| I-3 | 0.04 | 0.19 |
| I-4 | 0 | 0 |
| I-5 | 0.41 | 0.67 |
| I-6 | 0.44 | 0.59 |

As requested, the vertical hydraulic conductivity was estimated from the double ring infiltration test data. Per ASTM D 3385, the double-ring infiltration test method "cannot be used directly to determine the hydraulic conductivity of the soil." Therefore, assuming a constant-rate-test method and unit hydraulic gradient, the vertical hydraulic conductivity was estimated by dividing the flow rate by the area of the inner ring. Table 2 below summarizes the vertical hydraulic gradient for the average flow rate at each test location.

| Table 2: Estimated Vertical Hydraulic Conductivity | | | |
|---|---|---|---|
| Test Location | Average Flow Rate ($in^3$/min) | $K_{est}$ (in/min) | $K_{est}$ (cm/s) |
| I - 1 | 0.65 | 5.74E-3 | 2.43E-4 |
| I - 2 | 0.00 | 0 | 0 |
| I - 3 | 0.07 | 6.35E-4 | 2.69E-5 |
| I - 4 | 0.00 | 0 | 0 |
| I - 5 | 0.78 | 6.88E-3 | 2.91E-4 |
| I - 6 | 0.84 | 7.39E-3 | 3.13E-4 |

We appreciate the opportunity working with you and if you have any questions, please contact us.

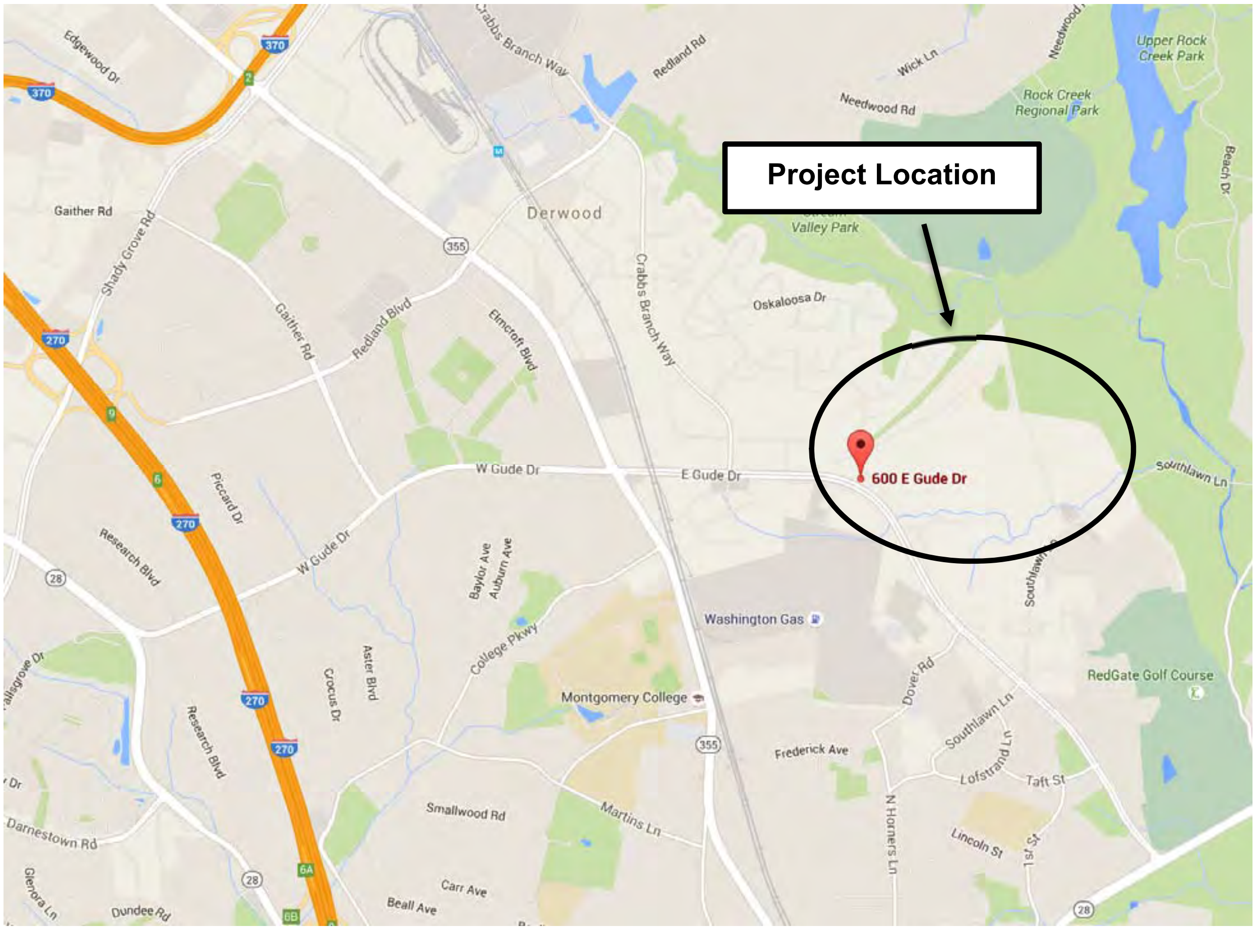
Soil and Land Use Technology Inc.

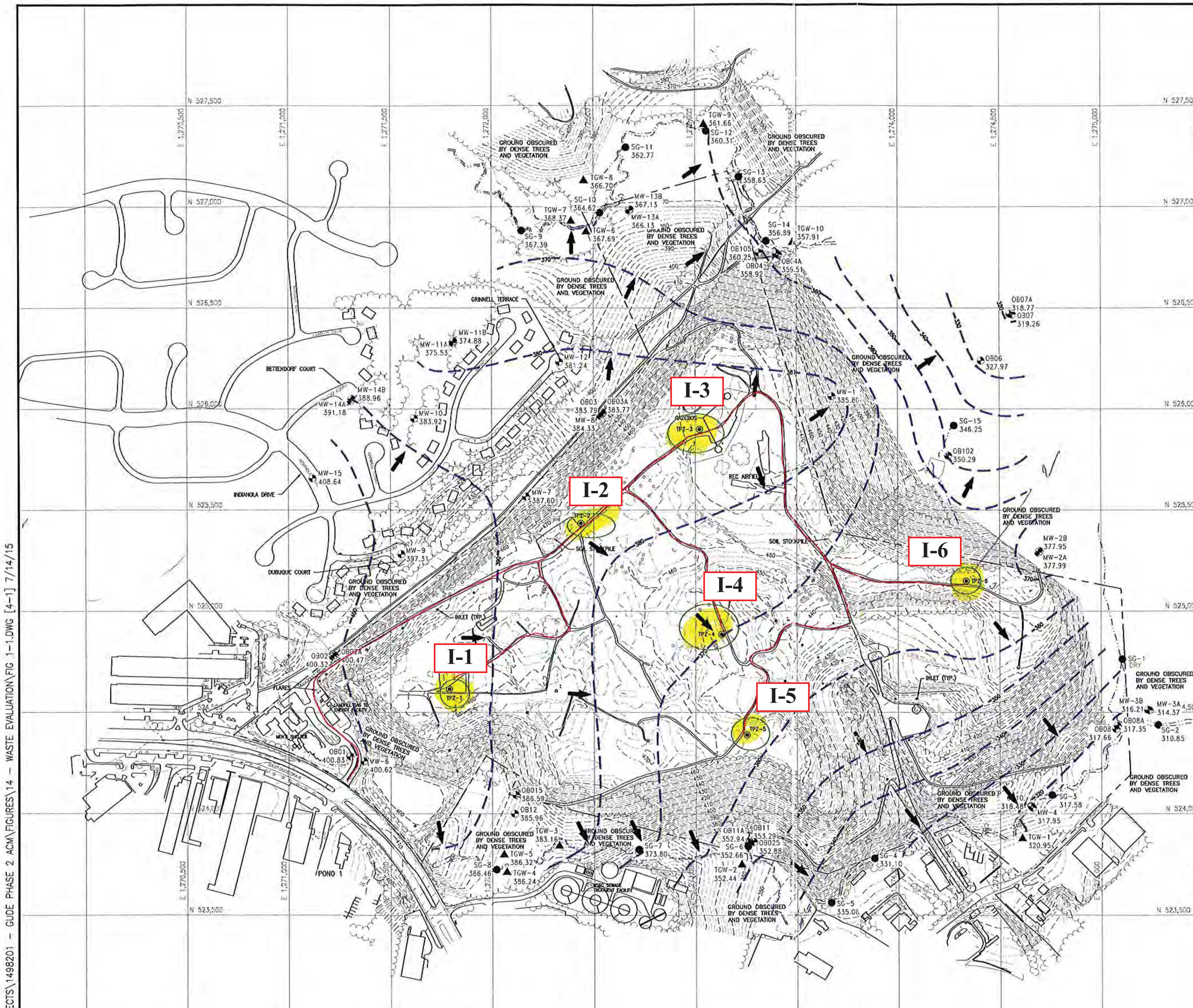
Edward H. Dalton, PE
Vice President

# Appendix A

## Contents:

**Figure A-1: Project Location Map**






N

NOTES:

1. TOPOGRAPHY COMPILED BY APPLIED MAPPING SOLUTIONS, INC. USING PHOTOGRAMMETRIC METHODS WITH PHOTOGRAPHY DATED 06/24/09 AND SUPPLEMENTED WITH FIELD SURVEY PERFORMED BY C.C. JOHNSON & MALHOTRA, P.C., OCTOBER 2009.
2. SURVEY OF STREAMS TAKEN FROM 2007 PHOTOGRAMMETRY BY AXIS GEOSPATIAL, LLC.
3. HORIZONTAL DATUM IS NORTH AMERICAN DATUM OF 1983/91 (NAD-83/91). COORDINATE SYSTEM IS MARYLAND STATE PLANE, U.S. SURVEY FEET. VERTICAL DATUM IS NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD-88) WITH ELEVATIONS SHOWN IN FEET.
4. TOPOGRAPHY IS APPROXIMATE IN AREAS NOTED "GROUND OBSCURED BY DENSE TREES AND VEGETATION".
5. FIELD SURVEY OF MW-14A, MW-14B, & MW-15, TEMPORARY GROUNDWATER MONITORING LOCATIONS, AND STREAM GAUGE LOCATIONS PERFORMED BY C.C. JOHNSON & MALHOTRA, P.C., AUGUST 2011.
6. GROUNDWATER ELEVATION DATA FOR OB102 (350.19') NOT USED IN CONTOURING BECAUSE IT IS INCONSISTENT WITH SURROUNDING DATA.

LEGEND

| | |
|---|---|
| 400 | 10-FT ELEVATION CONTOUR |
| | 2-FT ELEVATION CONTOUR |
| | PROPERTY BOUNDARY |
| | STREAM |
| | GROUNDWATER CONTOUR INTERVAL (10 FEET) |
| ● SG-X | TEMPORARY STREAM GAUGE LOCATION (2011) |
| MW-X | EXISTING GROUNDWATER MONITORING WELL |
| ▲ TGW-X | TEMPORARY GROUNDWATER MONITORING LOCATION (2011) |
| 318.40 | GROUNDWATER ELEVATION (FT. MSL.) |
| ➡ | INFERRED GROUNDWATER FLOW |
| ⊙ TPZ-X | TEMPORARY PIEZOMETER LOCATION |
| | APPROVED ROUTES OF TRAVEL FOR DRILL RIG |

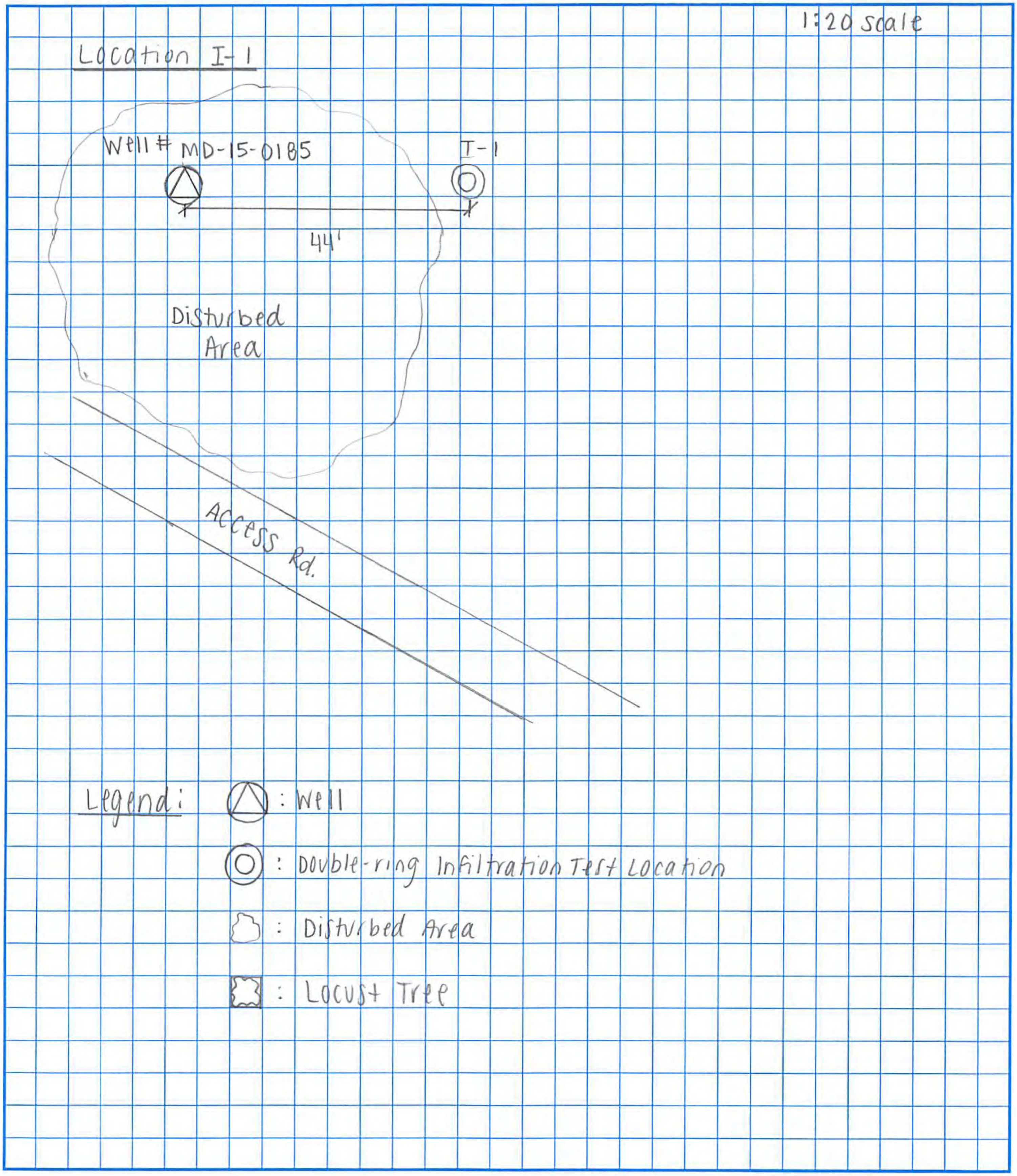
250 125 0 250 500
GRAPHIC SCALE IN FEET

| EA ENGINEERING, SCIENCE, AND TECHNOLOGY | GUDE LANDFILL<br>ASSESSMENT OF CORRECTIVE MEASURES<br>MONTGOMERY COUNTY, MARYLAND | FIGURE A-2<br>Infiltration Test Location Plan | DESIGNED BY<br>PL/LJO | DRAWN BY<br>TJP | DATE<br>JULY 2015 | PROJECT NO.<br>14982.01 |
|---|---|---|---|---|---|---|
| | | | CHECKED BY<br>PC | PROJECT MGR.<br>JK | DRAWING NO.<br>– | FIGURE<br>A-2 |

FILE PATH: Q:\PROJECTS\1498201 - GUDE PHASE 2 ACM\FIGURES\14 - WASTE EVALUATION\FIG 1-1.DWG [4-1] 7/14/15

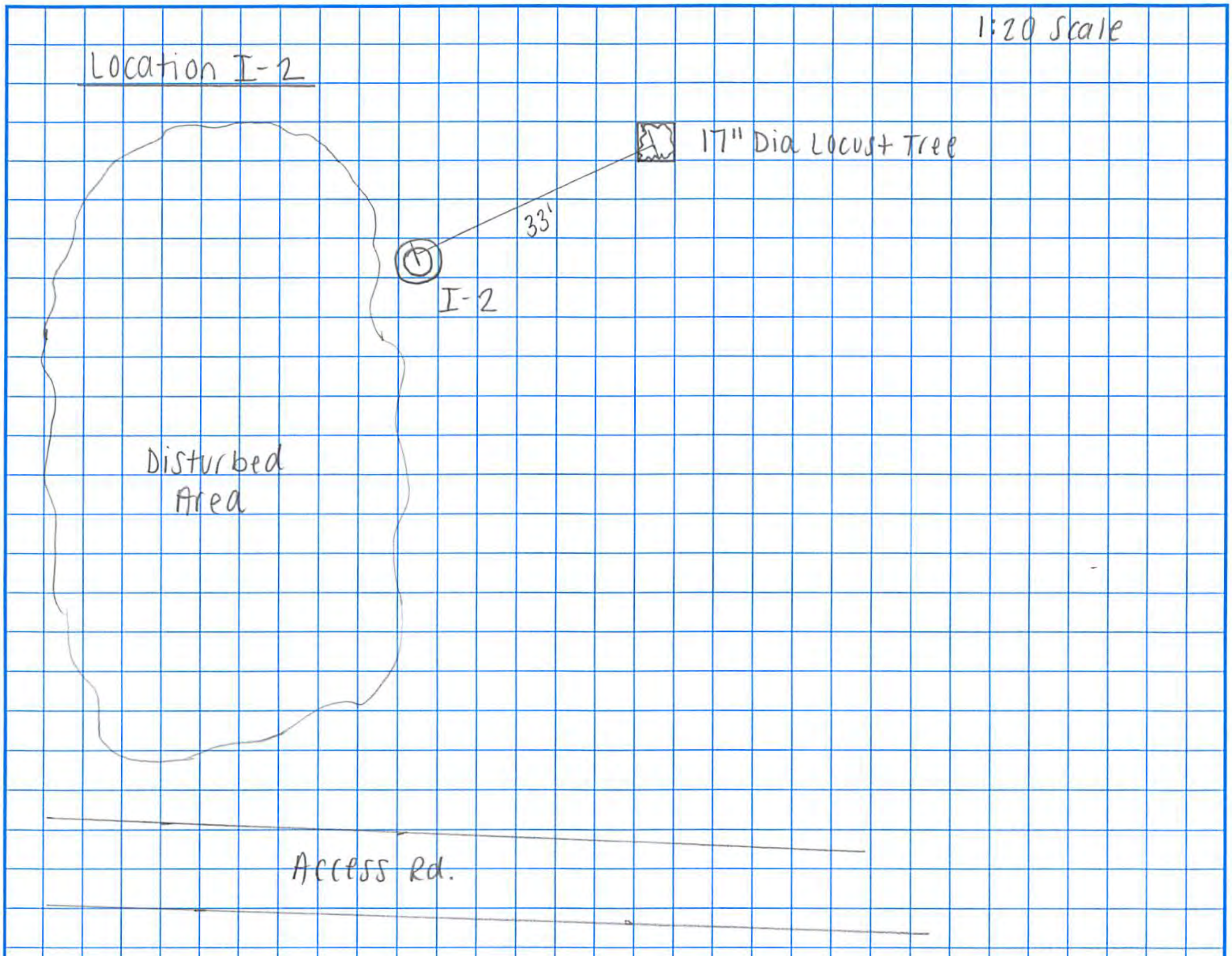
**Soil and Land Use Technology Inc. (SaLUT)**
*Geotechnical Engineers*
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

**Job:** Dude Landfill Double-Ring Infiltrometer
**Job No:** 15-00047 **Sheet No.** 1 **of** 4
**Calculated By:** DMO **Date:** 11/19/15
**Checked By:** **Date:**
**Subject:** Infiltration Test Location Sketch



**Soil and Land Use Technology Inc. (SaLUT)**
*Geotechnical Engineers*
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

**Job:** Gude Landfill Double-Ring Infiltrometer
**Job No:** 15-00047 **Sheet No.** 2 **of** 4
**Calculated By:** OMD **Date:** 11/19/15
**Checked By:** **Date:**
**Subject:** Infiltration Test Location Sketch




**Soil and Land Use Technology Inc. (SaLUT)**
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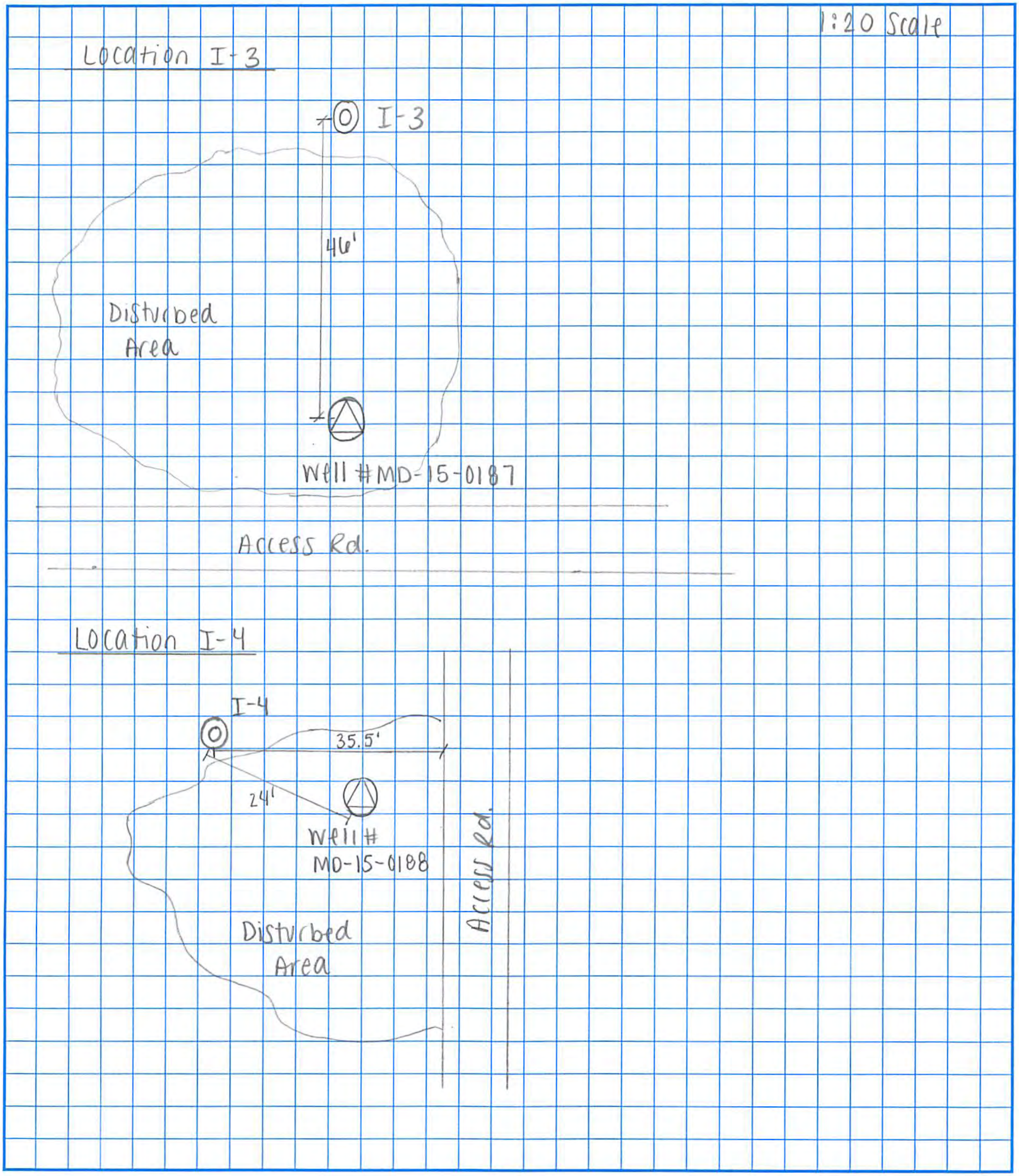
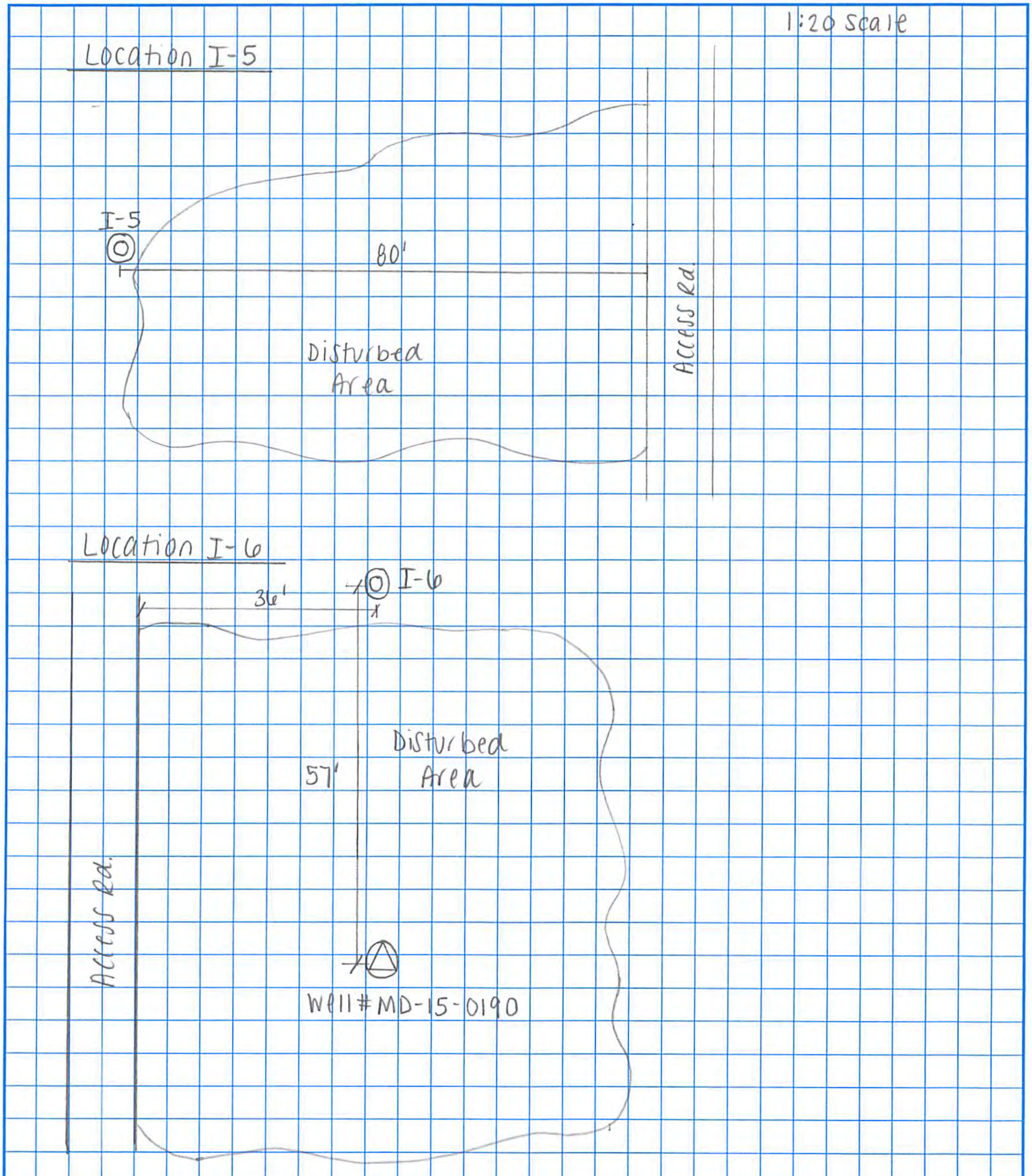
443-577-1600

