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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July 2020
EA Project No. 15646.01

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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, Procurement, 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, Floodplain Study Approval, Floodplain District 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. The existing drainage area to the eastern side of the site is approximately 96 acres and the proposed drainage area will be approximately 99 acres. A Floodplain Study Approval and Floodplain District Permit are required because drainage area is over 30 acres.

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

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]
(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

DPS Permit Submissions

H1 – Stormwater Management Concept Report
H2 – Stormwater Management Report
H3 – Sediment Control Report
H4 – Floodplain Study

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Attachment H1

H1 – Stormwater Management Concept Report

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Gude Landfill Remediation Design
Stormwater Management Report
Montgomery County, Maryland

Stormwater Concept Resubmission

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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February 2020
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Gude Landfill Remediation Design
Stormwater Management Report
Montgomery County, Maryland

Stormwater Concept Resubmission

Prepared for

Northeast Maryland Waste Disposal Authority and
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LIST OF ACRONYMS AND ABBREVIATIONS

cfs	Cubic feet per second
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
DA	Drainage Area
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
ESD	Environmental Site Design
HSG	Hydrologic soil group
the Landfill	Gude Landfill
M-NCPPC	Maryland-National Capital Park and Planning Commission
MDE	Maryland Department of the Environment
NRCS	Natural Resources Conservation Service
Q_2	2-Year peak flow
Q_{10}	10-Year peak flow
Q_{100}	100-Year peak flow

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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, Recycling and Resource Management Division (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 October 21, 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 based on the guidelines. Pre-development runoff characteristics must be maintained as nearly as possible.

Based on discussions with the Montgomery County Department of Permitting Services (DPS), this project is considered a "maintenance" activity since no new impervious area is proposed. Due to this classification, no ESD treatment is required.

This stormwater management report has been prepared to document the stormwater management design associated with the remediation design.

2. HYDROLOGY ANALYSIS

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	Not applicable
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 12 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

Drainage Area	Existing					Discharge Point
	Area (acres)	Runoff Curve Number	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)	
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 southerly 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. **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 – Southlawn Branch
DA-1B	22.6	45.0	93.9	32.8	66.8	142.3	Pond 3 – Southlawn Branch
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 a stormdrain that conveys discharge to Southlawn Branch. As the discharge from DA-1B increases from existing conditions, the stormdrain will provide safe conveyance of the 10-year storm. Additional discussion of the stormdrain is included in Section 3.1.

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 acres. However, discharge will decrease from existing conditions.

DA-9

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

DA-11

DA-11 will slightly increase in size from 3.15 to 3.18 acres. 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 to 15.13 acres and 5.80 to 5.78 acres, respectively. DA-8 will decrease from 3.88 to 3.34 acres and DA-10 will decrease from 0.99 to 0.84 acre. 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.

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3. STORMWATER MANAGEMENT

3.1 PROVIDING SAFE CONVEYANCE

Based on the results presented in **Table 3**, runoff flow rates increase in DA-1B. The receiving stormdrain will provide safe conveyance of the 10-year storm based on DPS requirements. Outlet protection will be provided to ensure non-erosive discharges at the outlet at Southlawn Branch.

3.2 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. Check dams as necessary will be used to reduce the velocity of the flow within the swales. The swales convey drainage to 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. The benches and downchutes will be protected from erosive impacts as necessary based on the velocity of the flow. A facility will be designed at the low point of the swale to discharge stormwater as sheet flow offsite.

3.3 INTEGRATION OF STORMWATER MANAGEMENT AND EROSION AND SEDIMENT CONTROL

The design will include a phased construction approach. Grading will be limited to 20-acre areas based on the limit imposed by the *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*. Phase boundaries will consider the drainage patterns. Pond 3 may be used as a sediment basin during construction. Further analysis will be required in future design stages.

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4. REFERENCES

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Figures

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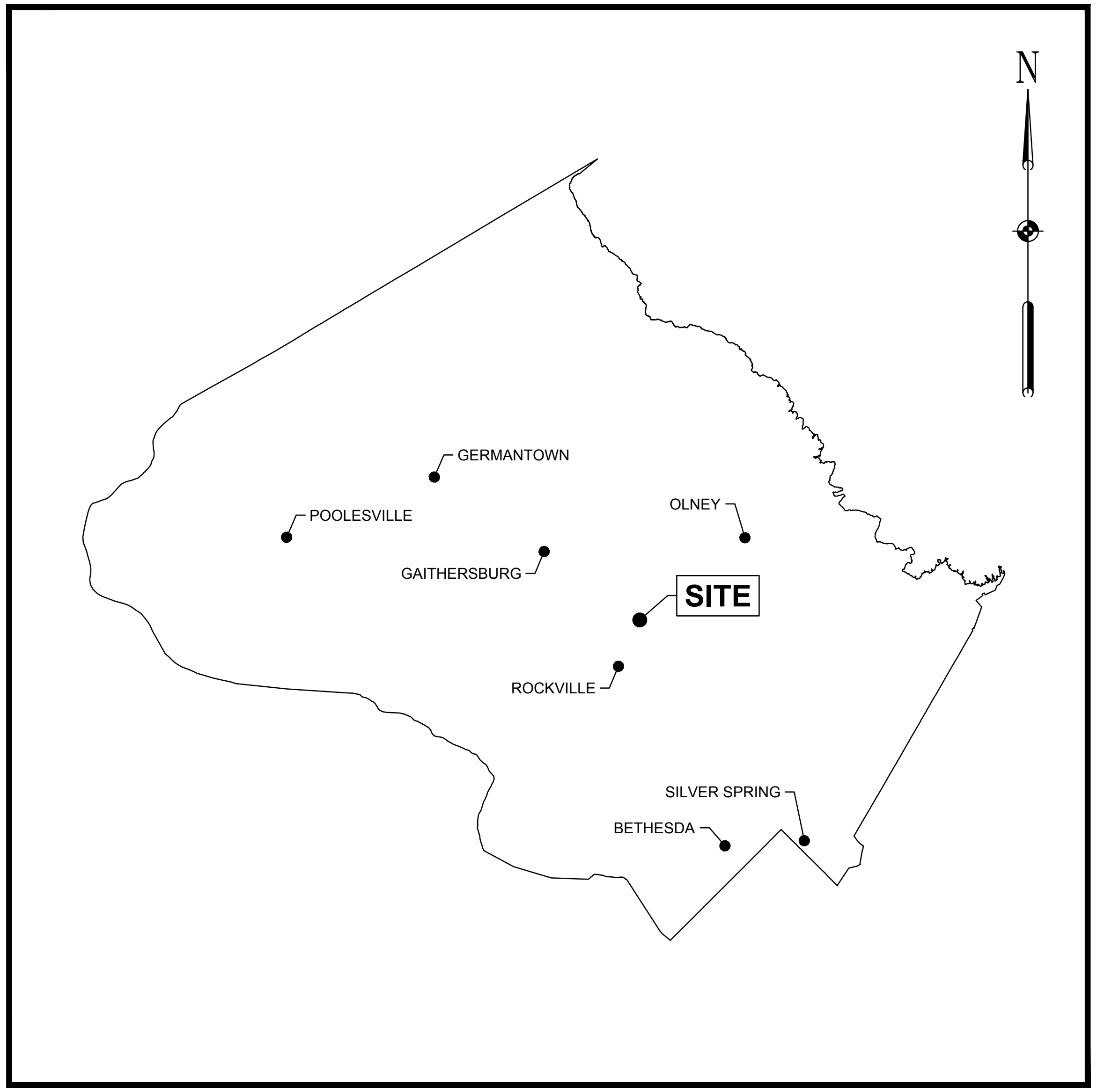
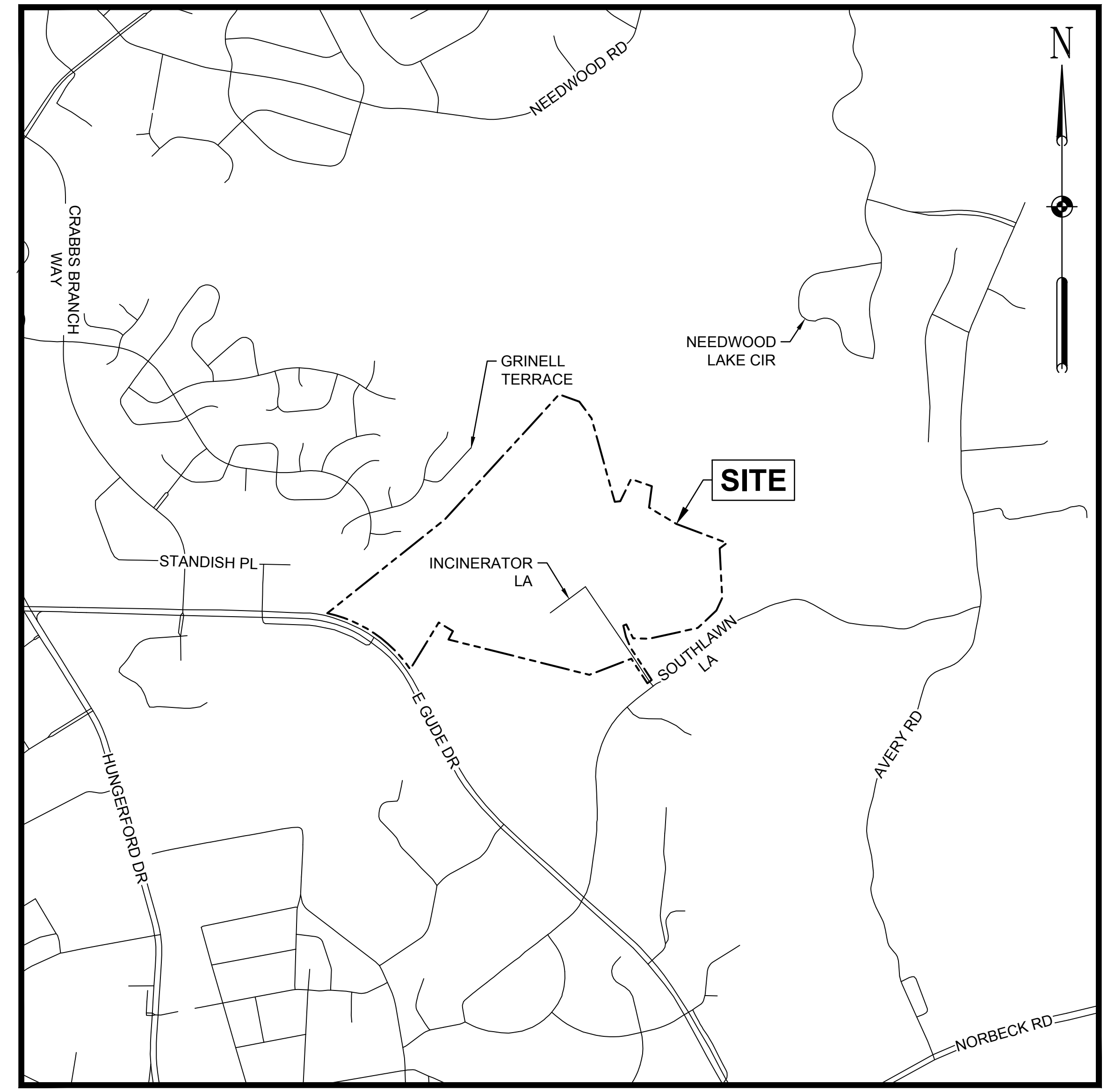


LOCATION MAP - MONTGOMERY COUNTY, MARYLAND
NOT TO SCALE



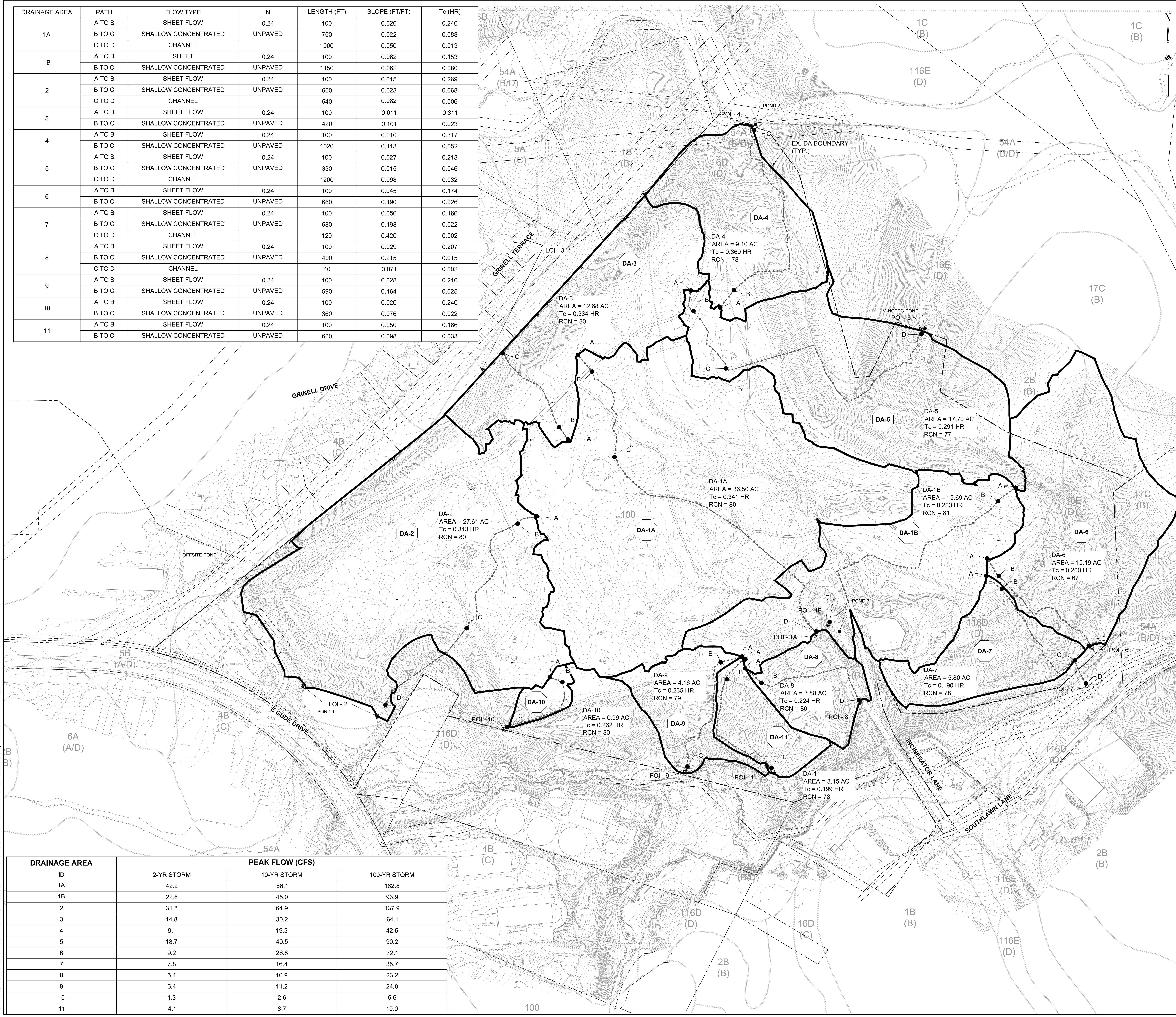
VICINITY MAP
SCALE: 1" = 2,000'

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		

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

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

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

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

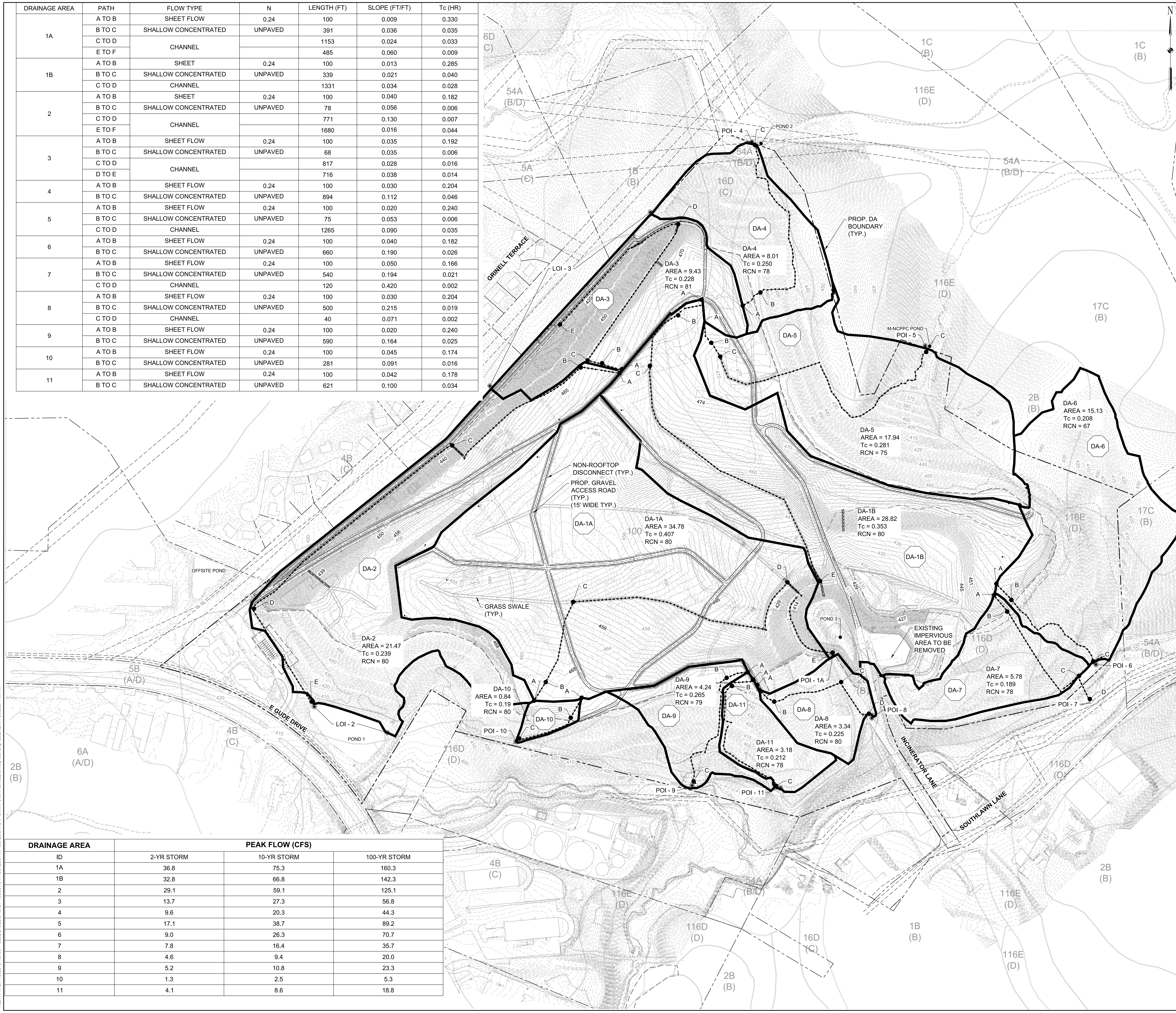
DATE: FEBRUARY 2020

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 (SfB 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%/ MAINTENANCE
SWM SUMMARY	
TARGET P_E/PROPOSED P_E	N/A - MAINTENANCE
TARGET ESD_V/PROVIDED ESD_V	N/A - MAINTENANCE
ESD MEASURES	N/A - MAINTENANCE
STRUCTURAL STORAGE REQUIRED/PROVIDED	N/A - MAINTENANCE
STRUCTURAL MEASURES	N/A - MAINTENANCE
WAIVER REQUEST/QL/QN/BOTH	N/A - MAINTENANCE
PROVIDED ESD_V + STRUCTURAL STORAGE PROVIDED + REQUESTED TO BE WAIVED	N/A - MAINTENANCE

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: FEBRUARY 2020
PROJECT NUMBER: 1564601