**Job:** Gude Landfill Double-Ring Infiltrometer
**Job No:** 15-00047 **Sheet No.** 3 **of** 4
**Calculated By:** DMD **Date:** 11/19/15
**Checked By:** ______ **Date:** ______
**Subject:** Infiltration Test Location Sketch



**Soil and Land Use Technology Inc. (SaLUT)**
*Geotechnical Engineers*
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

Job: Gude Landfill Double-Ring Infiltrometer
Job No: 15-00047 Sheet No. 4 of 4
Calculated By: OMD Date: 11/19/15
Checked By: Date:
Subject: Infiltration Test Location Sketch



# Appendix B

## Contents:

Infiltration Test Logs

Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Wade

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

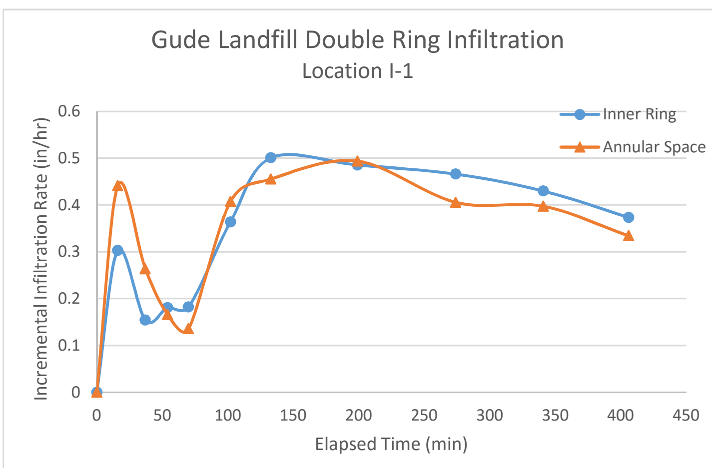
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 4 in

$A_{IR}$ = 113.1 $in^2$

Ring No. : 3 Location: I-1 $A_A$ = 336.9 $in^2$

| Reading No. | Date | Time (24 hr) | Elapsed Time, Δt (min) | Elapsed Time, total (min) | Elapsed Time, Δt (hr) | Flow/ Water Added: Inner Ring, $\Delta V_{IR}$ (mL) | Inner Ring, $\Delta V_{IR}$ ($in^3$) | Annular Space, $\Delta V_A$ (mL) | Annular Space, $\Delta V_A$ ($in^3$) | Water Temp (°F) | $V_{IR}$ (in/hr) | $V_A$ (in/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11/5/2015 | 8:34 AM | 0 | 0 | 0 | | | | | 65 | 0 | 0 |
| 2 | 11/5/2015 | 8:50 AM | 16 | 16 | 0.27 | 150 | 9.15 | 650 | 39.67 | 65 | 0.30 | 0.44 |
| 3 | 11/5/2015 | 9:11 AM | 21 | 37 | 0.35 | 100 | 6.10 | 510 | 31.12 | 65 | 0.15 | 0.26 |
| 4 | 11/5/2015 | 9:28 AM | 17 | 54 | 0.28 | 95 | 5.80 | 260 | 15.87 | 65 | 0.18 | 0.17 |
| 5 | 11/5/2015 | 9:44 AM | 16 | 70 | 0.27 | 90 | 5.49 | 200 | 12.20 | 65 | 0.18 | 0.14 |
| 6 | 11/5/2015 | 10:16 AM | 32 | 102 | 0.53 | 360 | 21.97 | 1200 | 73.23 | 65 | 0.36 | 0.41 |
| 7 | 11/5/2015 | 10:47 AM | 31 | 133 | 0.52 | 480 | 29.29 | 1300 | 79.33 | 65 | 0.50 | 0.46 |
| 8 | 11/5/2015 | 11:53 AM | 66 | 199 | 1.10 | 990 | 60.41 | 3000 | 183.07 | 65 | 0.49 | 0.49 |
| 9 | 11/5/2015 | 1:08 PM | 75 | 274 | 1.25 | 1080 | 65.91 | 2800 | 170.87 | 65 | 0.47 | 0.41 |
| 10 | 11/5/2015 | 2:15 PM | 67 | 341 | 1.12 | 890 | 54.31 | 2450 | 149.51 | 65 | 0.43 | 0.40 |
| 11 | 11/5/2015 | 3:20 PM | 65 | 406 | 1.08 | 750 | 45.77 | 2000 | 122.05 | 65 | 0.37 | 0.33 |
| **Average** | | | | | | | | | | | 0.34 | 0.35 |




$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
$V_{IR}$ = inner ring incremental infiltration velocity (in/hr)
$\Delta V_{IR}$ = volume of liquid used during time interval to maintain constant head in the inner ring ($in^3$)
$A_{IR}$ = internal area of inner ring ($in^2$)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
$V_A$ = annular space incremental infiltration velocity (in/hr)
$\Delta V_A$ = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings ($in^3$)
$A_A$ = area of annular space between the rings ($in^2$)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Wade

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

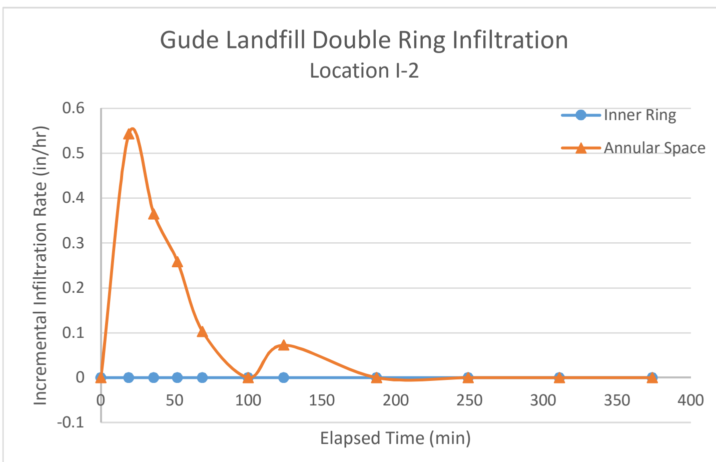
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 5.5 in

$A_{IR}$ = 113.1 $in^2$
$A_A$ = 336.9 $in^2$

Ring No. : 1    Location: I-2

| Reading No. | Date | Time | Elapsed Time, Δt (min) | Elapsed Time, total (min) | Elapsed Time, Δt (hr) | Flow/ Water Added: Inner Ring, $\Delta V_{IR}$ (mL) | Inner Ring, $\Delta V_{IR}$ ($in^3$) | Annular Space, $\Delta V_A$ (mL) | Annular Space, $\Delta V_A$ ($in^3$) | Water Temp (°F) | $V_{IR}$ (in/hr) | $V_A$ (in/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11/10/2015 | 7:56 AM | 0 | 0 | 0 | | | | | 59 | 0 | 0 |
| 2 | 11/10/2015 | 8:15 AM | 19 | 19 | 0.32 | 0 | 0.00 | 950 | 57.97 | 59 | 0.00 | 0.54 |
| 3 | 11/10/2015 | 8:32 AM | 17 | 36 | 0.28 | 0 | 0.00 | 570 | 34.78 | 59 | 0.00 | 0.36 |
| 4 | 11/10/2015 | 8:48 AM | 16 | 52 | 0.27 | 0 | 0.00 | 380 | 23.19 | 59 | 0.00 | 0.26 |
| 5 | 11/10/2015 | 9:05 AM | 17 | 69 | 0.28 | 0 | 0.00 | 160 | 9.76 | 59 | 0.00 | 0.10 |
| 6 | 11/10/2015 | 9:36 AM | 31 | 100 | 0.52 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 7 | 11/10/2015 | 10:00 AM | 24 | 124 | 0.40 | 0 | 0.00 | 160 | 9.76 | 55 | 0.00 | 0.07 |
| 8 | 11/10/2015 | 11:03 AM | 63 | 187 | 1.05 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 9 | 11/10/2015 | 12:05 PM | 62 | 249 | 1.03 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 10 | 11/10/2015 | 1:07 PM | 62 | 311 | 1.03 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 11 | 11/10/2015 | 2:10 PM | 63 | 374 | 1.05 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| **Average** | | | | | | | | | | | 0.00 | 0.13 |




$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
$V_{IR}$ = inner ring incremental infiltration velocity (in/hr)
$\Delta V_{IR}$ = volume of liquid used during time interval to maintain constant head in the inner ring ($in^3$)
$A_{IR}$ = internal area of inner ring ($in^2$)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
$V_A$ = annular space incremental infiltration velocity (in/hr)
$\Delta V_A$ = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings ($in^3$)
$A_A$ = area of annular space between the rings ($in^2$)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

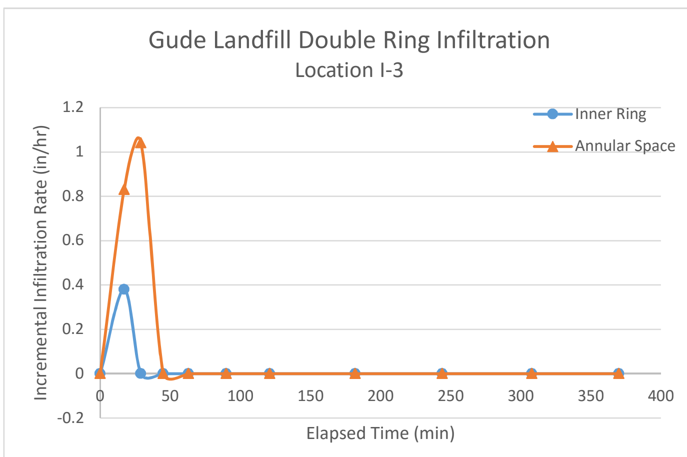
Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Wade
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes
Depth of Water = 8 in
Embedment Depth of Rings = 6 in

$A_{IR}$ = 113.1 $in^2$
$A_A$ = 336.9 $in^2$

Ring No. : 2 Location: I-3

| Reading No. | Date | Time (24 hr) | Elapsed Time, Δt (min) | Elapsed Time, total (min) | Elapsed Time, Δt (hr) | Flow/ Water Added: Inner Ring, $\Delta V_{IR}$ (mL) | Inner Ring, $\Delta V_{IR}$ ($in^3$) | Annular Space, $\Delta V_A$ (mL) | Annular Space, $\Delta V_A$ ($in^3$) | Water Temp (°F) | $V_{IR}$ (in/hr) | $V_A$ (in/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11/10/2015 | 8:05 AM | 0 | 0 | 0 | | | | | 59 | 0 | 0 |
| 2 | 11/10/2015 | 8:22 AM | 17 | 17 | 0.28 | 200 | 12.20 | 1300 | 79.33 | 59 | 0.38 | 0.83 |
| 3 | 11/10/2015 | 8:34 AM | 12 | 29 | 0.20 | 0 | 0.00 | 1150 | 70.18 | 59 | 0.00 | 1.04 |
| 4 | 11/10/2015 | 8:50 AM | 16 | 45 | 0.27 | 0 | 0.00 | 0 | 0.00 | 59 | 0.00 | 0.00 |
| 5 | 11/10/2015 | 9:08 AM | 18 | 63 | 0.30 | 0 | 0.00 | 0 | 0.00 | 59 | 0.00 | 0.00 |
| 6 | 11/10/2015 | 9:35 AM | 27 | 90 | 0.45 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 7 | 11/10/2015 | 10:06 AM | 31 | 121 | 0.52 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 8 | 11/10/2015 | 11:07 AM | 61 | 182 | 1.02 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 9 | 11/10/2015 | 12:09 PM | 62 | 244 | 1.03 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 10 | 11/10/2015 | 1:13 PM | 64 | 308 | 1.07 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| 11 | 11/10/2015 | 2:15 PM | 62 | 370 | 1.03 | 0 | 0.00 | 0 | 0.00 | 55 | 0.00 | 0.00 |
| **Average** | | | | | | | | | | | 0.04 | 0.19 |




$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
$V_{IR}$ = inner ring incremental infiltration velocity (in/hr)
$\Delta V_{IR}$ = volume of liquid used during time interval to maintain constant head in the inner ring ($in^3$)
$A_{IR}$ = internal area of inner ring ($in^2$)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
$V_A$ = annular space incremental infiltration velocity (in/hr)
$\Delta V_A$ = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings ($in^3$)
$A_A$ = area of annular space between the rings ($in^2$)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Terry

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

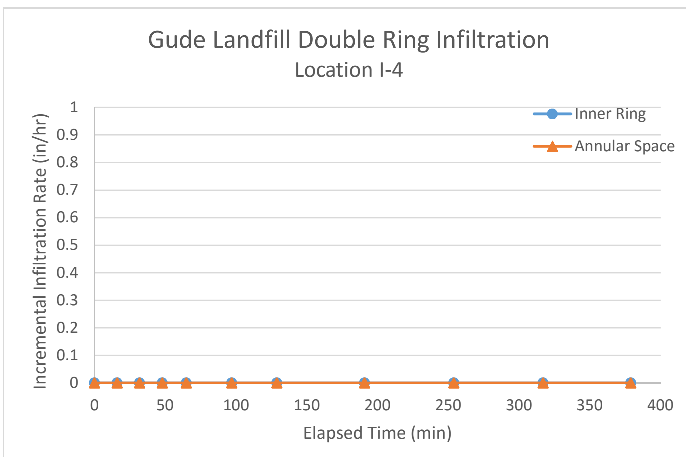
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 6 in

$A_{IR}$ = 113.1 $in^2$
$A_A$ = 336.9 $in^2$

Ring No. : 3    Location: I-4

| | | | | | | Flow/ Water Added | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reading No. | Date | Time (24 hr) | Elapsed Time, Δt (min) | Elapsed Time, total (min) | Elapsed Time, Δt (hr) | Inner Ring, $\Delta V_{IR}$ (mL) | Inner Ring, $\Delta V_{IR}$ ($in^3$) | Annular Space, $\Delta V_A$ (mL) | Annular Space, $\Delta V_A$ ($in^3$) | Water Temp (°F) | $V_{IR}$ (in/hr) | $V_A$ (in/hr) |
| 1 | 11/7/2015 | 9:16 AM | 0 | 0 | 0 | | | | | 67 | 0 | 0 |
| 2 | 11/7/2015 | 9:32 AM | 16 | 16 | 0.27 | 0 | 0.00 | 0 | 0.00 | 67 | 0.00 | 0.00 |
| 3 | 11/7/2015 | 9:48 AM | 16 | 32 | 0.27 | 0 | 0.00 | 0 | 0.00 | 67 | 0.00 | 0.00 |
| 4 | 11/7/2015 | 10:04 AM | 16 | 48 | 0.27 | 0 | 0.00 | 0 | 0.00 | 67 | 0.00 | 0.00 |
| 5 | 11/7/2015 | 10:21 AM | 17 | 65 | 0.28 | 0 | 0.00 | 0 | 0.00 | 67 | 0.00 | 0.00 |
| 6 | 11/7/2015 | 10:53 AM | 32 | 97 | 0.53 | 0 | 0.00 | 0 | 0.00 | 67 | 0.00 | 0.00 |
| 7 | 11/7/2015 | 11:25 AM | 32 | 129 | 0.53 | 0 | 0.00 | 0 | 0.00 | 65 | 0.00 | 0.00 |
| 8 | 11/7/2015 | 12:27 PM | 62 | 191 | 1.03 | 0 | 0.00 | 0 | 0.00 | 60 | 0.00 | 0.00 |
| 9 | 11/7/2015 | 1:30 PM | 63 | 254 | 1.05 | 0 | 0.00 | 0 | 0.00 | 60 | 0.00 | 0.00 |
| 10 | 11/7/2015 | 2:33 PM | 63 | 317 | 1.05 | 0 | 0.00 | 0 | 0.00 | 60 | 0.00 | 0.00 |
| 11 | 11/7/2015 | 3:35 PM | 62 | 379 | 1.03 | 0 | 0.00 | 0 | 0.00 | 60 | 0.00 | 0.00 |
| **Average** | | | | | | | | | | | 0.00 | 0.00 |




$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
$V_{IR}$ = inner ring incremental infiltration velocity (in/hr)
$\Delta V_{IR}$ = volume of liquid used during time interval to maintain constant head in the inner ring ($in^3$)
$A_{IR}$ = internal area of inner ring ($in^2$)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
$V_A$ = annular space incremental infiltration velocity (in/hr)
$\Delta V_A$ = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings ($in^3$)
$A_A$ = area of annular space between the rings ($in^2$)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Terry

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

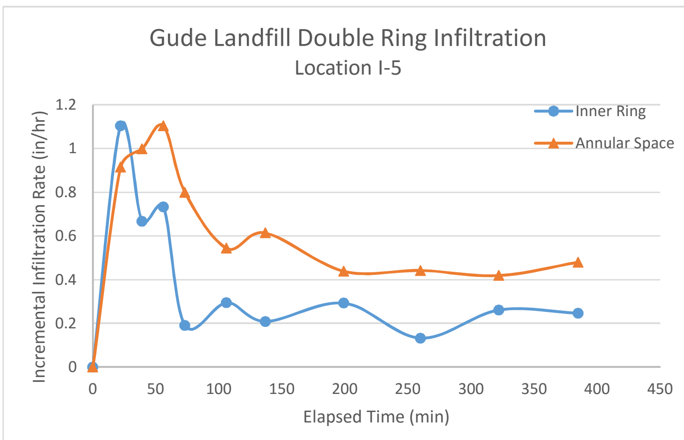
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 3.75 in

$A_{IR}$ = 113.1 $in^2$
$A_A$ = 336.9 $in^2$

Ring No. : 2 Location: I-5

| | | | | | | Flow/ Water Added | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reading No.** | **Date** | **Time (24 hr)** | **Elapsed Time, Δt (min)** | **Elapsed Time, total (min)** | **Elapsed Time, Δt (hr)** | **Inner Ring, $\Delta V_{IR}$ (mL)** | **Inner Ring, $\Delta V_{IR}$ ($in^3$)** | **Annular Space, $\Delta V_A$ (mL)** | **Annular Space, $\Delta V_A$ ($in^3$)** | **Water Temp (°F)** | **$V_{IR}$ (in/hr)** | **$V_A$ (in/hr)** |
| 1 | 11/7/2015 | 9:13 AM | 0 | 0 | 0 | | | | | 67 | 0 | 0 |
| 2 | 11/7/2015 | 9:35 AM | 22 | 22 | 0.37 | 750 | 45.77 | 1850 | 112.89 | 67 | 1.10 | 0.91 |
| 3 | 11/7/2015 | 9:52 AM | 17 | 39 | 0.28 | 350 | 21.36 | 1560 | 95.20 | 67 | 0.67 | 1.00 |
| 4 | 11/7/2015 | 10:09 AM | 17 | 56 | 0.28 | 385 | 23.49 | 1725 | 105.27 | 67 | 0.73 | 1.10 |
| 5 | 11/7/2015 | 10:26 AM | 17 | 73 | 0.28 | 185 | 6.10 | 1250 | 76.28 | 67 | 0.19 | 0.80 |
| 6 | 11/7/2015 | 10:59 AM | 33 | 106 | 0.55 | 300 | 18.31 | 1650 | 100.69 | 63 | 0.29 | 0.54 |
| 7 | 11/7/2015 | 11:30 AM | 31 | 137 | 0.52 | 200 | 12.20 | 1750 | 106.79 | 63 | 0.21 | 0.61 |
| 8 | 11/7/2015 | 12:32 PM | 62 | 199 | 1.03 | 560 | 34.17 | 2500 | 152.56 | 60 | 0.29 | 0.44 |
| 9 | 11/7/2015 | 1:33 PM | 61 | 260 | 1.02 | 250 | 15.26 | 2480 | 151.34 | 60 | 0.13 | 0.44 |
| 10 | 11/7/2015 | 2:35 PM | 62 | 322 | 1.03 | 500 | 30.51 | 2390 | 145.85 | 60 | 0.26 | 0.42 |
| 11 | 11/7/2015 | 3:38 PM | 63 | 385 | 1.05 | 480 | 29.29 | 2780 | 169.65 | 60 | 0.25 | 0.48 |
| **Average** | | | | | | | | | | | 0.41 | 0.67 |




$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
$V_{IR}$ = inner ring incremental infiltration velocity (in/hr)
$\Delta V_{IR}$ = volume of liquid used during time interval to maintain constant head in the inner ring ($in^3$)
$A_{IR}$ = internal area of inner ring ($in^2$)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
$V_A$ = annular space incremental infiltration velocity (in/hr)
$\Delta V_A$ = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings ($in^3$)
$A_A$ = area of annular space between the rings ($in^2$)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

Project: Gude Landfill Double- Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Terry

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

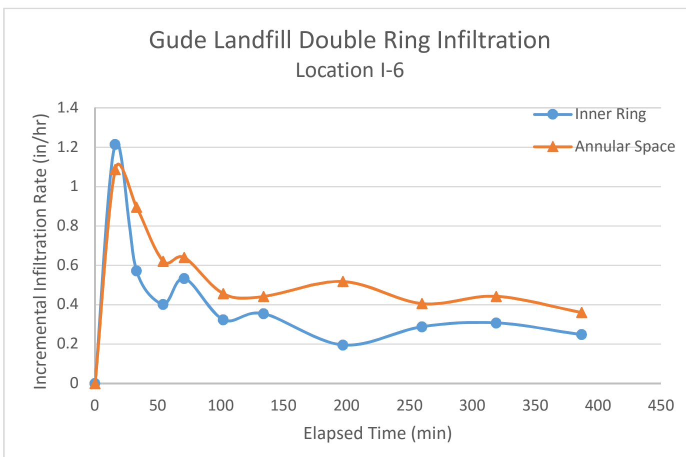
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 5 in

$A_{IR}$ = 113.1 $in^2$
$A_A$ = 336.9 $in^2$

Ring No. : 1 Location: I-6

| Reading No. | Date | Time (24 hr) | Elapsed Time, Δt (min) | Elapsed Time, total (min) | Elapsed Time, Δt (hr) | Flow/ Water Added: Inner Ring, $\Delta V_{IR}$ (mL) | Inner Ring, $\Delta V_{IR}$ ($in^3$) | Annular Space, $\Delta V_A$ (mL) | Annular Space, $\Delta V_A$ ($in^3$) | Water Temp (°F) | $V_{IR}$ (in/hr) | $V_A$ (in/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11/7/2015 | 9:03 AM | 0 | 0 | 0 | | | | | 67 | 0 | 0 |
| 2 | 11/7/2015 | 9:19 AM | 16 | 16 | 0.27 | 600 | 36.61 | 1600 | 97.64 | 67 | 1.21 | 1.09 |
| 3 | 11/7/2015 | 9:36 AM | 17 | 33 | 0.28 | 300 | 18.31 | 1400 | 85.43 | 67 | 0.57 | 0.89 |
| 4 | 11/7/2015 | 9:57 AM | 21 | 54 | 0.35 | 260 | 15.87 | 1200 | 73.23 | 67 | 0.40 | 0.62 |
| 5 | 11/7/2015 | 10:14 AM | 17 | 71 | 0.28 | 280 | 17.09 | 1000 | 61.02 | 67 | 0.53 | 0.64 |
| 6 | 11/7/2015 | 10:45 AM | 31 | 102 | 0.52 | 310 | 18.92 | 1300 | 79.33 | 63 | 0.32 | 0.46 |
| 7 | 11/7/2015 | 11:17 AM | 32 | 134 | 0.53 | 350 | 21.36 | 1300 | 79.33 | 63 | 0.35 | 0.44 |
| 8 | 11/7/2015 | 12:20 PM | 63 | 197 | 1.05 | 380 | 23.19 | 3000 | 183.07 | 60 | 0.20 | 0.52 |
| 9 | 11/7/2015 | 1:23 PM | 63 | 260 | 1.05 | 560 | 34.17 | 2350 | 143.41 | 60 | 0.29 | 0.41 |
| 10 | 11/7/2015 | 2:22 PM | 59 | 319 | 0.98 | 560 | 34.17 | 2400 | 146.46 | 60 | 0.31 | 0.44 |
| 11 | 11/7/2015 | 3:30 PM | 68 | 387 | 1.13 | 520 | 31.73 | 2250 | 137.30 | 60 | 0.25 | 0.36 |
| **Average** | | | | | | | | | | | 0.44 | 0.59 |




$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
$V_{IR}$ = inner ring incremental infiltration velocity (in/hr)
$\Delta V_{IR}$ = volume of liquid used during time interval to maintain constant head in the inner ring ($in^3$)
$A_{IR}$ = internal area of inner ring ($in^2$)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
$V_A$ = annular space incremental infiltration velocity (in/hr)
$\Delta V_A$ = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings ($in^3$)
$A_A$ = area of annular space between the rings ($in^2$)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

# HELP Model Results

| Project | Gude Landfill – Assessment of Corrective Measures | Project No. | 14982.01.0012 |
|---|---|---|---|
| Subject | Average Annual Leachate Infiltration | Sheet No. | 1 of 2 |
| | | Drawing No. | |

Computed by BTT Date 4/8/16 Checked by MJL Date 4/8/16

## REFERENCES:


EA Engineering, Science, and Technology, Inc., PBC (EA). 2015. *Waste Evaluation: Temporary Piezometer Installation Summary, Gude Landfill, Montgomery County, Maryland*. Technical Memorandum. 19 November.

EA. 2016. *Stormwater Engineering Evaluation*. Technical Memorandum. 4 April.

Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and Zappi, P. A. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3," EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

Schroeder, P. R., Dozier, T.S., Zappi, P. A., McEnroe, B. M., Sjostrom, J. W., and Peyton, R. L. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3," EPA/600/R-94/168b, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.


## OBJECTIVE:

Estimate the average annual leachate generation volume which infiltrates (percolates) through the bottom of the landfill. Compare the average annual leachate generation volume with and without an engineered geosynthetic cap over the existing landfill cover soil.

## PROCEDURE:

Using the Hydrologic Evaluation of Landfill Performance (HELP) Model (Version 3.07, November 1997), determine the average annual leachate volume (generated by precipitation percolating through the landfill) which infiltrates through the bottom layer of the landfill.

The HELP Model rainfall was synthetically generated over a 30-year period using HELP Model data for the Washington, DC area. The estimated annual rainfall is approximately 38 in. (see attached HELP Model output). The volume of leachate generated from the rainfall was averaged over the same 30-year period.

The average annual leachate volume was calculated over the entire landfill, including portions of the landfill that will remain uncapped. The landfill layer properties were estimated using averages of the soil properties based on the information obtained during drilling for the four temporary piezometers TPZ-1, TPZ-3, TPZ-4, and TPZ-6 (EA 2015). Hydraulic conductivity for the existing cover soil was estimated using the results of double ring infiltration testing (Soil and Land Use Technology, Inc. 2015).

The calculation for leachate volume produced from the uncapped side slopes were performed separately and added to the leachate volume produced by the remaining portions of the landfill with and without a geosynthetic cap. The capping scenario assumed a geocomposite drainage layer and a geosynthetic cap will be installed over the existing cover soil to promote drainage off of the landfill.

It was assumed that that 99.5% of the landfill allows runoff without a cap and 100% of the landfill area allows runoff with a cap. The runoff percent without a cap was calculated using the results of a Stormwater Engineering Evaluation (EA 2016).

**REFERENCES (continued):**

Soil and Land Use Technology, Inc. (SaLUT-TLB). 2015. Re: Gude Landfill Double Ring Infiltration Testing; Montgomery County, MD.; SaLUT Summary Report. Letter from Edward H. Dalton, Soil and Land Use Technology, Inc. to Laura Jo Oakes, EA Engineering, Science, and Technology, Inc., PBC. 20 November.

**CONCLUSION:**

The total leachate volume produced over the Landfill with and without a geosynthetic cap is shown in the table below (identified as percolation/leakage in the HELP Model). With the installation of a toupee cap, leachate volume decreased by approximately 65% over the entire landfill.

| | Annual Percolation (cft) - no cap | Annual Percolation (cft) - with cap | Percent Decrease in Infiltration |
|---|---|---|---|
| Top and West Side Slopes | 5,581,584 | 43,687 | 99 |
| Uncapped Side Slopes | 2,982,499 | 2,982,499 | 0 |
| **Total** | **8,565,787** | **2,085,978** | **65** |

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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:    T:\GUDEPREP.D4
TEMPERATURE DATA FILE:      T:\GUDETEMP.D7
SOLAR RADIATION DATA FILE:  T:\GUDESOLR.D13
EVAPOTRANSPIRATION DATA:    T:\GUDEEVAT.D11
SOIL AND DESIGN DATA FILE:  T:\GUDESSLP.D10
OUTPUT DATA FILE:           T:\GUDESSLO.OUT


TIME:  17:16     DATE:   4/ 8/2016


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

     TITLE:  GUDE SIDE SLOPES

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   6
           THICKNESS                 =      4.00   INCHES
           POROSITY                  =      0.4530 VOL/VOL
           FIELD CAPACITY            =      0.1900 VOL/VOL
           WILTING POINT             =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT  =    0.2138 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


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

```
              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     57.00   INCHES
POROSITY                     =      0.5010 VOL/VOL
FIELD CAPACITY               =      0.0020 VOL/VOL
WILTING POINT                =      0.0010 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.5010 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.146000006000E-03 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   8
THICKNESS                    =     30.00   INCHES
POROSITY                     =      0.4630 VOL/VOL
FIELD CAPACITY               =      0.2320 VOL/VOL
WILTING POINT                =      0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3003 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC


                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  18
THICKNESS                    =    495.00   INCHES
POROSITY                     =      0.6710 VOL/VOL
FIELD CAPACITY               =      0.2920 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3010 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   6
THICKNESS                    =     93.00   INCHES
POROSITY                     =      0.4530 VOL/VOL
FIELD CAPACITY               =      0.1900 VOL/VOL
WILTING POINT                =      0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2554 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.720000011000E-03 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-
```

GUDESSLO

SPECIFIED CURVE NUMBER OF 70.0, A SURFACE SLOPE OF 24.% AND A SLOPE LENGTH OF 167. FEET.

| | | | |
|---|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 73.40 | |
| FRACTION OF AREA ALLOWING RUNOFF | = | 100.0 | PERCENT |
| AREA PROJECTED ON HORIZONTAL PLANE | = | 49.080 | ACRES |
| EVAPORATIVE ZONE DEPTH | = | 4.0 | INCHES |
| INITIAL WATER IN EVAPORATIVE ZONE | = | 0.855 | INCHES |
| UPPER LIMIT OF EVAPORATIVE STORAGE | = | 1.812 | INCHES |
| LOWER LIMIT OF EVAPORATIVE STORAGE | = | 0.340 | INCHES |
| INITIAL SNOW WATER | = | 0.000 | INCHES |
| INITIAL WATER IN LAYER MATERIALS | = | 211.184 | INCHES |
| TOTAL INITIAL WATER | = | 211.184 | INCHES |
| TOTAL SUBSURFACE INFLOW | = | 0.00 | INCHES/YEAR |

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WASHINGTON DISTRICT OF COLUMB

| | | |
|---|---|---|
| STATION LATITUDE | = | 38.90 DEGREES |
| MAXIMUM LEAF AREA INDEX | = | 4.50 |
| START OF GROWING SEASON (JULIAN DATE) | = | 104 |
| END OF GROWING SEASON (JULIAN DATE) | = | 296 |
| EVAPORATIVE ZONE DEPTH | = | 4.0 INCHES |
| AVERAGE ANNUAL WIND SPEED | = | 9.30 MPH |
| AVERAGE 1ST QUARTER RELATIVE HUMIDITY | = | 60.00 % |
| AVERAGE 2ND QUARTER RELATIVE HUMIDITY | = | 62.00 % |
| AVERAGE 3RD QUARTER RELATIVE HUMIDITY | = | 68.00 % |
| AVERAGE 4TH QUARTER RELATIVE HUMIDITY | = | 65.00 % |

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 2.76 | 2.62 | 3.46 | 2.93 | 3.48 | 3.35 |
| 3.88 | 4.40 | 3.22 | 2.90 | 2.82 | 3.18 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.40 | 33.60 | 42.40 | 53.30 | 62.40 | 70.70 |
| 75.50 | 74.30 | 67.40 | 55.30 | 44.80 | 35.10 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

AND STATION LATITUDE = 38.90 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 2.55 | 2.78 | 3.17 | 3.03 | 3.40 | 3.79 |
| | 4.10 | 3.32 | 2.85 | 3.25 | 2.62 | 2.90 |
| STD. DEVIATIONS | 1.38 | 1.13 | 1.46 | 1.38 | 2.11 | 1.86 |
| | 2.25 | 1.65 | 1.98 | 2.21 | 1.10 | 1.63 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.345 | 1.287 | 0.453 | 0.000 | 0.012 | 0.022 |
| | 0.008 | 0.010 | 0.026 | 0.022 | 0.002 | 0.079 |
| STD. DEVIATIONS | 0.604 | 1.402 | 0.789 | 0.002 | 0.037 | 0.049 |
| | 0.023 | 0.045 | 0.091 | 0.050 | 0.012 | 0.330 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.876 | 0.833 | 1.745 | 1.780 | 1.986 | 2.375 |
| | 2.533 | 2.051 | 1.536 | 1.195 | 1.095 | 0.938 |
| STD. DEVIATIONS | 0.304 | 0.410 | 0.435 | 0.689 | 0.901 | 0.931 |
| | 0.979 | 0.917 | 0.808 | 0.494 | 0.418 | 0.213 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 2** | | | | | | |
| TOTALS | 0.9875 | 0.6654 | 1.7116 | 1.1888 | 1.4860 | 1.4725 |
| | 1.4923 | 1.3257 | 1.2554 | 1.9576 | 1.4363 | 1.5940 |
| STD. DEVIATIONS | 1.1129 | 0.7931 | 1.0903 | 0.7819 | 1.4536 | 1.2536 |
| | 1.5175 | 1.0179 | 1.3344 | 1.8606 | 0.9343 | 1.4222 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 5** | | | | | | |
| TOTALS | 1.6592 | 1.3607 | 1.7790 | 1.3540 | 1.1891 | 1.2390 |
| | 1.3224 | 1.5223 | 1.2737 | 1.4857 | 1.3190 | 1.2365 |
| STD. DEVIATIONS | 0.8982 | 0.6758 | 0.8034 | 0.6511 | 0.6308 | 0.6924 |
| | 0.6514 | 0.6621 | 0.7585 | 0.7165 | 0.7502 | 0.6910 |

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 0.0192 | 0.0186 | 0.0394 | 0.0231 | 0.0297 | 0.0311 |

GUDESSLO

| | | | | | | |
|---|---|---|---|---|---|---|
| | 0.0305 | 0.0245 | 0.0260 | 0.0367 | 0.0290 | 0.0271 |
| STD. DEVIATIONS | 0.0225 | 0.0223 | 0.0242 | 0.0175 | 0.0317 | 0.0297 |
| | 0.0354 | 0.0214 | 0.0284 | 0.0391 | 0.0218 | 0.0265 |

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

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 37.77 | ( 5.959) | 6729058.0 | 100.00 |
| RUNOFF | 2.268 | ( 1.4899) | 404004.06 | 6.004 |
| EVAPOTRANSPIRATION | 18.944 | ( 2.9354) | 3375101.25 | 50.157 |
| PERCOLATION/LEAKAGE THROUGH LAYER 2 | 16.57330 | ( 3.78598) | 2952706.000 | 43.87993 |
| AVERAGE HEAD ON TOP OF LAYER 2 | 0.028 | ( 0.006) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 16.74053 | ( 4.04880) | 2982499.000 | 44.32268 |
| CHANGE IN WATER STORAGE | -0.183 | ( 3.4512) | -32544.67 | -0.484 |

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

| | (INCHES) | (CU. FT.) |
|---|---|---|
| PRECIPITATION | 3.34 | 595055.750 |
| RUNOFF | 2.193 | 390710.0620 |
| PERCOLATION/LEAKAGE THROUGH LAYER 2 | 2.551147 | 454513.40600 |
| AVERAGE HEAD ON TOP OF LAYER 2 | 1.789 | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.195620 | 34851.67970 |
| SNOW WATER | 3.40 | 605259.6870 |

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4528

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0850

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FINAL WATER STORAGE AT END OF YEAR 30

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 0.3917 | 0.0979 |
| 2 | 28.5570 | 0.5010 |
| 3 | 8.7480 | 0.2916 |
| 4 | 145.5473 | 0.2940 |
| 5 | 22.4598 | 0.2415 |
| 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:     T:\GUDEPREP.D4
TEMPERATURE DATA FILE:       T:\GUDETEMP.D7
SOLAR RADIATION DATA FILE:   T:\GUDESOLR.D13
EVAPOTRANSPIRATION DATA:     T:\GUDEEVAT.D11
SOIL AND DESIGN DATA FILE:   T:\WOCAPIN.D10
OUTPUT DATA FILE:            T:\WOCAPOUT.OUT


TIME:  17:31     DATE:   4/ 8/2016


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     TITLE:  GUDE AVERAGE TOP WITHOUT CAP

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   6
           THICKNESS                   =      4.00   INCHES
           POROSITY                    =      0.4530 VOL/VOL
           FIELD CAPACITY              =      0.1900 VOL/VOL
           WILTING POINT               =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2139 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------
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                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     57.00   INCHES
POROSITY                      =      0.5010 VOL/VOL
FIELD CAPACITY                =      0.0020 VOL/VOL
WILTING POINT                 =      0.0010 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.5010 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.146000006000E-03 CM/SEC


                          LAYER  3
                          --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   8
THICKNESS                     =     30.00   INCHES
POROSITY                      =      0.4630 VOL/VOL
FIELD CAPACITY                =      0.2320 VOL/VOL
WILTING POINT                 =      0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2994 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.369999994000E-03 CM/SEC


                          LAYER  4
                          --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  18
THICKNESS                     =    495.00   INCHES
POROSITY                      =      0.6710 VOL/VOL
FIELD CAPACITY                =      0.2920 VOL/VOL
WILTING POINT                 =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3012 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                          LAYER  5
                          --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   6
THICKNESS                     =     93.00   INCHES
POROSITY                      =      0.4530 VOL/VOL
FIELD CAPACITY                =      0.1900 VOL/VOL
WILTING POINT                 =      0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2550 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.720000011000E-03 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-
```

WOCAPOUT

SPECIFIED CURVE NUMBER OF 71.0, A SURFACE SLOPE
OF 2.% AND A SLOPE LENGTH OF 1000. FEET.

| | | | |
|---|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 69.30 | |
| FRACTION OF AREA ALLOWING RUNOFF | = | 99.5 | PERCENT |
| AREA PROJECTED ON HORIZONTAL PLANE | = | 91.350 | ACRES |
| EVAPORATIVE ZONE DEPTH | = | 4.0 | INCHES |
| INITIAL WATER IN EVAPORATIVE ZONE | = | 0.855 | INCHES |
| UPPER LIMIT OF EVAPORATIVE STORAGE | = | 1.812 | INCHES |
| LOWER LIMIT OF EVAPORATIVE STORAGE | = | 0.340 | INCHES |
| INITIAL SNOW WATER | = | 0.000 | INCHES |
| INITIAL WATER IN LAYER MATERIALS | = | 211.216 | INCHES |
| TOTAL INITIAL WATER | = | 211.216 | INCHES |
| TOTAL SUBSURFACE INFLOW | = | 0.00 | INCHES/YEAR |

## EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WASHINGTON DISTRICT OF COLUMB

| | | | |
|---|---|---|---|
| STATION LATITUDE | = | 38.90 | DEGREES |
| MAXIMUM LEAF AREA INDEX | = | 4.50 | |
| START OF GROWING SEASON (JULIAN DATE) | = | 104 | |
| END OF GROWING SEASON (JULIAN DATE) | = | 296 | |
| EVAPORATIVE ZONE DEPTH | = | 4.0 | INCHES |
| AVERAGE ANNUAL WIND SPEED | = | 9.30 | MPH |
| AVERAGE 1ST QUARTER RELATIVE HUMIDITY | = | 60.00 | % |
| AVERAGE 2ND QUARTER RELATIVE HUMIDITY | = | 62.00 | % |
| AVERAGE 3RD QUARTER RELATIVE HUMIDITY | = | 68.00 | % |
| AVERAGE 4TH QUARTER RELATIVE HUMIDITY | = | 65.00 | % |

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 2.76 | 2.62 | 3.46 | 2.93 | 3.48 | 3.35 |
| 3.88 | 4.40 | 3.22 | 2.90 | 2.82 | 3.18 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.40 | 33.60 | 42.40 | 53.30 | 62.40 | 70.70 |
| 75.50 | 74.30 | 67.40 | 55.30 | 44.80 | 35.10 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 2.55 | 2.78 | 3.17 | 3.03 | 3.40 | 3.79 |
| | 4.10 | 3.32 | 2.85 | 3.25 | 2.62 | 2.90 |
| STD. DEVIATIONS | 1.38 | 1.13 | 1.46 | 1.38 | 2.11 | 1.86 |
| | 2.25 | 1.65 | 1.98 | 2.21 | 1.10 | 1.63 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.344 | 1.283 | 0.450 | 0.000 | 0.003 | 0.007 |
| | 0.001 | 0.004 | 0.009 | 0.008 | 0.000 | 0.073 |
| STD. DEVIATIONS | 0.602 | 1.397 | 0.784 | 0.000 | 0.012 | 0.021 |
| | 0.006 | 0.024 | 0.035 | 0.022 | 0.002 | 0.327 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.878 | 0.834 | 1.747 | 1.780 | 1.985 | 2.371 |
| | 2.535 | 2.050 | 1.537 | 1.192 | 1.092 | 0.937 |
| STD. DEVIATIONS | 0.304 | 0.410 | 0.436 | 0.690 | 0.901 | 0.935 |
| | 0.980 | 0.921 | 0.809 | 0.494 | 0.419 | 0.212 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 2** | | | | | | |
| TOTALS | 0.9754 | 0.6700 | 1.7137 | 1.1903 | 1.4960 | 1.4910 |
| | 1.4959 | 1.3345 | 1.2703 | 1.9778 | 1.4381 | 1.6123 |
| STD. DEVIATIONS | 1.0999 | 0.7955 | 1.0892 | 0.7834 | 1.4744 | 1.2746 |
| | 1.5203 | 1.0263 | 1.3757 | 1.8803 | 0.9363 | 1.4490 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 5** | | | | | | |
| TOTALS | 1.6628 | 1.3726 | 1.7890 | 1.3617 | 1.1957 | 1.2398 |
| | 1.3220 | 1.5249 | 1.2914 | 1.4929 | 1.3310 | 1.2485 |
| STD. DEVIATIONS | 0.9012 | 0.6817 | 0.8052 | 0.6515 | 0.6293 | 0.6927 |
| | 0.6539 | 0.6683 | 0.7743 | 0.7189 | 0.7532 | 0.6979 |

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 0.0186 | 0.0188 | 0.0392 | 0.0233 | 0.0297 | 0.0318 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | WOCAPOUT | | | |
| | 0.0309 | 0.0252 | 0.0262 | 0.0387 | 0.0285 | 0.0280 |
| STD. DEVIATIONS | 0.0223 | 0.0227 | 0.0240 | 0.0171 | 0.0319 | 0.0305 |
| | 0.0351 | 0.0219 | 0.0297 | 0.0412 | 0.0220 | 0.0281 |

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

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 37.77 | ( 5.959) | 12524438.0 | 100.00 |
| RUNOFF | 2.184 | ( 1.4619) | 724125.81 | 5.782 |
| EVAPOTRANSPIRATION | 18.936 | ( 2.9482) | 6279219.00 | 50.136 |
| PERCOLATION/LEAKAGE THROUGH LAYER 2 | 16.66524 | ( 3.80584) | 5526200.500 | 44.12334 |
| AVERAGE HEAD ON TOP OF LAYER 2 | 0.028 | ( 0.006) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 16.83225 | ( 4.06800) | 5581584.000 | 44.56554 |
| CHANGE IN WATER STORAGE | -0.182 | ( 3.4667) | -60488.99 | -0.483 |

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

| | (INCHES) | (CU. FT.) |
|---|---|---|
| PRECIPITATION | 3.34 | 1107545.620 |
| RUNOFF | 2.183 | 723971.3120 |
| PERCOLATION/LEAKAGE THROUGH LAYER 2 | 2.520311 | 835736.37500 |
| AVERAGE HEAD ON TOP OF LAYER 2 | 1.783 | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.196413 | 65130.56250 |
| SNOW WATER | 3.40 | 1126537.6200 |
| MAXIMUM VEG. SOIL WATER (VOL/VOL) | | 0.4500 |
| MINIMUM VEG. SOIL WATER (VOL/VOL) | | 0.0850 |

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FINAL WATER STORAGE AT END OF YEAR 30

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 0.3936 | 0.0984 |
| 2 | 28.5570 | 0.5010 |
| 3 | 8.7484 | 0.2916 |
| 4 | 145.5685 | 0.2941 |
| 5 | 22.4758 | 0.2417 |
| 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:     T:\GUDEPREP.D4
TEMPERATURE DATA FILE:       T:\GUDETEMP.D7
SOLAR RADIATION DATA FILE:   T:\GUDESOLR.D13
EVAPOTRANSPIRATION DATA:     T:\GUDEEVAT.D11
SOIL AND DESIGN DATA FILE:   T:\WCAPIN.D10
OUTPUT DATA FILE:            T:\WCAPOUT.OUT


TIME:  17:39     DATE:   4/ 8/2016


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     TITLE:  GUDE AVERAGE TOP WITH CAP

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   6
           THICKNESS                   =     24.00   INCHES
           POROSITY                    =      0.4530 VOL/VOL
           FIELD CAPACITY              =      0.1900 VOL/VOL
           WILTING POINT               =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2466 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------
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              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2105 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      4.00   PERCENT
DRAINAGE LENGTH             =   1000.0    FEET


                        LAYER  3
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     10.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  4
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   6
THICKNESS                   =      4.00   INCHES
POROSITY                    =      0.4530 VOL/VOL
FIELD CAPACITY              =      0.1900 VOL/VOL
WILTING POINT               =      0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2102 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.720000011000E-03 CM/SEC


                        LAYER  5
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     57.00   INCHES
POROSITY                    =      0.5010 VOL/VOL
FIELD CAPACITY              =      0.2840 VOL/VOL
WILTING POINT               =      0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2846 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.146000006000E-03 CM/SEC
```

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

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   8
THICKNESS                    =     30.00   INCHES
POROSITY                     =      0.4630 VOL/VOL
FIELD CAPACITY               =      0.2320 VOL/VOL
WILTING POINT                =      0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC


                      LAYER  7
                      --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER  18
THICKNESS                    =    495.00   INCHES
POROSITY                     =      0.6710 VOL/VOL
FIELD CAPACITY               =      0.2920 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                      LAYER  8
                      --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   6
THICKNESS                    =     93.00   INCHES
POROSITY                     =      0.4530 VOL/VOL
FIELD CAPACITY               =      0.1900 VOL/VOL
WILTING POINT                =      0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1900 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.720000011000E-03 CM/SEC


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

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-
           SPECIFIED CURVE NUMBER OF 71.0, A SURFACE SLOPE
           OF  4.% AND A SLOPE LENGTH OF 1000. FEET.