FIGURE 3
SHEET: - OF -

Appendix A

Web Soil Survey

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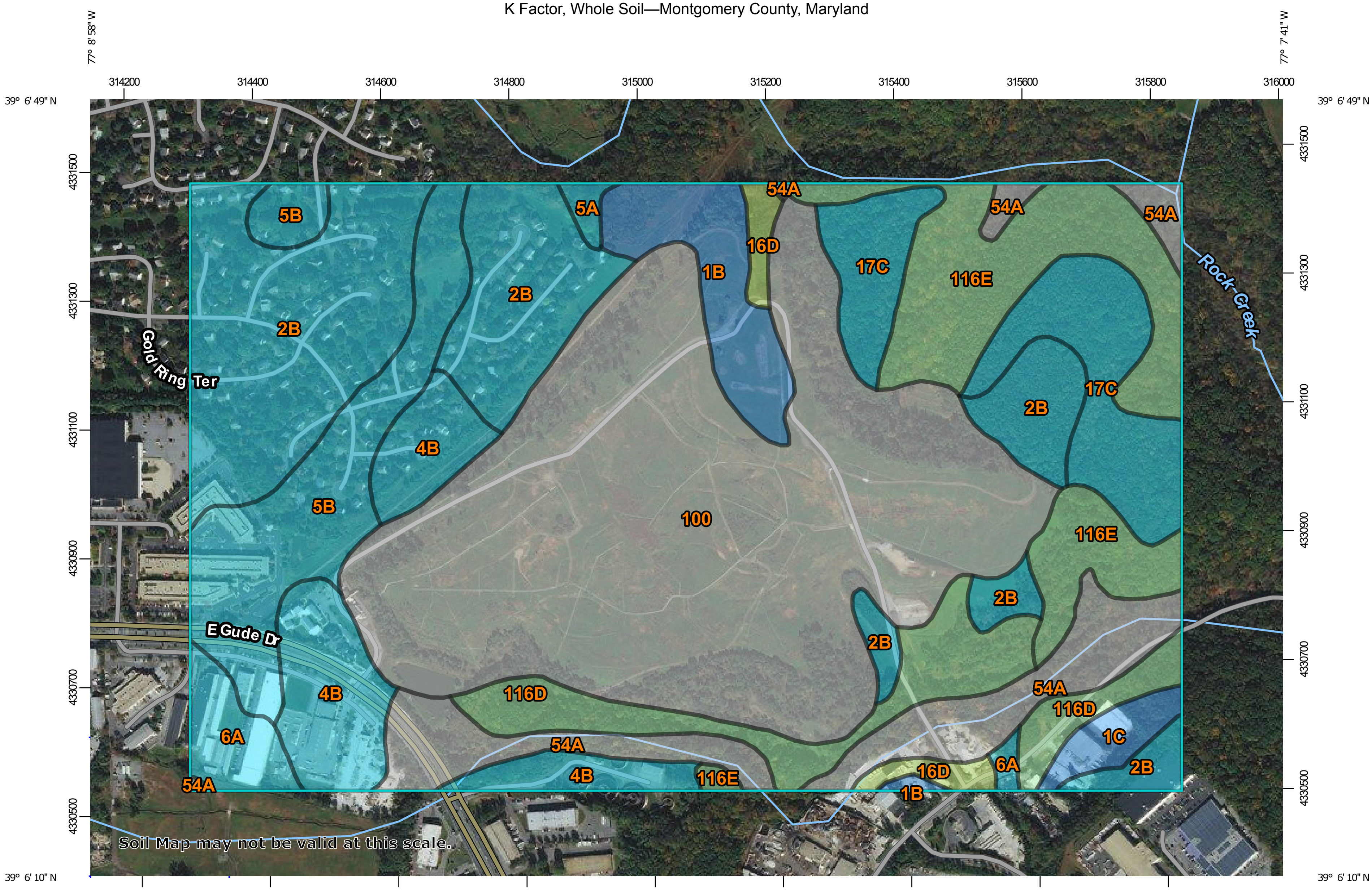
K Factor, Whole Soil—Montgomery County, Maryland



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

Meters: 0, 100, 200, 400, 600

Feet: 0, 400, 800, 1600, 2400

N

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

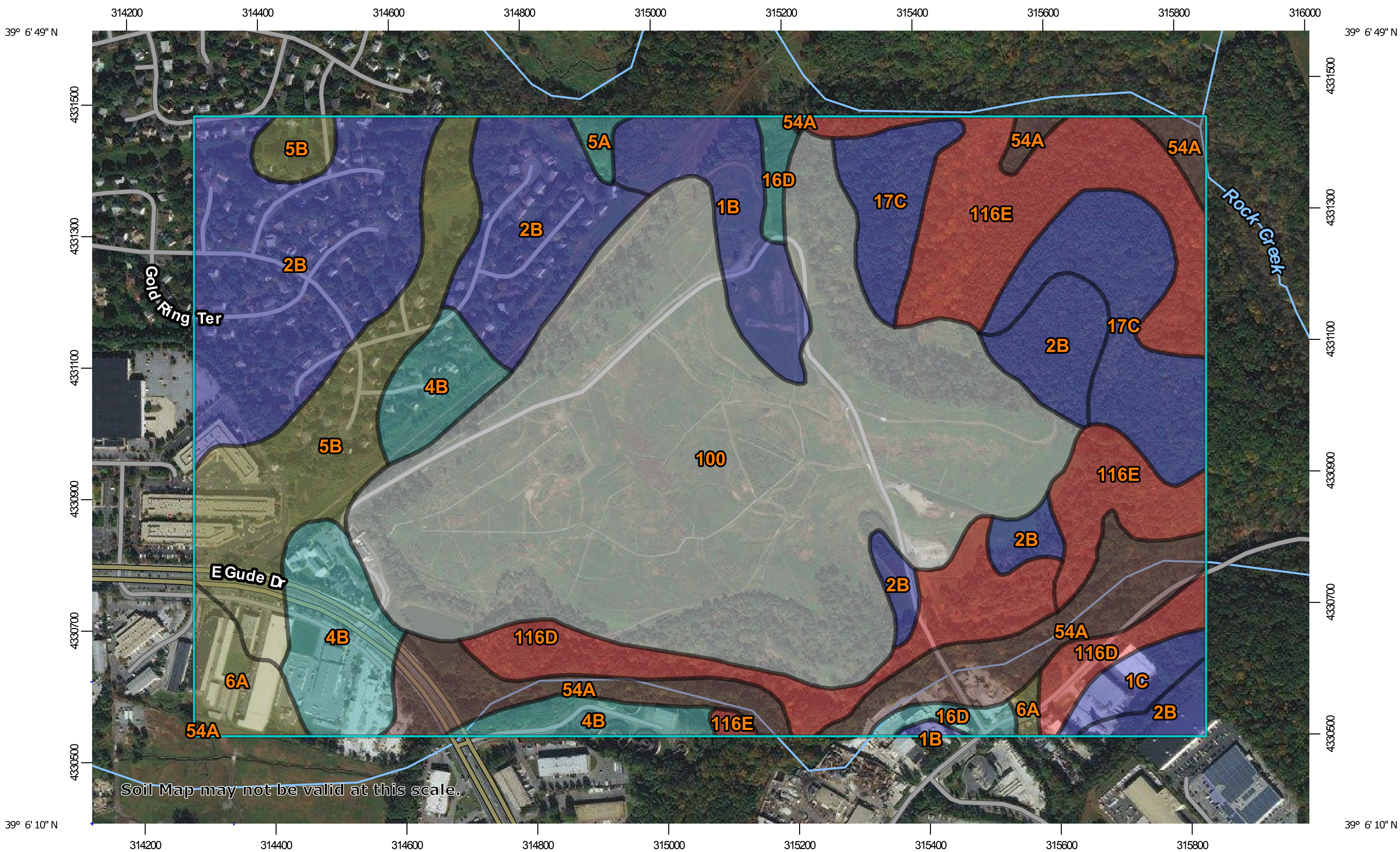
Aggregation Method: Dominant Condition

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 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

- 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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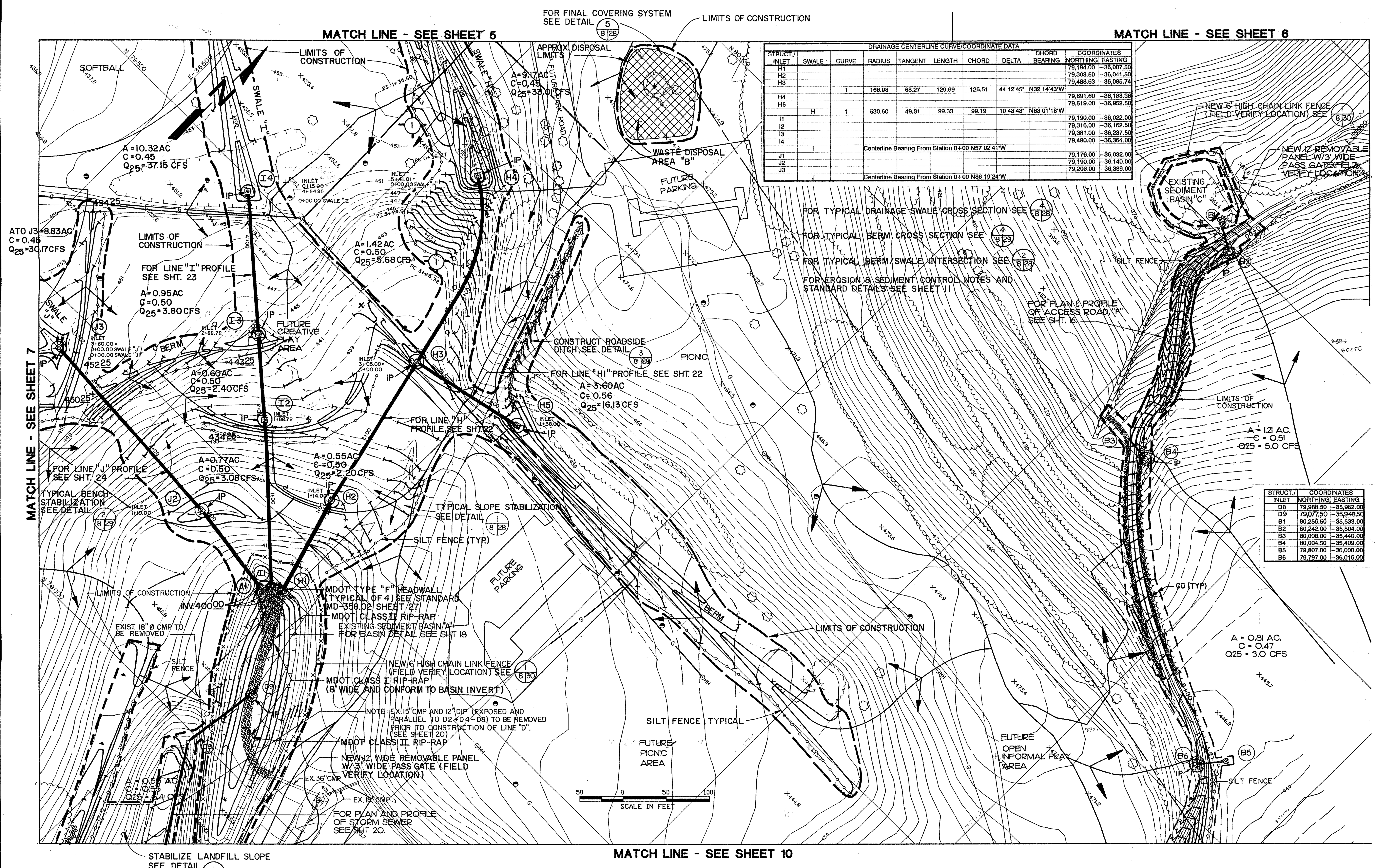


DRAINAGE CENTERLINE CURVE/COORDINATE DATA

STRUCT./ INLET	SWALE	CURVE	RADIUS	TANGENT	LENGTH	CHORD	DELTA	CHORD BEARING	COORDINATES NORTHING	COORDINATES 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	COORDINATES 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

STATE OF MARYLAND – ROBERT TERRANCE THOMAS – LIC. REG. CERT. NO. 18759 – PROFESSIONAL ENGINEER

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'

SHEET NO. 8 of 30

****************** 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	389.5?
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

SEDIMENTATION BASIN A

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

$$IA = \left(\text{sq.rt}(Area1) + \frac{E_i - E_1}{E_2 - E_1} \cdot (\text{sq.rt}(Area2) - \text{sq.rt}(Area1))\right)^2$$

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.?946	
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

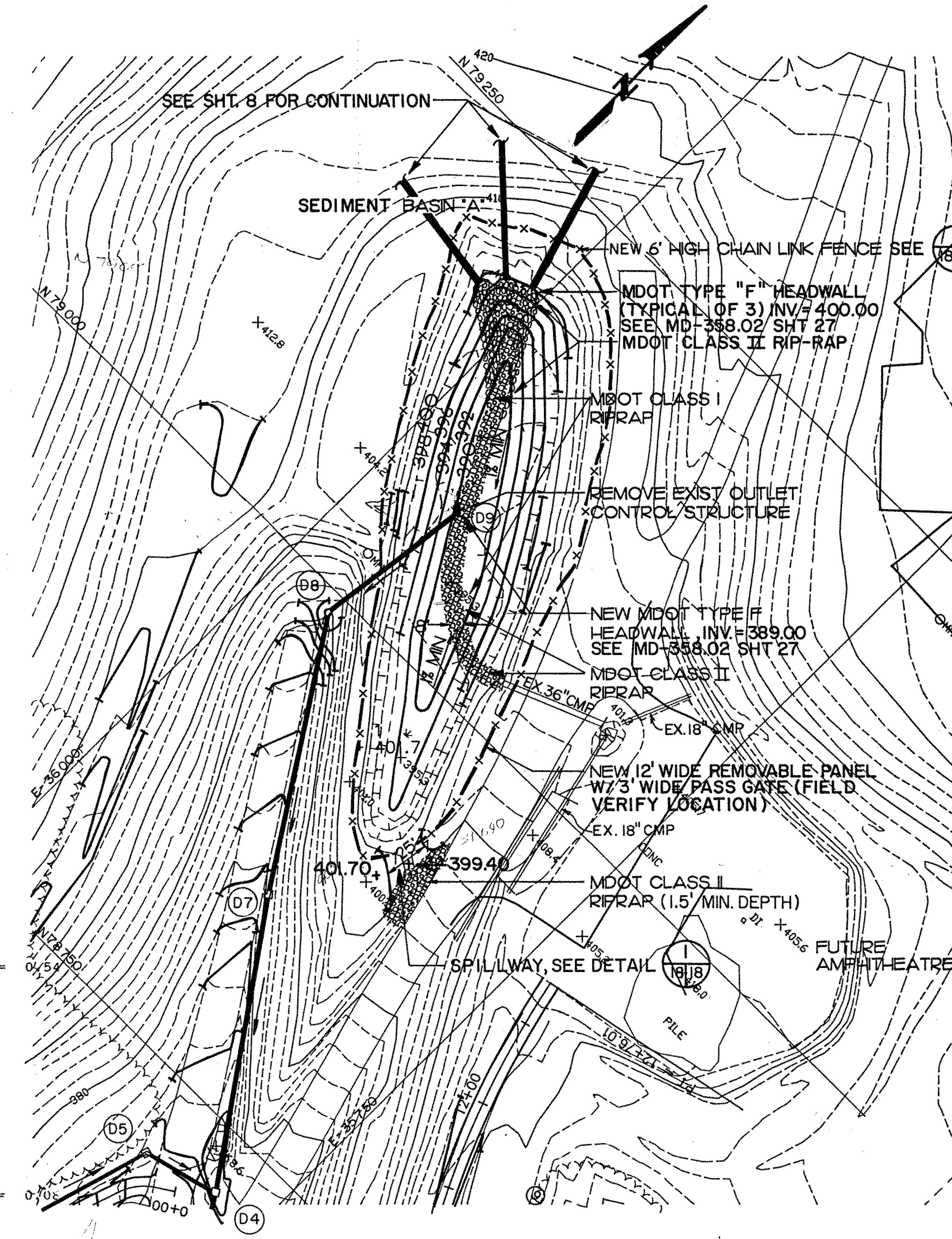
RUNOFF CURVE NUMBER DATA

::

Composite Area: DA7

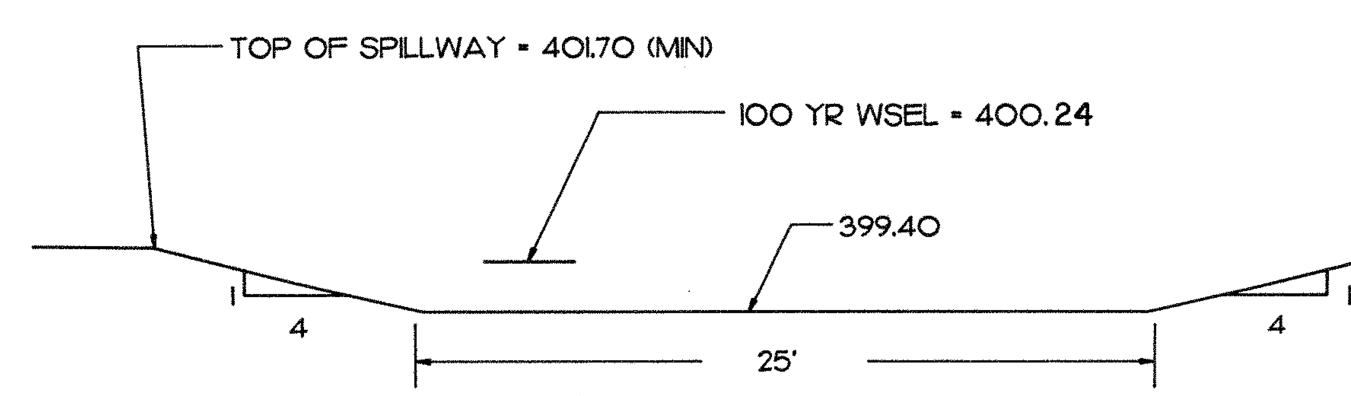
SURFACE DESCRIPTION	AREA (acres)	CN	
GRAVEL ROAD D	0.50	91	
WOODED POOR D	1.83	83	
WOODED FAIR D	0.59	79	
PASTURE GOOD D	48.28	80	
IMPERVIOUS D	0.50	98	
COMPOSITE AREA --->	51.70	80.4	(80)

::



SEDIMENTATION BASIN "A"

SCALE IN FEET (50 0 50 100)



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|18

NO SCALE

NO.	REVISION / DATE
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
CHK. BY	P. MANDEVILLE
DSN. BY	R. THOMAS
APP. BY	P. MANDEVILLE
CADD FILE:	BASIN
DATE:	6-22-92
SCALE:	1"=50'
SHEET NO.	18 of 30

Appendix C

TR-55 Calculations – Existing and Proposed

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-1A
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

Date: 12/11/2019
Units: English
Areal Units: Acres

--- 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>

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

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
Project: Gude
SubTitle: DA-1B
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

Date: 12/11/2019
Units: English
Areal Units: Acres

--- 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>

Gude
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

DA-1B
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-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)

Gude
DA-1B
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-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
Project: Gude
SubTitle: DA-2
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

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

--- 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>

DA-2

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-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

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

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
				=====	==

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WinTR-55 Current Data Description

--- Identification Data ---

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

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

--- 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>

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

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	30.15	64.06
	12.26	12.25	12.23
DA-3 PR	13.68	27.31	56.82
	12.19	12.19	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)

Gude
DA-3
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-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

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
Project: Gude
SubTitle: DA-4
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

Date: 12/13/2019
Units: English
Areal Units: Acres

--- 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>

DA-4
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-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)

Gude
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

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	78
				===	==
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	78
				====	==

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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>

EA Gude
DA-5
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-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 12.23	40.48 12.23	90.17 12.22
DA-5 PR	17.05 12.22	38.71 12.22	89.23 12.21
REACHES			
OUTLET	35.64	79.09	179.09

DA-5
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-5 EX	17.70	0.291	77	Outlet	
DA-5 PR	17.94	0.281	75	Outlet	

Total Area: 35.64 (ac)

EA

Gude
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

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
				=====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-6
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-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

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)

EA

Gude
DA-6
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-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

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

EA Gude

DA-7

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-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

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
Project: Gude
SubTitle: DA-8
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-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>

EA   Gude
DA-8
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-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

EA Gude

DA-8

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-8 EX	5.40 12.19	10.94 12.18	23.19 12.18
DA-8 PR	4.64 12.18	9.44 12.19	19.97 12.18
REACHES			
OUTLET	10.04	20.34	43.13

DA-8
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-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

DA-8
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-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
				====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-9
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

Date: 12/13/2019
Units: English
Areal Units: Acres

--- 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>

DA-9

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-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

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)

EA Gude

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>

DA-10

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-10	1.29	2.62	5.57
DA-10 PR	1.25	2.53	5.34
REACHES			
OUTLET	2.49	5.07	10.73

EA Gude
DA-10
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-10	1.29 12.21	2.62 12.21	5.57 12.20
DA-10 PR	1.25 12.17	2.53 12.17	5.34 12.16
REACHES			
OUTLET	2.49	5.07	10.73

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

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
Project:
SubTitle:
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-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

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 12.17	8.73 12.17	19.04 12.16
DA-11 PR	4.07 12.19	8.60 12.18	18.77 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
				====	==