SCS RUNOFF CURVE NUMBER            =     69.80
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     91.350  ACRES
EVAPORATIVE ZONE DEPTH             =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      2.343  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      4.530  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      0.850  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =    192.186  INCHES
TOTAL INITIAL WATER                =    192.186  INCHES
```

TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WASHINGTON DISTRICT OF COLUMB

| | | |
|---|---|---|
| STATION LATITUDE | = | 38.90 DEGREES |
| MAXIMUM LEAF AREA INDEX | = | 4.50 |
| START OF GROWING SEASON (JULIAN DATE) | = | 104 |
| END OF GROWING SEASON (JULIAN DATE) | = | 296 |
| EVAPORATIVE ZONE DEPTH | = | 10.0 INCHES |
| AVERAGE ANNUAL WIND SPEED | = | 9.30 MPH |
| AVERAGE 1ST QUARTER RELATIVE HUMIDITY | = | 60.00 % |
| AVERAGE 2ND QUARTER RELATIVE HUMIDITY | = | 62.00 % |
| AVERAGE 3RD QUARTER RELATIVE HUMIDITY | = | 68.00 % |
| AVERAGE 4TH QUARTER RELATIVE HUMIDITY | = | 65.00 % |

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 2.76 | 2.62 | 3.46 | 2.93 | 3.48 | 3.35 |
| 3.88 | 4.40 | 3.22 | 2.90 | 2.82 | 3.18 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.40 | 33.60 | 42.40 | 53.30 | 62.40 | 70.70 |
| 75.50 | 74.30 | 67.40 | 55.30 | 44.80 | 35.10 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA
AND STATION LATITUDE = 38.90 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 | 2.55 | 2.78 | 3.17 | 3.03 | 3.40 | 3.79 |
| | 4.10 | 3.32 | 2.85 | 3.25 | 2.62 | 2.90 |
| STD. DEVIATIONS | 1.38 | 1.13 | 1.46 | 1.38 | 2.11 | 1.86 |
| | 2.25 | 1.65 | 1.98 | 2.21 | 1.10 | 1.63 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.231 | 0.972 | 0.321 | 0.000 | 0.004 | 0.004 |
| | 0.002 | 0.002 | 0.009 | 0.009 | 0.002 | 0.054 |
| STD. DEVIATIONS | 0.420 | 1.178 | 0.581 | 0.000 | 0.020 | 0.014 |
| | 0.008 | 0.009 | 0.036 | 0.031 | 0.008 | 0.255 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.944 | 0.922 | 2.334 | 2.535 | 2.902 | 3.224 |
| | 3.272 | 2.864 | 2.026 | 1.400 | 1.297 | 1.017 |
| STD. DEVIATIONS | 0.368 | 0.491 | 0.466 | 0.883 | 1.107 | 1.329 |
| | 1.371 | 1.185 | 1.072 | 0.444 | 0.353 | 0.182 |
| **LATERAL DRAINAGE COLLECTED FROM LAYER 2** | | | | | | |
| TOTALS | 1.1878 | 0.8607 | 1.7002 | 0.6985 | 0.8250 | 0.6237 |
| | 0.5717 | 0.5986 | 0.5606 | 1.2947 | 1.1587 | 1.2389 |
| STD. DEVIATIONS | 0.8557 | 0.8771 | 0.8414 | 0.7193 | 1.0662 | 0.6719 |
| | 0.7315 | 0.6480 | 0.7825 | 1.4524 | 1.0477 | 1.1715 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 3** | | | | | | |
| TOTALS | 0.0087 | 0.0091 | 0.0212 | 0.0051 | 0.0089 | 0.0047 |
| | 0.0043 | 0.0038 | 0.0127 | 0.0219 | 0.0118 | 0.0160 |
| STD. DEVIATIONS | 0.0108 | 0.0168 | 0.0230 | 0.0100 | 0.0246 | 0.0083 |
| | 0.0108 | 0.0051 | 0.0426 | 0.0426 | 0.0226 | 0.0327 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 8** | | | | | | |
| TOTALS | 0.0131 | 0.0106 | 0.0138 | 0.0173 | 0.0207 | 0.0135 |
| | 0.0051 | 0.0045 | 0.0033 | 0.0060 | 0.0088 | 0.0151 |
| STD. DEVIATIONS | 0.0139 | 0.0122 | 0.0148 | 0.0162 | 0.0267 | 0.0192 |
| | 0.0108 | 0.0096 | 0.0087 | 0.0119 | 0.0104 | 0.0146 |

## AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

| | | | | | | |
|---|---|---|---|---|---|---|
| **DAILY AVERAGE HEAD ON TOP OF LAYER 3** | | | | | | |
| AVERAGES | 0.0656 | 0.0860 | 0.2015 | 0.0345 | 0.0766 | 0.0339 |
| | 0.0295 | 0.0226 | 0.1344 | 0.2227 | 0.1068 | 0.1495 |
| STD. DEVIATIONS | 0.1149 | 0.1979 | 0.2571 | 0.1084 | 0.2721 | 0.0871 |
| | 0.1159 | 0.0467 | 0.5061 | 0.4779 | 0.2578 | 0.3676 |

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

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 37.77 | ( 5.959) | 12524438.0 | 100.00 |
| RUNOFF | 1.611 | ( 1.2442) | 534291.81 | 4.266 |
| EVAPOTRANSPIRATION | 24.737 | ( 3.4278) | 8202647.00 | 65.493 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 2 | 11.31905 | ( 3.66468) | 3753401.500 | 29.96862 |
| PERCOLATION/LEAKAGE THROUGH LAYER 3 | 0.12807 | ( 0.09013) | 42467.023 | 0.33907 |
| AVERAGE HEAD ON TOP OF LAYER 3 | 0.097 | ( 0.085) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 8 | 0.13175 | ( 0.08414) | 43687.285 | 0.34882 |
| CHANGE IN WATER STORAGE | -0.029 | ( 1.1838) | -9586.85 | -0.077 |

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

| | (INCHES) | (CU. FT.) |
|---|---|---|
| PRECIPITATION | 3.34 | 1107545.620 |
| RUNOFF | 1.980 | 656660.1870 |
| DRAINAGE COLLECTED FROM LAYER 2 | 0.44825 | 148639.28100 |
| PERCOLATION/LEAKAGE THROUGH LAYER 3 | 0.044864 | 14876.79390 |
| AVERAGE HEAD ON TOP OF LAYER 3 | 15.952 | |
| MAXIMUM HEAD ON TOP OF LAYER 3 | 27.743 | |
| LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN) | 129.1 FEET | |
| PERCOLATION/LEAKAGE THROUGH LAYER 8 | 0.005176 | 1716.27661 |
| SNOW WATER | 3.40 | 1126537.6200 |

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4066

MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0850

*** 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 | 5.1823 | 0.2159 |
| 2 | 0.0216 | 0.1096 |
| 3 | 0.0000 | 0.0000 |
| 4 | 0.7600 | 0.1900 |
| 5 | 16.1873 | 0.2840 |
| 6 | 6.9597 | 0.2320 |
| 7 | 144.5277 | 0.2920 |
| 8 | 17.6797 | 0.1901 |
| SNOW WATER | 0.000 | |

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# Attachment C

# Laboratory Reports

Maryland Spectral Services

Analytical Chemistry Services

1500 Caton Center Dr Suite G
Baltimore MD 21227
410-247-7600
www.mdspectral.com
VELAP ID 460040

14 March 2019

Laura Oakes
EA Engineering
225 Schilling Circle, STE 400
Hunt Valley, MD 21031
RE: GUDE LANDFILL

Enclosed are the results of analyses for samples received by the laboratory on 03/05/19 15:54.

Maryland Spectral Services, Inc. is a TNI 2009 Standard accredited laboratory and as such, all analyses performed at Maryland Spectral Services included in this report are 2009 TNI certified except as indicated at the end of this report. Please visit our website at www.mdspectral.com for a complete listing of our TNI 2009 Standard accreditations.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Will Brewington
President

Maryland Spectral Services

Analytical Chemistry Services

# Analytical Results

1500 Caton Center Dr Suite G
Baltimore MD 21227
410-247-7600
www.mdspectral.com

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

| Client Sample ID | Alternate Sample ID | Laboratory ID | Matrix | Date Sampled | Date Received |
|---|---|---|---|---|---|
| FLARE SUMP | | 9030516-01 | Nonpotable Water | 03/05/19 09:53 | 03/05/19 15:54 |
| FIELD SUMP | | 9030516-02 | Nonpotable Water | 03/05/19 10:29 | 03/05/19 15:54 |
| TRIP BLANK | | 9030516-03 | Nonpotable Water | 03/05/19 00:00 | 03/05/19 15:54 |

*The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.*

Will Brewington, President

All analyses performed at Maryland Spectral Services included in the report are TNI certified except as indicated at the end of the report

Maryland Spectral Services

Analytical Chemistry Services

1500 Caton Center Dr Suite G
Baltimore MD 21227
410-247-7600
www.mdspectral.com

# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:** 03/14/19 13:26

## FLARE SUMP

**9030516-01 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **pH MEASUREMENT BY EPA 9045D** | | | | | | | | | **O-04, O-05** |
| **pH** | **7.05** | | pH Units | | | 1 | 03/07/19 | 03/07/19 19:29 | VVD |
| **TURBIDITY BY EPA 180.1** | | | | | | | | | |
| **Turbidity** | **8.69** | | NTU | 0.500 | 0.500 | 1 | 03/06/19 | 03/06/19 20:25 | VVD |
| **VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS)** | | | | | | | | | |
| **Acetone** | **82.4** | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Acrylonitrile | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Allyl chloride (3-Chloropropylene) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Benzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Bromochloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Bromodichloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Bromoform | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Bromomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 2-Butanone (MEK) | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Carbon disulfide | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Carbon tetrachloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Chlorobenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Chloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Chloroform | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Chloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Chloroprene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Dibromochloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,2-Dibromo-3-chloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,2-Dibromoethane (EDB) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Dibromomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,2-Dichlorobenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| **1,4-Dichlorobenzene** | **2.2** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| trans-1,4-Dichloro-2-butene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,1-Dichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,2-Dichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,1-Dichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| **cis-1,2-Dichloroethene** | **1.0** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| trans-1,2-Dichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,2-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |

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Will Brewington, President

All analyses performed at Maryland Spectral Services included in the report are TNI certified except as indicated at the end of the report

1500 Caton Center Dr Suite G
Baltimore MD 21227
410-247-7600
www.mdspectral.com

# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

## FLARE SUMP

**9030516-01 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS) (continued)** | | | | | | | | | |
| 1,3-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 2,2-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,1-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| cis-1,3-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| trans-1,3-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Ethyl methacrylate | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Ethylbenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 2-Hexanone | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Isobutanol | ND | | ug/L | 100 | 100 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Iodomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Methyl tert-butyl ether (MTBE) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 4-Methyl-2-pentanone | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Methylene chloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Methyl methacrylate | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Styrene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,1,1,2-Tetrachloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,1,2,2-Tetrachloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Tetrachloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Toluene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,1,1-Trichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,1,2-Trichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Trichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Trichlorofluoromethane (Freon 11) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| 1,2,3-Trichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Vinyl acetate | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| Vinyl chloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| **o-Xylene** | **1.1** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |
| **m- & p-Xylenes** | **1.9** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 13:13 | GM |

| | | | | |
|---|---|---|---|---|
| *Surrogate: 1,2-Dichloroethane-d4* | *80-120* | *99 %* | *03/12/19* | *03/12/19 13:13* |
| *Surrogate: Toluene-d8* | *88-110* | *94 %* | *03/12/19* | *03/12/19 13:13* |
| *Surrogate: 4-Bromofluorobenzene* | *86-115* | *102 %* | *03/12/19* | *03/12/19 13:13* |

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Will Brewington, President

All analyses performed at Maryland Spectral Services included in the report are TNI certified except as indicated at the end of the report

Maryland spectral Services

Analytical Chemistry Services

# Analytical Results

1500 Caton Center Dr Suite G
Baltimore MD 21227
410-247-7600
www.mdspectral.com

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

**Reported:** 03/14/19 13:26

## FLARE SUMP

**9030516-01 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL METALS ANALYSIS BY EPA 3010A/6020A** | | | | | | | | | |
| **Hardness as CaCO3** | **130000** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Antimony** | **31.7** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Arsenic** | **3.31** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Barium** | **24.2** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Beryllium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Cadmium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Calcium** | **34800** | | ug/L | 80.0 | 80.0 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Chromium** | **5.27** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Cobalt | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Copper** | **11.0** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Iron** | **1090** | | ug/L | 100 | 100 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Lead | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Magnesium** | **10500** | | ug/L | 100 | 100 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Manganese** | **45.9** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Mercury | ND | | ug/L | 0.100 | 0.100 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Nickel** | **8.05** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Potassium** | **3690** | | ug/L | 100 | 100 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Selenium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Silver | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Sodium** | **99700** | | ug/L | 100 | 100 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Thallium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| Vanadium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **Zinc** | **36.7** | | ug/L | 4.00 | 4.00 | 1 | 03/06/19 | 03/08/19 01:14 | VVD |
| **CHEMICAL OXYGEN DEMAND BY EPA 410.4** | | | | | | | | | |
| **COD** | **37.8** | | mg/L | 20.0 | 20.0 | 1 | 03/12/19 | 03/12/19 16:26 | VVD |

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Will Brewington, President

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Maryland spectral Services

Analytical Chemistry Services

1500 Caton Center Dr Suite G
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# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

## FLARE SUMP

**9030516-01 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL SUSPENDED SOLIDS BY USGS I-3765-85** | | | | | | | | | |
| **Solids, Suspended** | **4.3** | | mg/L | 2.7 | 2.7 | 1 | 03/11/19 | 03/11/19 17:32 | AM |
| **Wet Chemistry Performed at Enviro-Chem** | | | | | | | | | |
| **Ammonia Nitrogen** | **0.95** | | mg/L | 0.10 | 0.05 | 1 | 03/08/19 | 03/08/19 14:13 | FRD |
| **Chloride** | **157** | | mg/L | 5.0 | 5.0 | 10 | 03/07/19 | 03/07/19 21:44 | SES |
| **Conductivity** | **782** | | us/Cm | 1.00 | 1.00 | 1 | 03/09/19 | 03/09/19 16:30 | SES |
| **Dissolved Solids** | **432** | | mg/L | 5.0 | 5.0 | 1 | 03/09/19 | 03/09/19 11:50 | SES |
| **Nitrate (as N)** | **1.1** | | mg/L | 0.2 | 0.1 | 1 | 03/06/19 | 03/06/19 18:32 | SES |
| **Sulfate** | **28.5** | | mg/L | 1.0 | 0.5 | 1 | 03/06/19 | 03/06/19 18:32 | SES |
| **Alkalinity SM2320B Performed at Enviro-Chem** | | | | | | | | | |
| **Alkalinity as CaCO3** | **112** | | mg/L | 1.0 | 1.0 | 1 | 03/08/19 | 03/08/19 16:30 | SES |

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# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

**FIELD SUMP**

**9030516-02 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **pH MEASUREMENT BY EPA 9045D** | | | | | | | | | **O-04, O-05** |
| **pH** | **7.76** | | pH Units | | | 1 | 03/07/19 | 03/07/19 19:29 | VVD |
| **TURBIDITY BY EPA 180.1** | | | | | | | | | |
| **Turbidity** | **17.4** | | NTU | 0.500 | 0.500 | 1 | 03/06/19 | 03/06/19 20:28 | VVD |
| **VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS)** | | | | | | | | | |
| **Acetone** | **621** | Ea | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Acrylonitrile | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Allyl chloride (3-Chloropropylene) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Benzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Bromochloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Bromodichloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Bromoform | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Bromomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| **2-Butanone (MEK)** | **727** | Ea | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Carbon disulfide | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Carbon tetrachloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Chlorobenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Chloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Chloroform | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Chloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Chloroprene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Dibromochloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,2-Dibromo-3-chloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,2-Dibromoethane (EDB) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Dibromomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,2-Dichlorobenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| **1,4-Dichlorobenzene** | **5.5** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| trans-1,4-Dichloro-2-butene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,1-Dichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,2-Dichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,1-Dichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| cis-1,2-Dichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| trans-1,2-Dichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,2-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |

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Maryland Spectral Services

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# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

**FIELD SUMP**

**9030516-02 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS) (continued)** | | | | | | | | | |
| 1,3-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 2,2-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,1-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| cis-1,3-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| trans-1,3-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Ethyl methacrylate | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| **Ethylbenzene** | **1.1** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| **2-Hexanone** | **5.4** | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Isobutanol | ND | | ug/L | 100 | 100 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Iodomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Methyl tert-butyl ether (MTBE) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| **4-Methyl-2-pentanone** | **29.0** | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Methylene chloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Methyl methacrylate | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Styrene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,1,1,2-Tetrachloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,1,2,2-Tetrachloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Tetrachloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| **Toluene** | **2.2** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,1,1-Trichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,1,2-Trichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Trichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Trichlorofluoromethane (Freon 11) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| 1,2,3-Trichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Vinyl acetate | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| Vinyl chloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| **o-Xylene** | **2.6** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |
| **m- & p-Xylenes** | **5.7** | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:47 | GM |

| | | | | |
|---|---|---|---|---|
| *Surrogate: 1,2-Dichloroethane-d4* | *80-120* | *100 %* | *03/12/19* | *03/12/19 12:47* |
| *Surrogate: Toluene-d8* | *88-110* | *93 %* | *03/12/19* | *03/12/19 12:47* |
| *Surrogate: 4-Bromofluorobenzene* | *86-115* | *103 %* | *03/12/19* | *03/12/19 12:47* |

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Maryland spectral Services

Analytical Chemistry Services

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# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

## FIELD SUMP

**9030516-02 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL METALS ANALYSIS BY EPA 3010A/6020A** | | | | | | | | | |
| **Hardness as CaCO3** | **586000** | | ug/L | 20.0 | 20.0 | 20 | 03/06/19 | 03/11/19 13:14 | VVD |
| **Antimony** | **79.6** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Arsenic** | **4.22** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Barium** | **60.8** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Beryllium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Cadmium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Calcium** | **119000** | | ug/L | 1600 | 1600 | 20 | 03/06/19 | 03/11/19 13:14 | VVD |
| Chromium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Cobalt** | **14.6** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Copper | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Iron** | **1480** | | ug/L | 100 | 100 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Lead | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Magnesium** | **69900** | | ug/L | 2000 | 2000 | 20 | 03/06/19 | 03/11/19 13:14 | VVD |
| **Manganese** | **12900** | | ug/L | 20.0 | 20.0 | 20 | 03/06/19 | 03/11/19 13:14 | VVD |
| Mercury | ND | | ug/L | 0.100 | 0.100 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Nickel** | **6.08** | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Potassium** | **278** | | ug/L | 100 | 100 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Selenium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Silver | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **Sodium** | **20500** | | ug/L | 100 | 100 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Thallium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Vanadium | ND | | ug/L | 1.00 | 1.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| Zinc | ND | | ug/L | 4.00 | 4.00 | 1 | 03/06/19 | 03/08/19 01:20 | VVD |
| **CHEMICAL OXYGEN DEMAND BY EPA 410.4** | | | | | | | | | |
| **COD** | **67.2** | | mg/L | 20.0 | 20.0 | 1 | 03/12/19 | 03/12/19 16:27 | VVD |

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Maryland spectral Services

Analytical Chemistry Services

# Analytical Results

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**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

**FIELD SUMP**

**9030516-02 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL SUSPENDED SOLIDS BY USGS I-3765-85** | | | | | | | | | |
| **Solids, Suspended** | **3.5** | | mg/L | 3.1 | 3.1 | 1 | 03/11/19 | 03/11/19 17:32 | AM |
| **Wet Chemistry Performed at Enviro-Chem** | | | | | | | | | |
| **Ammonia Nitrogen** | **3.07** | | mg/L | 0.10 | 0.05 | 1 | 03/08/19 | 03/08/19 14:16 | FRD |
| **Chloride** | **154** | | mg/L | 5.0 | 5.0 | 10 | 03/07/19 | 03/07/19 22:02 | SES |
| **Conductivity** | **1240** | | us/Cm | 1.00 | 1.00 | 1 | 03/09/19 | 03/09/19 16:30 | SES |
| **Dissolved Solids** | **756** | | mg/L | 5.0 | 5.0 | 1 | 03/09/19 | 03/09/19 11:50 | SES |
| **Nitrate (as N)** | **0.4** | | mg/L | 0.2 | 0.1 | 1 | 03/06/19 | 03/06/19 18:50 | SES |
| **Sulfate** | **63.1** | | mg/L | 1.0 | 0.5 | 1 | 03/06/19 | 03/06/19 18:50 | SES |
| **Alkalinity SM2320B Performed at Enviro-Chem** | | | | | | | | | |
| **Alkalinity as $CaCO_3$** | **196** | | mg/L | 1.0 | 1.0 | 1 | 03/08/19 | 03/08/19 16:30 | SES |

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Maryland spectral Services

Analytical Chemistry Services

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# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

## TRIP BLANK

**9030516-03 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS)** | | | | | | | | | |
| Acetone | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Acrylonitrile | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Allyl chloride (3-Chloropropylene) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Benzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Bromochloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Bromodichloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Bromoform | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Bromomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 2-Butanone (MEK) | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Carbon disulfide | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Carbon tetrachloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Chlorobenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Chloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Chloroform | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Chloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Chloroprene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Dibromochloromethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,2-Dibromo-3-chloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,2-Dibromoethane (EDB) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Dibromomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,2-Dichlorobenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,4-Dichlorobenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| trans-1,4-Dichloro-2-butene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,1-Dichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,2-Dichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,1-Dichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| cis-1,2-Dichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| trans-1,2-Dichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,2-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,3-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 2,2-Dichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,1-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| cis-1,3-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |

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Will Brewington, President

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Maryland spectral Services

Analytical Chemistry Services

1500 Caton Center Dr Suite G
Baltimore MD 21227
410-247-7600
www.mdspectral.com

# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

**TRIP BLANK**

**9030516-03 (Nonpotable Water)**
**Sample Date: 03/05/19**

| Analyte | Result | Notes | Units | Reporting Limit (MRL) | Quantitation Limit (LOQ) | Dilution | Prepared | Analyzed | Analyst |
|---|---|---|---|---|---|---|---|---|---|
| **VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS) (continued)** | | | | | | | | | |
| trans-1,3-Dichloropropene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Ethyl methacrylate | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Ethylbenzene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 2-Hexanone | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Isobutanol | ND | | ug/L | 100 | 100 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Iodomethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Methyl tert-butyl ether (MTBE) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 4-Methyl-2-pentanone | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Methylene chloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Methyl methacrylate | ND | | ug/L | 5.0 | 5.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Styrene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,1,1,2-Tetrachloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,1,2,2-Tetrachloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Tetrachloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Toluene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,1,1-Trichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,1,2-Trichloroethane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Trichloroethene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Trichlorofluoromethane (Freon 11) | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| 1,2,3-Trichloropropane | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Vinyl acetate | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| Vinyl chloride | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| o-Xylene | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| m- & p-Xylenes | ND | | ug/L | 1.0 | 1.0 | 1 | 03/12/19 | 03/12/19 12:22 | GM |
| *Surrogate: 1,2-Dichloroethane-d4* | | | *80-120* | *100 %* | *03/12/19* | | *03/12/19 12:22* | | |
| *Surrogate: Toluene-d8* | | | *88-110* | *94 %* | *03/12/19* | | *03/12/19 12:22* | | |
| *Surrogate: 4-Bromofluorobenzene* | | | *86-115* | *101 %* | *03/12/19* | | *03/12/19 12:22* | | |

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Will Brewington, President

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Maryland spectral Services

Analytical Chemistry Services

# Analytical Results

1500 Caton Center Dr Suite G
Baltimore MD 21227
410-247-7600
www.mdspectral.com

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

**Reported:**
03/14/19 13:26

Maryland Spectral Services does not maintain certification for the following analytical parameters:

## Enviro-Chem

Matrix , Method , Analyte

Water | TDS | Dissolved Solids

Water | SO4-IC | Sulfate

Water | NO3-IC | Nitrate (as N)

Water | NH3 | Ammonia Nitrogen

Water | COND | Conductivity

Water | CL-IC | Chloride

Water | ALK | Alkalinity as CaCO3

## Maryland Spectral Services

Matrix , Method , Analyte

Soil | pH (pH Meter) | pH

Matrix , Method , Analyte

Water | Turbidity | Turbidity

Water | COD | COD

Water | 8260 (Low Level) | Acrylonitrile

Water | 8260 (Low Level) | Allyl chloride (3-Chloropropylene)

Water | 8260 (Low Level) | Chloroprene

Water | 8260 (Low Level) | trans-1,4-Dichloro-2-butene

Water | 8260 (Low Level) | Ethyl methacrylate

Water | 8260 (Low Level) | Isobutanol

Water | 8260 (Low Level) | Iodomethane

Water | 8260 (Low Level) | Methyl methacrylate

Water | 8260 (Low Level) | Vinyl acetate

Water | 6020 (MDE Landfill Table-II) | Hardness as CaCO3

Water | 6020 (MDE Landfill Table-II) | Antimony

Water | 6020 (MDE Landfill Table-II) | Arsenic

Water | 6020 (MDE Landfill Table-II) | Barium

Water | 6020 (MDE Landfill Table-II) | Beryllium

Water | 6020 (MDE Landfill Table-II) | Cadmium

Water | 6020 (MDE Landfill Table-II) | Calcium

Water | 6020 (MDE Landfill Table-II) | Chromium

Water | 6020 (MDE Landfill Table-II) | Cobalt

Water | 6020 (MDE Landfill Table-II) | Copper

Water | 6020 (MDE Landfill Table-II) | Iron

Water | 6020 (MDE Landfill Table-II) | Lead

Water | 6020 (MDE Landfill Table-II) | Magnesium

Water | 6020 (MDE Landfill Table-II) | Manganese

Water | 6020 (MDE Landfill Table-II) | Mercury

Water | 6020 (MDE Landfill Table-II) | Nickel

Water | 6020 (MDE Landfill Table-II) | Potassium

Water | 6020 (MDE Landfill Table-II) | Selenium

Water | 6020 (MDE Landfill Table-II) | Silver

Water | 6020 (MDE Landfill Table-II) | Sodium

Water | 6020 (MDE Landfill Table-II) | Thallium

Water | 6020 (MDE Landfill Table-II) | Vanadium

Water | 6020 (MDE Landfill Table-II) | Zinc

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Will Brewington, President

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Baltimore MD 21227
410-247-7600
www.mdspectral.com

# Analytical Results

**Project: GUDE LANDFILL**

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

**Reported:**

03/14/19 13:26

## Notes and Definitions

| | |
|---|---|
| O-05 | This sample was prepared outside of the EPA recommended holding time. |
| O-04 | This sample was analyzed outside the EPA recommended holding time. |
| Ea | The concentration indicated for this analyte is an estimated value above the calibration range of the instrument. This value is considered an estimate (CLP E-flag). |
| E | Over Calibration Estimated Result |
| DET | Analyte DETECTED |
| ND | Analyte NOT DETECTED at or above the reporting limit |
| NR | Not Reported |
| dry | Sample results reported on a dry weight basis |
| RPD | Relative Percent Difference |
| %-Solids | Percent Solids is a supportive test and as such does not require accreditation |

*The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.*

Will Brewington, President

| Company Name: EA Engineering, Science & Tech. | Project Manager: Laura Oakes |
|---|---|
| Project Name: Gude Landfill | Project ID: 1556404.0008.0001 |
| Sampler(s): Rob Moncure | P.O. Number: 18961 |

# CHAIN-OF-CUSTODY RECORD

Maryland Spectral Services, Inc.
1500 Caton Center Drive, Suite G
Baltimore, MD 21227
410-247-7600 • Fax 410-247-7602
reporting@mdspectral.com

Matrix Codes: NW (non-potable water) PW (potable

Analysis Requested

| Field Sample ID | Date | Time | Water | Soil | Other | No. of Containers | 8260LL VOC | 6020 MDE Landfill List | Chloride, Nitrate, Sulfate | Alkalinity, Nitrogen- | Turbidity, pH | Dissolved Solids | Suspended Solids | Conductivity | COD | | Preservative: 1+1 HCl, $H_2SO_4$, Methanol, $Na_2S_2O_3$, $NaHCO_3$ | Field pH, Residual Chlorine, QC Request, Trip Blank, Field Blank | MSS Lab ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flare Sump | 3/5/19 | 0953 | x | | | | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | 9030516-01 |
| Field Sump | 3/5/19 | 1029 | x | | | | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | ↓ -02 |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |

| Relinquished by: (Signature) | Date/Time | Received by: (Signature) | Relinquished by: (Signature) | Date/Time | Received by: (Signature) |
|---|---|---|---|---|---|
| [signature] | 3/5/19 1554 | [signature] | | | |
| (Printed) Rob Moncure-EA | | (Printed) Samantha Adnan | (Printed) | | (Printed) |
| Relinquished by: (Signature) | Date/Time | Received by Lab: (Signature) | | | |
| (Printed) | | (Printed) | | | |

**Turn Around Time:**
- ☐ Normal (7 day)
- ☐ 5 day
- ☐ 4 day
- ☐ 3 day
- ☐ Rush (2 day)
- ☐ Next Day
- ☐ Other: ____
- ☐ Specific Due Date: ____

**Lab Use:**
Temp: 5.4 °C
- ☑ Received on Ice
- ☐ Received same day
- ☐ Preservation Appropriate

**Sample Disposal:**
- ☐ Return to Client
- ☐ Disposal by lab
- ☐ Archive for ____ days

**Delivery Method:**
- ☐ Courier
- ☐ Client
- ☐ UPS
- ☐ FedEx
- ☐ USPS
- ☐ Other: ____

**Special Instructions/QC Requirements & Comments:**

# SUBCONTRACT ORDER
## Maryland Spectral Services

**9030516**

| SENDING LABORATORY: | RECEIVING LABORATORY: |
|---|---|
| Maryland Spectral Services | Enviro-Chem Laboratories, Inc |
| 1500 Caton Center Dr. Suite G | 47 Loveton Circle, Suite K |
| Halethorpe, MD 21227 | Sparks, MD 21152 |
| Phone: 410.247.7600 | Phone :(410) 472-1112 |
| Project Manager: Cory Koons | Fax: (410) 472-1116 |
| Reports Email: Reporting@mdspectral.com | |

**Due 4:00 PM** 03/14/19 **Laboratory ID** **Comments**

**Sample ID: 9030516-01** **FLARE SUMP** **Water** **Sampled:03/05/19 09:53**

| | | | |
|---|---|---|---|
| Alkalinity | Chloride | Conductance | Nitrogen, Ammonia |
| Nitrogen, Nitrate | Solids (Total Dissolved) | Sulfate | |

*Containers Supplied:*
Plastic, 0.050L None (D) Plastic, 0.050L None (E) Plastic, 0.050L None (F)

**Sample ID: 9030516-02** **FIELD SUMP** **Water** **Sampled:03/05/19 10:29**

| | | | |
|---|---|---|---|
| Alkalinity | Chloride | Conductance | Nitrogen, Ammonia |
| Nitrogen, Nitrate | Solids (Total Dissolved) | Sulfate | |

*Containers Supplied:*
Plastic, 0.050L None (D) Plastic, 0.050L None (E) Plastic, 0.050L None (F)

908 2.6°C

| Released By | Date | Received By | Date |
|---|---|---|---|
| [signature] | 3/6/19 | [signature] | 3/6/19 |
| Released By | Date | Received By | Date |

# Attachment K

# Landfill Gas Calculations

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*References:*
LANDTEC. Landfill Gas System Engineering Design: A Practical Approach. 1994

## PART 1 – PIPE SIZING AND PRESSURE DROP

**OBJECTIVE:**
To determine what pipe diameters will be used to convey landfill gas (LFG). This will be calculated using the Darcy-Weisbach Equation of Pressure Loss to ensure that there is enough flow pressure to convey the gas along each length of pipe in the network.

**PROCEDURE:**
Use Continuity, Reynolds Number, and Darcy-Weisbach Equation for Piping Pressure Drop to size the pipes necessary. Assume fully turbulent flow.

**A. Continuity**—This analysis will be used to calculate the velocity of the gas in each length of pipe based on knowing the inner diameter of a trial pipe size and estimated gas flow.

$$v = \frac{Q}{(\frac{\pi d^2}{4})}$$

where:

- Q = Flowrate of gas (cubic feet per minute [$ft^3$/min]) = 507 $ft^3$/min (total) or 5.9 cfm/well for 86 LFG wells
- d = Inner diameter of pipe (feet [ft])
- v = Mean flow velocity (feet per second [ft/s]).

**B. Reynolds Number**—Calculate so that a friction factor can be determined for use in the Darcy-Weisbach Equation. Assume absolute viscosity is 8.0E-06 pound-mass ($lb_m$)/ft s and density is 0.061 $lb_m/ft^3$.

$$Re = \frac{d * v * \rho}{\mu}$$

where:

- d = Inner diameter of pipe (ft)
- v = Mean flow velocity (ft/s)
- ρ = Density of LFG ($lb_m/ft^3$) = 0.061 $lb_m/ft^3$
- μ = Absolute viscosity ($lb_m$/ft s) = 8.0E-06 $lb_m$/ft s
- Re = Reynolds Number.

**C. Darcy Friction Factor**—Friction factor is found by calculating the relative roughness in which the absolute roughness was assumed to be 7E-05 ft for high-density polyethylene (HDPE). Using a Moody diagram, relative roughness, and Reynolds number, the friction factor can be determined.

$$relative\ roughness = \frac{\varepsilon}{d}$$

where:

- d = Inner diameter of pipe (ft)
- ε = Absolute Roughness (ft) = 7E-05 ft.

**D. Darcy-Weisbach Equation**—This analysis will be used to calculate the change in pressure over the length of the pipe. Gravity is assumed to be 32.2 ($lb_m$/ft-pound-force [$lb_f$])/$s^2$. A conversion of 27.7 is used to convert a pressure of pounds per square inch (psi) to inches of water column.

$$\Delta P = \frac{\rho * f * L * v^2}{144 * d * 2g} * 27.7$$

where:

- ΔP = Pressure drop (inches [in.] of water column [w.c.])
- ρ = Density of LFG ($lb_m/ft^3$)
- f = Darcy friction factor
- L = Length of piping (ft)
- v = Mean flow velocity (ft/s)
- d = Inner diameter of pipe (ft)
- g = Gravitational constant (($lb_m$/ft-$lb_f$)/$s^2$) = 32.2 ($lb_m$/ft-$lb_f$)$s^2$.

**Solution:** Computed using Excel in the attached table

**<u>CONCLUSION</u>:**

The 8-in. nominal diameter pipe will be effective for LFG extraction design for header pipes and 6-in. nominal diameter pipe for lateral piping. In addition, EA has verified that there is sufficient vacuum pressure available at the existing blower, considering pressure losses from the proposed LFG collection system.

## PART 2 – CONDENSATE ESTIMATION AND PIPE SIZING

**OBJECTIVE:**
Estimate the quantity of condensate production in the LFG collection system to determine the appropriate line size and frequency of condensate traps required to remove condensate from the LFG collection system.

**PROCEDURE:**
Use Antoine's Equation to determine a conservative estimate of condensate produced within the system and then use Manning's Equation to verify maximum flow capacity.

**A. Antoine's Equation**—Use Antoine's equation to provide a conservative estimate for LFG production.

$$V_{cond} = 5{,}694 * {}^{10^{\beta}}/_{P_s}$$

where:

| | | |
|---|---|---|
| $V_{cond}$ | = | Volume of condensate (water) produced (gallons per million cubic foot of LFG) |
| $\beta$ | = | 6.32-(3081/T+385) |
| T | = | Maximum gas temperature (degrees Fahrenheit [°F]) = Assume average initial temperature of gas at 110 °F |
| $P_s$ | = | System pressure (psia) = Assume 13.617 @ 30 in. w.c. vacuum (average). |

$$V_{cond} = 521.3 \frac{gal}{MMcfLFG}$$

**Solution:** Total gas production from the landfill is estimated at 507 cfm; therefore, the Total Volume of condensate produced per minute is estimated at 0.264 gallon per minute (gpm). If assumed condensate production is even across all 86 LFG wells, total condensate production per well is estimated at = 0.0030 gpm.

**B. Manning's Equation**—The system has been designed to drain all condensate by gravity and share collection lines with the LFG collection system. Using the Manning's equation, a maximum flow capacity was calculated for both 6-in.- and 8-in.-diameter piping.

$$Q = (1.486/n)(AR^{2/3})(S^{1/2})$$

$$R = A/(2 * \prod r)$$

where:

Q = Flow (cubic feet per second [cfs]); 1 cfs = 448.8 gpm
n = Manning's coefficient, assume 0.010 for HDPE
A = Area of pipe, 0.20 ft$^2$ for 6-in. and 0.35 ft$^2$ for 8-in.
R = Hydraulic Radius as calculated above
S = Slope, assume minimum 0.03.

**Solution:** Using the Manning's Equation above at slope 0.03, the flow capacity of a 6-in. pipe was calculated to be 0.90 cfs (405 gpm) and 1.9 cfs (872 gpm) for 8-in. pipe. We expect small pipe sizes are more likely to be affected by landfill settlement and, therefore, pipe installation at higher slope is important for these pipe runs. For shorter piping runs at 0.06 slope, the flow capacity was calculated to be 1.28 cfs (573 gpm) for 6-in. pipe and 2.7 cfs (1234 gpm) for 8-in. pipe.

**CONCLUSION:**

The contribution of 0.0030 gpm condensate across the entire LFG collection system relative to the significantly larger capacity of the LFG collection piping was determined to be negligible in pipe sizing. However, as good design practice and to accommodate future landfill settlement, multiple condensate traps were placed throughout the collection header within the landfill to allow for condensate drainage back into the landfill.

**Pressure Loss Through Pipes and Fittings**

| Segment | Start | Start Elevation (ft) | Finish | Finish Elevation (ft) | Horizontal Pipe Length (ft) | Pipe Slope (ft/ft) | Actual Pipe Length (+20%) (ft) | Vapor Density ($lb_m/ft^3$) | Vacuum Pressure (psi) | Absolute Viscosity ($lb_m$/ft*s) | Wells Added | Flow Added (cfm) | Flow (cfm) | Nominal Size (in) | ID (in) | ID Area ($ft^2$) | Velocity (ft/s) | Reynolds Number | Absolute Factor | Relative Roughness (in) | Darcy friction Factor | Pressure Loss (in WC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EAST LOOP (EAST OF MIDDLE HEADER) | | | | | | | | | | | | | | | | | | | | | | |
| L1 | EW-111 | 421.23 | EB | 464.81 | 164 | -0.266 | 204 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00151 |
| LEB.EC | EB | 464.81 | EC | 466.60 | 120 | -0.015 | 144 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00031 |
| L2 | EW-112 | 425.03 | EC | 466.30 | 159 | -0.260 | 197 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00146 |
| LEC.ED | EC | 466.30 | ED | 467.53 | 77 | -0.016 | 92 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 11.79 | 8 | 7.45 | 0.30 | 0.649155 | 3030.05 | 0.00007 | 0.0001128 | 0.05534 | 0.00063 |
| L3 | EW-10 | 470.72 | ED | 467.53 | 76 | 0.042 | 91 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00068 |
| LED.EE | ED | 467.53 | EE | 468.35 | 59 | -0.014 | 71 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 17.69 | 8 | 7.45 | 0.30 | 0.973732 | 4545.08 | 0.00007 | 0.0001128 | 0.04904 | 0.00097 |
| L4 | EW-113 | 427.86 | EE | 468.35 | 157 | -0.258 | 195 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00144 |
| LEE.EF | EE | 468.35 | EF | 469.26 | 21 | -0.043 | 26 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00057 |
| L5 | EW-172 | 474.35 | EF | 469.26 | 348 | 0.015 | 418 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00309 |
| LEF.EG | EF | 469.26 | EG | 471.07 | 203 | -0.009 | 244 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00798 |
| L6 | EW-177 | 475.63 | EG | 471.07 | 111 | 0.041 | 133 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00099 |
| LEG.EH | EG | 471.07 | EH | 471.15 | 8 | -0.010 | 10 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 35.37 | 8 | 7.45 | 0.30 | 1.947465 | 9090.16 | 0.00007 | 0.0001128 | 0.04006 | 0.00043 |
| L7 | EW-170 | 433 | EH | 471.15 | 139 | -0.274 | 173 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00128 |
| LEH.EH1 | EH | 471.15 | EH1 | 471.48 | 33 | -0.010 | 40 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.00231 |
| LEH1.EH2 | EH1 | 471.48 | EH2 | 468.57 | 127 | 0.023 | 152 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.00888 |
| LEH2.EI | EH2 | 468.57 | EI | 468.91 | 49 | -0.007 | 59 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.00343 |
| L8 | EW-175 | 441.73 | EI | 468.91 | 114 | -0.238 | 141 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00104 |
| LEI-EJ | EI | 468.91 | EJ | 469.18 | 10 | -0.027 | 12 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 47.16 | 8 | 7.45 | 0.30 | 2.596619 | 12120.22 | 0.00007 | 0.0001128 | 0.03690 | 0.00088 |
| L9 | EW-176 | 470.54 | EJ | 469.18 | 32 | 0.043 | 38 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00028 |
| LEJ.EJ1 | EJ | 469.18 | EJ1 | 469.90 | 35 | -0.021 | 42 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.00377 |
| LEJ1.EJ2 | EJ1 | 469.9 | EJ2 | 473.30 | 76 | -0.045 | 91 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.00819 |
| LEJ2.EJ3 | EJ2 | 473.3 | EJ3 | 472.82 | 28 | 0.017 | 34 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.00301 |
| LEJ3.EJ4 | EJ3 | 472.82 | EJ4 | 473.82 | 10 | -0.100 | 12 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.00108 |
| LEJ4.EJ5 | EJ4 | 473.82 | EJ5 | 472.35 | 35 | 0.042 | 42 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.00377 |
| LEJ5.EK | EJ5 | 472.35 | EK | 474.69 | 41 | -0.057 | 49 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.00442 |
| L10 | EW-174 | 475.22 | EK | 474.69 | 17 | 0.031 | 21 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00015 |
| LEK.EK1 | EK | 474.69 | EK1 | 475.00 | 118 | -0.003 | 142 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.01522 |
| LEK1.EK2 | EK1 | 472.35 | EK2 | 476.00 | 175 | -0.021 | 210 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.02258 |
| LEK2.EK3 | EK2 | 474.69 | EL | 476.45 | 100 | -0.018 | 120 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.01290 |
| L11 | EW-173 | 475.09 | EL | 476.45 | 32 | -0.043 | 38 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00028 |
| LEL.EL1 | EL | 476.45 | EL1 | 474.17 | 89 | 0.026 | 107 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 64.85 | 8 | 7.45 | 0.30 | 3.570352 | 16665.30 | 0.00007 | 0.0001128 | 0.03374 | 0.01356 |
| LEL1.EL2 | EL1 | 474.17 | EL2 | 471.78 | 57 | 0.042 | 68 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 64.85 | 8 | 7.45 | 0.30 | 3.570352 | 16665.30 | 0.00007 | 0.0001128 | 0.03374 | 0.00867 |
| LEL2.EL3 | EL2 | 471.78 | EL3 | 469.68 | 76 | 0.028 | 91 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 64.85 | 8 | 7.45 | 0.30 | 3.570352 | 16665.30 | 0.00007 | 0.0001128 | 0.03374 | 0.01155 |
| LEL3.EM | EL3 | 469.68 | EM | 472.26 | 79 | -0.033 | 95 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 64.85 | 8 | 7.45 | 0.30 | 3.570352 | 16665.30 | 0.00007 | 0.0001128 | 0.03374 | 0.01201 |
| L12 | EW-15 | 472.54 | EM | 471.96 | 79 | 0.007 | 95 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00070 |
| LEM.EM1 | EM | 471.96 | EM1 | 469.93 | 52 | 0.039 | 62 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.00919 |
| LEM1.EM2 | EM1 | 469.93 | EM2 | 470.97 | 20 | -0.052 | 24 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.00353 |
| LEM2.EM3 | EM2 | 470.97 | EM3 | 467.69 | 246 | 0.013 | 295 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.04343 |
| LEM3.EN | EM3 | 467.69 | EN | 462.00 | 52 | 0.109 | 63 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.00923 |
| L13 | EW-17 | 466.96 | EN | 462.00 | 38 | 0.131 | 46 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00034 |
| LEN.EN1 | EN | 462.00 | EN1 | 463.46 | 84 | -0.017 | 101 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 76.64 | 8 | 7.45 | 0.30 | 4.219507 | 19695.35 | 0.00007 | 0.0001128 | 0.03221 | 0.01702 |
| LEN1.EO | EN1 | 463.46 | EO | 461.56 | 263 | 0.007 | 316 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 76.64 | 8 | 7.45 | 0.30 | 4.219507 | 19695.35 | 0.00007 | 0.0001128 | 0.03221 | 0.05329 |
| L14 | EW-18 | 467.12 | EO | 461.56 | 28 | 0.199 | 34 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00025 |
| LEO.EO1 | EO | 461.56 | EO1 | 461.00 | 120 | 0.005 | 144 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.02763 |
| LEO1.EP | EO1 | 461.00 | EP | 460.19 | 57 | 0.014 | 68 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 88.43 | 8 | 7.45 | 0.30 | 4.868662 | 22725.40 | 0.00007 | 0.0001128 | 0.03096 | 0.01478 |
| L15 | EW-178 | 434.63 | EP | 460.19 | 153 | -0.167 | 186 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00138 |