Appendix D

Stormwater Bypass Drawing

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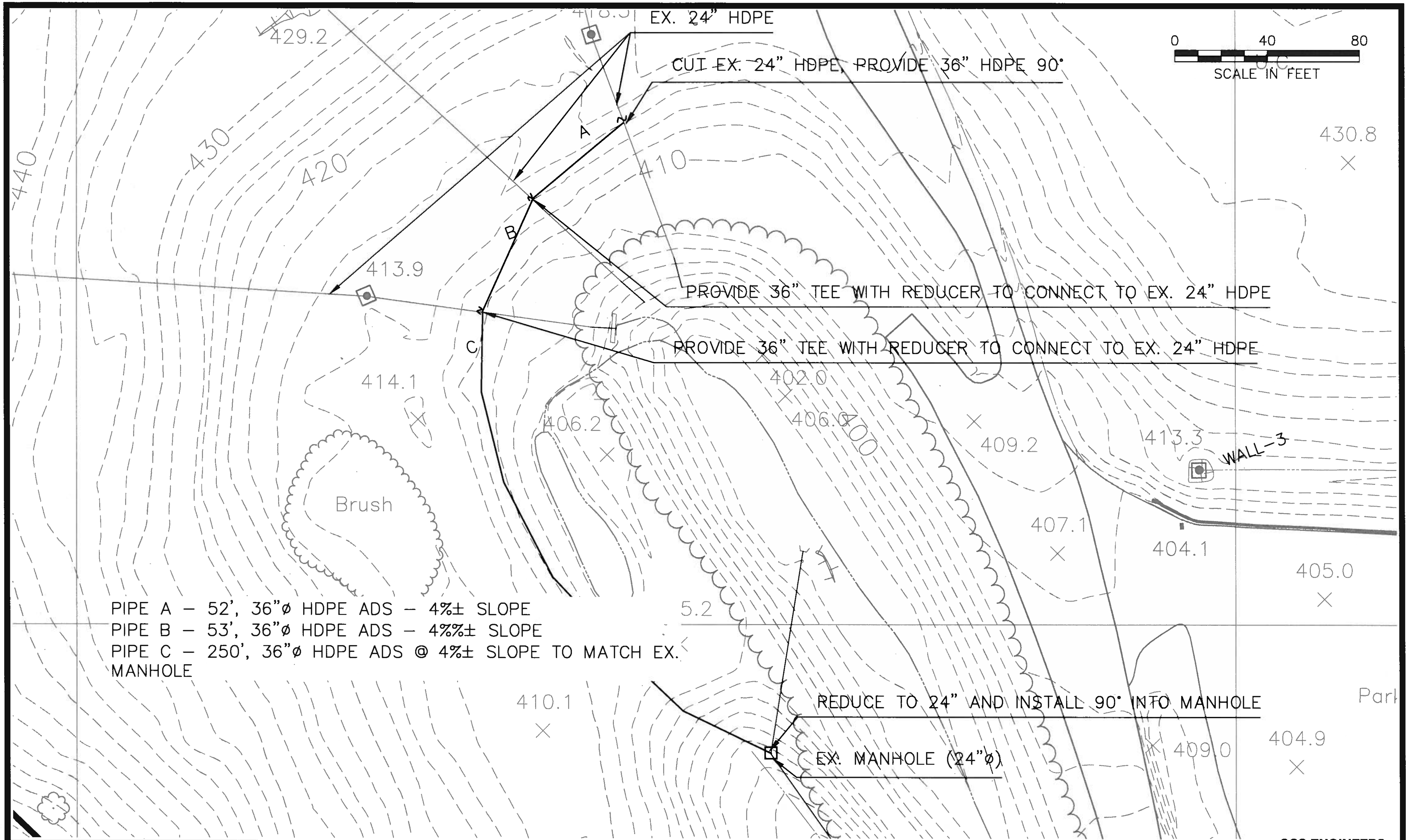
DRAWN BY: SMS DATE: 4/4/08 FILE NAME: 02203039.13\ROUGH GRADING



ROUGH GRADING STORMWATER MANAGEMENT DIVERSION

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Attachment H2

H2 – Stormwater Management Report

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Gude Landfill Remediation Design
Montgomery County, Maryland

Stormwater Management Design Report

Prepared for

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

Prepared by

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

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: 25 August 2020

July 2020
EA Project No. 15646.01

Gude Landfill Remediation Design
Montgomery County, Maryland

Stormwater Management Design Report

Prepared for

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

Prepared by

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

July 2020
EA Project No. 15646.01

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

cfs	Cubic feet per second
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
DA	Drainage Area
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
HSG	Hydrologic soil group
the Landfill	Gude Landfill
M-NCPPC	Maryland-National Capital Park and Planning Commission
MDE	Maryland Department of the Environment
NRCS	Natural Resources Conservation Service
TR-55	Technical Release 55
Q_2	2-Year peak flow
Q_{10}	10-Year peak flow
Q_{100}	100-Year peak flow

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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). This report summarizes the stormwater management and hydrology design requirements for the Gude Landfill site. The erosion and sediment control design is discussed in the *Sediment Control Report* (EA 2020), under separate cover.

1.1 SITE INFORMATION

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, Recycling and Resource Management Division (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 October 21, 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 and other existing features. 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.

Montgomery County Department of Permitting Services (DPS) has determined this project is "maintenance" activity. Due to this classification, no Environmental Site Design treatment in accordance with the *2000 Maryland Stormwater Design Manual* is required. This stormwater management report has been prepared to present the quantitative analysis associated with the remediation design.

2. STORMWATER MANAGEMENT

Montgomery County requires safe and stable conveyance of stormwater discharges at all points of discharge from the site. The site's pre-development runoff characteristics were maintained to the greatest extent possible. EA analyzed the 2-year, 10-year, and 100-year storm events for existing and proposed conditions.

The hydrologic analyses contained within this report are based upon the methods outlined in the Natural Resources Conservation Service (NRCS) TR-55 Manual, Montgomery County Government (2013; Revised 2014) Drainage Design Criteria, and the *2000 Maryland Stormwater Design Manual*. The United States Department of Agriculture Soil Conservation Service's "SCS Runoff Curve Number Method" (utilizing TR-55 Software) computations and procedures were utilized to determine the weighted runoff curve number and time of concentration for the existing conditions of the site.

2.1 SOILS ANALYSIS

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	Not applicable
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 RUNOFF CHARACTERISTICS

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

For both existing and proposed conditions, EA will assume the same land use category for the grassed areas of the Landfill. In addition, while there is no hydrologic soil group (HSG) rating for the soil within the footprint of the Landfill, SCS Engineers' analysis assumed HSG D soils. In keeping with this assumption, EA will utilize HSG D soils for the existing and proposed analyses throughout the site. HSG D is typically utilized for landfill projects where surficial soils are disturbed and compacted.

2.3 EXISTING DRAINAGE AREA ANALYSIS

The Landfill in existing condition has been divided into 13 drainage areas (DAs), shown on the existing conditions drainage area map (**Figure 2**). **Table 2** summarizes the existing condition hydrology for the Landfill. Calculations are included in **Appendix C**.

Table 2 Existing Conditions Hydrology Summary

Drainage Area	Existing					Discharge Point
	Area (acres)	Runoff Curve Number	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)	
DA-1A	36.95	80	39.86	81.52	173.52	Pond 3 Bypass
DA-1B	16.07	81	21.64	43.20	90.22	Pond 3
DA-2	28.63	80	35.82	72.89	155.01	Pond 1
DA-3	11.90	80	14.99	30.51	64.81	Sheet Flow
DA-4	9.06	78	8.88	18.91	41.56	Pond 2
DA-5	17.47	78	20.41	43.24	94.76	M-NCPPC Pond
DA-6	15.65	77	19.81	42.70	94.54	Southlawn Branch
DA-7	5.78	78	8.02	16.92	36.76	Southlawn Branch
DA-8	3.88	79	5.03	10.43	22.44	Southlawn Branch
DA-9	8.10	78	9.90	20.94	45.84	Southlawn Branch
DA-10	1.53	80	1.85	3.77	8.00	Southlawn Branch
DA-11	0.39	88	1.00	1.76	3.31	Southlawn Branch
DA-12	0.47	79	0.71	1.47	3.14	Southlawn Branch
Total	**155.88**		**187.92**	**388.26**	**833.91**	

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 36.95-acre area while DA-1B is 16.07 acres. These drainage areas are located centrally on the site. Both DA-1A and DA-1B drain toward Pond 3, located on the west 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 28.63-acre area on the western portion of the Landfill. Drainage from DA-2 is conveyed, via overland flow and an existing stormdrain system, to Pond 1, which is located at the base of the Landfill in the southwest 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 11.90-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 9.06-acre area located at the northern point 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 17.47-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 15.65-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 5.78-acre area on the southeast portion of the Landfill. Discharge from DA-7 is conveyed to an existing culvert and ultimately discharges into 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 an existing stormdrain system and ultimately discharges into Southlawn Branch.

DA- 9

DA- 9 is located at the southern portion of the Landfill and receives drainage from approximately 8.10 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 discharges into Southlawn Branch.

DA-10

DA-10 receives drainage from an approximate 1.53-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 to an existing culvert and ultimately discharges offsite to Southlawn Branch.

DA-11

DA-11 receives drainage from an approximate 0.39-acre area at the entrance road to the Landfill. Drainage from DA-11 is conveyed via overland flow offsite and ultimately discharges into Southlawn Branch.

DA-12

DA-12 receives drainage from an approximate 0.47-acre area on the southern portion of the Landfill. The majority of this drainage area consists of the Landfill side slopes. Discharge from DA-12 is conveyed to an existing roadside ditch and discharges offsite to the west and ultimately to Southlawn Branch.

2.4 PROPOSED DRAINAGE AREA ANALYSIS

Drainage areas were delineated for the proposed grading plan and are identified on the proposed conditions drainage area map (**Figure 3**). Existing drainage patterns were maintained to the greatest extent possible in the development of the proposed grading plans. However, in order to maintain the project's phasing to comply with erosion and sediment control requirements and the project's overall cut/fill balancing, there are adjustments to the drainage divides. **Table 3** summarizes the changes in peak discharges from existing conditions to proposed conditions at the Landfill and provides a sitewide discharge total for each storm event. The proposed sitewide discharges for the project is less than the sitewide discharges for each of the evaluated storm events.

Table 3 Hydrology Comparison Summary

Drainage Area	Area (acres)	Existing Q_2 (cfs)	Existing Q_{10} (cfs)	Existing Q_{100} (cfs)	Proposed Q_2 (cfs)	Proposed Q_{10} (cfs)	Proposed Q_{100} (cfs)	Discharge Point
DA-1A	36.95	39.86	81.52	173.52	36.99	75.59	161.02	Pond 3 Bypass – Southlawn Branch
DA-1B	16.07	21.64	43.2	90.22	36.73	73.58	153.87	Pond 3 – Southlawn Branch
DA-2	28.63	35.82	72.89	155.01	23.83	48.63	103.62	Pond 1
DA-3	11.90	14.99	30.51	64.81	12.81	25.62	53.63	Point Discharge/Sheet Flow
DA-4	9.06	8.88	18.91	41.56	11	23.18	50.48	Pond 2
DA-5	17.48	20.41	43.24	94.76	16.07	34.24	75.38	M-NCPPC Pond
DA-6	15.65	19.81	42.7	94.54	20.46	44.01	97.24	Southlawn Branch
DA-7	5.78	8.02	16.92	36.76	8.48	17.84	38.72	Southlawn Branch
DA-8	3.88	5.03	10.43	22.44	6.72	13.56	28.53	Southlawn Branch
DA-9	8.10	9.9	20.94	45.84	11.16	23.14	49.63	Southlawn Branch
DA-10	1.53	1.85	3.77	8	1.24	2.5	5.28	Southlawn Branch
DA-11	0.39	1	1.76	3.31	0.93	1.66	3.17	Southlawn Branch
DA-12	0.46	0.71	1.47	3.14	0.71	1.47	3.14	Southlawn Branch
Total	**155.88**	**187.92**	**388.26**	**833.91**	**187.13**	**385.02**	**823.71**	

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 (36.95 acres) and DA 1-B (16.07 acres) will eventually drain to an existing stormdrain that conveys discharge to Southlawn Branch. DA-1A is conveyed in proposed swales to the stormdrain system. DA-1B drains to Pond 3 and then into the stormdrain system. Although the peak discharge from DA-1B increases in proposed conditions, the stormdrain system maintains safe conveyance of the 10-year storm. Additional discussion of the stormdrain is included in Section 3.2.

DA-2

DA-2 (28.63 acres) discharges to the banks of 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 proposed design reduces DA-2 area, which reduces the onsite area draining to Pond 1.

DA-3

DA-3 decreases from 11.90 to 9.98 acres. The majority of the runoff from DA-3 is conveyed by one of the proposed conveyance swales onsite to a low point, and then discharges via proposed culverts. The remainder of the area discharges by sheet flow to the northwest.

DA-4

DA-4 decreases from 9.06 to 8.05 acres. 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 decreases from 17.47 to 17.39 acres. Peak discharges decrease from existing conditions.

DA-6

DA-6 receives drainage from an approximate 15.65-acre area on the east portion of the Landfill. Discharge from DA-6 is conveyed to the south and ultimately Southlawn Branch. There is a slight increase in discharge given the steep slopes of the site.

DA-7

DA-7 increases from a 5.78-acre area in existing condition to a 5.8-acre area in proposed conditions, resulting in a slight increase in peak discharge.

DA-8

DA-8 increases from 3.88 acres in existing condition to 4.06 acres in proposed conditions, resulting in a slight increase in peak discharge.

DA-9

DA-9 increases from 8.10 acres in existing condition to 8.51 acres in proposed conditions, resulting in a slight increase in peak discharge.

DA-10

DA-10 decreases from 1.53 to 0.84 acre. Peak discharges decrease from existing conditions.

DA-11

DA-11 decreases from 0.39 to 0.38 acre, resulting in peak discharges decreasing from existing conditions.

DA-12

DA-12 areas and peak discharges remained the same in existing and proposed conditions.

2.5 CONCLUSIONS

Based on the results presented in **Table 3**, peak discharge rates increase slightly in several of the drainage areas largely due to the adjustments to the drainage areas between existing and proposed conditions. However, the overall site provides an overall decrease of runoff after construction completion. For DA-1A and DA-1B, the receiving stormdrain has capacity to handle the increase in flow for the proposed condition and will provide safe conveyance of the 10-year storm based on DPS requirements.

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3. STORM DRAINAGE

3.1 CONVEYANCE SWALES

Drainage on the upper surface of the Landfill is conveyed primarily by a network of open channel swales. Design standards for the conveyance swales were based on the Montgomery County Drainage Design Criteria dated June 10, 2014. The swales were designed to convey the 10-year peak discharge while providing the minimum freeboard of 0.5 foot from the design storm flow depth to the top of the channel.

Several of the swales convey drainage to small stormdrain networks along the perimeter of the Landfill and tie into existing stormdrains. The drainage from the remaining swales will be conveyed by benches and down chutes.

Swales will be lined with turf reinforcement materials to avoid erosion issues. Where swales intersect their point of outfalling riprap outlet protection or gabion outlet protection will be provided to prevent erosion at the transition points. The benches and downchutes will also be protected from erosive impacts as necessary.

Table 4 summarizes the 10-year peak discharges and the flow depth in the swales. TR-55 was used to determine the 10-year storm flows in the conveyance swale. Hydraflow was used to determine the flow depth for the 10-year design storm. Calculations are provided in **Appendix E.**

Table 4 Conveyance Swale Summary

Swale	Q_{10} (cfs)	Depth (ft)
1	13.22	0.73
2	4.56	0.26
3	22.82	0.77
4	18.51	0.30
4A	3.86	0.22
5	24.05	0.59
6	2.07	0.17
7	0.46	0.05
8	39.95	0.86
9A	4.87	0.29
9	7.16	0.36
10	92.57	1.16
11	6.55	0.28
12	9.54	0.35
13	41.10	0.74
14A	3.24	0.23
14B	3.32	0.19
14	6.86	0.35
15	31.65	0.64
16	27.50	0.64
17	30.90	0.84
18	2.63	0.24
19	0.54	0.10

3.2 STORMDRAIN SYSTEMS

There are three separate, proposed stormdrain systems location on the site. The first system ties into the existing 60-inch stormdrain that drains to Pond 1 on the southwestern edge of the site. The second and third stormdrain systems collects runoff from the north and east of Pond 3.

All of the proposed inlets are located within conveyance swales and are in a sumped condition. Montgomery County Type J inlets will be utilized throughout except for Inlet 2. Inlet 2 will be an open yard inlet.

The NRCS (TR-55) method was used to determine the 10-year storm flows that enter the stormdrain systems. The Design Spreadsheets in Appendix D of the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria were utilized to summarize the stormdrain system analysis and calculate the velocity in the storm drainpipe networks, based on size and slope of the pipes.

Design standards for inlets, piping material, piping alignment, and piping slope and depth are based on the Montgomery County Drainage Design Criteria dated 10 June 2014:

- Preferred piping materials consist of reinforced concrete pipe.
- Minimum allowable pipe size of 15 in.
- Minimum slope is 0.5 percent, with preferred minimum slope of 1 percent.
- One foot minimum cover over the outside of the pipe.
- All closed systems shall be designed so that the 10-year hydraulic grade line is no higher than 1 foot above the crown of the pipe and at least 1 foot below the top of any inlet grate or manhole cover.

Supporting calculations are included in **Appendix E**.

DA-1A and DA-1B both drain to an existing stormdrain system that conveys discharge to Southlawn Branch. DA-1A is conveyed in proposed swales, which then tie into the stormdrain system. DA-1B drains to Pond 3 and then into the stormdrain system. Although the peak discharge from DA-1B increases in proposed conditions, the stormdrain system maintains stable conveyance of the 10-year storm.

3.3 CULVERTS

There are seven culverts proposed throughout the site. The proposed culverts convey swale flow under the site access roads.

TR-55 was used to determine the 10-year storm flows in the conveyance swales draining to the culverts. HY-8 was used to design each culvert crossing. A 3.25-foot-wide by 1.5-foot-high, double-span box culvert is proposed at each access road crossing. The Design Sheet in Appendix D of the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria was utilized to summarize the HY-8 analysis for each the culverts.

Supporting calculations are included in **Appendix E**.

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4. EROSION AND SEDIMENT CONTROL

The erosion and sediment control design will include a phased construction approach. Grading will be limited to 20-acre areas based on the limit imposed by the *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*. Phase boundaries will consider the proposed drainage patterns. Existing Pond 3 is proposed to be converted to a temporary sediment basin during construction and decommissioned after construction is completed. Further discussion is provided in the *Sediment Control Report* (EA 2020), under separate cover.

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5. POND 3 / SEDIMENT BASIN NO. 1 FINAL CONDITIONS

As previously stated, existing Pond No. 3 will be expanded and converted to Sediment Basin No. 1 during Phase S-IV of the project and will be utilized through the remainder of the subgrade phases and through final grading. As a last step in construction, Sediment Basin No. 1 will be decommissioned by removing the dewatering device, riser structure, and outfall pipe. In addition, a portion of the constructed embankment will be removed and replaced with a 30-ft wide channel to allow stormwater runoff to flow out of the decommissioned sediment basin to the downstream inlet structures and ultimately offsite.

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6. REFERENCES

EA Engineering, Science, and Technology, Inc., PBC (EA). 2020. *Sediment Control Report*.

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Figures

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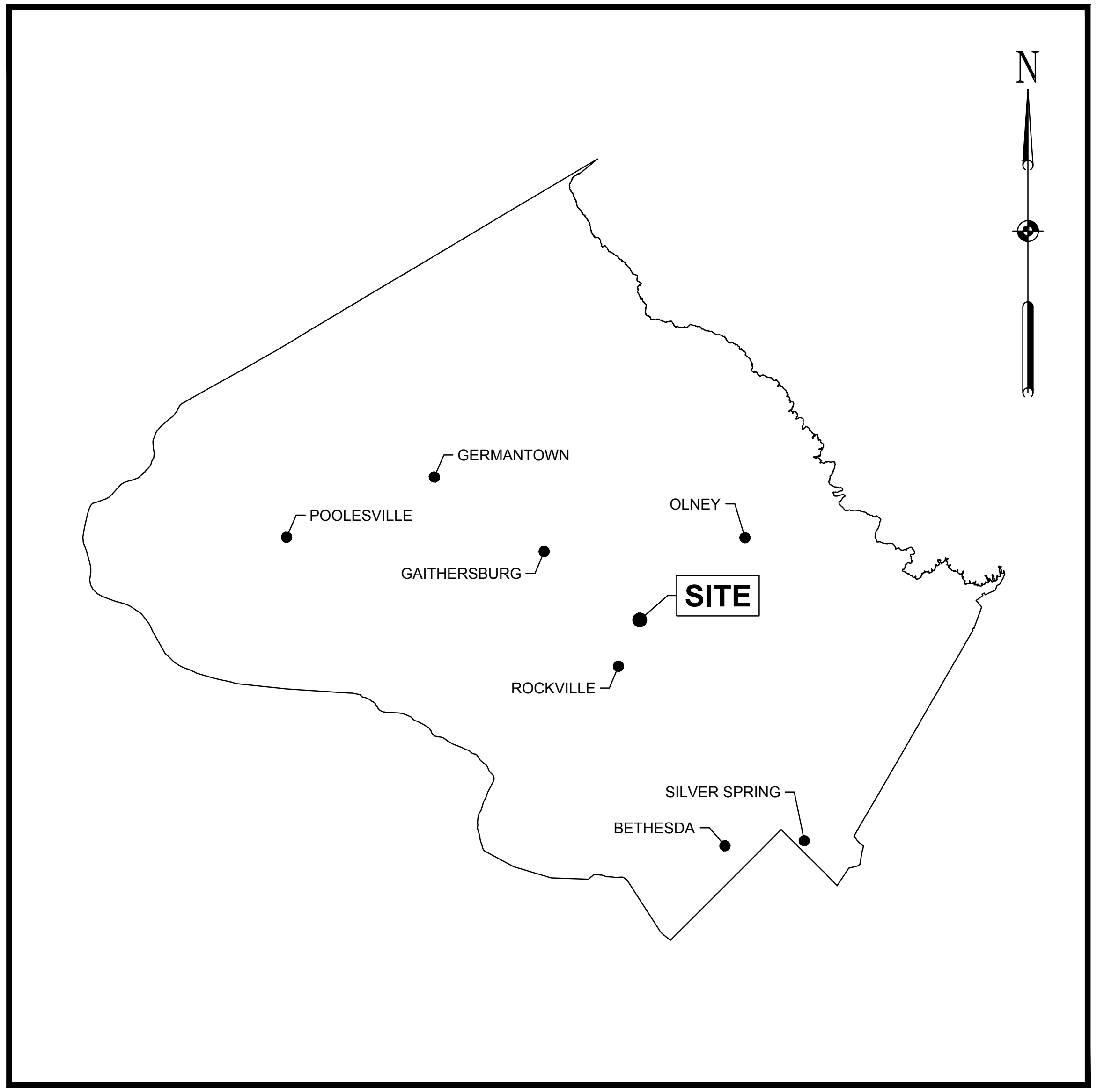
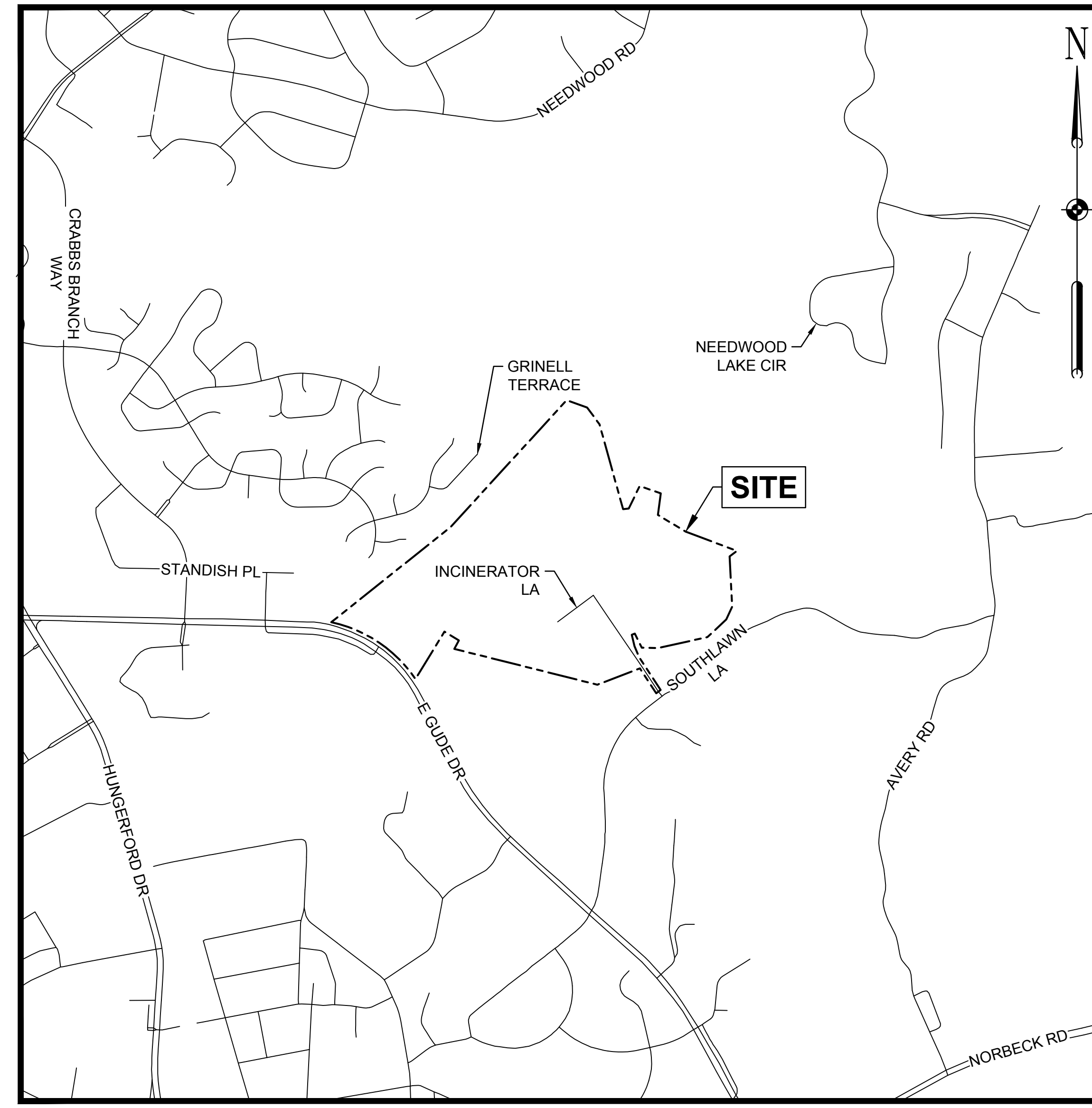


LOCATION MAP - MONTGOMERY COUNTY, MARYLAND
NOT TO SCALE



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:	DESIGNED BY:	DRAWN BY:	FIGURE:
1564601	KEF/SMB	SMB	1
DATE:	CHECKED BY:	PROJECT MGR.:	SHEET NUMBER:
DECEMBER 2019	LJO	MJG	1 OF 1

GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
MONTGOMERY COUNTY, MARYLAND

FIGURE 1 - LOCATION AND VICINITY MAP

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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	0.012	0.295
	B TO C	SHALLOW CONCENTRATED	UNPAVED	369	0.038	0.033
	C TO D	CHANNEL		900	0.030	0.035
	E TO F			418	0.030	0.008
1B	A TO B	SHEET	0.24	100	0.015	0.269
	B TO C	SHALLOW CONCENTRATED	UNPAVED	300	0.025	0.033
	C TO D	CHANNEL		1260	0.030	0.021
	D TO E			169	0.129	0.002
2	A TO B	SHEET	0.24	100	0.035	0.192
	B TO C	SHALLOW CONCENTRATED	UNPAVED	752	0.020	0.092
	C TO D	CHANNEL		861	0.010	0.058
	D TO E			1680	0.016	0.044
3	A TO B	SHEET FLOW	0.24	100	0.240	0.190
	B TO C	SHALLOW CONCENTRATED	UNPAVED	794	0.050	0.094
	C TO D	CHANNEL		172	0.030	0.003
	D TO E			517	0.030	0.015
4	A TO B	SHEET FLOW	0.24	100	0.089	0.132
	B TO C	SHALLOW CONCENTRATED	UNPAVED	952	0.110	0.049
5	A TO B	SHEET FLOW	0.24	100	0.044	0.175
	B TO C	SHALLOW CONCENTRATED	UNPAVED	35	0.066	0.002
	C TO D	CHANNEL		383	0.005	0.235
	D TO E			961	0.216	0.019
6	A TO B	SHEET FLOW	0.24	100	0.063	0.152
	B TO C	SHALLOW CONCENTRATED	UNPAVED	616	0.238	0.022
7	A TO B	SHEET FLOW	0.24	100	0.095	0.129
	B TO C	SHALLOW CONCENTRATED	UNPAVED	550	0.246	0.019
	C TO D	CHANNEL		120	0.410	0.002
8	A TO B	SHEET FLOW	0.24	100	0.124	0.116
	B TO C	SHALLOW CONCENTRATED	UNPAVED	434	0.181	0.018
	C TO D	CHANNEL		40	0.013	0.005
	D TO E			230	0.068	0.002
9	A TO B	SHEET FLOW	0.24	100	0.029	0.207
	B TO C	SHALLOW CONCENTRATED	UNPAVED	586	0.222	0.021
10	A TO B	SHEET FLOW	0.24	100	0.062	0.153
	B TO C	SHALLOW CONCENTRATED	UNPAVED	30	0.100	0.002
	C TO D	CHANNEL		249	0.091	0.038
	D TO E			31	0.023	0.002
11	A TO B	SHEET FLOW	0.24	100	0.011	0.012
	B TO C	SHALLOW CONCENTRATED	UNPAVED	128	0.025	0.005
12	A TO B	SHEET	0.24	100	0.083	0.136
	B TO C	SHALLOW CONCENTRATED	UNPAVED	124	0.218	0.005
	C TO D	CHANNEL		115	0.138	0.014

DRAINAGE AREA	PEAK FLOW (CFS)		
ID	2-YR STORM	10-YR STORM	100-YR STORM
1A	36.99	75.59	161.02
1B	36.73	73.58	153.87
2	23.83	48.63	103.62
3	12.81	25.62	53.63
4	11.00	23.18	50.48
5	16.07	34.24	75.38
6	20.46	44.01	97.24
7	8.48	17.84	38.72
8	6.72	13.56	28.53
9	11.16	23.14	49.63
10	1.24	2.50	5.28
11	0.93	1.66	3.17
12	0.71	1.47	3.14

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

DRAINAGE AREA MAP - PROPOSED CONDITIONS

SC/SWM SHEET 27 OF 35

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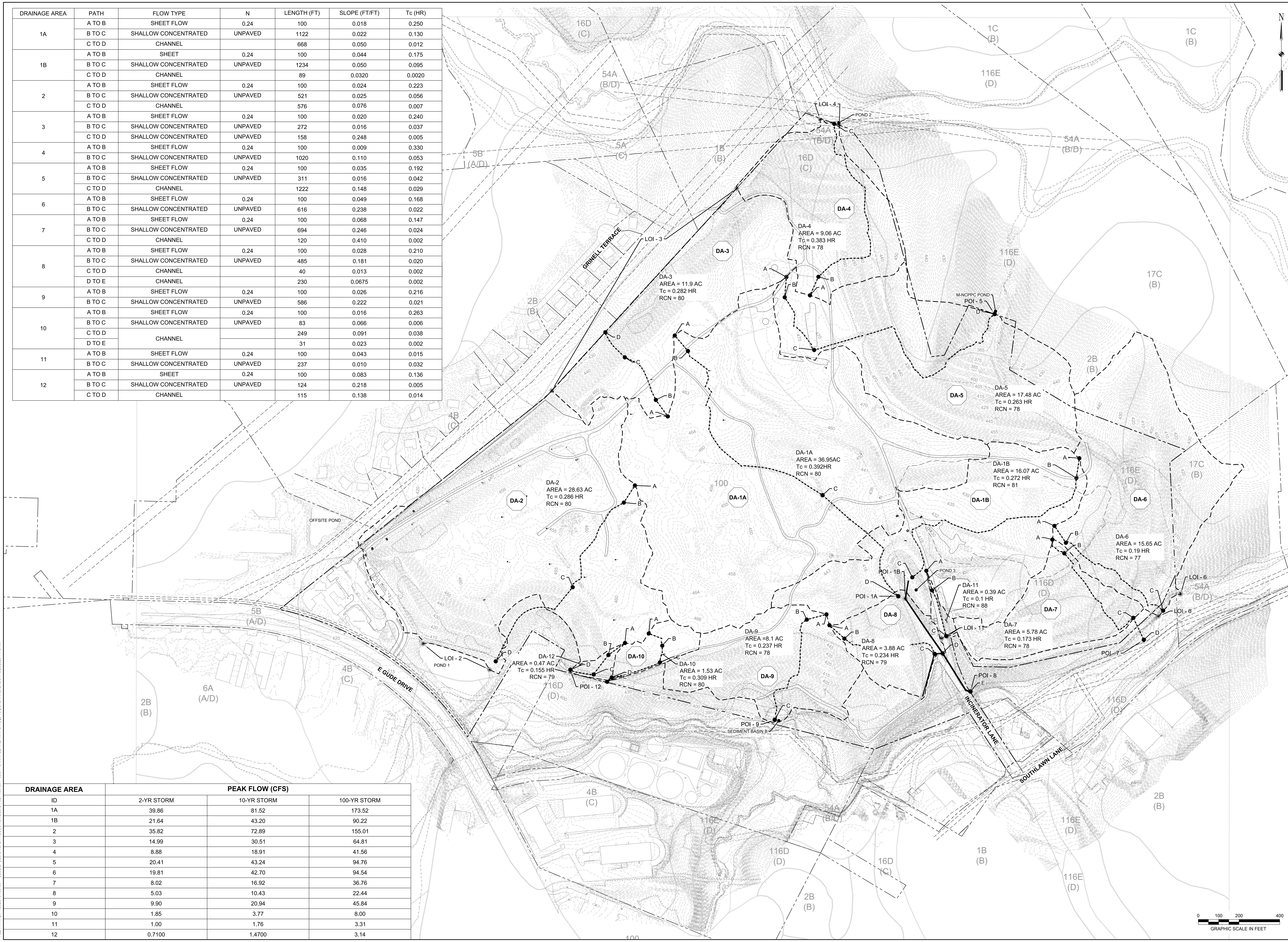
DATE: JANUARY 2020

PROJECT NUMBER: 1564601

C-168

60% REVISED DESIGN PLANS - NOT FOR CONSTRUCTION

DRAINAGE AREA	PATH	FLOW TYPE	N	LENGTH (FT)	SLOPE (FT/FT)	Tc (HR)
1A	A TO B	SHEET FLOW	0.24	100	0.018	0.250
	B TO C	SHALLOW CONCENTRATED	UNPAVED	1122	0.022	0.130
	C TO D	CHANNEL		668	0.050	0.012
1B	A TO B	SHEET	0.24	100	0.044	0.175
	B TO C	SHALLOW CONCENTRATED	UNPAVED	1234	0.050	0.095
	C TO D	CHANNEL		89	0.0320	0.0020
2	A TO B	SHEET FLOW	0.24	100	0.024	0.223
	B TO C	SHALLOW CONCENTRATED	UNPAVED	521	0.025	0.056
	C TO D	CHANNEL		576	0.076	0.007
3	A TO B	SHEET FLOW	0.24	100	0.020	0.240
	B TO C	SHALLOW CONCENTRATED	UNPAVED	272	0.016	0.037
	C TO D	SHALLOW CONCENTRATED	UNPAVED	158	0.248	0.005
4	A TO B	SHEET FLOW	0.24	100	0.009	0.330
	B TO C	SHALLOW CONCENTRATED	UNPAVED	1020	0.110	0.053
5	A TO B	SHEET FLOW	0.24	100	0.035	0.192
	B TO C	SHALLOW CONCENTRATED	UNPAVED	311	0.016	0.042
	C TO D	CHANNEL		1222	0.148	0.029
6	A TO B	SHEET FLOW	0.24	100	0.049	0.168
	B TO C	SHALLOW CONCENTRATED	UNPAVED	616	0.238	0.022
7	A TO B	SHEET FLOW	0.24	100	0.068	0.147
	B TO C	SHALLOW CONCENTRATED	UNPAVED	694	0.246	0.024
	C TO D	CHANNEL		120	0.410	0.002
8	A TO B	SHEET FLOW	0.24	100	0.028	0.210
	B TO C	SHALLOW CONCENTRATED	UNPAVED	485	0.181	0.020
	C TO D	CHANNEL		40	0.013	0.002
	D TO E	CHANNEL		230	0.0675	0.002
9	A TO B	SHEET FLOW	0.24	100	0.026	0.216
	B TO C	SHALLOW CONCENTRATED	UNPAVED	586	0.222	0.021
10	A TO B	SHEET FLOW	0.24	100	0.016	0.263
	B TO C	SHALLOW CONCENTRATED	UNPAVED	83	0.066	0.006
	C TO D	CHANNEL		249	0.091	0.038
	D TO E			31	0.023	0.002
11	A TO B	SHEET FLOW	0.24	100	0.043	0.015
	B TO C	SHALLOW CONCENTRATED	UNPAVED	237	0.010	0.032
12	A TO B	SHEET	0.24	100	0.083	0.136
	B TO C	SHALLOW CONCENTRATED	UNPAVED	124	0.218	0.005
	C TO D	CHANNEL		115	0.138	0.014



DRAINAGE AREA	PEAK FLOW (CFS)		
ID	2-YR STORM	10-YR STORM	100-YR STORM
1A	39.86	81.52	173.52
1B	21.64	43.20	90.22
2	35.82	72.89	155.01
3	14.99	30.51	64.81
4	8.88	18.91	41.56
5	20.41	43.24	94.76
6	19.81	42.70	94.54
7	8.02	16.92	36.76
8	5.03	10.43	22.44
9	9.90	20.94	45.84
10	1.85	3.77	8.00
11	1.00	1.76	3.31
12	0.7100	1.4700	3.14

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

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NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
MONTGOMERY COUNTY DEPARTMENT OF ENVIRONMENTAL PROTECTION
MONTGOMERY COUNTY, MARYLAND

DRAINAGE AREA MAP - EXISTING CONDITIONS
SC/SWM SHEET 26 OF 35

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DATE: JANUARY 2020
PROJECT NUMBER: 1564601

C-167
SHEET: 70 OF 109

60% REVISED DESIGN PLANS - NOT FOR CONSTRUCTION

Appendix A

Web Soil Survey

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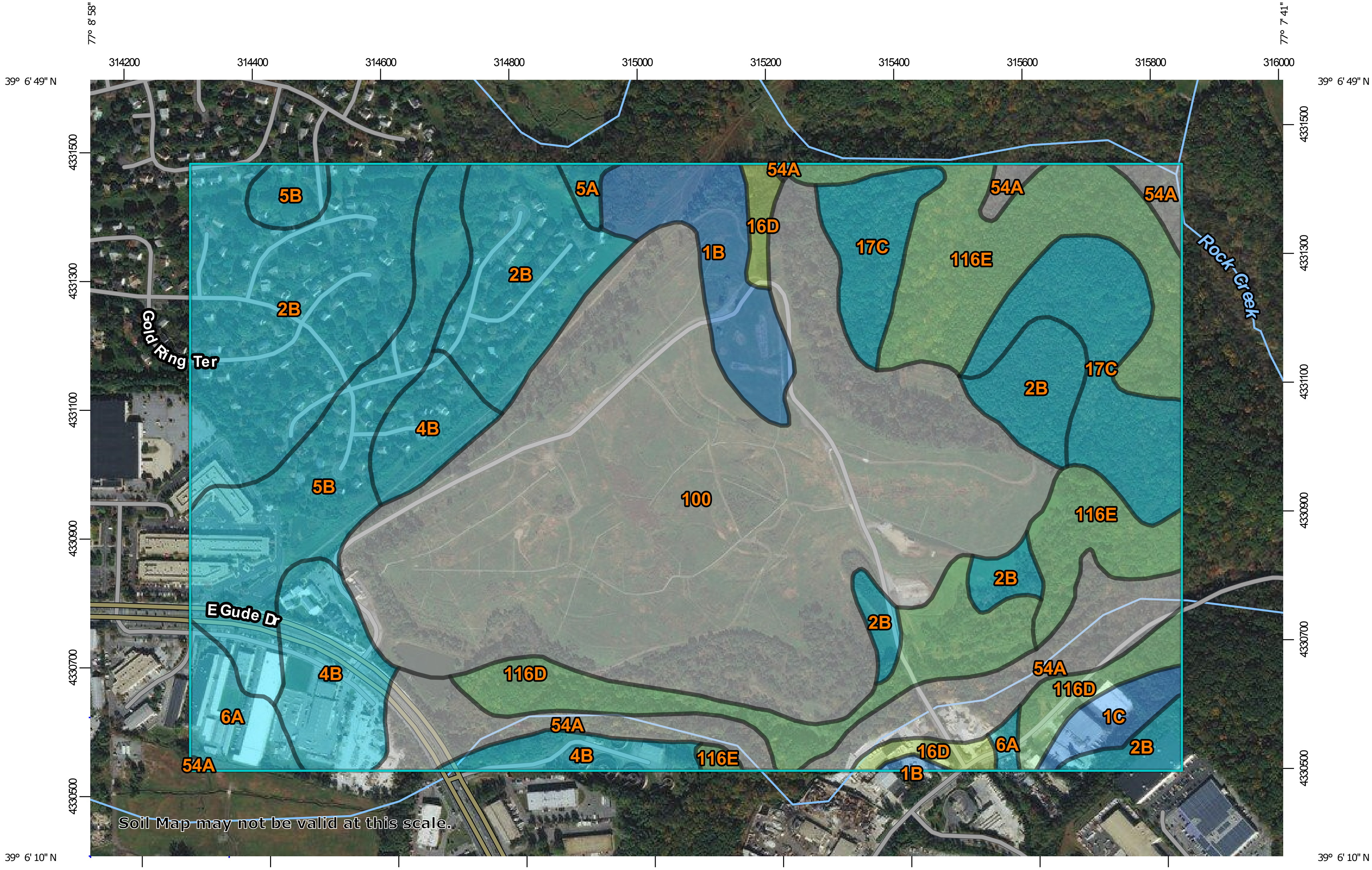
K Factor, Whole Soil—Montgomery County, Maryland