| LEP.EP1 | EP | 460.19 | EP1 | 458.78 | 60 | 0.024 | 72 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 88.43 | 8 | 7.45 | 0.30 | 4.868662 | 22725.40 | 0.00007 | 0.0001128 | 0.03096 | 0.01556 |
| LEP1.EP2 | EP1 | 458.78 | EP2 | 458.75 | 43 | 0.001 | 52 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 88.43 | 8 | 7.45 | 0.30 | 4.868662 | 22725.40 | 0.00007 | 0.0001128 | 0.03096 | 0.01115 |
| LEP2.EP3 | EP2 | 458.75 | EP3 | 456.12 | 48 | 0.055 | 58 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 88.43 | 8 | 7.45 | 0.30 | 4.868662 | 22725.40 | 0.00007 | 0.0001128 | 0.03096 | 0.01247 |
| LEP3.EQ | EP3 | 456.12 | EQ | 455.56 | 51 | 0.011 | 61 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 88.43 | 8 | 7.45 | 0.30 | 4.868662 | 22725.40 | 0.00007 | 0.0001128 | 0.03096 | 0.01323 |
| L16 | EW-167 | 460.70 | EQ | 455.56 | 50 | 0.103 | 60 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00045 |
| LEQ1.EQ2 | EQ | 455.56 | EQ1 | 457.30 | 126 | -0.014 | 151 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 94.33 | 8 | 7.45 | 0.30 | 5.193239 | 24240.43 | 0.00007 | 0.0001128 | 0.03042 | 0.03653 |
| LEQ2.EQ3 | EQ1 | 457.30 | EQ2 | 457.30 | 126 | 0.000 | 151 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 94.33 | 8 | 7.45 | 0.30 | 5.193239 | 24240.43 | 0.00007 | 0.0001128 | 0.03042 | 0.03653 |
| LEQ3.ER | EQ2 | 457.30 | ER | 457.25 | 104 | 0.000 | 125 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 94.33 | 8 | 7.45 | 0.30 | 5.193239 | 24240.43 | 0.00007 | 0.0001128 | 0.03042 | 0.03015 |
| L17 | EW-166 | 463.58 | ER | 457.25 | 211 | 0.030 | 253 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00188 |
| LER.ER1 | ER | 457.25 | ER1 | 452.98 | 39 | 0.109 | 47 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 100.22 | 8 | 7.45 | 0.30 | 5.517816 | 25755.46 | 0.00007 | 0.0001128 | 0.02992 | 0.01269 |

**Pressure Loss Through Pipes and Fittings**

| Segment | Start | Start Elevation (ft) | Finish | Finish Elevation (ft) | Horizontal Pipe Length (ft) | Pipe Slope (ft/ft) | Actual Pipe Length (+20%) (ft) | Vapor Density ($lb_m/ft^3$) | Vacuum Pressure (psi) | Absolute Viscosity ($lb_m$/ft*s) | Wells Added | Flow Added (cfm) | Flow (cfm) | Nominal Size (in) | ID (in) | ID Area ($ft^2$) | Velocity (ft/s) | Reynolds Number | Absolute Factor | Relative Roughness (in) | Darcy friction Factor | Pressure Loss (in WC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LER1.ER2 | ER1 | 452.98 | ER2 | 452.18 | 7 | 0.119 | 8 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 100.22 | 8 | 7.45 | 0.30 | 5.517816 | 25755.46 | 0.00007 | 0.0001128 | 0.02992 | 0.00218 |
| LER2.ES | ER2 | 452.18 | ES | 453.75 | 66 | -0.024 | 79 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 100.22 | 8 | 7.45 | 0.30 | 5.517816 | 25755.46 | 0.00007 | 0.0001128 | 0.02992 | 0.02122 |
| L18 | EW-165 | 463.58 | ES | 453.75 | 211 | 0.047 | 253 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00188 |
| LES.ES1 | ES | 453.75 | ES1 | 451.95 | 32 | 0.056 | 38 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27270.49 | 0.00007 | 0.0001128 | 0.02946 | 0.01139 |
| LES1.ES2 | ES1 | 453.75 | ES2 | 450.79 | 36 | 0.082 | 43 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27270.49 | 0.00007 | 0.0001128 | 0.02946 | 0.01283 |
| LES2.ES3 | ES2 | 453.75 | ES3 | 445.00 | 100 | 0.088 | 120 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27270.49 | 0.00007 | 0.0001128 | 0.02946 | 0.03567 |
| LES3.ET | ES3 | 451.95 | ET | 443.81 | 102 | 0.080 | 123 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27270.49 | 0.00007 | 0.0001128 | 0.02946 | 0.03636 |
| L19 | EW-169 | 433.69 | ET | 443.81 | 46 | -0.220 | 57 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00042 |
| LET.ET1 | ET | 443.81 | ET1 | 443.65 | 57 | 0.003 | 68 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 112.01 | 8 | 7.45 | 0.30 | 6.166971 | 28785.51 | 0.00007 | 0.0001128 | 0.02903 | 0.02224 |
| LET1.ET2 | ET1 | 443.65 | ET2 | 439.92 | 52 | 0.072 | 63 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 112.01 | 8 | 7.45 | 0.30 | 6.166971 | 28785.51 | 0.00007 | 0.0001128 | 0.02903 | 0.02034 |
| LET2.EU | ET2 | 439.92 | EU | 439.50 | 85 | 0.005 | 102 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 112.01 | 8 | 7.45 | 0.30 | 6.166971 | 28785.51 | 0.00007 | 0.0001128 | 0.02903 | 0.03316 |
| L20 | EW-164 | 415.50 | EU | 439.20 | 95 | -0.249 | 117 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00087 |
| LEU.EU1 | EU | 439.50 | EU1 | 434.68 | 39 | 0.124 | 47 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 117.91 | 8 | 7.45 | 0.30 | 6.491549 | 30300.54 | 0.00007 | 0.0001128 | 0.02863 | 0.01675 |
| LEU1.EU2 | EU1 | 439.20 | EU2 | 419.31 | 155 | 0.128 | 188 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 117.91 | 8 | 7.45 | 0.30 | 6.491549 | 30300.54 | 0.00007 | 0.0001128 | 0.02863 | 0.06663 |
| LEU2.EU3 | EU2 | 434.68 | EU3 | 430.20 | 119 | 0.038 | 143 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 117.91 | 8 | 7.45 | 0.30 | 6.491549 | 30300.54 | 0.00007 | 0.0001128 | 0.02863 | 0.05077 |
| LEU3.EV | EU3 | 430.20 | EV | 429.30 | 119 | 0.008 | 143 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 117.91 | 8 | 7.45 | 0.30 | 6.491549 | 30300.54 | 0.00007 | 0.0001128 | 0.02863 | 0.05074 |
| L21 | EW-163 | 429.87 | EV | 429.30 | 6 | 0.095 | 7 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00005 |
| LEV.EV1 | EV | 429.30 | EV1 | 429.00 | 82 | 0.004 | 98 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31815.57 | 0.00007 | 0.0001128 | 0.02826 | 0.03804 |
| LEV1.EV2 | EV1 | 429.00 | EV2 | 433.56 | 73 | -0.062 | 88 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31815.57 | 0.00007 | 0.0001128 | 0.02826 | 0.03393 |
| LEV2.EV3 | EV2 | 433.56 | EV3 | 434.58 | 18 | -0.057 | 22 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31815.57 | 0.00007 | 0.0001128 | 0.02826 | 0.00836 |
| LEV3.EW | EV3 | 434.58 | EW | 435.53 | 17 | -0.056 | 20 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31815.57 | 0.00007 | 0.0001128 | 0.02826 | 0.00790 |
| L22 | EW-16 | 457.51 | EWL1 | 454.43 | 195 | 0.016 | 234 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00173 |
| LEWL1.EWL2 | EWL1 | 454.43 | EWL2 | 448.13 | 130 | 0.048 | 156 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33330.59 | 0.00007 | 0.0001128 | 0.02791 | 0.06545 |
| L23 | EW-162 | 445.00 | EWL2 | 448.13 | 9 | -0.361 | 11 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00008 |
| LEWL2.EWL3 | EWL2 | 448.13 | EWL3 | 442.00 | 195 | 0.031 | 234 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 135.59 | 8 | 7.45 | 0.30 | 7.465281 | 34845.62 | 0.00007 | 0.0001128 | 0.02758 | 0.10596 |
| LEWL3.EW | EWL3 | 442.00 | EW | 435.00 | 130 | 0.054 | 156 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 135.59 | 8 | 7.45 | 0.30 | 7.465281 | 34845.62 | 0.00007 | 0.0001128 | 0.02758 | 0.07044 |
| L24 | EW-162 | 443.54 | EW | 435.00 | 34 | 0.251 | 42 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00031 |
| LEW.EW1 | EW | 435.00 | EW1 | 435.50 | 54 | -0.009 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 141.49 | 8 | 7.45 | 0.30 | 7.789858 | 36360.65 | 0.00007 | 0.0001128 | 0.02727 | 0.03158 |
| LEW1.EW2 | EW1 | 435.50 | EW2 | 437.00 | 50 | -0.030 | 60 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 141.49 | 8 | 7.45 | 0.30 | 7.789858 | 36360.65 | 0.00007 | 0.0001128 | 0.02727 | 0.02925 |
| LEW1.EX | EW2 | 437.00 | EX | 437.50 | 45 | -0.011 | 54 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 141.49 | 8 | 7.45 | 0.30 | 7.789858 | 36360.65 | 0.00007 | 0.0001128 | 0.02727 | 0.02631 |
| L25 | EW-161 | 441.10 | EX | 437.50 | 10 | 0.360 | 13 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00009 |
| LEX.EY | EX | 437.50 | EY | 437.70 | 26 | -0.008 | 31 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 147.38 | 8 | 7.45 | 0.30 | 8.114436 | 37875.67 | 0.00007 | 0.0001128 | 0.02698 | 0.01632 |
| L26 | EW-38 | 443.63 | EY | 437.3 | 222 | 0.029 | 266 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00197 |
| LEY.EZ | EY | 437.50 | EZ | 437.30 | 30 | 0.007 | 36 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 153.28 | 8 | 7.45 | 0.30 | 8.439013 | 39390.70 | 0.00007 | 0.0001128 | 0.02670 | 0.02015 |
| L27 | EW-37 | 447.99 | EZ | 437.30 | 237 | 0.045 | 285 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00211 |
| LEZ.EZA | EY | 437.30 | EZA | 438.28 | 76 | -0.013 | 91 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 159.17 | 8 | 7.45 | 0.30 | 8.763591 | 40905.73 | 0.00007 | 0.0001128 | 0.02643 | 0.05452 |
| L28 | EW-160 | 402.00 | EZA | 438.28 | 134 | -0.271 | 167 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00123 |
| LEZA.EZA1 | EZA | 438.28 | EZA1 | 438.50 | 39 | -0.006 | 47 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 165.07 | 8 | 7.45 | 0.30 | 9.088168 | 42420.76 | 0.00007 | 0.0001128 | 0.02618 | 0.02980 |
| LEZA1.EZA2 | EZA1 | 438.50 | EZA2 | 438.50 | 31 | 0.000 | 37 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 165.07 | 8 | 7.45 | 0.30 | 9.088168 | 42420.76 | 0.00007 | 0.0001128 | 0.02618 | 0.02369 |
| LEZA2.EZB | EZA2 | 438.50 | EZB | 440.63 | 16 | -0.133 | 19 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 165.07 | 8 | 7.45 | 0.30 | 9.088168 | 42420.76 | 0.00007 | 0.0001128 | 0.02618 | 0.01233 |
| L29 | EW-35 | 441.08 | EZA2 | 438.50 | 20 | 0.129 | 24 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00018 |
| L30 | EW-35 | 441.08 | EZB | 440.63 | 20 | 0.022 | 24 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00018 |
| LEZB.EZC | EZB | 440.63 | EZC | 440.93 | 30 | -0.010 | 36 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 170.97 | 8 | 7.45 | 0.30 | 9.412746 | 43935.78 | 0.00007 | 0.0001128 | 0.02594 | 0.02436 |
| L31 | EW-34 | 445.46 | EZC | 440.93 | 274 | 0.017 | 329 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00244 |
| LEZC.EZC1 | EZC | 440.93 | EZC1 | 445.31 | 66 | -0.066 | 79 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 176.86 | 8 | 7.45 | 0.30 | 9.737323 | 45450.81 | 0.00007 | 0.0001128 | 0.02571 | 0.05697 |
| LEZC1.EZC2 | EZC1 | 445.31 | EZC2 | 443.30 | 10 | 0.201 | 12 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 176.86 | 8 | 7.45 | 0.30 | 9.737323 | 45450.81 | 0.00007 | 0.0001128 | 0.02571 | 0.00879 |
| LEZC2.EZC3 | EZC2 | 443.30 | MH | 448.00 | 450 | -0.010 | 540 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 176.86 | 8 | 7.45 | 0.30 | 9.737323 | 45450.81 | 0.00007 | 0.0001128 | 0.02571 | 0.38762 |
| SPLIT MIDDLE HEADER CONNECTION | | | | | | | | | | | | | | | | | | | | | | |
| L1 | EW-111 | 421.23 | EB | 464.81 | 164 | -0.266 | 204 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00151 |
| LEB.EA | EB | 464.81 | EA | 465.50 | 118 | -0.006 | 142 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00030 |
| LEA.MH1 | EA | 465.50 | MH1 | 468.00 | 120 | -0.021 | 144 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00031 |
| MH1.MH2 | MH1 | 468.00 | MH2 | 466.00 | 130 | 0.015 | 156 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00033 |
| L32 | EW-5 | 469.39 | MH2 | 466.00 | 111 | 0.030 | 111 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00083 |
| LMH2.MH3 | MH2 | 466.00 | MH3 | 464.05 | 164 | 0.012 | 197 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 11.79 | 8 | 7.45 | 0.30 | 0.649155 | 3030.05 | 0.00007 | 0.0001128 | 0.05534 | 0.00135 |
| L33 | EW-4 | 467.04 | MH3 | 464.05 | 124 | 0.024 | 149 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00110 |
| LMH3.MH4 | MH3 | 464.05 | MH4 | 459.35 | 147 | 0.032 | 176 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 17.69 | 8 | 7.45 | 0.30 | 0.973732 | 4545.08 | 0.00007 | 0.0001128 | 0.04904 | 0.00242 |
| LMH4.MH5 | MH4 | 459.35 | MH5 | 461.45 | 39 | -0.054 | 47 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 17.69 | 8 | 7.45 | 0.30 | 0.973732 | 4545.08 | 0.00007 | 0.0001128 | 0.04904 | 0.00064 |

**Pressure Loss Through Pipes and Fittings**

| Segment | Start | Start Elevation (ft) | Finish | Finish Elevation (ft) | Horizontal Pipe Length (ft) | Pipe Slope (ft/ft) | Actual Pipe Length (+20%) (ft) | Vapor Density ($lb_m/ft^3$) | Vacuum Pressure (psi) | Absolute Viscosity ($lb_m$/ft*s) | Wells Added | Flow Added (cfm) | Flow (cfm) | Nominal Size (in) | ID (in) | ID Area ($ft^2$) | Velocity (ft/s) | Reynolds Number | Absolute Factor | Relative Roughness (in) | Darcy friction Factor | Pressure Loss (in WC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L34 | EW-73 | 465.45 | MH5 | 461.45 | 266 | 0.015 | 319 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00236 |
| LMH5.MH6 | MH5 | 461.45 | MH6 | 460.87 | 108 | 0.005 | 130 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00290 |
| L35 | EW-39 | 462.16 | MH7 | 458.99 | 74 | 0.043 | 89 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00066 |
| LMH7.MH8 | MH7 | 458.99 | MH8 | 458.02 | 330 | 0.003 | 396 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.01297 |
| L36 | EW-36 | 459.61 | MH8 | 458.02 | 20 | 0.080 | 159 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00118 |
| L37 | EW-57 | 464.23 | MH10 | 458.02 | 195 | 0.032 | 159 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00118 |
| LMH8.MH6 | MH8 | 458.02 | MH6 | 460.87 | 229 | -0.012 | 275 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.01601 |
| L38 | EW-71 | 469.56 | MH9 | 468.36 | 72 | 0.017 | 86 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00064 |
| L39 | EW-52 | 470.05 | MH9 | 468.36 | 68 | 0.025 | 82 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00060 |
| LMH9.MH10 | MH9 | 468.36 | MH10 | 464.11 | 189 | 0.022 | 227 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.02034 |
| LMH10.MH11 | MH10 | 464.11 | MH11 | 467.00 | 151 | -0.019 | 181 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.01627 |
| L40 | EW-72 | 467.58 | MH15 | 467.00 | 50 | 0.012 | 60 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00044 |
| LMH11.MH12 | MH11 | 467 | MH12 | 462.78 | 186 | 0.023 | 223 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.02400 |
| L41 | EW-168 | 463.12 | MH12 | 462.78 | 50 | 0.007 | 60 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00044 |
| LMH12.MH6 | MH12 | 462.78 | MH6 | 460.69 | 87 | 0.024 | 104 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 64.85 | 8 | 7.45 | 0.30 | 3.570352 | 16665.30 | 0.00007 | 0.0001128 | 0.03374 | 0.01322 |
| L42 | EW-76 | 460.96 | MH16 | 460.69 | 10 | 0.028 | 12 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00009 |
| LMH16.MH17 | MH16 | 460.69 | MH17 | 460.17 | 32 | 0.016 | 38 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.00556 |
| L43 | EW-29 | 468.25 | MH18 | 464.49 | 205 | 0.018 | 246 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00182 |
| L44 | EW-30 | 463.00 | MH18 | 464.49 | 10 | -0.143 | 13 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00009 |
| LMH18.MH17 | MH18 | 464.49 | MH17 | 460.17 | 157 | 0.027 | 189 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.03623 |
| LMH17.MH19 | MH17 | 460.17 | MH19 | 455.30 | 211 | 0.023 | 253 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.04859 |
| LMH19.MH20 | MH19 | 455.3 | MH20 | 448.19 | 228 | 0.031 | 274 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.05252 |
| L45 | EW-25 | 450.74 | MH20 | 448.19 | 45 | 0.057 | 54 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00040 |
| LMH20.MH | MH20 | 448.19 | MH | 447.06 | 55 | 0.020 | 66 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 88.43 | 8 | 7.45 | 0.30 | 4.868662 | 22725.40 | 0.00007 | 0.0001128 | 0.03096 | 0.01434 |
| NORTHWEST OF MIDDLE HEADER TO BLOWER-FLARE FACILIY | | | | | | | | | | | | | | | | | | | | | | |
| L1 | EW-112 | 425.03 | EA | 466.3 | 246 | -0.168 | 299 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00222 |
| LEA.WA | EA | 466.30 | WA | 464.36 | 115 | 0.017 | 138 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00029 |
| L46 | EW-111 | 421.23 | WA | 464.36 | 164 | -0.263 | 203 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00151 |
| LWA.WA1 | WA | 464.36 | WA1 | 463.56 | 46 | 0.018 | 55 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 11.79 | 8 | 7.45 | 0.30 | 0.649155 | 3030.05 | 0.00007 | 0.0001128 | 0.05534 | 0.00038 |
| LWA1.WA2 | WA1 | 463.56 | WA2 | 463.49 | 31 | 0.002 | 37 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 11.79 | 8 | 7.45 | 0.30 | 0.649155 | 3030.05 | 0.00007 | 0.0001128 | 0.05534 | 0.00026 |
| LWA2.WA3 | WA2 | 463.49 | WA3 | 461.17 | 139 | 0.017 | 167 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 11.79 | 8 | 7.45 | 0.30 | 0.649155 | 3030.05 | 0.00007 | 0.0001128 | 0.05534 | 0.00115 |
| LWA3.WB | WA3 | 461.17 | WB | 461.05 | 7 | 0.017 | 8 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 11.79 | 8 | 7.45 | 0.30 | 0.649155 | 3030.05 | 0.00007 | 0.0001128 | 0.05534 | 0.00006 |
| L47 | EW-158 | 465.19 | WB | 461.05 | 72 | 0.058 | 86 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00064 |
| LWB.WB1 | WB | 461.05 | WB1 | 459.54 | 20 | 0.077 | 24 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 17.69 | 8 | 7.45 | 0.30 | 0.973732 | 4545.08 | 0.00007 | 0.0001128 | 0.04904 | 0.00032 |
| LWB1.WC | WB1 | 459.54 | WC | 459.33 | 20 | 0.011 | 24 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 17.69 | 8 | 7.45 | 0.30 | 0.973732 | 4545.08 | 0.00007 | 0.0001128 | 0.04904 | 0.00032 |
| L48 | EW-110 | 425.18 | WC1 | 450.74 | 91 | -0.281 | 114 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00084 |
| L49 | EW-130 | 452.40 | WC1 | 450.74 | 10 | 0.175 | 12 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00009 |
| LWC1.WC | WC1 | 450.74 | WC | 460.75 | 67 | -0.150 | 81 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00265 |
| LWC.WC2 | WC | 460.75 | WC2 | 458.14 | 59 | 0.044 | 71 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00232 |
| LWC2.WCD | WC2 | 458.14 | WD | 453.47 | 25 | 0.187 | 31 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00100 |
| L50 | EW-122 | 432.33 | WD1 | 438.08 | 37 | -0.155 | 45 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00033 |
| L51 | EW-109 | 438.88 | WD1 | 438.08 | 22 | 0.036 | 26 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00020 |
| LWD1.WD | WD1 | 438.08 | WD | 459.00 | 114 | -0.184 | 139 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.00809 |
| LWD.WD2 | WD | 438.08 | WD2 | 456.19 | 111 | -0.163 | 135 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.00786 |
| LWD2.WD3 | WD2 | 459.00 | WD3 | 456.19 | 111 | 0.025 | 133 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.00776 |
| LWD3.WE | WD3 | 456.19 | WE | 456.11 | 25 | 0.003 | 29 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.00171 |
| L52 | EW-108 | 437.20 | WE | 456.11 | 91 | -0.208 | 112 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00083 |
| LWE.WE1 | WE | 456.11 | WE1 | 455.79 | 80 | 0.004 | 96 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 47.16 | 8 | 7.45 | 0.30 | 2.596619 | 12120.22 | 0.00007 | 0.0001128 | 0.03690 | 0.00705 |
| LWE1.WF | WE1 | 455.79 | WF | 455.72 | 18 | 0.004 | 22 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 47.16 | 8 | 7.45 | 0.30 | 2.596619 | 12120.22 | 0.00007 | 0.0001128 | 0.03690 | 0.00158 |
| L53 | EW-156 | 441.19 | WF1 | 455.72 | 10 | -1.529 | 21 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00015 |
| L54 | EW-126 | 444.13 | WF1 | 455.72 | 2 | -5.795 | 14 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00010 |
| LWF.WF1 | WF | 455.72 | WF1 | 453.16 | 47 | 0.054 | 56 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.00607 |
| LWF1.WF2 | WF1 | 455.72 | WF2 | 452.51 | 27 | 0.118 | 33 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.00355 |
| LWF2.WG | WF2 | 452.51 | WG | 452.55 | 19 | -0.002 | 23 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.00249 |
| L55 | EW-73 | 470.03 | WG1 | 460.48 | 250 | 0.038 | 301 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00223 |
| L56 | EW-152 | 459.74 | WG1 | 460.48 | 11 | -0.066 | 13 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00010 |
| LWG1.WG | WG1 | 460.48 | WG | 452.55 | 162 | 0.049 | 194 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.02858 |

**Pressure Loss Through Pipes and Fittings**

| Segment | Start | Start Elevation (ft) | Finish | Finish Elevation (ft) | Horizontal Pipe Length (ft) | Pipe Slope (ft/ft) | Actual Pipe Length (+20%) (ft) | Vapor Density ($lb_m/ft^3$) | Vacuum Pressure (psi) | Absolute Viscosity ($lb_m$/ft*s) | Wells Added | Flow Added (cfm) | Flow (cfm) | Nominal Size (in) | ID (in) | ID Area ($ft^2$) | Velocity (ft/s) | Reynolds Number | Absolute Factor | Relative Roughness (in) | Darcy friction Factor | Pressure Loss (in WC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LWG.WG2 | WG | 452.55 | WG2 | 453.24 | 40 | -0.017 | 48 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.00706 |
| LWG2.WH | WG2 | 453.24 | WH | 457.04 | 102 | -0.037 | 122 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.01793 |
| L57 | EW-171 | 452.00 | WH | 457.04 | 48 | -0.106 | 57 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00042 |
| LWH.WH1 | WH | 457.04 | WH1 | 457.39 | 29 | -0.012 | 35 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 76.64 | 8 | 7.45 | 0.30 | 4.219507 | 19695.35 | 0.00007 | 0.0001128 | 0.03221 | 0.00588 |
| LWH1.WH2 | WH1 | 457.39 | WH2 | 455.65 | 103 | 0.017 | 124 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 76.64 | 8 | 7.45 | 0.30 | 4.219507 | 19695.35 | 0.00007 | 0.0001128 | 0.03221 | 0.02093 |
| LWH2.WH3 | WH2 | 455.65 | WH3 | 455.32 | 16 | 0.021 | 19 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 76.64 | 8 | 7.45 | 0.30 | 4.219507 | 19695.35 | 0.00007 | 0.0001128 | 0.03221 | 0.00324 |
| L58 | EW-157 | 449.15 | WH3 | 455.32 | 79 | -0.078 | 95 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00070 |
| LWI.WJ | WI | 455.32 | WJ | 454.4 | 40 | 0.023 | 48 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.00921 |
| LWJ.WJ1 | WJ | 454.4 | WJ1 | 453.16 | 32 | 0.038 | 39 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.00747 |
| LWJ1.WJ2 | WJ1 | 453.16 | WJ2 | 450.26 | 30 | 0.097 | 36 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.00694 |
| LWJ2.WJ3 | WJ2 | 450.26 | WJ3 | 448.69 | 47 | 0.033 | 56 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.01080 |
| LWJ4.WK | WJ4 | 448.69 | WK | 449.64 | 50 | -0.019 | 60 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.01151 |
| L59 | EW-119 | 441.66 | WK1 | 443.04 | 71 | -0.019 | 85 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00063 |
| L60 | EW-104 | 445.27 | WK1 | 443.04 | 6 | 0.354 | 8 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00006 |
| LWK1.WK | WK1 | 443.04 | WK | 449.64 | 94 | -0.070 | 113 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 94.33 | 8 | 7.45 | 0.30 | 5.193239 | 24161.21 | 0.00007 | 0.0001128 | 0.03045 | 0.02717 |
| L61 | EW-1 | 460.93 | WK2 | 460.23 | 127 | 0.006 | 152 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00113 |
| LWK2.WK3 | WK2 | 460.23 | WK3 | 460.00 | 45 | 0.005 | 54 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 100.22 | 8 | 7.45 | 0.30 | 5.517816 | 25671.29 | 0.00007 | 0.0001128 | 0.02995 | 0.01452 |
| L62 | EW-132 | 460.73 | WK3 | 460.00 | 7 | 0.104 | 8 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00006 |
| LWK3.WK4 | WK3 | 460.00 | WK4 | 459.50 | 126 | 0.004 | 151 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27181.37 | 0.00007 | 0.0001128 | 0.02949 | 0.04466 |
| LWK4.WK | WK4 | 459.50 | WK | 451.14 | 94 | 0.089 | 113 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27181.37 | 0.00007 | 0.0001128 | 0.02949 | 0.03345 |
| LWK.WK5 | WK | 451.14 | WK5 | 450.26 | 33 | 0.027 | 40 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27181.37 | 0.00007 | 0.0001128 | 0.02949 | 0.01170 |
| LWK5.WK6 | WK5 | 450.26 | WK6 | 449.54 | 20 | 0.036 | 24 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27181.37 | 0.00007 | 0.0001128 | 0.02949 | 0.00709 |
| LWK6.WK7 | WK6 | 450.26 | WK7 | 447.92 | 40 | 0.058 | 48 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27181.37 | 0.00007 | 0.0001128 | 0.02949 | 0.01420 |
| LWK5.WK7 | WK7 | 449.54 | WL | 442.61 | 66 | 0.105 | 80 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27181.37 | 0.00007 | 0.0001128 | 0.02949 | 0.02352 |
| L63 | EW-103 | 436.27 | WL | 442.61 | 56 | -0.113 | 68 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00050 |
| LWL.WL1 | WL | 442.61 | WL1 | 437.24 | 67 | 0.080 | 81 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 112.01 | 8 | 7.45 | 0.30 | 6.166971 | 28691.44 | 0.00007 | 0.0001128 | 0.02906 | 0.02628 |
| LWL1.WM | WL1 | 437.24 | WM | 436.79 | 8 | 0.058 | 9 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 112.01 | 8 | 7.45 | 0.30 | 6.166971 | 28691.44 | 0.00007 | 0.0001128 | 0.02906 | 0.00304 |
| L64 | EW-102 | 438.8 | WM | 436.79 | 19 | 0.108 | 22 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00017 |