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

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

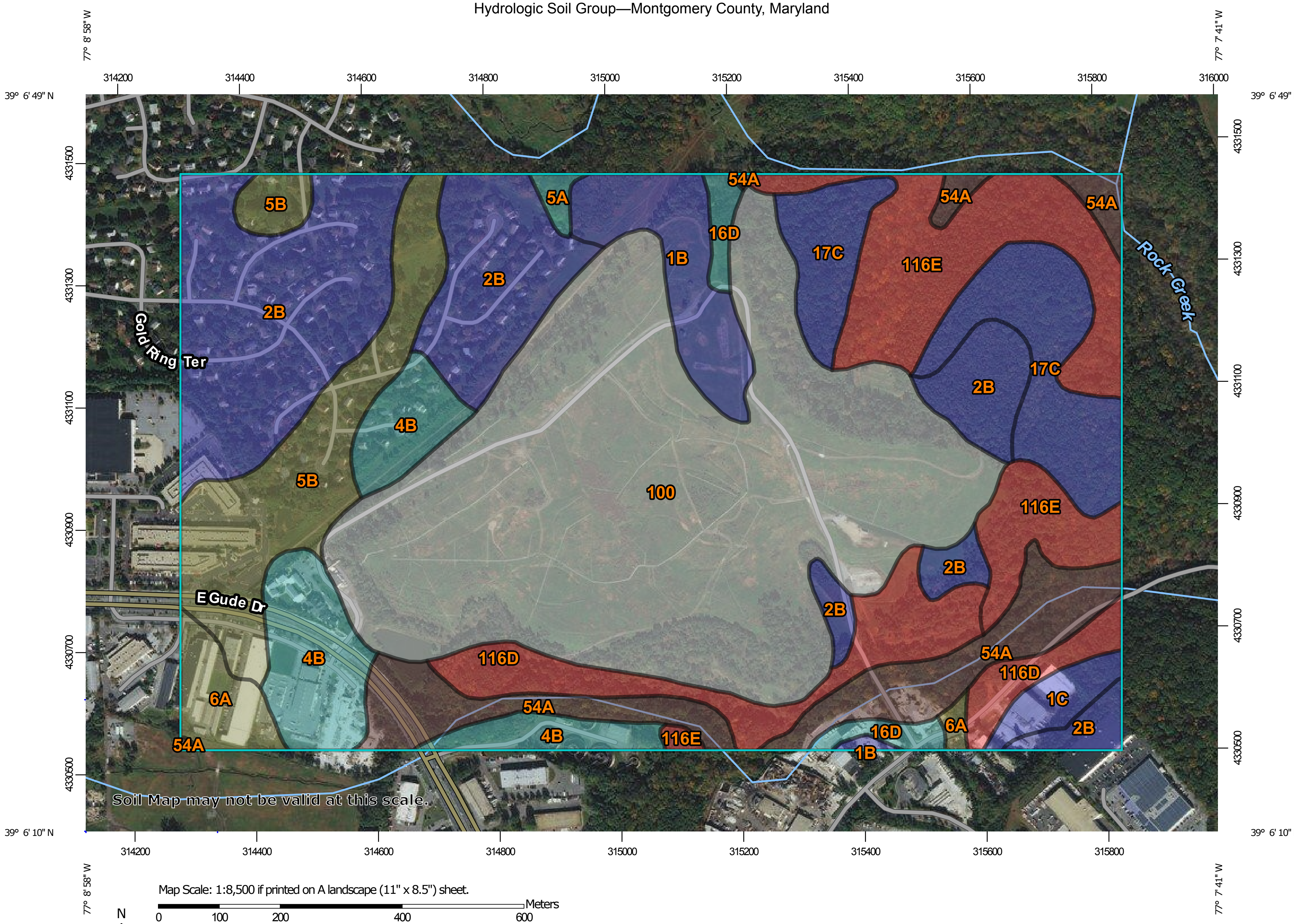
Aggregation Method: Dominant Condition

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

Meters: 0, 100, 200, 400, 600

Feet: 0, 400, 800, 1600, 2400

N

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
- 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.

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

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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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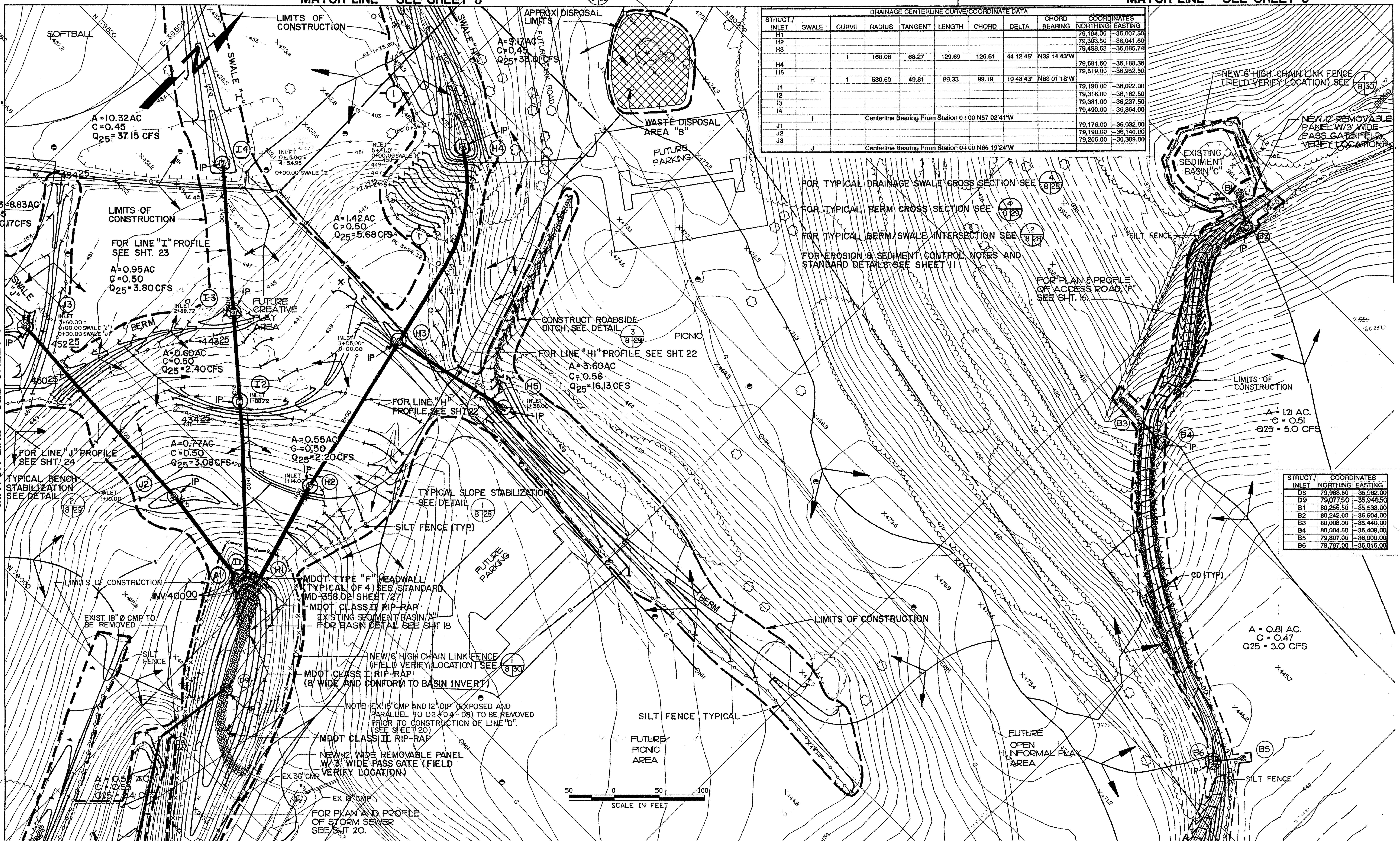


DRAINAGE CENTERLINE CURVE/COORDINATE DATA										
STRUCT./ INLET	SWALE	CURVE	RADIUS	TANGENT	LENGTH	CHORD	DELTA	CHORD BEARING	COORDINATES NORTHING	EASTING
H1									79,194.00	–36,007.50
H2									79,303.50	–36,041.50
H3									79,488.63	–36,085.74
		1	168.08	68.27	129.69	126.51	44 12'45"	N32 14'43"W		
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

STATE OF MARYLAND — PROFESSIONAL ENGINEER

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. 02190136 | DSN. BY: R. THOMAS | DWN. BY: E. CAZENAS | CHK. BY: P. MANDEVILLE | Q/A RVW BY: | APP. BY: P. MANDEVILLE

CADD FILE: SHT6

DATE: 6-22-92

SCALE: 1" = 50'

SHEET NO. 8 of 30

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

$$IA = (sq.rt(Area1) + ((Ei-E1)/(E2-E1))*(sq.rt(Area2)-sq.rt(Area1)))^2$$

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

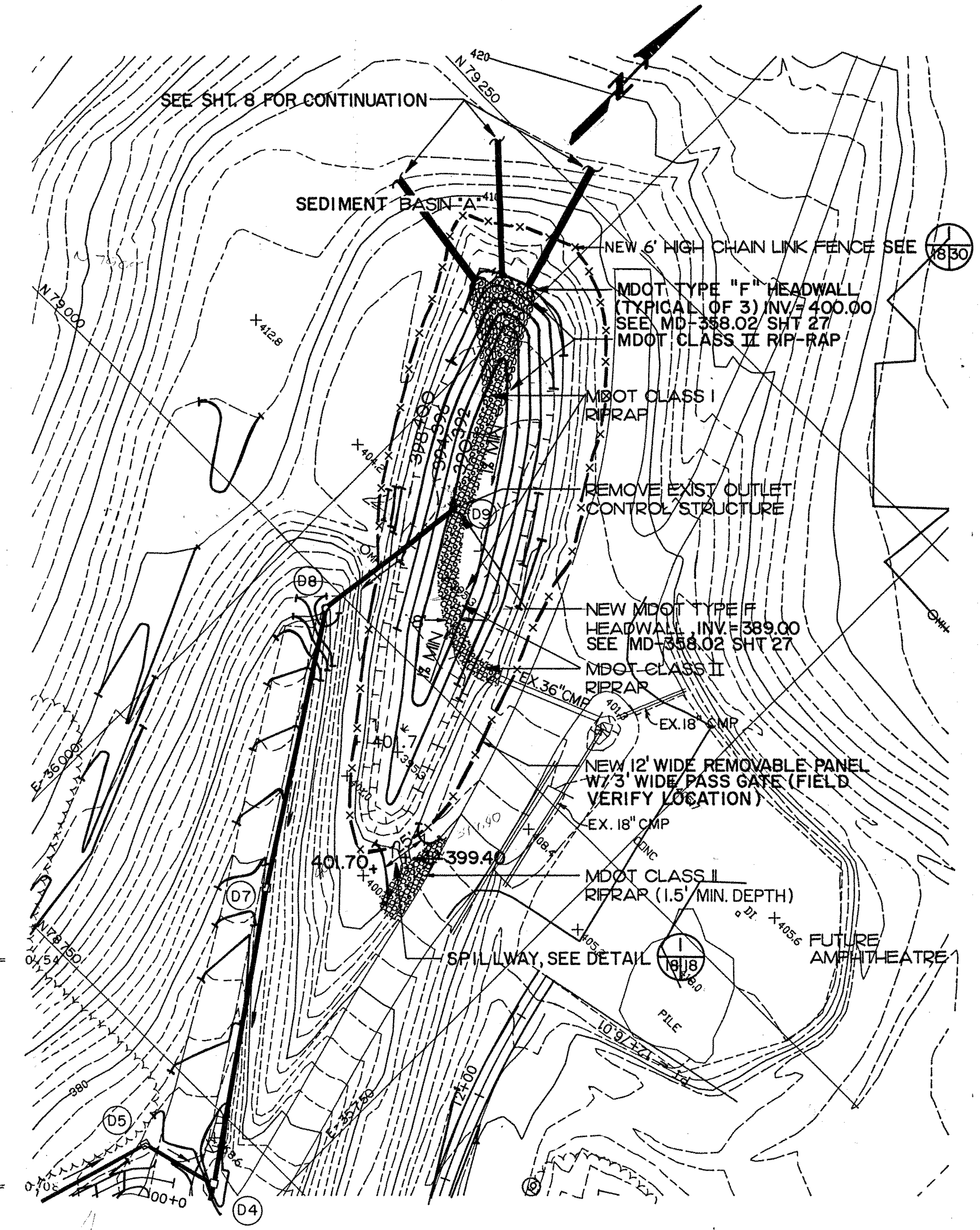
TOTAL TIME (hrs) 0.66

GUDE LANDFILL SEDIMENTATION BASIN A
DRAINAGE AREA 7 POST DEVELOPED CONDITIONS

RUNOFF CURVE NUMBER DATA

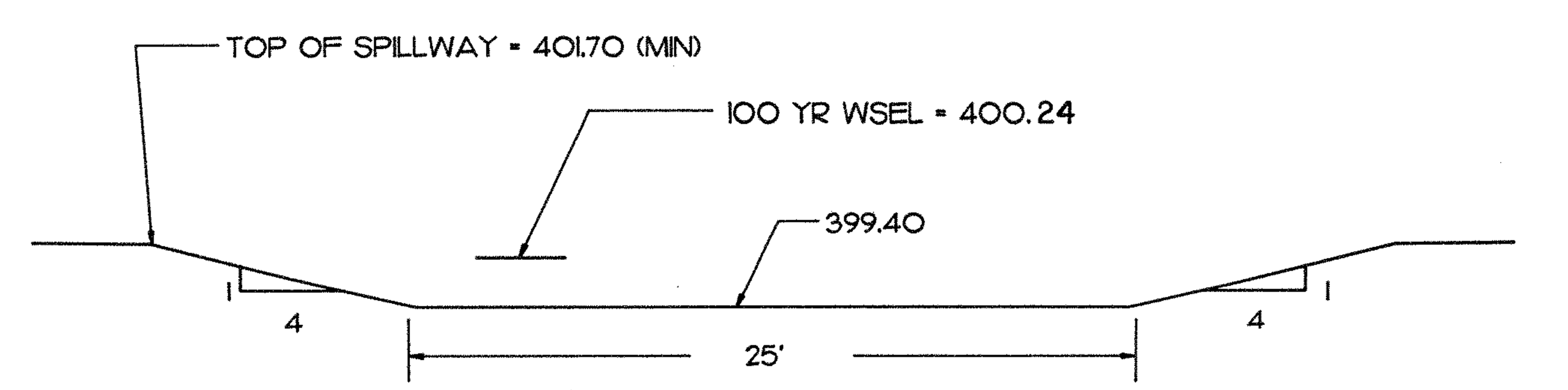
Composite Area: DA7

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

NO. | REVISION | DATE

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 | APP. BY: P. MANDEVILLE

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

Appendix C

TR-55 Calculations – Existing and Proposed

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-1A
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/18/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-1A EX		Outlet	36.95	80	.392
DA-1A PR		Outlet	33.36	80	.371

Total area: 70.31 (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-1A
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-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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-1A EX	39.86	81.52	117.24	173.52
DA-1A PR	36.99	75.59	108.49	161.02
REACHES				
OUTLET	76.71	156.78	225.57	334.11

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-1A EX	39.86	81.52	117.24	173.52
	12.29	12.27	12.28	12.27
DA-1A PR	36.99	75.59	108.49	161.02
	12.27	12.26	12.28	12.26
REACHES				
OUTLET	76.71	156.78	225.57	334.11

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-1A EX	36.95	0.392	80	Outlet	
DA-1A PR	33.36	0.371	80	Outlet	

Total Area: 70.31 (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	0.0180	0.240				0.250
SHALLOW	1122	0.0220	0.050				0.130
CHANNEL	668	0.0500	0.013	3.12	6.28	15.463	0.012
					Time of Concentration		.392
DA-1A PR							
SHEET	100	0.0120	0.240				0.295
SHALLOW	369	0.0380	0.050				0.033
CHANNEL	900	0.0200	0.030	14.04	13.90	7.143	0.035
CHANNEL	418	0.0600	0.030	20.12	15.83	14.514	0.008
					Time of Concentration		.371

EA Gude

DA-1A

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-1A EX	Dirt (w/ right-of-way)		D	1.13	89
	Pasture, grassland or range	(good)	D	35.78	80
	Woods	(good)	D	.04	77
	Total Area / Weighted Curve Number			36.95	80
				=====	==
DA-1A PR	Gravel (w/ right-of-way)		D	1.5	91
	Pasture, grassland or range	(good)	D	31.86	80
	Total Area / Weighted Curve Number			33.36	80
				=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User:	EA	Date:	3/18/2020
Project:	Gude	Units:	English
SubTitle:	DA-1B	Areal Units:	Acres
State:	Maryland		
County:	Montgomery NOAA-C		

Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-1B EX		Outlet	16.07	81	.272
DA-1B PR		Outlet	29.57	81	.325

Total area: 45.64 (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>

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-1B EX	21.64	43.20	61.55	90.22
DA-1B PR	36.73	73.58	104.61	153.87
REACHES				
OUTLET	57.98	116.04	165.33	242.51

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-1B EX	21.64	43.20	61.55	90.22
	12.22	12.21	12.21	12.21
DA-1B PR	36.73	73.58	104.61	153.87
	12.25	12.24	12.23	12.23
REACHES				
OUTLET	57.98	116.04	165.33	242.51

DA-1B

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-1B EX	16.07	0.272	81	Outlet	
DA-1B PR	29.57	0.325	81	Outlet	

Total Area: 45.64 (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	0.0440	0.240				0.175
SHALLOW	1234	0.0500	0.050				0.095
CHANNEL	89	0.0320	0.013	4.99	7.85	12.361	0.002
						Time of Concentration	.272
DA-1B PR							
SHEET	100	0.0150	0.240				0.269
SHALLOW	300	0.0250	0.050				0.033
CHANNEL	1260	0.0300	0.013	9.71	12.38	16.667	0.021
CHANNEL	169	0.1290	0.013	1.59	4.62	23.472	0.002
						Time of Concentration	.325

EA Gude

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	.58	89
	Pasture, grassland or range	(good)	D	14.75	80
	Woods	(good)	D	.19	77
	Total Area / Weighted Curve Number			16.07	81
				=====	==
DA-1B PR	Gravel (w/ right-of-way)		D	1.87	91
	Pasture, grassland or range	(good)	D	27.55	80
	Woods	(good)	D	.15	77
	Total Area / Weighted Curve Number			29.57	81
				=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-2
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/18/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-2 EX		Outlet	28.63	80	.286
DA-2 PR		Outlet	21.88	80	.386

Total area: 50.51 (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>

Gude
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-2 EX	35.82	72.89	104.81	155.01
DA-2 PR	23.83	48.63	69.89	103.62
REACHES				
OUTLET	58.54	119.55	171.79	254.29

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-2 EX	35.82	72.89	104.81	155.01
	12.23	12.23	12.22	12.21
DA-2 PR	23.83	48.63	69.89	103.62
	12.29	12.27	12.28	12.28
REACHES				
OUTLET	58.54	119.55	171.79	254.29

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-2 EX	28.63	0.286	80	Outlet	
DA-2 PR	21.88	0.386	80	Outlet	

Total Area: 50.51 (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-2 EX							
SHEET	100	0.0240	0.240				0.223
SHALLOW	521	0.0253	0.050				0.056
CHANNEL	576	0.0760	0.013	4.91	7.90	22.857	0.007
					Time of Concentration		.286
DA-2 PR							
SHEET	100	0.0350	0.240				0.192
SHALLOW	752	0.0200	0.050				0.092
CHANNEL	861	0.0100	0.030	6.74	8.87	4.124	0.058
CHANNEL	1680	0.0160	0.013	4.91	7.90	10.606	0.044
					Time of Concentration		.386

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	.914	89
	Pasture, grassland or range	(good)	D	26.098	80
	Woods	(good)	D	1.615	77
	Total Area / Weighted Curve Number			28.63	80
				=====	==
DA-2 PR	Gravel (w/ right-of-way)		D	.9	91
	Pasture, grassland or range	(good)	D	19.96	80
	Woods	(good)	D	1.02	77
	Total Area / Weighted Curve Number			21.88	80
				=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-3
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/18/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-3 EX		Outlet	11.9	80	.282
DA-3 PR		Outlet	9.98	81	.302

Total area: 21.88 (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-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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-3 EX	14.99	30.51	43.80	64.81
DA-3 PR	12.81	25.62	36.52	53.63
REACHES				
OUTLET	27.78	56.00	80.24	118.13

EA Gude
DA-3
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-3 EX	14.99	30.51	43.80	64.81
	12.23	12.21	12.22	12.21
DA-3 PR	12.81	25.62	36.52	53.63
	12.24	12.23	12.23	12.22
REACHES				
OUTLET	27.78	56.00	80.24	118.13

EA Gude

DA-3

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-3 EX	11.90	0.282	80	Outlet	
DA-3 PR	9.98	0.302	81	Outlet	

Total Area: 21.88 (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	0.0200	0.240				0.240
SHALLOW	272	0.0160	0.050				0.037
SHALLOW	158	0.2480	0.050				0.005
				Time of Concentration			.282
DA-3 PR							
SHEET	100	0.0360	0.240				0.190
SHALLOW	794	0.0210	0.050				0.094
CHANNEL	172	0.0930	0.030	24.00	16.94	15.926	0.003
CHANNEL	517	0.0240	0.030	24.00	16.94	9.574	0.015
				Time of Concentration			.302

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	.02	98
	Dirt (w/ right-of-way)		D	.19	89
	Pasture, grassland or range	(good)	D	11.11	80
	Woods	(good)	D	.58	77
	Total Area / Weighted Curve Number			11.9	80
				====	==
DA-3 PR	Gravel (w/ right-of-way)		D	.62	91
	Pasture, grassland or range	(good)	D	9.36	80
	Total Area / Weighted Curve Number			9.98	81
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-4
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/18/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-4 EX		Outlet	9.06	78	.383
DA-4 PR		Outlet	8.05	78	.181

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>

DA-4
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-4 EX	8.88	18.91	27.62	41.56
DA-4 PR	11.00	23.18	33.73	50.48
REACHES				
OUTLET	17.96	38.41	56.23	84.61

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-4 EX	8.88	18.91	27.62	41.56
	12.28	12.29	12.29	12.27
DA-4 PR	11.00	23.18	33.73	50.48
	12.17	12.16	12.16	12.16
REACHES				
OUTLET	17.96	38.41	56.23	84.61

EA Gude
DA-4
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-4 EX	9.06	0.383	78	Outlet	
DA-4 PR	8.05	0.181	78	Outlet	

Total Area: 17.11 (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-4 EX							
SHEET	100	0.0090	0.240				0.330
SHALLOW	1020	0.1100	0.050				0.053
				Time of Concentration			.383
DA-4 PR							
SHEET	100	0.0890	0.240				0.132
SHALLOW	952	0.1100	0.050				0.049
				Time of Concentration			.181

EA Gude
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	.227	89
	Pasture, grassland or range	(good)	D	2.357	80
	Woods	(good)	D	6.476	77
	Total Area / Weighted Curve Number			9.06	78
				====	==
DA-4 PR	Pasture, grassland or range	(good)	D	1.57	80
	Woods	(good)	D	6.48	77
	Total Area / Weighted Curve Number			8.05	78
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-5
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/18/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-5 EX		Outlet	17.48	78	.263
DA-5 PR		Outlet	17.39	78	.431

Total area: 34.87 (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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-5 EX	20.41	43.24	63.11	94.76
DA-5 PR	16.07	34.24	50.14	75.38
REACHES				
OUTLET	34.62	73.90	107.99	162.52

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-5 EX	20.41	43.24	63.11	94.76
	12.21	12.20	12.20	12.20
DA-5 PR	16.07	34.24	50.14	75.38
	12.33	12.32	12.31	12.30
REACHES				
OUTLET	34.62	73.90	107.99	162.52

DA-5
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-5 EX	17.48	0.263	78	Outlet	
DA-5 PR	17.39	0.431	78	Outlet	

Total Area: 34.87 (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-5 EX							
SHEET	100	0.0350	0.240				0.192
SHALLOW	311	0.0160	0.050				0.042
CHANNEL	1222	0.1477	0.030	3.00	6.32	11.705	0.029
					Time of Concentration		.263
DA-5 PR							
SHEET	100	0.0440	0.240				0.175
SHALLOW	35	0.0660	0.050				0.002
CHANNEL	383	0.0050	0.030	24.00	516.94	0.453	0.235
CHANNEL	961	0.2160	0.030	3.00	6.32	14.050	0.019
					Time of Concentration		.431

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	.238	98
	Dirt (w/ right-of-way)		D	.101	89
	Pasture, grassland or range	(good)	D	3.64	80
	Woods	(good)	D	13.5	77
	Total Area / Weighted Curve Number			17.48	78
				=====	==
DA-5 PR	Gravel (w/ right-of-way)		D	.114	91
	Pasture, grassland or range	(good)	D	3.774	80
	Woods	(good)	D	13.499	77
	Total Area / Weighted Curve Number			17.39	78
				=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-6
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/18/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-6 EX		Outlet	15.65	77	.19
DA-6 PR		Outlet	15.59	77	.174

Total area: 31.24 (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-6

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-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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-6 EX	19.81	42.70	62.70	94.54
DA-6 PR	20.46	44.01	64.56	97.24
REACHES				
OUTLET	40.21	86.41	127.06	191.59

EA Gude

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-6 EX	19.81	42.70	62.70	94.54
	12.17	12.16	12.17	12.17
DA-6 PR	20.46	44.01	64.56	97.24
	12.16	12.16	12.16	12.16
REACHES				
OUTLET	40.21	86.41	127.06	191.59

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-6 EX	15.65	0.190	77	Outlet	
DA-6 PR	15.59	0.174	77	Outlet	

Total Area: 31.24 (ac)

DA-6

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-6 EX							
SHEET	100	0.0490	0.240				0.168
SHALLOW	616	0.2380	0.050				0.022
				Time of Concentration			.19
DA-6 PR							
SHEET	100	0.0630	0.240				0.152
SHALLOW	616	0.2380	0.050				0.022
				Time of Concentration			.174

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	.045	89
	Pasture, grassland or range	(good)	D	2.132	80
	Woods	(good)	D	13.474	77
	Total Area / Weighted Curve Number			15.65	77
				=====	==
DA-6 PR	Gravel (w/ right-of-way)		D	.02	91
	Pasture, grassland or range	(good)	D	2.1	80
	Woods	(good)	D	13.47	77
	Total Area / Weighted Curve Number			15.59	77
				=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-7
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/17/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-7 EX		Outlet	5.78	78	.173
DA-7 PR		Outlet	5.8	78	.15

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>

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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-7 EX	8.02	16.92	24.59	36.76
DA-7 PR	8.48	17.84	25.87	38.72
REACHES				
OUTLET	16.46	34.62	50.35	75.12

DA-7

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-7 EX	8.02	16.92	24.59	36.76
	12.16	12.16	12.16	12.16
DA-7 PR	8.48	17.84	25.87	38.72
	12.15	12.15	12.15	12.14
REACHES				
OUTLET	16.46	34.62	50.35	75.12

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-7 EX	5.78	0.173	78	Outlet	
DA-7 PR	5.80	0.150	78	Outlet	

Total Area: 11.58 (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-7 EX							
SHEET	100	0.0680	0.240				0.147
SHALLOW	694	0.2460	0.050				0.024
CHANNEL	120	0.4096	0.013	1.77	14.71	16.667	0.002
						Time of Concentration	.173
DA-7 PR							
SHEET	100	0.0945	0.240				0.129
SHALLOW	550	0.2460	0.050				0.019
CHANNEL	120	0.4096	0.013	1.77	14.71	16.667	0.002
						Time of Concentration	.15

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	2.65	80
	Woods	(good)	D	3.13	77
	Total Area / Weighted Curve Number			5.78	78
				====	==
DA-7 PR	Pasture, grassland or range	(good)	D	2.676	80
	Woods	(good)	D	3.126	77
	Total Area / Weighted Curve Number			5.8	78
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-8
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/17/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-8 EX		Outlet	3.88	79	.234
DA-8 PR		Outlet	4.06	80	.141

Total area: 7.94 (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-8

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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-8 EX	5.03	10.43	15.04	22.44
DA-8 PR	6.72	13.56	19.38	28.53
REACHES				
OUTLET	11.33	23.19	33.34	49.42

EA Gude

DA-8

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-8 EX	5.03	10.43	15.04	22.44
	12.20	12.19	12.18	12.19
DA-8 PR	6.72	13.56	19.38	28.53
	12.14	12.14	12.14	12.14
REACHES				
OUTLET	11.33	23.19	33.34	49.42

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	0.234	79	Outlet	
DA-8 PR	4.06	0.141	80	Outlet	

Total Area: 7.94 (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	0.0280	0.240				0.210
SHALLOW	485	0.1810	0.050				0.020
CHANNEL	40	0.0133	0.013	1.77	4.71	5.556	0.002
CHANNEL	230	0.0675	0.013	9.12	8.75	31.944	0.002
					Time of Concentration		.234
DA-8 PR							
SHEET	100	0.1235	0.240				0.116
SHALLOW	434	0.1810	0.050				0.018
CHANNEL	40	0.0133	0.013	1.77	24.71	2.222	0.005
CHANNEL	230	0.0675	0.013	9.12	8.75	31.944	0.002
					Time of Concentration		.141

DA-8

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-8 EX	Pasture, grassland or range	(good)	D	1.9	80
	Woods - grass combination	(good)	D	1.98	79
	Total Area / Weighted Curve Number			3.88	79
				====	==
DA-8 PR	Pasture, grassland or range	(good)	D	2.04	80
	Woods - grass combination	(good)	D	2.02	79
	Total Area / Weighted Curve Number			4.06	80
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-9
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/17/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-9 EX		Outlet	8.1	78	.237
DA-9 PR		Outlet	8.51	79	.228

Total area: 16.61 (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-9
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-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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-9 EX	9.90	20.94	30.50	45.84
DA-9 PR	11.16	23.14	33.36	49.63
REACHES				
OUTLET	21.02	44.03	63.84	95.42

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-9 EX	9.90	20.94	30.50	45.84
	12.20	12.20	12.20	12.19
DA-9 PR	11.16	23.14	33.36	49.63
	12.19	12.19	12.19	12.18
REACHES				
OUTLET	21.02	44.03	63.84	95.42

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-9 EX	8.10	0.237	78	Outlet	
DA-9 PR	8.51	0.228	79	Outlet	

Total Area: 16.61 (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-9 EX							
SHEET	100	0.0260	0.240				0.216
SHALLOW	586	0.2220	0.050				0.021
				Time of Concentration			.237
DA-9 PR							
SHEET	100	0.0290	0.240				0.207
SHALLOW	586	0.2220	0.050				0.021
				Time of Concentration			.228

Gude
DA-9
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-9 EX	Dirt (w/ right-of-way)		D	.27	89
	Pasture, grassland or range	(good)	D	2.84	80
	Woods	(good)	D	4.99	77
	Total Area / Weighted Curve Number			8.1	78
				===	==
DA-9 PR	Gravel (w/ right-of-way)		D	.23	91
	Pasture, grassland or range	(good)	D	3.29	80
	Woods	(good)	D	4.99	77
	Total Area / Weighted Curve Number			8.51	79
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-10
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/17/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-10 EX		Outlet	1.53	80	.309
DA-10 PR		Outlet	0.84	80	.195

Total area: 2.37 (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-10
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-10 EX	1.85	3.77	5.40	8.00
DA-10 PR	1.24	2.50	3.58	5.28
REACHES				
OUTLET	2.96	6.05	8.69	12.84

DA-10

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-10 EX	1.85	3.77	5.40	8.00
	12.24	12.23	12.24	12.22
DA-10 PR	1.24	2.50	3.58	5.28
	12.17	12.17	12.16	12.17
REACHES				
OUTLET	2.96	6.05	8.69	12.84

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-10 EX	1.53	0.309	80	Outlet	
DA-10 PR	.84	0.195	80	Outlet	

Total Area: 2.37 (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 EX							
SHEET	100	0.0160	0.240				0.263
SHALLOW	83	0.0660	0.050				0.006
CHANNEL	249	0.0910	0.150	3.00	6.32	1.820	0.038
CHANNEL	31	0.0232	0.019	1.23	3.93	4.306	0.002
				Time of Concentration			.309
DA-10 PR							
SHEET	100	0.0620	0.240				0.153
SHALLOW	30	0.1000	0.050				0.002
CHANNEL	249	0.0910	0.150	3.00	6.32	1.820	0.038
CHANNEL	31	0.0232	0.019	1.23	3.93	4.306	0.002
				Time of Concentration			.195

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-10 EX	Dirt (w/ right-of-way)		D	.07	89
	Pasture, grassland or range	(good)	D	1.37	80
	Woods	(good)	D	.09	77
	Total Area / Weighted Curve Number			1.53	80
				====	==
DA-10 PR	Dirt (w/ right-of-way)		D	.04	89
	Pasture, grassland or range	(good)	D	.71	80
	Woods	(good)	D	.09	77
	Total Area / Weighted Curve Number			.84	80
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project:
SubTitle:
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/17/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-11 EX		Outlet	0.39	88	0.1
DA-11 PR		Outlet	0.38	87	0.1

Total area: .77 (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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-11 EX	1.00	1.76	2.37	3.31
DA-11 PR	0.93	1.66	2.26	3.17
REACHES				
OUTLET	1.94	3.42	4.62	6.48

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-11 EX	1.00	1.76	2.37	3.31
	12.12	12.12	12.12	12.12
DA-11 PR	0.93	1.66	2.26	3.17
	12.12	12.12	12.12	12.12
REACHES				
OUTLET	1.94	3.42	4.62	6.48

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	.39	0.100	88	Outlet	
DA-11 PR	.38	0.100	87	Outlet	

Total Area: .77 (ac)

EA

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	0.0430	0.011				0.015
SHALLOW	237	0.0100	0.025				0.032
				Time of Concentration			0.1
DA-11 PR							
SHEET	100	0.0770	0.011				0.012
SHALLOW	128	0.1070	0.025				0.005
				Time of Concentration			0.1

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	Paved parking lots, roofs, driveways		D	.18	98
	Pasture, grassland or range	(good)	D	.21	80
	Total Area / Weighted Curve Number			.39	88
				===	==
DA-11 PR	Paved parking lots, roofs, driveways		D	.14	98
	Pasture, grassland or range	(good)	D	.24	80
	Total Area / Weighted Curve Number			.38	87
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-12
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/17/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-12 EX		Outlet	0.47	79	.155
DA-12 PR		Outlet	0.47	79	.155

Total area: .94 (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-12

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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DA-12 EX	0.71	1.47	2.12	3.14
DA-12 PR	0.71	1.47	2.12	3.14
REACHES				
OUTLET	1.42	2.94	4.23	6.28

EA Gude

DA-12

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DA-12 EX	0.71	1.47	2.12	3.14
	12.15	12.15	12.14	12.15
DA-12 PR	0.71	1.47	2.12	3.14
	12.15	12.15	12.14	12.15
REACHES				
OUTLET	1.42	2.94	4.23	6.28

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-12 EX	.47	0.155	79	Outlet	
DA-12 PR	.47	0.155	79	Outlet	

Total Area: .94 (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-12 EX							
SHEET	100	0.0830	0.240				0.136
SHALLOW	124	0.2180	0.050				0.005
CHANNEL	115	0.1380	0.150	3.00	6.32	2.282	0.014
				Time of Concentration			.155
DA-12 PR							
SHEET	100	0.0830	0.240				0.136
SHALLOW	124	0.2180	0.050				0.005
CHANNEL	115	0.1380	0.150	3.00	6.32	2.282	0.014
				Time of Concentration			.155

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-12 EX	Dirt (w/ right-of-way)		D	.05	89
	Pasture, grassland or range	(good)	D	.18	80
	Woods	(good)	D	.24	77
	Total Area / Weighted Curve Number			.47	79
				===	==
DA-12 PR	Dirt (w/ right-of-way)		D	.05	89
	Pasture, grassland or range	(good)	D	.18	80
	Woods	(good)	D	.24	77
	Total Area / Weighted Curve Number			.47	79
				===	==

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Appendix D

Stormwater Bypass Drawing

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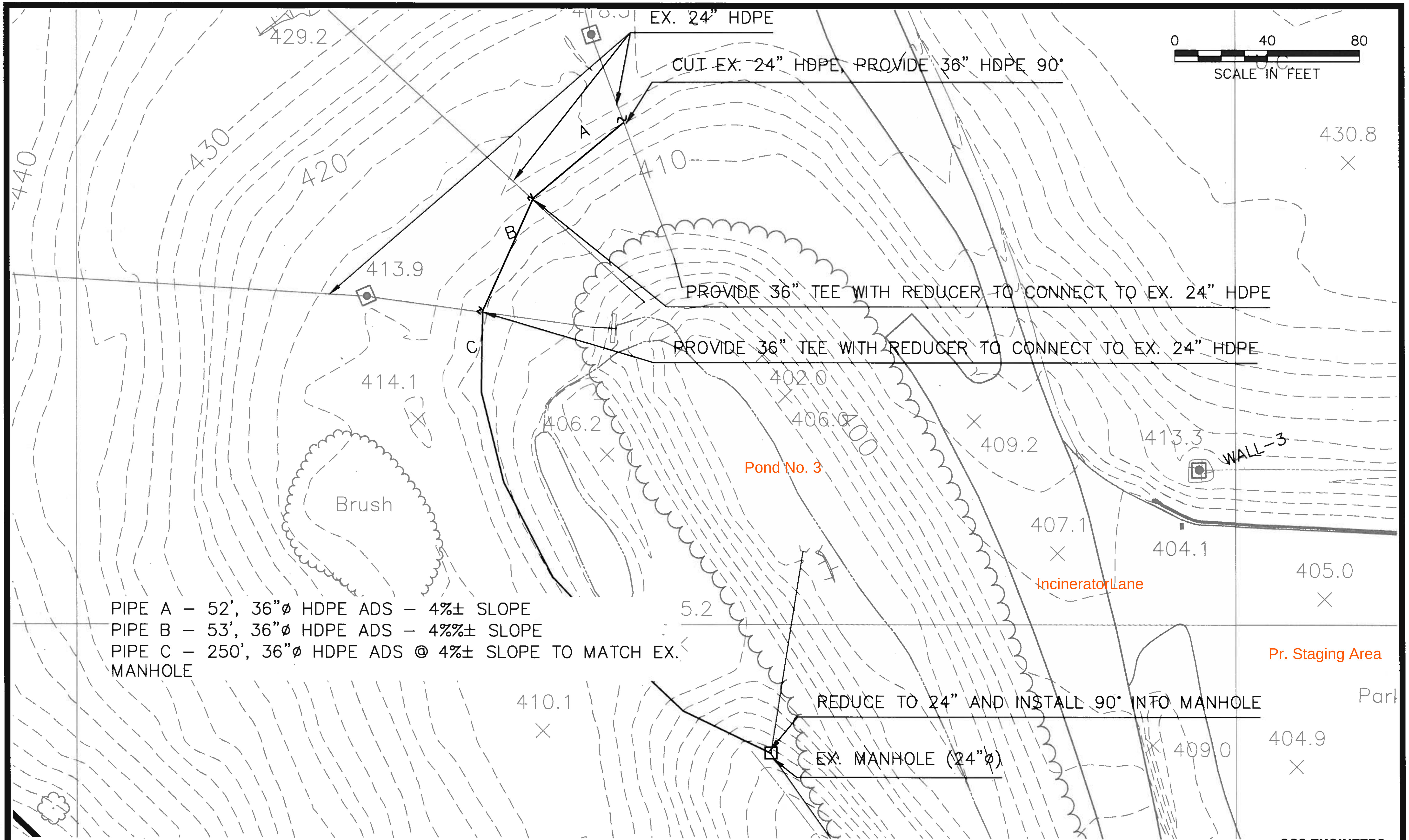

ROUGH GRADING STORMWATER MANAGEMENT DIVERSION

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Appendix E

Storm Drainage Computations

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Montgomery County Drainage Design Criteria. Montgomery County Department of Transportation, Rockville, Maryland, 10 June 2014.

OBJECTIVE:

Confirm swale size is adequate for peak discharge, velocity and depth of flow.

PROCEDURE:

NRCS (TR-55) was used to determine the peak discharges for 2-year, 10-year, 25-year, and 100-year storm events for the eighteen proposed conveyance swales.

ASSUMPTIONS:

- Swales were sized based on 10-year storm peak discharge
- The minimum freeboard of 0.5 feet to the top of the channel was based on the 10-year storm depth
- Actual time of concentrations were calculated using NRCS (TR-55)

CALCULATIONS:

1) Delineate drainage area for each swale.

2) Use TR-55 to determine peak discharges for 2-year, 10-year, 25-year, and 100-year storm events.

3) Use AutoCAD Civil 3D Hydraflow Express to determine velocity and depth of flow in each swale.

CONCLUSIONS:

The swale sizes are adequate regarding velocity and freeboard required by Montgomery County.