| LWM.WM1 | WM | 436.79 | WM1 | 429.33 | 128 | 0.058 | 154 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 117.91 | 8 | 7.45 | 0.30 | 6.491549 | 30201.52 | 0.00007 | 0.0001128 | 0.02866 | 0.05462 |
| LWM1.WN | WM1 | 429.33 | WN | 427.28 | 40 | 0.051 | 48 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 117.91 | 8 | 7.45 | 0.30 | 6.491549 | 30201.52 | 0.00007 | 0.0001128 | 0.02866 | 0.01699 |
| L65 | EW-101 | 429.38 | WN | 427.28 | 5 | 0.420 | 7 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00005 |
| LWN.WN1 | WN | 427.28 | WN1 | 426.36 | 26 | 0.035 | 32 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31711.59 | 0.00007 | 0.0001128 | 0.02829 | 0.01223 |
| LWN1.WN2 | WN1 | 426.36 | WN2 | 424.59 | 43 | 0.041 | 51 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31711.59 | 0.00007 | 0.0001128 | 0.02829 | 0.01983 |
| LWN2.WN3 | WN2 | 424.59 | WN3 | 418.04 | 102 | 0.064 | 123 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31711.59 | 0.00007 | 0.0001128 | 0.02829 | 0.04744 |
| L66 | EW-100 | 425.39 | WN3 | 418.04 | 18 | 0.408 | 23 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00017 |
| LWN3.WN4 | WN3 | 418.04 | WN4 | 419.28 | 28 | -0.045 | 33 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.01381 |
| LWN4.WN5 | WN4 | 419.28 | WN5 | 419.43 | 6 | -0.027 | 7 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.00281 |
| LWN5.WN6 | WN5 | 419.43 | WN6 | 420.02 | 22 | -0.026 | 27 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.01124 |
| LWN6.WO | WN6 | 420.02 | WO | 421.33 | 8 | -0.170 | 9 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.00392 |
| LWO.WO1 | WO | 421.33 | WO1 | 423.07 | 7 | -0.249 | 9 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.00362 |
| LWO1.WO2 | WO1 | 423.07 | WO2 | 425.95 | 12 | -0.240 | 15 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.00619 |
| LWO2.WO3 | WO2 | 425.95 | WO3 | 432.20 | 33 | -0.187 | 41 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.01705 |
| LWO3.WO4 | WO3 | 432.20 | WO4 | 435.58 | 17 | -0.198 | 21 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.00874 |
| LWO4.WO5 | WO4 | 435.58 | WO5 | 438.95 | 22 | -0.150 | 27 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.01136 |
| LWO5.WO6 | WO5 | 438.95 | WO6 | 440.70 | 11 | -0.159 | 13 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.00559 |
| LWO6.WO7 | WO6 | 440.70 | WO7 | 449.23 | 47 | -0.181 | 57 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.02396 |
| LWO7.WO8 | WO7 | 440.70 | WO8 | 455.12 | 35 | -0.408 | 46 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.01913 |
| LWO8.WO9 | WO8 | 449.23 | WO9 | 454.72 | 34 | -0.161 | 41 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.01728 |
| LWO9.BF | WO9 | 454.72 | BF | 456.62 | 35 | -0.055 | 42 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33221.67 | 0.00007 | 0.0001128 | 0.02794 | 0.01748 |
| Southwest of Middle Header to Blower-Flare Facility | | | | | | | | | | | | | | | | | | | | | | |
| LMH.SA | MH | 448 | SA | 447.85 | 39 | 0.004 | 47 | 0.061 | 20.000 | 0.000008 | 0 | 5.90 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00010 |
| LSA.SA1 | SA | 447.85 | SA1 | 454.21 | 22 | -0.294 | 27 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00006 |
| LSA1.SA2 | SA1 | 454.21 | SA2 | 456.6 | 59 | -0.041 | 70 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00015 |
| LSA2.SB | SA2 | 456.6 | SB | 456.25 | 24 | 0.014 | 29 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 5.90 | 8 | 7.45 | 0.30 | 0.324577 | 1515.03 | 0.00007 | 0.0001128 | 0.06830 | 0.00006 |
| L67 | EW-32 | 459.36 | SB1 | 457.5 | 56 | 0.033 | 67 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00050 |
| LSB1.SB | SB1 | 457.5 | SB | 456.19 | 56 | 0.023 | 67 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 11.79 | 8 | 7.45 | 0.30 | 0.649155 | 3030.05 | 0.00007 | 0.0001128 | 0.05534 | 0.00046 |
| LSB.SC | SB | 456.19 | SC | 454.4 | 129 | 0.014 | 155 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 11.79 | 8 | 7.45 | 0.30 | 0.649155 | 3030.05 | 0.00007 | 0.0001128 | 0.05534 | 0.00106 |

**Pressure Loss Through Pipes and Fittings**

| Segment | Start | Start Elevation (ft) | Finish | Finish Elevation (ft) | Horizontal Pipe Length (ft) | Pipe Slope (ft/ft) | Actual Pipe Length (+20%) (ft) | Vapor Density ($lb_m/ft^3$) | Vacuum Pressure (psi) | Absolute Viscosity ($lb_m$/ft*s) | Wells Added | Flow Added (cfm) | Flow (cfm) | Nominal Size (in) | ID (in) | ID Area ($ft^2$) | Velocity (ft/s) | Reynolds Number | Absolute Factor | Relative Roughness (in) | Darcy friction Factor | Pressure Loss (in WC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L68 | EW-159 | 456.10 | SC | 454.4 | 5 | 0.321 | 7 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00005 |
| LSC.SC1 | SC | 454.4 | SC1 | 455.28 | 87 | -0.010 | 104 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 17.69 | 8 | 7.45 | 0.30 | 0.973732 | 4545.08 | 0.00007 | 0.0001128 | 0.04904 | 0.00142 |
| LSC1.SD | SC1 | 455.28 | SD | 459.85 | 67 | -0.068 | 81 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 17.69 | 8 | 7.45 | 0.30 | 0.973732 | 4545.08 | 0.00007 | 0.0001128 | 0.04904 | 0.00110 |
| L69 | EW-31 | 455.09 | SD | 459.85 | 25 | -0.187 | 31 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00023 |
| LSD.SD1 | SD | 459.85 | SD1 | 460.91 | 14 | -0.074 | 17 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00039 |
| LSD1.SD2 | SD1 | 460.91 | SD2 | 463.71 | 68 | -0.041 | 81 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00181 |
| LSD2.SD3 | SD2 | 463.71 | SD3 | 464.74 | 53 | -0.020 | 63 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00142 |
| LSD3.SE | SD3 | 464.74 | SE | 465.3 | 102 | -0.006 | 122 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00272 |
| LSE.SE1 | SE | 465.3 | SE1 | 466.89 | 125 | -0.013 | 150 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00336 |
| LSE1.SF | SE1 | 466.89 | SF | 467.66 | 15 | -0.050 | 19 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00041 |
| LSF.SF1 | SF | 467.66 | SF1 | 469.64 | 44 | -0.045 | 53 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00119 |
| LSF1.SF2 | SF1 | 469.64 | SF2 | 470 | 37 | -0.010 | 44 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00098 |
| LSF2.SG | SF2 | 470 | SG | 467.23 | 49 | 0.057 | 58 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 23.58 | 8 | 7.45 | 0.30 | 1.29831 | 6060.11 | 0.00007 | 0.0001128 | 0.04506 | 0.00130 |
| L70 | EW-149 | 468.57 | SG | 467.23 | 10 | 0.141 | 12 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00009 |
| LSG.SH | SG | 467.23 | SH | 464.85 | 90 | 0.026 | 108 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00355 |
| LSH.SH1 | SH | 464.85 | SH1 | 465.35 | 26 | -0.019 | 31 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00101 |
| LSH1.SI | SH1 | 465.35 | SI | 465.04 | 10 | 0.030 | 12 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00041 |
| LSI.SI1 | SI | 465.04 | SI1 | 465.37 | 19 | -0.017 | 23 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00075 |
| LSI1.SI2 | SI1 | 465.37 | SI2 | 462.97 | 86 | 0.028 | 103 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00336 |
| LSI2.SI3 | SI2 | 462.97 | SI3 | 462.01 | 74 | 0.013 | 89 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00291 |
| LSI3.SJ | SI3 | 462.01 | SJ | 461.56 | 9 | 0.051 | 11 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 29.48 | 8 | 7.45 | 0.30 | 1.622887 | 7575.13 | 0.00007 | 0.0001128 | 0.04222 | 0.00035 |
| L71 | EW-146 | 428.57 | SJ | 467.23 | 164 | -0.236 | 202 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00150 |
| LSJ.SJ1 | SJ | 467.23 | SJ1 | 453.25 | 99 | 0.142 | 120 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 35.37 | 8 | 7.45 | 0.30 | 1.947465 | 9090.16 | 0.00007 | 0.0001128 | 0.04006 | 0.00535 |
| L72 | EW-24 | 460.90 | SJ | 460.22 | 24 | 0.028 | 29 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00021 |
| LSJ1.SK | SJ1 | 453.25 | SK | 451.97 | 54 | 0.024 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 41.27 | 8 | 7.45 | 0.30 | 2.272042 | 10605.19 | 0.00007 | 0.0001128 | 0.03833 | 0.00380 |
| L73 | EW-26 | 462.39 | SK1 | 465.37 | 164 | -0.018 | 197 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00146 |
| L74 | EW-54 | 470.00 | SK1 | 462.97 | 180 | 0.039 | 216 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00160 |
| LSK1.SK2 | SK1 | 462.97 | SK2 | 460.0 | 10 | 0.297 | 13 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.00112 |
| LSK.SL | SK | 451.97 | SL | 453.31 | 50 | -0.027 | 60 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 53.06 | 8 | 7.45 | 0.30 | 2.921197 | 13635.24 | 0.00007 | 0.0001128 | 0.03569 | 0.00535 |
| L75 | EW-145 | 450.58 | SL | 453.31 | 50 | -0.055 | 59 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00044 |
| LSL.SL1 | SL | 453.31 | SL1 | 456.53 | 61 | -0.053 | 73 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.00783 |
| LSL1.SM | SL1 | 456.53 | SM | 458.08 | 54 | -0.029 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 58.95 | 8 | 7.45 | 0.30 | 3.245774 | 15150.27 | 0.00007 | 0.0001128 | 0.03465 | 0.00694 |
| L76 | EW-23 | 428.57 | SM | 458.08 | 164 | -0.180 | 200 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00148 |
| LSM.SN | SM | 458.08 | SN | 458.64 | 99 | -0.006 | 118 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 64.85 | 8 | 7.45 | 0.30 | 3.570352 | 16665.30 | 0.00007 | 0.0001128 | 0.03374 | 0.01500 |
| L77 | EW-144 | 432.37 | SN | 458.64 | 144 | -0.183 | 175 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00130 |
| LSN.SO | SN | 458.64 | SO | 458.62 | 50 | 0.000 | 60 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 70.74 | 8 | 7.45 | 0.30 | 3.894929 | 18180.32 | 0.00007 | 0.0001128 | 0.03293 | 0.00877 |
| L78 | EW-2 | 464.49 | SO1 | 462.5 | 120 | 0.017 | 144 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00107 |
| LSO1.SO2 | SO1 | 462.5 | SO2 | 456.53 | 61 | 0.099 | 73 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 76.64 | 8 | 7.45 | 0.30 | 4.219507 | 19695.35 | 0.00007 | 0.0001128 | 0.03221 | 0.01234 |
| L79 | EW-51 | 461.81 | SO2 | 462.20 | 177 | -0.002 | 212 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00157 |
| LSO2.SO3 | SO2 | 462.2 | SO3 | 456.53 | 46 | 0.123 | 56 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.01067 |
| LSO3.SO4 | SO3 | 458.64 | SO4 | 456.53 | 16 | 0.132 | 19 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.00372 |
| LSO4.SO5 | SO4 | 458.64 | SO5 | 456.53 | 98 | 0.022 | 118 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.02257 |
| LSO5.SO6 | SO5 | 458.64 | SO6 | 456.53 | 31 | 0.068 | 37 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.00715 |
| LSO6.SO7 | SO6 | 458.64 | SO7 | 456.53 | 48 | 0.044 | 58 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.01106 |
| LSO7.SO8 | SO7 | 458.08 | SO8 | 456.53 | 13 | 0.119 | 16 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.00301 |
| LSO8.SO9 | SO8 | 458.50 | SO9 | 458.80 | 21 | -0.014 | 25 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.00484 |
| LSO9.SP | SO9 | 458.8 | SP | 458.50 | 29 | 0.010 | 35 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 82.53 | 8 | 7.45 | 0.30 | 4.544084 | 21210.38 | 0.00007 | 0.0001128 | 0.03156 | 0.00668 |
| L80 | EW-143 | 461.81 | SP | 458.50 | 50 | 0.067 | 60 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00044 |
| LSP.SQ | SP | 458.50 | SQ | 459.32 | 61 | -0.014 | 73 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 88.43 | 8 | 7.45 | 0.30 | 4.868662 | 22725.40 | 0.00007 | 0.0001128 | 0.03096 | 0.01572 |
| L81 | EW-142 | 420.00 | SQ1 | 458.80 | 141 | -0.275 | 175 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00130 |
| L82 | EW-141 | 445.03 | SQ1 | 458.80 | 28 | -0.492 | 37 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00028 |
| LSQ1.SQ | SQ1 | 458.50 | SQ | 459.32 | 54 | -0.015 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 100.22 | 8 | 7.45 | 0.30 | 5.517816 | 25755.46 | 0.00007 | 0.0001128 | 0.02992 | 0.01732 |
| LSQ.SQ2 | SQ | 459.32 | SQ2 | 459.51 | 54 | -0.004 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 100.22 | 8 | 7.45 | 0.30 | 5.517816 | 25755.46 | 0.00007 | 0.0001128 | 0.02992 | 0.01732 |
| LSQ2.SR | SQ2 | 459.51 | SR | 459.32 | 54 | 0.004 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 100.22 | 8 | 7.45 | 0.30 | 5.517816 | 25755.46 | 0.00007 | 0.0001128 | 0.02992 | 0.01732 |
| L83 | EW-22 | 461.81 | SR | 459.32 | 50 | 0.050 | 59 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00044 |
| LSR.SS | SR | 459.32 | SS | 459.19 | 54 | 0.002 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 106.12 | 8 | 7.45 | 0.30 | 5.842394 | 27270.49 | 0.00007 | 0.0001128 | 0.02946 | 0.01912 |
| L84 | EW-140 | 461.81 | SS | 459.19 | 50 | 0.053 | 59 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00044 |

**Pressure Loss Through Pipes and Fittings**

| Segment | Start | Start Elevation (ft) | Finish | Finish Elevation (ft) | Horizontal Pipe Length (ft) | Pipe Slope (ft/ft) | Actual Pipe Length (+20%) (ft) | Vapor Density ($lb_m/ft^3$) | Vacuum Pressure (psi) | Absolute Viscosity ($lb_m$/ft*s) | Wells Added | Flow Added (cfm) | Flow (cfm) | Nominal Size (in) | ID (in) | ID Area ($ft^2$) | Velocity (ft/s) | Reynolds Number | Absolute Factor | Relative Roughness (in) | Darcy friction Factor | Pressure Loss (in WC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LSS.SS1 | SS | 459.19 | SS1 | 459.79 | 54 | -0.011 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 112.01 | 8 | 7.45 | 0.30 | 6.166971 | 28785.51 | 0.00007 | 0.0001128 | 0.02903 | 0.02099 |
| LSS1.ST | SS1 | 459.79 | ST | 457.68 | 54 | 0.039 | 65 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 112.01 | 8 | 7.45 | 0.30 | 6.166971 | 28785.51 | 0.00007 | 0.0001128 | 0.02903 | 0.02101 |
| L85 | EW-138 | 461.81 | ST | 457.68 | 50 | 0.083 | 60 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00044 |
| LSS1.ST | SS1 | 458.57 | ST | 459.19 | 25 | -0.025 | 30 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 117.91 | 8 | 7.45 | 0.30 | 6.491549 | 30300.54 | 0.00007 | 0.0001128 | 0.02863 | 0.01066 |
| LST.SU | ST | 459.19 | SU | 459.79 | 58 | -0.010 | 70 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 117.91 | 8 | 7.45 | 0.30 | 6.491549 | 30300.54 | 0.00007 | 0.0001128 | 0.02863 | 0.02473 |
| L86 | EW-139 | 430.49 | SU | 459.79 | 167 | -0.175 | 203 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00151 |
| LSU.SU1 | SU | 459.79 | SU1 | 459.79 | 25 | 0.000 | 30 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31815.57 | 0.00007 | 0.0001128 | 0.02826 | 0.01160 |
| LSU1.SU2 | SU | 459.79 | SU2 | 457.14 | 58 | 0.046 | 70 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31815.57 | 0.00007 | 0.0001128 | 0.02826 | 0.02694 |
| LSU2.SV | SU2 | 457.14 | SV | 457.36 | 58 | -0.004 | 70 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 123.80 | 8 | 7.45 | 0.30 | 6.816126 | 31815.57 | 0.00007 | 0.0001128 | 0.02826 | 0.02691 |
| L87 | EW-21 | 430.49 | SV | 457.36 | 22 | -1.221 | 42 | 0.061 | 20.000 | 0.000008 | 1 | 5.90 | 5.90 | 6 | 5.80 | 0.18 | 0.535519 | 1946.03 | 0.00007 | 0.0001448 | 0.06830 | 0.00031 |
| LSV.SV1 | SV | 457.36 | SV1 | 456.62 | 20 | 0.037 | 24 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33330.59 | 0.00007 | 0.0001128 | 0.02791 | 0.01006 |
| LSV1.BF | SV1 | 456.62 | BF | 457.35 | 48 | -0.015 | 58 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 129.70 | 8 | 7.45 | 0.30 | 7.140704 | 33330.59 | 0.00007 | 0.0001128 | 0.02791 | 0.02414 |
| CONVERGE AT OUTLET | | | | | | | | | | | | | | | | | | | | | | |
| LBF.BF1 | BF | 457.35 | BF1 | 451.25 | 45 | 0.135 | 55 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 519.00 | 12 | 11.50 | 0.72 | 11.99204 | 86404.56 | 0.00007 | 7.304E-05 | 0.01962 | 0.02952 |
| LBF1.BF2 | BF1 | 451.25 | BF2 | 434.93 | 72 | 0.228 | 88 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 519.00 | 12 | 11.50 | 0.72 | 11.99204 | 86404.56 | 0.00007 | 7.304E-05 | 0.01962 | 0.04748 |
| LBF2.BF3 | BF2 | 434.93 | BF3 | 417.37 | 134 | 0.131 | 162 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 519.00 | 12 | 11.50 | 0.72 | 11.99204 | 86404.56 | 0.00007 | 7.304E-05 | 0.01962 | 0.08720 |
| LBF3.BF4 | BF3 | 417.37 | Skid | 413.25 | 23 | 0.181 | 28 | 0.061 | 20.000 | 0.000008 | 0 | 0.00 | 519.00 | 12 | 11.50 | 0.72 | 11.99204 | 86404.56 | 0.00007 | 7.304E-05 | 0.01962 | 0.01496 |

**Summary of Pressure Loss Through Pipes and Fittings**

| | | | |
|---|---|---|---|
| Path 1 | East of Middle Header to Blower-Flare Station | 2.58252 | in WC |
| Path 2 | Middle Header to Blower-Flare Station | 0.90783 | in WC |
| Path 3 | West of Middle Header to Blower-Flare Station | 0.89569 | in WC |

**Pressure Loss through Valves**

| Valve Number | Darcy Friction Factor | K' | d | Cv | density | # of wells | Q | Delta P | Delta P (in w.c.) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 2 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 3 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 4 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 5 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 6 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 7 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 8 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 9 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 10 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 11 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 12 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 13 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 14 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 15 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 16 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 17 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 18 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 19 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 20 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 21 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 3 | 17.69 | 0.000721 | 2.60E-05 |
| 22 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 23 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 24 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 25 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 26 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 27 | 0.06830 | 40 | 7.45 | 262.394 | 0.065 | 11 | 64.85 | 0.003560 | 1.29E-04 |
| 28 | 0.06830 | 40 | 7.45 | 262.394 | 0.065 | 11 | 64.85 | 0.003560 | 1.29E-04 |
| 29 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 30 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 31 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 32 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 33 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 34 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 35 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 3 | 17.69 | 0.000721 | 2.60E-05 |
| 36 | 0.06830 | 41 | 5.80 | 157.085 | 0.065 | 1 | 5.90 | 0.000082 | 2.96E-06 |
| 37 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 38 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 39 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 40 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 41 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 42 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 43 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |

**Pressure Loss through Valves**

| Valve Number | Darcy Friction Factor | K' | d | Cv | density | # of wells | Q | Delta P | Delta P (in w.c.) |
|---|---|---|---|---|---|---|---|---|---|
| 44 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 45 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 46 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 47 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 48 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 49 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 50 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 51 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 52 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 53 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 54 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 55 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 56 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 57 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 58 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 59 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 60 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 61 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 62 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 63 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 64 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 65 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 66 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 67 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 4 | 23.58 | 0.001281 | 4.63E-05 |
| 68 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 69 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 70 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 71 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 2 | 11.79 | 0.000320 | 1.16E-05 |
| 72 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 73 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 74 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 75 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 76 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 77 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 78 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| 79 | 0.06830 | 40 | 5.80 | 159.037 | 0.065 | 1 | 5.90 | 0.000080 | 2.89E-06 |
| Skid | 0.06830 | 40 | 11.50 | 625.226 | 0.065 | 84 | 495.21 | 0.036562 | 1.32E-03 |
| Skid | 0.06830 | 40 | 11.50 | 625.226 | 0.065 | 84 | 495.21 | 0.036562 | 1.32E-03 |

| | | |
|---|---|---|
| Total | 3.32E-03 | in WC |

| | | |
|---|---|---|
| **TOTAL HEAD LOSS THROUGH PIPES, FITTINGS, AND VALVES** | **2.59** | |
| **Reserve** | **10** | |
| **Total** | **12.59** | in WC |

Plastics Pipe Institute, Handbook of PE Pipe, Second Edition (Equation 3-10).

**OBJECTIVE:**

Calculate the deflection of the underground landfill gas collection header pipes, Standard Dimension Ratio (SDR) 17, HDPE pipe due to the embedment and landfill loads.

**PROCEDURE:**

Use the standard formulas below to determine the safety factors against ring deflection , wall crushing, and wall buckling.

**A. Ring Deflection -** Ring deflection is the change in vertical diameter of the pipe as the pipe-bedding layer / aggregate system deforms under the external vertical pressure. The actual ring deflection of the pipe must be less than the allowable ring deflection of the pipe. According to the Plastics Pipe Institute, the allowable ring deflection may be assumed to be 7.5%. The pipe ring deflection may be estimated as equal to the strain of the soil backfill around the pipe, which is calculated by the following equation.

$$\frac{\Delta X}{D_M} = \frac{1}{144}\left(\frac{K_{BED}L_{DL}P_E + K_{BED}P_L}{\frac{2E}{3}\left(\frac{1}{DR-1}\right)^3 + 0.061F_S E'}\right)$$

Where:

| | | |
|---|---|---|
| $K_{BED}$ | = | Bedding factor (assume 0.1) |
| $L_{DL}$ | = | Deflection lag factor (assume 1.25) |
| $\gamma$ | = | Unit weight of cover soil, lb/ft$^2$ (assume 70) |
| H | = | Thickness of cover soil, ft (1.5) |
| $P_E$ | = | Vertical soil pressure due to earth load, lb/ft$^2$ |
| $P_L$ | = | Vertical soil pressure due to live load, lb/ft$^2$ (assume 1900) |
| E | = | Apparent modulus of elasticity of pipe, lb/in$^2$ (27,000) |
| DR | = | Pipe dimension ratio (17) |
| $F_S$ | = | Soil support factor (assume 1.1) |
| E' | = | Modulus of soil reaction, lb/in$^2$ (assume 1000) |
| $D_M$ | = | Mean pipe diameter, in |

Vertical soil pressure due to earth load is calculated by:

$$P_E = \gamma \times H$$

Where:

$\gamma$ = Unit weight of cover soil, lb/ft$^3$ (assume 70)

H = Thickness of cover soil, ft (1.5)

$P_E$ = Vertical soil pressure due to earth load, lb/ft$^2$

Assuming, PE pipe material designation as PE 3408 and duration of sustained loading of 100 years, apparent modulus of elasticity of pipe was obtained as 27,000 psi using Table B.1.1 of Chapter 3.

Solved:

$$\frac{\Delta X}{D_M} = \frac{1}{144}\left(\frac{(0.1\,x\,1.25\,x\,105) + (0.1\,x\,1900)}{\frac{2x27{,}000}{3}\left(\frac{1}{17-1}\right)^3 + 0.061\,x\,1.1\,x\,1000}\right)$$

$$\frac{\Delta X}{D_M} = 2.0\%$$

**2.0% < 7.5%**

**B. Pipe Wall Crushing -** Wall crushing occurs when the stress in the pipe wall, due to external, vertical pressure, exceeds the compressive strength of the pipe material. Pipe wall compressive stress is calculated by the following equation.

Plastics Pipe Institute, Handbook of PE Pipe, Second Edition (Equation 3-13).

$$S = \frac{(P_{E+}P_L)DR}{288}$$

$P_E$ = Vertical soil pressure due to earth load, lb/ft$^2$