ATTACHMENTS:

Swale Size Summary Table
TR-55 Outputs

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude
SubTitle: Swale 1
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 3/10/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 1		Outlet	5.28	81	.32

Total area: 5.28 (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>

Swale 1
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
Swale 1
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 1	6.61	13.22	18.83	27.67
REACHES				
OUTLET	6.61	13.22	18.83	27.67

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 1	6.61	13.22	18.83	27.67
	12.25	12.24	12.23	12.24
REACHES				
OUTLET	6.61	13.22	18.83	27.67

Gude
Swale 1
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
Swale 1	5.28	0.320	81	Outlet	

Total Area: 5.28 (ac)

Gude
Swale 1
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)
Swale 1							
SHEET	100	0.0350	0.240				0.192
SHALLOW	752	0.0200	0.050				0.092
CHANNEL	86	0.2300	0.030	6.00	4.87	23.889	0.001
CHANNEL	861	0.0140	0.030	6.00	4.87	6.833	0.035
					Time of Concentration		.32

Gude
Swale 1
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
Swale 1	Gravel (w/ right-of-way)		D	.338	91
	Pasture, grassland or range	(good)	D	4.937	80
	Total Area / Weighted Curve Number			5.28	81
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 2
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

Date: 3/11/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 2		Outlet	1.18	82	0.1

Total area: 1.18 (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>

SS

Gude Landfill
Swale 2
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>

SS

Gude Landfill
Swale 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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 2	2.36	4.56	6.41	9.29
REACHES				
OUTLET	2.36	4.56	6.41	9.29

SS

Gude Landfill
Swale 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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 2	2.36 12.12	4.56 12.12	6.41 12.12	9.29 12.12
REACHES				
OUTLET	2.36	4.56	6.41	9.29

SS

Gude Landfill
Swale 2
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
Swale 2	1.18	0.100	82	Outlet	

Total Area: 1.18 (ac)

Gude Landfill
Swale 2
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)
Swale 2							
SHEET	100	0.3290	0.240				0.078
SHALLOW	119	0.0140	0.050				0.017
						Time of Concentration	0.1
							========

SS

Gude Landfill
Swale 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
Swale 2	Gravel (w/ right-of-way)		D	.168	91
	Pasture, grassland or range	(good)	D	1.013	80
	Total Area / Weighted Curve Number			1.18	82
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 3
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

Date: 3/24/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 3		Outlet	1.2	82	.137

Total area: 1.20 (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>

SS

Gude Landfill
Swale 3
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 Landfill
Swale 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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 3	2.22	4.31	6.06	8.79
REACHES				
OUTLET	2.22	4.31	6.06	8.79

Gude Landfill
Swale 3
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 3	2.22	4.31	6.06	8.79
	12.14	12.14	12.14	12.13
REACHES				
OUTLET	2.22	4.31	6.06	8.79

Gude Landfill
Swale 3
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
Swale 3	1.20	0.137	82	Outlet	

Total Area: 1.20 (ac)

Gude Landfill
Swale 3
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)
Swale 3							
SHEET	100	0.1160	0.240				0.119
SHALLOW	50	0.0920	0.050				
CHANNEL	602	0.0270	0.030	6.00	4.87	9.290	0.018
					Time of Concentration		.137

Gude Landfill
Swale 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
Swale 3	Gravel (w/ right-of-way)		D	.18	91
	Pasture, grassland or range	(good)	D	1.018	80
	Total Area / Weighted Curve Number			1.2	82
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS   Date: 3/11/2020
Project: Gude Landfill   Units: English
SubTitle: Swale 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\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 4		Outlet	5.77	80	.289

Total area: 5.77 (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>

Gude Landfill
Swale 4
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 Landfill
Swale 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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 4	7.19	14.65	21.02	31.12
REACHES				
OUTLET	7.19	14.65	21.02	31.12

Gude Landfill
Swale 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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 4	7.19	14.65	21.02	31.12
	12.22	12.23	12.23	12.21
REACHES				
OUTLET	7.19	14.65	21.02	31.12

Gude Landfill
Swale 4
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
Swale 4	5.77	0.289	80	Outlet	

Total Area: 5.77 (ac)

SS

Gude Landfill
Swale 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)
Swale 4							
SHEET	100	0.0360	0.240				0.190
SHALLOW	794	0.0210	0.050				0.094
CHANNEL	46	0.1820	0.030	10.00	12.47	12.778	0.001
CHANNEL	172	0.0930	0.030	10.00	12.47	11.944	0.004
						Time of Concentration	.289

Gude Landfill
Swale 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
Swale 4	Gravel (w/ right-of-way)		D	.23	91
	Pasture, grassland or range	(good)	D	5.543	80
	Total Area / Weighted Curve Number			5.77	80
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 4A
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

Date: 3/11/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 4A		Outlet	1.36	81	.241

Total area: 1.36 (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>

Gude Landfill
Swale 4A
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 Landfill
Swale 4A
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 4A	1.93	3.86	5.49	8.05
REACHES				
OUTLET	1.93	3.86	5.49	8.05

SS

Gude Landfill
Swale 4A
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 4A	1.93 12.20	3.86 12.20	5.49 12.19	8.05 12.19
REACHES				
OUTLET	1.93	3.86	5.49	8.05

Gude Landfill
Swale 4A
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
Swale 4A	1.36	0.241	81	Outlet	

Total Area: 1.36 (ac)

SS

Gude Landfill
Swale 4A
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)
Swale 4A							
SHEET	69	0.0120	0.240				0.219
SHALLOW	15	0.0180	0.025				0.002
SHALLOW	112	0.0600	0.050				0.008
CHANNEL	262	0.0200	0.030	10.00	12.47	6.065	0.012
					Time of Concentration		.241

Gude Landfill
Swale 4A
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
Swale 4A	Gravel (w/ right-of-way)		D	.107	91
	Pasture, grassland or range	(good)	D	1.248	80
	Total Area / Weighted Curve Number			1.36	81
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User:	SS	Date:	3/20/2020
Project:	Gude Landfill	Units:	English
SubTitle:	Swale 5	Areal Units:	Acres
State:	Maryland		
County:	Montgomery NOAA-C		

Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 5		Outlet	6.94	81	.138

Total area: 6.94 (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>

Gude Landfill
Swale 5
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>

SS

Gude Landfill
Swale 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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 5	12.16	24.05	34.12	49.87
REACHES				
OUTLET	12.16	24.05	34.12	49.87

SS

Gude Landfill
Swale 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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 5	12.16	24.05	34.12	49.87
	12.14	12.14	12.14	12.13
REACHES				
OUTLET	12.16	24.05	34.12	49.87

Gude Landfill
Swale 5
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
Swale 5	6.94	0.138	81	Outlet	

Total Area: 6.94 (ac)

SS

Gude Landfill
Swale 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)
Swale 5							
SHEET	100	0.1280	0.240				0.114
SHALLOW	290	0.1100	0.050				0.015
CHANNEL	282	0.0440	0.030	10.00	12.47	8.704	0.009
						Time of Concentration	.138

Gude Landfill
Swale 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
Swale 5	Gravel (w/ right-of-way)		D	.539	91
	Pasture, grassland or range	(good)	D	6.402	80
	Total Area / Weighted Curve Number			6.94	81
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Date: 3/11/2020
Project: Gude Landfill
Units: English
SubTitle: Swale 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\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 6		Outlet	0.75	80	.235

Total area: .75 (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>

SS

Gude Landfill
Swale 6
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 Landfill
Swale 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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 6	1.02	2.07	2.98	4.40
REACHES				
OUTLET	1.02	2.07	2.98	4.40

SS

Gude Landfill
Swale 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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 6	1.02 12.19	2.07 12.19	2.98 12.19	4.40 12.19
REACHES				
OUTLET	1.02	2.07	2.98	4.40

Gude Landfill
Swale 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
Swale 6	.75	0.235	80	Outlet	

Total Area: .75 (ac)

Gude Landfill
Swale 6
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)
Swale 6							
SHEET	100	0.0250	0.240				0.220
SHALLOW	40	0.0200	0.050				0.005
CHANNEL	213	0.0200	0.030	10.00	12.47	5.917	0.010
						Time of Concentration	.235

SS

Gude Landfill
Swale 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
Swale 6	Pasture, grassland or range	(good)	D	.75	80
	Total Area / Weighted Curve Number			.75	80
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Date: 3/11/2020
Project: Gude Landfill
Units: English
SubTitle: Swale 7
Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 7		Outlet	0.16	80	.218

Total area: .16 (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>

SS

Gude Landfill
Swale 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 Landfill
Swale 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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 7	0.23	0.46	0.66	0.97
REACHES				
OUTLET	0.23	0.46	0.66	0.97

SS

Gude Landfill
Swale 7
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 7	0.23	0.46	0.66	0.97
	12.18	12.18	12.18	12.17
REACHES				
OUTLET	0.23	0.46	0.66	0.97

Gude Landfill
Swale 7
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
Swale 7	.16	0.218	80	Outlet	

Total Area: .16 (ac)

SS

Gude Landfill
Swale 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)
Swale 7							
SHEET	82	0.0180	0.240				0.214
CHANNEL	118	0.0410	0.030	10.00	12.47	8.194	0.004
						Time of Concentration	.218

Gude Landfill
Swale 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
Swale 7	Pasture, grassland or range	(good)	D	.158	80
	Total Area / Weighted Curve Number			.16	80
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 8
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

Date: 3/11/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 8		Outlet	15.55	80	.281

Total area: 15.55 (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>

SS

Gude Landfill
Swale 8
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 Landfill
Swale 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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 8	19.61	39.95	57.37	84.67
REACHES				
OUTLET	19.61	39.95	57.37	84.67

Gude Landfill
Swale 8
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 8	19.61	39.95	57.37	84.67
	12.22	12.21	12.22	12.22
REACHES				
OUTLET	19.61	39.95	57.37	84.67

SS

Gude Landfill
Swale 8
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
Swale 8	15.55	0.281	80	Outlet	

Total Area: 15.55 (ac)

Gude Landfill
Swale 8
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)
Swale 8							
SHEET	100	0.0310	0.240				0.201
SHALLOW	35	0.0420	0.050				0.003
CHANNEL	1600	0.0180	0.030	10.00	12.47	5.772	0.077
						Time of Concentration	.281

Gude Landfill
Swale 8
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
Swale 8	Gravel (w/ right-of-way)		D	.701	91
	Pasture, grassland or range	(good)	D	14.849	80
	Total Area / Weighted Curve Number			15.55	80
				=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 3/11/2020
Project: Gude Landfill Units: English
SubTitle: Swale 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\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 9		Outlet	0.63	80	0.1

Total area: .63 (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>

Gude Landfill
Swale 9
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 Landfill
Swale 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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 9	1.14	2.29	3.27	4.80
REACHES				
OUTLET	1.14	2.29	3.27	4.80

Gude Landfill
Swale 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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 9	1.14	2.29	3.27	4.80
	12.12	12.12	12.12	12.12
REACHES				
OUTLET	1.14	2.29	3.27	4.80

SS

Gude Landfill
Swale 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
Swale 9	.63	0.100	80	Outlet	

Total Area: .63 (ac)

Gude Landfill
Swale 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)
Swale 9							
CHANNEL	82	0.0050	0.030	13.65	13.80	3.254	0.007
						Time of Concentration	0.1

Gude Landfill
Swale 9
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
Swale 9	Pasture, grassland or range	(good)	D	.625	80
	Total Area / Weighted Curve Number			.63	80
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 9A
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

Date: 3/11/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 9A		Outlet	1.58	81	.194

Total area: 1.58 (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>

SS

Gude Landfill
Swale 9A
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 Landfill
Swale 9A
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 9A	2.45	4.87	6.93	10.15
REACHES				
OUTLET	2.45	4.87	6.93	10.15

SS

Gude Landfill
Swale 9A
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 9A	2.45	4.87	6.93	10.15
	12.18	12.17	12.17	12.16
REACHES				
OUTLET	2.45	4.87	6.93	10.15

SS

Gude Landfill
Swale 9A
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
Swale 9A	1.58	0.194	81	Outlet	

Total Area: 1.58 (ac)

SS

Gude Landfill
Swale 9A
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)
Swale 9A							
SHEET	100	0.0440	0.240				0.175
SHALLOW	35	0.0650	0.050				0.002
CHANNEL	235	0.0085	0.030	10.00	12.47	3.840	0.017
						Time of Concentration	.194

SS

Gude Landfill
Swale 9A
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
Swale 9A	Gravel (w/ right-of-way)		D	.113	91
	Pasture, grassland or range	(good)	D	1.465	80
	Total Area / Weighted Curve Number			1.58 ====	81 ==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Date: 3/11/2020
Project: Gude Landfill
Units: English
SubTitle: Swale 10
Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 10		Outlet	3.46	80	.143

Total area: 3.46 (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>

Gude Landfill
Swale 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>

Gude Landfill
Swale 10
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 10	5.71	11.52	16.47	24.27
REACHES				
OUTLET	5.71	11.52	16.47	24.27

Gude Landfill
Swale 10
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 10	5.71 12.14	11.52 12.14	16.47 12.14	24.27 12.14
REACHES				
OUTLET	5.71	11.52	16.47	24.27

Gude Landfill
Swale 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
Swale 10	3.46	0.143	80	Outlet	

Total Area: 3.46 (ac)

Gude Landfill
Swale 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)
Swale 10							
SHEET	100	0.1360	0.240				0.112
SHALLOW	40	0.1590	0.050				0.002
CHANNEL	469	0.0300	0.030	10.00	12.47	7.238	0.018
CHANNEL	419	0.0630	0.030	10.00	12.47	10.581	0.011
						Time of Concentration	.143

SS

Gude Landfill
Swale 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
Swale 10	Gravel (w/ right-of-way)		D	.069	91
	Pasture, grassland or range	(good)	D	3.392	80
	Total Area / Weighted Curve Number			3.46	80
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 11
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

Date: 3/11/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 11		Outlet	2.36	82	.271

Total area: 2.36 (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>

Gude Landfill
Swale 11
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 Landfill
Swale 11
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 11	3.35	6.55	9.27	13.50
REACHES				
OUTLET	3.35	6.55	9.27	13.50

SS

Gude Landfill
Swale 11
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 11	3.35	6.55	9.27	13.50
	12.22	12.22	12.20	12.21
REACHES				
OUTLET	3.35	6.55	9.27	13.50

Gude Landfill
Swale 11
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
Swale 11	2.36	0.271	82	Outlet	

Total Area: 2.36 (ac)

Gude Landfill
Swale 11
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)
Swale 11							
SHEET	100	0.0200	0.240				0.240
SHALLOW	57	0.0220	0.050				0.007
SHALLOW	76	0.0750	0.025				0.004
CHANNEL	678	0.0470	0.030	10.00	12.47	9.417	0.020
					Time of Concentration		.271

Gude Landfill
Swale 11
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
Swale 11	Gravel (w/ right-of-way)		D	.398	91
	Pasture, grassland or range	(good)	D	1.963	80
	Total Area / Weighted Curve Number			2.36	82
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Date: 3/11/2020
Project: Gude Landfill
Units: English
SubTitle: Swale 12
Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 12		Outlet	3.31	81	.23

Total area: 3.31 (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>

SS

Gude Landfill
Swale 12
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 Landfill
Swale 12
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 12	4.79	9.54	13.57	19.92
REACHES				
OUTLET	4.79	9.54	13.57	19.92

SS

Gude Landfill
Swale 12
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 12	4.79	9.54	13.57	19.92
	12.19	12.19	12.19	12.19
REACHES				
OUTLET	4.79	9.54	13.57	19.92

Gude Landfill
Swale 12
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
Swale 12	3.31	0.230	81	Outlet	

Total Area: 3.31 (ac)

Gude Landfill
Swale 12
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)
Swale 12							
SHEET	100	0.0400	0.240				0.182
SHALLOW	285	0.0400	0.050				0.025
CHANNEL	500	0.0200	0.030	10.00	12.47	6.039	0.023
					Time of Concentration		.23

Gude Landfill
Swale 12
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
Swale 12	Gravel (w/ right-of-way)		D	.224	91
	Pasture, grassland or range	(good)	D	3.09	80
	Total Area / Weighted Curve Number			3.31	81
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 13
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

Date: 3/18/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 13		Outlet	14.35	81	0.234

Total area: 14.35 (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>

Gude Landfill
Swale 13
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 Landfill
Swale 13
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 13	20.61	41.10	58.42	85.76
REACHES				
OUTLET	20.61	41.10	58.42	85.76

Gude Landfill
Swale 13
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 13	20.61	41.10	58.42	85.76
	12.19	12.19	12.18	12.19
REACHES				
OUTLET	20.61	41.10	58.42	85.76

Gude Landfill
Swale 13
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
Swale 13	14.35	0.234	81	Outlet	

Total Area: 14.35 (ac)

Gude Landfill
Swale 13
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)
Swale 13							
SHEET	100	0.0250	0.150				0.151
SHALLOW	122	0.0280	0.050				0.013
CHANNEL	1520	0.0200	0.030	10.00	12.47	6.032	0.070
					Time of Concentration		0.234

Gude Landfill
Swale 13
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
Swale 13	Gravel (w/ right-of-way)		D	.725	91
	Pasture, grassland or range	(good)	D	13.621	80
	Total Area / Weighted Curve Number			14.35	81
				=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Date: 7/1/2020
Project: Gude Landfill
Units: English
SubTitle: Swale 14
Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desi

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 14		Outlet	0.11	80	0.1

Total area: .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>

Gude Landfill
Swale 14
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 Landfill
Swale 14
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 14	0.20	0.40	0.57	0.83
REACHES				
OUTLET	0.20	0.40	0.57	0.83

SS

Gude Landfill
Swale 14
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 14	0.20	0.40	0.57	0.83
	12.12	12.12	12.12	12.12
REACHES				
OUTLET	0.20	0.40	0.57	0.83

SS

Gude Landfill
Swale 14
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
Swale 14	.11	0.100	80	Outlet	

Total Area: .11 (ac)

Gude Landfill
Swale 14
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)
Swale 14							
CHANNEL	130	0.0120	0.030	10.00	12.47	4.514	0.008
					Time of Concentration		0.1

SS

Gude Landfill
Swale 14
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
Swale 14	Pasture, grassland or range	(good)	D	.106	80
	Total Area / Weighted Curve Number			.11	80
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Date: 7/1/2020
Project: Gude Landfill
Units: English
SubTitle: Swale 14A
Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desi

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 14A		Outlet	0.44	80	0.1

Total area: .44 (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>

Gude Landfill
Swale 14A
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 Landfill
Swale 14A
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 14A	0.80	1.61	2.30	3.38
REACHES				
OUTLET	0.80	1.61	2.30	3.38

SS

Gude Landfill
Swale 14A
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 14A	0.80 12.12	1.61 12.12	2.30 12.12	3.38 12.12
REACHES				
OUTLET	0.80	1.61	2.30	3.38

SS

Gude Landfill
Swale 14A
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
Swale 14A	.44	0.100	80	Outlet	

Total Area: .44 (ac)

Gude Landfill
Swale 14A
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)
Swale 14A							
SHEET	100	0.1380	0.150				0.076
SHALLOW	93	0.1520	0.050				0.004
CHANNEL	150	0.0160	0.030	10.00	12.47	5.208	0.008
						Time of Concentration	0.1

SS

Gude Landfill
Swale 14A
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
Swale 14A	Pasture, grassland or range	(good)	D	.439	80
	Total Area / Weighted Curve Number			.44	80
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User:	SS	Date:	7/1/2020
Project:	Gude Landfill	Units:	English
SubTitle:	Swale 14B	Areal Units:	Acres
State:	Maryland		
County:	Montgomery NOAA-C		

Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desi

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 14B		Outlet	1.55	80	.134

Total area: 1.55 (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>

SS

Gude Landfill
Swale 14B
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>

SS

Gude Landfill
Swale 14B
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 14B	2.61	5.26	7.52	11.04
REACHES				
OUTLET	2.61	5.26	7.52	11.04

SS

Gude Landfill
Swale 14B
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 14B	2.61 12.14	5.26 12.14	7.52 12.14	11.04 12.14
REACHES				
OUTLET	2.61	5.26	7.52	11.04

Gude Landfill
Swale 14B
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
Swale 14B	1.55	0.134	80	Outlet	

Total Area: 1.55 (ac)

SS

Gude Landfill
Swale 14B
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)
Swale 14B							
SHEET	95	0.0420	0.150				0.118
SHALLOW	191	0.1370	0.050				0.009
CHANNEL	154	0.0200	0.030	10.00	12.47	6.111	0.007
						Time of Concentration	.134

Gude Landfill
Swale 14B
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
Swale 14B	Pasture, grassland or range	(good)	D	1.55	80
	Total Area / Weighted Curve Number			1.55	80
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 15
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desi

Date: 7/1/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 15		Outlet	9.03	80	.12

Total area: 9.03 (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>

SS

Gude Landfill
Swale 15
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 Landfill
Swale 15
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 15	15.70	31.58	45.06	66.33
REACHES				
OUTLET	15.70	31.58	45.06	66.33

SS

Gude Landfill
Swale 15
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 15	15.70	31.58	45.06	66.33
	12.13	12.13	12.13	12.13
REACHES				
OUTLET	15.70	31.58	45.06	66.33

Gude Landfill
Swale 15
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
Swale 15	9.03	0.120	80	Outlet	

Total Area: 9.03 (ac)

Gude Landfill
Swale 15
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)
Swale 15							
SHEET	36	0.0660	0.240				0.066
SHALLOW	15	0.0660	0.025				0.001
SHALLOW	551	0.0630	0.050				0.038
CHANNEL	380	0.0270	0.030	10.00	12.47	7.037	0.015
					Time of Concentration		.12
							========