$P_L$ = Vertical soil pressure due to live load, lb/ft$^2$ (assume 1900)

DR = Pipe dimension ratio (17)

Solved:

$$S = \frac{(105 + 1900)\,x\,17}{288}$$

$$= 118 \text{ lb/in}^2$$

Allowable Compressive Stress for HDPE is 118 lb/in$^2$ which is less than allowable compressive stress, 1000 lb/in$^2$.

**C. Wall Buckling -** Wall buckling is a failure along the longitudinal plane of the pipe wall. Buckling can occur when the external vertical pressure exceeds the critical buckling pressure of the pipe/bedding aggregate system. Allowable constrained buckling pressure is calculated by the following equation.

$$P_{WC} = \frac{5.65}{N}\sqrt{RB'E'\frac{E}{12(DR-1)^3}}$$

Plastics Pipe Institute, Handbook of PE Pipe, Second Edition (Equations 3-15, 3-17, 3-18).

Where:

$P_{WC}$ = Allowable constrained buckling pressure, lb/in$^2$

N = Safety factor (assume 1)

R = Buoyancy reduction factor

B' = Soil support factor

E' = Modulus of soil reaction, lb/in$^2$ (assume 1000)

E = Apparent modulus of elasticity of pipe, lb/in2 (27,000)

DR = Pipe dimension ratio (17)

Buoyancy reduction factor is calculated by:

$$R = 1 - 0.33\frac{H_{GW}}{H}$$

Where:

$H_{GW}$ = Height of liquid above pipe (0 ft)

H = Depth of cover, ft

Soil support factor is calculated by:

$$B' = \frac{1}{1 + 4e^{(-0.065H)}}$$

Solved:

Buoyancy reduction factor and soil support factors are calculated as 1.0 and 0.216, respectively using above mentioned equations.

$$P_{WC} = \frac{5.65}{1}\sqrt{(1\ x\ 0.216\ x\ 1000)\frac{27000}{12(17-1)^3}}$$

$$P_{WC} = 61.55 \text{ psi}$$

Therefore, the factor of safety against buckling is:

$$F.O.S = \frac{61.55\ x\ 144}{(105+1900)}$$

$$F.O.S = 4.4$$

Factor of safety > 2 is acceptable.

## CONCLUSIONS:

A conservative factor of safety against crushing and buckling is 2 to 1. Calculated pipe wall compressive stress for the SDR17 pipe in this application is less than the acceptable allowable stress. The pipe also provides a factor of safety of 4.4 against buckling which is above the design minimum. The percent ring deflection allowed in the SDR17 pipe is 7.5% and in this application, the maximum ring deflection is determined to be less of 2.0%. **Therefore, the SDR17 pipe will provide sufficient strength against the crushing, buckling, and ring deflection under the maximum load.**

*Reference:*
NSPS Background Information Document (BID). Appendix E. 1991

**OBJECTIVE:**

To determine the spacing between landfill gas extraction wells. This will be calculated using the EPA method.

**PROCEDURE:**

Well spacing is determined by finding the radius of influence using the EPA method and using this radius to determine the spacing.

**A. EPA Method** – This analysis will be used to calculate the radius of influence of the landfill gas extraction wells.

$$R = 131.1\,(\frac{Q_w DC}{L\rho Q_{gen}\eta})^{1/2}$$

Where:
R = Radius of Influence (ft)
$Q_w$ = Well Flow (scfm)
DC = Design Capacity (tons)
L = Length of Perforations (feet)
ρ = Waste Density (lb/cyd)
$Q_{gen}$ = LFG generation rate
η = Extraction Efficiency

**B. Spacing** – Well spacing is found from the radius of influence:

$$spacing = R\sqrt{3}$$

Where:
R = Radius of Influence (ft)
Spacing = spacing of wells (ft)

**Solution:**

Due to heterogeneity of landfills not every well is going to be the same depth. Minimally, it is assumed that 507 scfm total for $Q_w$ is divided among the 86 extraction wells, therefore the $Q_w$ is 5.9 scfm per well. DC is known to be 5.16E06 tons, ρ is 1400 lb/cyd, $Q_{gen}$ is 507 scfm and η is 75%. Completing this calculation yields:

$$R = 131.1\,(\frac{5.9 * 5.16E06}{25 * 1400 * 507 * 0.75})^{1/2}$$

$$R = 198\,ft$$

$$spacing = 198 * \sqrt{3}$$
$$spacing = 343\ ft$$

Using the standard that 1 scfm per foot of perforated pipe the maximal spacing was determined. On average the landfill is approximately 40 ft deep, therefore an average well would have 20 ft of solid pipe and 20 ft of perforated pipe. As before, DC is 5.16E06 tons, ρ is 1400 lb/cyd, $Q_{gen}$ is 507 scfm and η is 75%. Solving this calculation shows that the spacing necessary is:

$$R = 131.1\ (\frac{20 * 5.16E06}{20 * 1400 * 507 * 0.75})^{1/2}$$

$$R = 408\ ft$$

$$spacing = 408 * \sqrt{3}$$
$$spacing = 707\ ft$$

**CONCLUSION:**

Knowing that there will be $Q_{w\_total}$ =507 scfm over the entire area of the landfill it can be concluded that the maximal calculation overestimates the spacing. Therefore, being conservative, the wells are spaced at approximately 300 ft to balance the landfill gas extraction capacity with the cost of the system.


GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY

MONTGOMERY COUNTY, MARYLAND

FIGURE 5: LANDFILL GAS RADIUS OF INFLUENCE

**EA Engineering, Science, and Technology, Inc., PBC**
Hunt Valley Center
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

DATE: NOVEMBER 2018

PROJECT NUMBER: 1564601

**Figure 5**

SHEET: 1 OF 1

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# Attachment L

# Environmental Assessment Report [Future Design Submittals]

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# Attachment M

# Post-Closure Care Plan

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# Gude Landfill Remediation Design
# Post-Closure Care Plan
# Montgomery County, Maryland

## 60% Revised Submission

*Prepared for*

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Division of Solid Waste Services
Montgomery County, Maryland

*Prepared by*

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
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(410) 584-7000

January 2020
EA Project No. 15646.01

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# Gude Landfill Remediation Design
# Post-Closure Care Plan
# Montgomery County, Maryland

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January 2020
EA Project No. 15646.01

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# TABLE OF CONTENTS

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| COMAR | Code of Maryland Regulations |
| the County | Montgomery County Department of Environmental Protection, Division of Solid Waste Services |
| the Landfill | Gude Landfill |
| MDE | Maryland Department of the Environment |
| M-NCPPC | Maryland-National Capital Park and Planning Commission |

# 1. POST-CLOSURE CARE

## 1.1 INTRODUCTION

EA Engineering, Science, and Technology, Inc. has prepared this Post-Closure Care Plan for the Montgomery County Department of Environmental Protection, Division of Solid Waste Services (the County) to document the post-closure care plan for the Gude Landfill (the Landfill) located in Rockville, Maryland. This plan describes activities necessary to satisfy the post-closure criteria identified in the Code of Maryland Annotated Regulations (COMAR) 26.04.07.22.

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. The site has road access at two (2) locations: East Gude Drive and Southlawn Lane.

The Landfill is currently owned and maintained by the County Department of Environmental Protection. The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately one hundred sixty-two (162) acres, of which approximately one hundred forty (140) acres were used for waste disposal. An additional seventeen (17) acres of waste disposal area were delineated in 2009 on Maryland-National Capital Park and Planning Commission (M-NCPPC) property, beyond the northeastern property boundary of the Landfill. A land exchange between the County and M-NCPPC on 21 October 2014 transferred ownership of this additional waste disposal area to the County in exchange for a similar area of land without waste, which was transferred to M-NCPPC.

The post-closure care period refers to that period of time following the completion of final site closure activities during which the landfill and the landfill surroundings will be inspected, monitored, and maintained. Post-closure care for the Landfill is proposed for a minimum 30-year period, after which the need for continued monitoring should be reassessed by the Maryland Department of the Environment (MDE), and a decision should be made to continue, decrease, or cease monitoring activities. The anticipated post-closure care activities at the Landfill include inspections, monitoring, and maintenance.

## 1.2 POST-CLOSURE CARE

### 1.2.1 Site Maintenance Plan

Site maintenance during post-closure will consist of semi-annual inspections with irregularities and problems corrected within 30 days and that include at a minimum:

- The integrity of the landfill cover is maintained
- Erosion damage and drainage irregularities are repaired
- Surface expressions of leachate are repaired
- Monitoring wells are routinely checked.

### 1.2.2 Post-Closure Activity

Post-closure use of the property will not disturb the integrity of the final cover, liner(s), or other components of the containment system, or the function of the monitoring systems.

The future land uses after final closure have not been determined at the time of the writing of this document. MDE will be notified for approval with future site development plans.

## 1.3 MONITORING PLAN

### 1.3.1 Surface Water Management System

The County will monitor surface water during routine monitoring in accordance with the County's *Groundwater and Surface Water Monitoring Plan*, updated September 2016 (Montgomery County 2016) and all MDE-approved updates.

### 1.3.2 Groundwater Monitoring

Groundwater will be monitored during routine monitoring in accordance with the County's *Groundwater and Surface Water Monitoring Plan*, updated September 2016 (Montgomery County 2016) and all MDE-approved updates.

### 1.3.3 Landfill Gas Management System

Landfill gas monitoring around the landfill perimeter during the post-closure period will be performed in accordance with the County's *Landfill Gas Monitoring Plan* (Montgomery County Department of Environmental Protection 2009) and all MDE-approved updates.

### 1.3.4 Cover System

Inspections will be performed two (2) times per year during the post-closure period and after major storm events (two [2]-year, twenty-four [24]-hour—three and two-tenths [3.2] inches). Inspections will be documented in accordance with the example Landfill Site Inspection Checklist included in Appendix A.

The inspection will include observation of the cover at the landfill, notation of any settlement of the landfill surface, subsidence of slopes, drainage irregularities, signs of cover erosion, burrowing animals, or growth of woody vegetation.

## 1.4 POST-CLOSURE SECURITY

### 1.4.1 Site Security

The site security will be discussed in this section in future design submittals.

### 1.4.2 Entry Control

All vehicles must enter the site through the Incinerator Lane or the entrance from East Gude Drive. After hours the facility is locked.

## 1.5 POST-CLOSURE MAINTENANCE ACTIVITIES

This section of the plan details the requirements for inspecting, reporting, and implementing corrective actions for any of the Landfill's infrastructure or systems that may need repair. Each of the following subsections is included in the example Landfill Site Inspection Checklist included in Appendix A. Corrective action of problems or deficiencies will be documented by the County on the example Landfill Site Maintenance Log included in Appendix B.

### 1.5.1 Repair of Security Devices

The County will repair the fence or access gate as needed to maintain site security.

### 1.5.2 Vegetation Management

The County will maintain the vegetation over the closure system and may apply fertilizer or spray for noxious weeds, if deemed necessary by the County. The County will remove woody vegetation, which can compromise the landfill cover system. Mowing should be minimized to promote the benefit of the native grasses.

### 1.5.3 Repair of Erosion or Cracking of Final Cover

Erosion can be mitigated by spreading straw mulch over the eroded sections until the eroded soil is replaced and the site revegetated. Repair of erosion of the final cover will be made as soon as possible based on weather conditions and the potential need to procure a contractor to complete the repairs.

### 1.5.4 Repair of Settlement Depressions

If significant differential settlement becomes apparent, the County will investigate the integrity of the liner system. If areas of significant settlement are detected (e.g., greater than two [2] feet) that impede surface water runoff, the affected area will also be brought back to grade, with depressed areas graded to facilitate drainage.

### 1.5.5 Maintenance of Landfill Gas Control System

The County will inspect, operate, and maintain the landfill gas control system in accordance with the Operations and Maintenance Manual prepared by the installer of the new landfill gas processing equipment. Key components include the extraction wells, gas collection piping, gas condensate system, blower(s), and flare. Required repair of the landfill gas control system will be made as soon as possible based on weather conditions and the potential need to procure a contractor to complete the repairs.

### 1.5.6 Maintenance of Groundwater Monitoring Systems

The County will inspect the groundwater monitoring systems during routine monitoring activities in accordance with the County's *Groundwater and Surface Water Monitoring Plan*, updated September 2016 (Montgomery County 2016) and all MDE-approved updates. Required repair of groundwater monitoring systems will be made as soon as possible based on weather conditions and the potential need to procure a contractor to complete the repairs.

### 1.5.7 Post-Closure Personnel Training

All landfill personnel responsible for post-closure maintenance will be trained in their specific assigned duties. Personnel will be provided with instructions on inspection frequency, forms, and corrective action to ensure the landfill is maintained in adherence with the applicable post-closure requirements.

### 1.5.8 Post-Closure Contact

Montgomery County Department of Environmental Protection shall be contacted regarding post-closure activities:

Montgomery County
Department of Environmental Protection
Recycling and Resource Management Division
Attn: Division Chief
101 Monroe Street, 6th Floor
Rockville, Maryland 20850
Phone: (240) 777-0311

### 1.5.9 Post-Closure Site Use

Montgomery County has no current plans for future development of the Landfill beyond what is currently permitted (operational area and passive recreational use). There are no current plans to disturb the final cover system. MDE will be notified for approval should any future development of the site be proposed. Proposed future development on the landfill cover system will be subject to the post-closure requirements in this plan.

### 1.5.10 Post-Closure Cost Estimate and Financial Assurance

Montgomery County will maintain inspection and operations of the post-closure system as required to maintain adherence to the COMAR regulations. Post-closure maintenance will be funded through the County's annual operations and maintenance budget.

# 2. REFERENCES

Maryland Department of the Environment (MDE). 2011. *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*. Revised January 2012.

Montgomery County. 2016. *Groundwater and Surface Water Monitoring Plan.* Maryland. September.

Montgomery County. 2009. *Landfill Gas Monitoring Plan.* Maryland.

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# Appendix A

# Site Inspection Checklist

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## LANDFILL SITE INSPECTION CHECKLIST

**INSPECTOR:** ______________________________

**DATE/TIME:** ______________________________

**WEATHER:** ______________________________

**SITE:** ______________________________

| | | GOOD | FAIR | POOR | N/A |
|---|---|---|---|---|---|
| I. | SITE INSPECTION | | | | |
| A. | Site Security (Condition of Gate/Lock) | | | | |
| B. | Access Road Condition | | | | |
| C. | Landfill Cover Soil/Vegetation | | | | |
| D. | Surface Drainage Control | | | | |
| E. | Landfill Gas Extraction System | | | | |

| | | YES | NO |
|---|---|---|---|
| F. | Settlement of Landfill Surface | | |
| G. | Subsidence of Side Slopes | | |
| H. | Erosion of Cover Soil/Vegetation | | |
| I. | Presence of Exposed Waste/Leachate Seeps | | |
| J. | Evidence of Animal Burrowing | | |
| K. | Evidence of Unauthorized Dumping | | |

II. COMMENTS/RECOMMENDATIONS/ACTION ITEMS

______________________________

______________________________

______________________________

______________________________

______________________________

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# Appendix B

# Landfill Site Maintenance Log

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## LANDFILL SITE MAINTENANCE LOG

**INSPECTOR:** ______________________________

**DATE/TIME:** ______________________________

**WEATHER:** ______________________________

**SITE:** ______________________________

| | Date Problem Identified | Date Scheduled for Corrective Action | Date Problem Corrected |
|---|---|---|---|
| **1. Landfill Cover/ Vegetation** | __________ | __________ | __________ |

Description of Corrective Action ______________________________

Comments ______________________________

| | Date Problem Identified | Date Scheduled for Corrective Action | Date Problem Corrected |
|---|---|---|---|
| **2. Cover Settlement** | __________ | __________ | __________ |

Description of Corrective Action ______________________________

Comments ______________________________

| | Date Problem Identified | Date Scheduled for Corrective Action | Date Problem Corrected |
|---|---|---|---|
| **3. Slope Subsidence** | ______ | ______ | ______ |

Description of Corrective Action ______

Comments ______

| | Date Problem Identified | Date Scheduled for Corrective Action | Date Problem Corrected |
|---|---|---|---|
| **4. Surface Drainage** | ______ | ______ | ______ |

Description of Corrective Action ______

Comments ______

| | Date Problem Identified | Date Scheduled for Corrective Action | Date Problem Corrected |
|---|---|---|---|
| **5. Erosion of Cover Soil/ Vegetation** | ______ | ______ | ______ |

Description of Corrective Action ______

Comments ______

| | Date Problem Identified | Date Scheduled for Corrective Action | Date Problem Corrected |
|---|---|---|---|
| **6. Landfill Gas Extraction System** | ______ | ______ | ______ |

Description of Corrective Action ____________________

Comments ____________________

| | Date Problem Identified | Date Scheduled for Corrective Action | Date Problem Corrected |
|---|---|---|---|
| **7. Access Road/Site Security** | ______ | ______ | ______ |

Description of Corrective Action ____________________

Comments ____________________

| | Date Problem Identified | Date Scheduled for Corrective Action | Date Problem Corrected |
|---|---|---|---|
| **8. Other** | ______ | ______ | ______ |

Description of Corrective Action ____________________

Comments ____________________

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# Attachment N

# Construction Schedule

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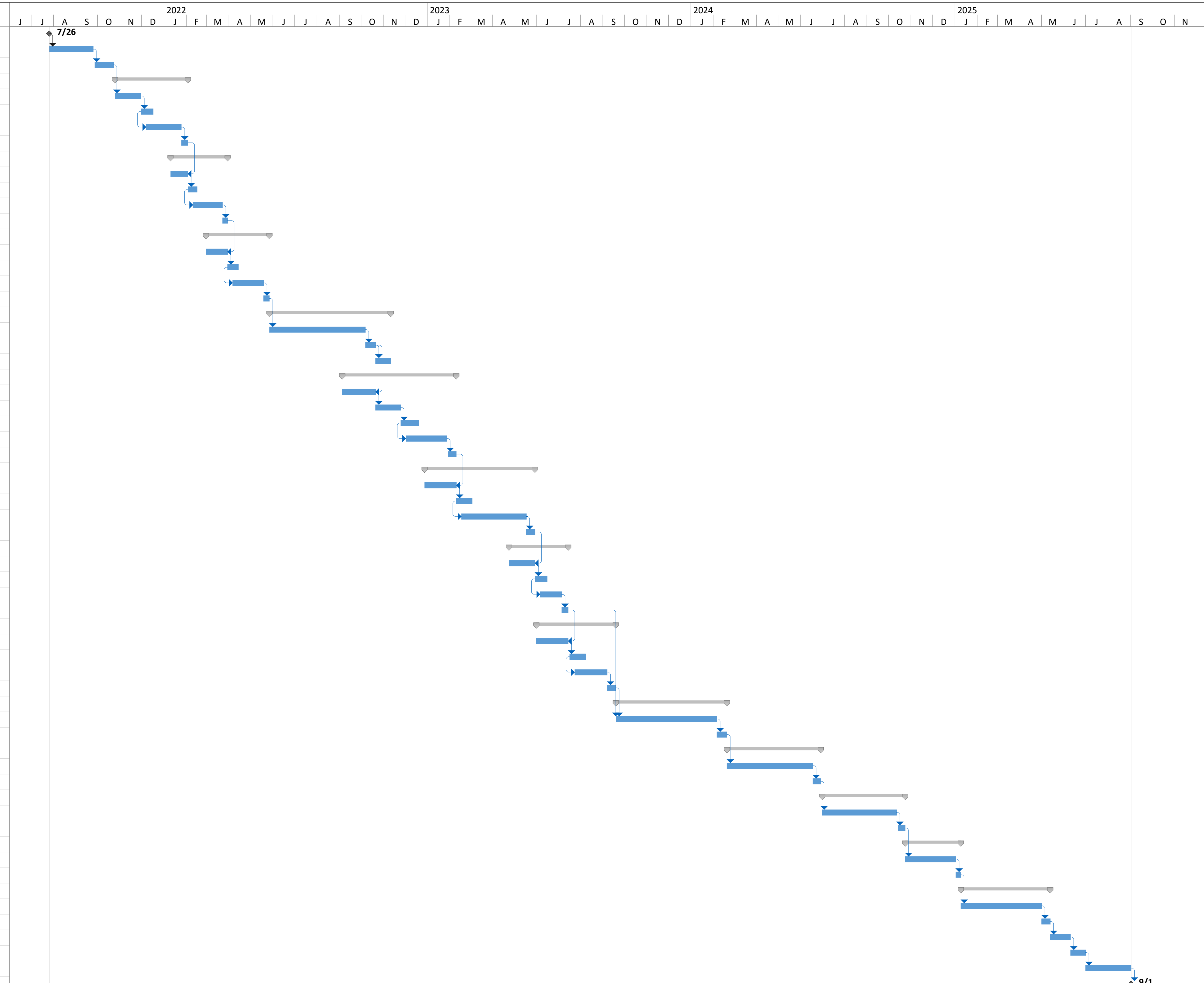
**ENGINEER'S OPINION OF GUDE LANDFILL REMEDIATION SCHEDULE**
**BASED ON 60% REVISED DESIGN**

| ID | Task Name | Duration | Start | Finish | Predecessors |
|---|---|---|---|---|---|
| 1 | NTP | 0 days | Mon 7/26/21 | Mon 7/26/21 | |
| 2 | Project Planning and Submittals | 45 days | Mon 7/26/21 | Fri 9/24/21 | 1 |
| 3 | Mobilization | 20 days | Mon 9/27/21 | Fri 10/22/21 | 2 |
| 4 | **Phase S-I** | 73 days | Mon 10/25/21 | Wed 2/2/22 | |
| 5 | Erosion and Sediment and Other Environmental Controls | 26 days | Mon 10/25/21 | Mon 11/29/21 | 3 |
| 6 | Clearing and Grubbing | 13 days | Tue 11/30/21 | Thu 12/16/21 | 5 |
| 7 | Subgrade Preparation/Waste Relocation and LFG Adjustments | 35 days | Tue 12/7/21 | Mon 1/24/22 | 6SS+5 days |
| 8 | Vegetative Stabilization | 7 days | Tue 1/25/22 | Wed 2/2/22 | 7 |
| 9 | **Phase S-II** | 57 days | **Mon 1/10/22** | **Tue 3/29/22** | |
| 10 | Erosion and Sediment and Other Environmental Controls | 18 days | Mon 1/10/22 | Wed 2/2/22 | 8FF |
| 11 | Clearing and Grubbing | 9 days | Thu 2/3/22 | Tue 2/15/22 | 10 |
| 12 | Subgrade Preparation/Waste Relocation and LFG Adjustments | 29 days | Thu 2/10/22 | Tue 3/22/22 | 11SS+5 days |
| 13 | Vegetative Stabilization | 5 days | Wed 3/23/22 | Tue 3/29/22 | 12 |
| 14 | **Phase S-III** | 64 days | **Mon 2/28/22** | **Thu 5/26/22** | |
| 15 | Erosion and Sediment and Other Environmental Controls | 22 days | Mon 2/28/22 | Tue 3/29/22 | 13FF |
| 16 | Clearing and Grubbing | 11 days | Wed 3/30/22 | Wed 4/13/22 | 15 |
| 17 | Subgrade Preparation/Waste Relocation and LFG Adjustments | 31 days | Wed 4/6/22 | Wed 5/18/22 | 16SS+5 days |
| 18 | Vegetative Stabilization | 6 days | Thu 5/19/22 | Thu 5/26/22 | 17 |
| 19 | **Phase F-I** | 120 days | **Fri 5/27/22** | **Thu 11/10/22** | |
| 20 | Closure Cap/LFG/Access Road Construction | 95 days | Fri 5/27/22 | Thu 10/6/22 | 18 |
| 21 | Vegetative Stabilization | 10 days | Fri 10/7/22 | Thu 10/20/22 | 20 |
| 22 | Northwest Boundary Tree Planting and Fencing | 15 days | Fri 10/21/22 | Thu 11/10/22 | 21 |
| 23 | **Phase S-IV** | 114 days | Mon 9/5/22 | Thu 2/9/23 | |
| 24 | Erosion and Sediment and Other Environmental Controls | 34 days | Mon 9/5/22 | Thu 10/20/22 | 21FF |
| 25 | Pond 3 / Sediment Basin Construction | 25 days | Fri 10/21/22 | Thu 11/24/22 | 24 |
| 26 | Clearing and Grubbing | 17 days | Fri 11/25/22 | Mon 12/19/22 | 25 |
| 27 | Subgrade Preparation/Waste Relocation and LFG Adjustments | 41 days | Fri 12/2/22 | Fri 1/27/23 | 26SS+5 days |
| 28 | Vegetative Stabilization | 9 days | Mon 1/30/23 | Thu 2/9/23 | 27 |
| 29 | **Phase S-V** | 109 days | **Wed 12/28/22** | **Mon 5/29/23** | |
| 30 | Erosion and Sediment and Other Environmental Controls | 32 days | Wed 12/28/22 | Thu 2/9/23 | 28FF |
| 31 | Clearing and Grubbing | 16 days | Fri 2/10/23 | Fri 3/3/23 | 30 |
| 32 | Subgrade Preparation/Waste Relocation and LFG Adjustments | 64 days | Fri 2/17/23 | Wed 5/17/23 | 31SS+5 days |
| 33 | Vegetative Stabilization | 8 days | Thu 5/18/23 | Mon 5/29/23 | 32 |
| 34 | **Phase S-VI** | 60 days | **Mon 4/24/23** | **Fri 7/14/23** | |
| 35 | Erosion and Sediment and Other Environmental Controls | 26 days | Mon 4/24/23 | Mon 5/29/23 | 33FF |
| 36 | Clearing and Grubbing | 13 days | Tue 5/30/23 | Thu 6/15/23 | 35 |
| 37 | Subgrade Preparation/Waste Relocation and LFG Adjustments | 22 days | Tue 6/6/23 | Wed 7/5/23 | 36SS+5 days |
| 38 | Vegetative Stabilization | 7 days | Thu 7/6/23 | Fri 7/14/23 | 37 |
| 39 | **Phase S-VII** | 78 days | **Thu 6/1/23** | **Mon 9/18/23** | |
| 40 | Erosion and Sediment and Other Environmental Controls | 32 days | Thu 6/1/23 | Fri 7/14/23 | 38FF |
| 41 | Clearing and Grubbing | 16 days | Mon 7/17/23 | Mon 8/7/23 | 40 |
| 42 | Subgrade Preparation/Waste Relocation and LFG Adjustments | 33 days | Mon 7/24/23 | Wed 9/6/23 | 41SS+5 days |
| 43 | Vegetative Stabilization | 8 days | Thu 9/7/23 | Mon 9/18/23 | 42 |
| 44 | **Phase F-II** | 110 days | **Tue 9/19/23** | **Mon 2/19/24** | |
| 45 | Closure Cap/LFG/Access Road Construction | 100 days | Tue 9/19/23 | Mon 2/5/24 | 43,38 |
| 46 | Vegetative Stabilization | 10 days | Tue 2/6/24 | Mon 2/19/24 | 45 |
| 47 | **Phase F-III** | 94 days | **Tue 2/20/24** | **Fri 6/28/24** | |
| 48 | Closure Cap/LFG/Access Road Construction | 85 days | Tue 2/20/24 | Mon 6/17/24 | 46 |
| 49 | Vegetative Stabilization | 9 days | Tue 6/18/24 | Fri 6/28/24 | 48 |
| 50 | **Phase F-IV** | 83 days | **Mon 7/1/24** | **Wed 10/23/24** | |
| 51 | Closure Cap/LFG/Access Road Construction | 75 days | Mon 7/1/24 | Fri 10/11/24 | 49 |
| 52 | Vegetative Stabilization | 8 days | Mon 10/14/24 | Wed 10/23/24 | 51 |
| 53 | **Phase F-V** | 55 days | **Thu 10/24/24** | **Wed 1/8/25** | |
| 54 | Closure Cap/LFG/Access Road Construction | 50 days | Thu 10/24/24 | Wed 1/1/25 | 52 |
| 55 | Vegetative Stabilization | 5 days | Thu 1/2/25 | Wed 1/8/25 | 54 |
| 56 | **Phase F-VI** | 88 days | **Thu 1/9/25** | **Mon 5/12/25** | |
| 57 | Closure Cap/LFG/Access Road Construction | 80 days | Thu 1/9/25 | Wed 4/30/25 | 55 |
| 58 | Vegetative Stabilization | 8 days | Thu 5/1/25 | Mon 5/12/25 | 57 |
| 59 | Recreational Land Uses | 20 days | Tue 5/13/25 | Mon 6/9/25 | 58 |
| 60 | As-Built Survey | 15 days | Tue 6/10/25 | Mon 6/30/25 | 59 |
| 61 | Project Closeout and Demobilization | 45 days | Tue 7/1/25 | Mon 9/1/25 | 60 |
| 62 | Construction Complete | 0 days | Mon 9/1/25 | Mon 9/1/25 | 61 |




Date: Thu 1/9/20 | Task | Milestone | Summary



Task durations are in working days.
This represents one possible remediation schedule to illustrate potential construction duration.
This schedule does not illustrate potential winter shutdowns that may be required.