SS

Gude Landfill
Swale 15
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
Swale 15	Gravel (w/ right-of-way)		D	.307	91
	Pasture, grassland or range	(good)	D	8.723	80
	Total Area / Weighted Curve Number			9.03	80
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 3/11/2020
Project: Gude Landfill Units: English
SubTitle: Swale 16 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 16		Outlet	7.7	80	.349

Total area: 7.70 (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>

Gude Landfill
Swale 16
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 Landfill
Swale 16
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 16	8.79	17.96	25.76	38.13
REACHES				
OUTLET	8.79	17.96	25.76	38.13

(Columns 2-Yr through 100-Yr: Peak Flow by Rainfall Return Period)

SS

Gude Landfill
Swale 16
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 16	8.79 12.26	17.96 12.26	25.76 12.26	38.13 12.26
REACHES				
OUTLET	8.79	17.96	25.76	38.13

SS

Gude Landfill
Swale 16
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
Swale 16	7.70	0.349	80	Outlet	

Total Area: 7.70 (ac)

Gude Landfill
Swale 16
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)
Swale 16							
SHEET	100	0.0150	0.240				0.269
SHALLOW	300	0.0250	0.050				0.033
CHANNEL	1260	0.0300	0.030	10.00	12.47	7.447	0.047
						Time of Concentration	.349

Gude Landfill
Swale 16
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
Swale 16	Gravel (w/ right-of-way)		D	.161	91
	Pasture, grassland or range	(good)	D	7.536	80
	Total Area / Weighted Curve Number			7.7	80
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 3/24/2020
Project: Gude Landfill Units: English
SubTitle: Swale 17 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 17		Outlet	0.9	81	0.1

Total area: .90 (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>

SS

Gude Landfill
Swale 17
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 Landfill
Swale 17
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 17	1.73	3.40	4.81	7.02
REACHES				
OUTLET	1.73	3.40	4.81	7.02

Gude Landfill
Swale 17
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 17	1.73	3.40	4.81	7.02
	12.13	12.12	12.12	12.12
REACHES				
OUTLET	1.73	3.40	4.81	7.02

SS

Gude Landfill
Swale 17
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
Swale 17	.90	0.100	81	Outlet	

Total Area: .90 (ac)

SS

Gude Landfill
Swale 17
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)
Swale 17							
SHEET	100	0.0780	0.011				0.012
SHALLOW	55	0.0780	0.025				0.003
SHALLOW	84	0.1360	0.050				0.004
CHANNEL	55	0.0100	0.030	10.00	12.47	3.819	0.004
					Time of Concentration		0.1

Gude Landfill
Swale 17
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
Swale 17	Gravel (w/ right-of-way)		D	.055	91
	Pasture, grassland or range	(good)	D	.844	80
	Total Area / Weighted Curve Number			.9	81
				==	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Date: 3/11/2020
Project: Gude Landfill
Units: English
SubTitle: Swale 18
Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\90% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 18		Outlet	0.89	80	.2

Total area: .89 (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>

Gude Landfill
Swale 18
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 Landfill
Swale 18
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 18	1.30	2.63	3.77	5.56
REACHES				
OUTLET	1.30	2.63	3.77	5.56

SS

Gude Landfill
Swale 18
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 18	1.30	2.63	3.77	5.56
	12.18	12.17	12.17	12.17
REACHES				
OUTLET	1.30	2.63	3.77	5.56

Gude Landfill
Swale 18
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
Swale 18	.89	0.200	80	Outlet	

Total Area: .89 (ac)

SS

Gude Landfill
Swale 18
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)
Swale 18							
SHEET	100	0.0510	0.240				0.165
SHALLOW	127	0.0430	0.050				0.011
CHANNEL	167	0.0020	0.030	10.00	12.47	1.933	0.024
					Time of Concentration		.2

SS

Gude Landfill
Swale 18
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
Swale 18	Pasture, grassland or range	(good)	D	.891	80
	Total Area / Weighted Curve Number			.89	80
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS
Project: Gude Landfill
SubTitle: Swale 18
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\Projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desi

Date: 7/1/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 18		Outlet	0.15	80	0.1

Total area: .15 (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>

Gude Landfill
Swale 18
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>

SS

Gude Landfill
Swale 18
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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
Swale 18	0.27	0.54	0.77	1.13
REACHES				
OUTLET	0.27	0.54	0.77	1.13

SS

Gude Landfill
Swale 18
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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
Swale 18	0.27 12.12	0.54 12.12	0.77 12.12	1.13 12.12
REACHES				
OUTLET	0.27	0.54	0.77	1.13

SS

Gude Landfill
Swale 18
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
Swale 18	.15	0.100	80	Outlet	

Total Area: .15 (ac)

Gude Landfill
Swale 18
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)
Swale 18							
SHEET	33	0.3450	0.240				0.032
CHANNEL	208	0.1140	0.030	10.00	12.47	14.444	0.004
					Time of Concentration		0.1

Gude Landfill
Swale 18
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
Swale 18	Pasture, grassland or range	(good)	D	.148	80
	Total Area / Weighted Curve Number			.15	80
				===	==

Montgomery County Government (2013; Revised 2014). Drainage Design Criteria, Department of Transportation

OBJECTIVE:

Confirm stormdrain pipe size and layout to convey site storm drainage. Confirm that inlets provide required capacity.

PROCEDURE :

The NRCS (TR-55) Method was used to determine the 10-year storm flows that enter the stormdrain systems. The Design Spreadsheets in Appendix D from the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria was utilized to summarize the storm drain system analysis and calculate the velocity in the storm drainpipe networks, based on size and slope of the pipes. The pipe sizes and slopes were determined to ensure that the hydraulic grade line is not surcharged and is located at least 1 ft below the top of the structure elevation and no more than 1 foot above the crown of the pipe for the 10-year storm.

BACKGROUND:

There are two separate, proposed stormdrain systems location on the site. One system ties into the existing 60” stormdrain that drains to Pond 1 on the south-western edge of the site, and the other section of stormdrain carries flow from two conveyance swales to Pond 3.

All of the proposed inlets are located within conveyance swales and are in a sumped condition. Montgomery County Type J inlets will be utilized throughout except for Inlet 2. Inlet 2 will be an open yard inlet.

ASSUMPTIONS:

- Stormdrain piping was sized based on 10-year storm peak discharge at stormdrain inlet drainage areas.
- The capacity of inlets was based on 10-year storm peak discharge at stormdrain inlet drainage areas per Montgomery County Government (2013; Revised 2014). Drainage Design Criteria.
- Actual time of concentrations were calculated using NRCS (TR-55)
- Rainfall Intensities were obtained from Table 3-7 based on the time of concentration computed in TR-55
- Pipe layout placed to maintain the hydraulic grade line (HGL) a minimum of 1-ft below the structure elevation and no more than 1 foot above the crown of pipe.

CALCULATIONS:

1. **Compute a Composite "CN" Value for Drainage Areas-** determine areas of land use soils and cover for each drainage area that enters the stormdrain system.

2. **Determine Time of Concentration to Inlets** – Determine the flow path and length from the hydraulically most distant point representative of the drainage area

3. **Determine Flows to Inlets** –NRCS (TR-55) calculates the peak flow as a function of drainage area, time of concentration, land cover/soil type, and peak hour precipitation.

   TR-55 Computations are attached.

4. **Stormdrain Design and Hydraulic Grade Line Calculations** – The Design Spreadsheets in Appendix D from the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria was utilized to summarize the storm drain system analysis and calculate the velocity in the storm drainpipe networks, based on size and slope of the pipes.

   Hydraflow Storm Sewers was then used to calculate the Hydraulic Grade Line Location in the proposed stormdrains. Calculations are attached.

5. **Check Inlet Capacities** – All proposed inlets are in sump condition located within conveyance swales. The Design Spreadsheets in Appendix D from the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria and Hydraflow Express was used to calculate inlet capacities. Hydraflow Express utilizes standard weir and orifice equations for calculating head at sump inlets.

   The Design Spreadsheets are attached.

CONCLUSIONS:

Results from the Stormdrain Design Calculations show that pipe sizes shown on the Contract Drawings can adequately convey the design storm. Inlet capacities are also adequate.

ATTACHMENTS:

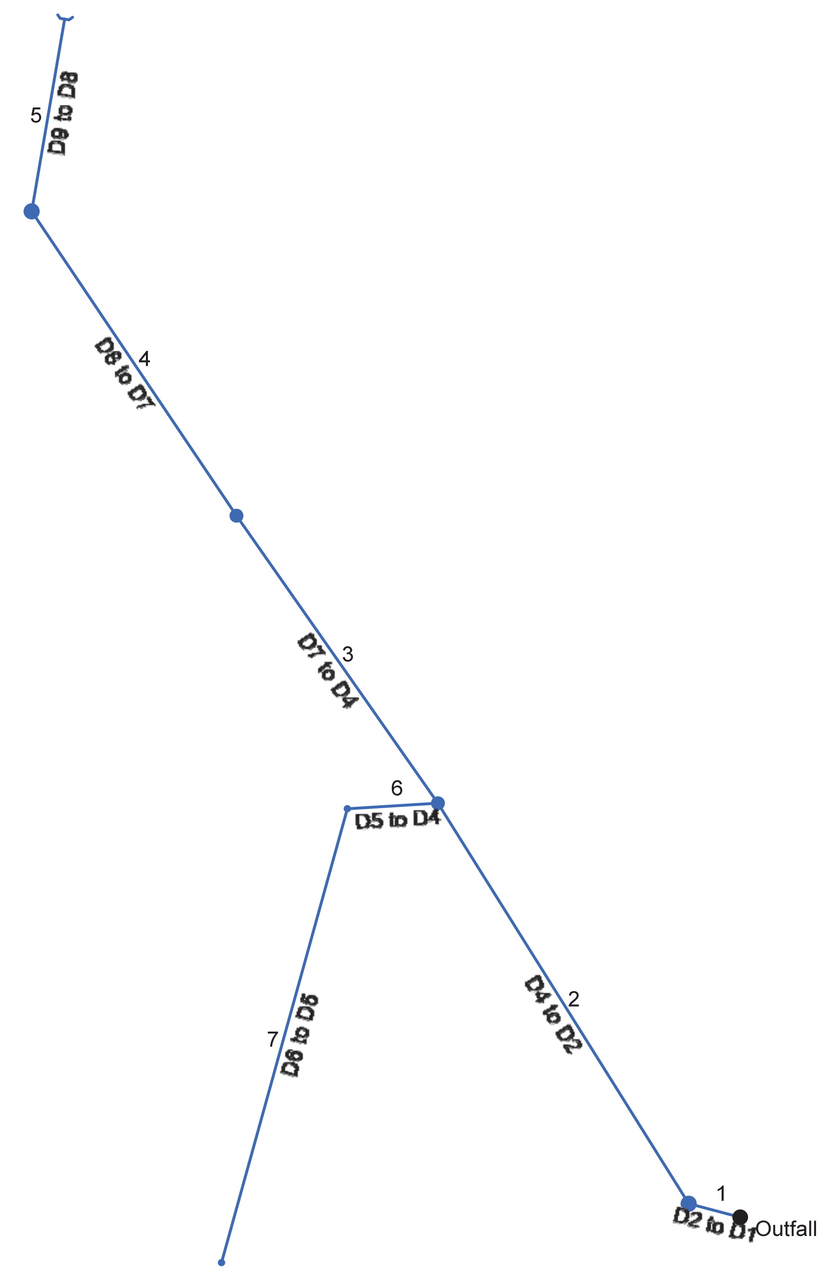
Montgomery County Inlet Capacity Computation Table
Montgomery County Storm Drain Computation Table
Hydraflow Express Inlet Capacity Calculations
Hydra Flow Storm Sewers Analysis

PIPE COMPUTATIONS

PIPE		AREA		R=C	AR	∑AR	TC	I	Q	PIPE SIZE	MIN SLOPE	V	PIPE LENGTH	TIME IN PIPE	REMARKS
FROM	TO	INCR. AREA	TOTAL AREA				(min)	(in/hr)	(cfs)	(Inches)	(%)	(fps)	(feet)	(min)	
I-1	I-5	5.28	5.28	0.57	3.01		19.2	4.46	13.22	18	1.09%	**7.62**	190.44	0.42	Q is from TR-55
I-5	A2	6.88	12.16	0.58	7.05	10.06	8.28	6.22	37.27	30	1.00%	**7.23**	84.6	0.20	Sum of Q from TR-55
A2	Ex A1	0.206	12.366	0.58	7.17	17.23	6	6.78	43.03	30	2.67%	**10.74**	46.28	0.07	Sum of Q from TR-55
I-4	MH	9.03	9.03	0.56	5.06	5.06	7.2	6.47	31.58	30	5.00%	**18.06**	94.56	0.09	Q is from TR-55
I-3	MH	2.36	2.36	0.61	1.44	6.50	16.26	4.83	6.55	30	8.00%	**65.18**	89.12	0.02	Q is from TR-55
MH	Pond 3 HW	-	11.39	-	-	11.55	-	-	38.13	30	1.00%	**7.12**	49.53	0.12	Sum of Q from TR-55
Z-6	Z-2	2.095	2.095	0.55	1.15	1.15	6	6.78	7.27	24	0.60%	**12.37**	166	0.22	Q is from TR-55
Z-2	Z-1	0.963	0.963	0.73	0.70	1.86	6	6.78	12.58	24	0.77%	**9.72**	65	0.11	

EA ENGINEERING, SCIENCE, AND TECHNOLOGY	**PIPE COMPUTATIONS**	**COMPUTED**	**LMO**	**DATE**
		CHECKED		**Jul-20**
	GUDE LANDFILL REMEDIATION DESIGN	**SHEET NO.**		**PROJECT NO.**
		1		**1564601**

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Ex SD D Analysis.stm	Number of lines: 7	Date: 3/26/2020

Storm Sewers v11.00

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	D2 to D1	135.2	42	Cir	23.994	348.20	348.50	1.250	351.70*	352.13*	2.24	354.37	End	Manhole
2	D4 to D2	135.2	42	Cir	213.738	349.03	359.38	4.842	354.37	362.71	n/a	362.71	1	DropGrate
3	D7 to D4	124.7	42	Cir	158.705	363.70	369.35	3.560	365.77	372.63	n/a	372.63	2	DropGrate
4	D8 to D7	124.7	36	Cir	165.929	372.68	380.62	4.785	374.81	383.58	5.36	383.58	3	DropGrate
5	D9 to D8	43.20	30	Cir	88.349	385.66	388.52	3.237	387.04	390.71	n/a	390.71	4	OpenHeadwall
6	D5 to D4	10.43	18	Cir	40.946	363.82	364.35	1.294	364.84	365.59	0.99	365.59	2	DropGrate
7	D6 to D5	10.43	18	Cir	213.219	364.73	385.61	9.793	365.59	386.85	0.69	386.85	6	DropGrate

Project File: Ex SD D Analysis.stm | Number of lines: 7 | Run Date: 3/26/2020

NOTES: Return period = 10 Yrs. ; *Surcharged (HGL above crown).

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	23.994	0.00	0.00	0.00	0.00	0.00	0.0	1.0	0.0	135.2	112.5	14.05	42	1.25	348.20	348.50	351.70	352.13	0.00	356.46	D2 to D1
2	1	213.738	0.00	0.00	0.00	0.00	0.00	0.0	0.7	0.0	135.2	221.4	14.17	42	4.84	349.03	359.38	354.37	362.71	356.46	369.77	D4 to D2
3	2	158.705	0.00	0.00	0.00	0.00	0.00	0.0	0.3	0.0	124.7	189.8	17.18	42	3.56	363.70	369.35	365.77	372.63	369.77	379.33	D7 to D4
4	3	165.929	0.00	0.00	0.00	0.00	0.00	0.0	0.2	0.0	124.7	145.9	20.44	36	4.79	372.68	380.62	374.81	383.58	379.33	391.97	D8 to D7
5	4	88.349	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	43.20	73.79	12.54	30	3.24	385.66	388.52	387.04	390.71	391.97	391.81	D9 to D8
6	2	40.946	0.00	0.00	0.00	0.00	0.00	0.0	0.6	0.0	10.43	12.94	7.41	18	1.29	363.82	364.35	364.84	365.59	369.77	369.78	D5 to D4
7	6	213.219	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	10.43	35.60	8.31	18	9.79	364.73	385.61	365.59	386.85	369.78	390.82	D6 to D5

Project File: Ex SD D Analysis.stm | Number of lines: 7 | Run Date: 3/26/2020

NOTES:Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83; Return period =Yrs. 10 ; c = cir e = ellip b = box

MyReport

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross Sl, Sw (ft/ft)	Cross Sl, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	9.62	9.62	n/a	0.20	0.50	0.90	112.50	3.33	....	....	....	-165.229	3.50	3.50	Outfall	0.00	1274096.99	354.77	355.20	0.433
2	9.45	9.45	Sag	0.20	0.50	0.90	221.39	3.33	0.020	0.020	....	43.263	3.50	3.33**	1	0.00	1273983.84	357.44	365.89	3.601
3	5.93	9.37	Sag	0.20	0.50	0.90	189.83	3.28	0.020	0.020	....	-2.941	2.07	3.28**	2	0.00	1273893.02	368.53	375.39	0.000
4	5.38	7.05	Sag	0.20	0.50	0.90	145.89	2.96	0.020	0.020	....	1.054	2.13	2.96**	3	0.00	1273800.59	379.68	388.45	0.000
5	2.77	4.56	n/a	0.20	0.50	0.90	73.79	2.19	....	....	....	43.554	1.38	2.19**	4	0.00	1273815.47	388.43	392.11	0.000
6	1.28	1.56	Sag	0.20	0.50	0.90	12.94	1.24	0.020	0.020	....	-61.536	1.02	1.24**	2	0.00	1273942.97	365.53	366.28	0.000
7	1.05	1.56	Sag	0.20	0.50	0.90	35.60	1.24	0.020	0.020	....	-71.069	0.86	1.24**	6	0.00	1273886.24	366.28	387.54	0.000

Project File: Ex SD D Analysis.stm	Number of lines: 7	Date: 3/26/2020

NOTES: ** Critical depth

MyReport

Flow Rate (cfs)	Sf Ave (ft/ft)	Sf Dn (ft/ft)	Grate Area (sqft)	Grate Len (ft)	Grate Width (ft)	Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Gutter Depth (ft)	Gutter Slope (ft/ft)	Gutter Spread (ft)	Gutter Width (ft)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	HGL Jmp Dn (ft)	HGL Jmp Up (ft)	Incr CxA	Incr Q (cfs)	Inlet Depth (ft)
135.15	1.805	1.805	....	....	....	0.00	356.46	....	....	....	....	351.70	352.13	354.37	....	....	0.00	0.00	....
135.15	1.685	1.805	16.00	4.00	4.00	356.46	369.77	0.00	Sag	4.00	2.00	354.37	362.71	362.71	....	....	0.00	0.00	0.00
124.72	0.000	0.000	16.00	4.00	4.00	369.77	379.33	0.00	Sag	4.00	2.00	365.77	372.63	372.63	....	....	0.00	0.00	0.00
124.72	0.000	0.000	16.00	4.00	4.00	379.33	391.97	1.42	Sag	146.37	2.00	374.81	383.58	383.58	....	....	0.00	81.52	1.42
43.20	0.000	0.000	....	....	....	391.97	391.81	....	....	....	....	387.04	390.71	390.71	....	....	0.00	43.20	....
10.43	0.000	0.000	16.00	4.00	4.00	369.77	369.78	0.00	Sag	4.00	2.00	364.84	365.59	365.59	....	....	0.00	0.00	0.00
10.43	0.000	0.000	16.00	4.00	4.00	369.78	390.82	0.36	Sag	40.12	2.00	365.59	386.85	386.85	....	....	0.00	10.43	0.36

Project File: Ex SD D Analysis.stm | Number of lines: 7 | Date: 3/26/2020

NOTES: ** Critical depth

MyReport

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
....	D2	Sag	....	0.0	0.00	0.00	348.20	348.50	....	....	0.00	0.00	0.73	MH	0.00	1,211	1,090	1,029
0	D4	Sag	4.00	0.0	0.00	0.00	349.03	359.38	....	....	0.00	0.00	1.35 z	Dp-Grate	0.00	14,991	13,492	12,742
0	D7	Sag	4.00	0.0	0.00	0.00	363.70	369.35	....	....	0.00	0.00	0.50 z	Dp-Grate	0.00	10,611	9,550	9,019
100	D8	Sag	146.37	0.0	0.00	0.00	372.68	380.62	....	....	0.00	0.00	1.10 z	Dp-Grate	81.52	11,404	10,264	9,693
100	D9	Sag	....	0.0	0.00	0.00	385.66	388.52	....	....	0.00	0.00	1.00 z	Hdwall	43.20	4,132	3,719	3,512
0	D5	Sag	4.00	0.0	0.00	0.00	363.82	364.35	....	....	0.00	0.00	1.43 z	Dp-Grate	0.00	1,740	1,566	1,479
100	D6	Sag	40.12	0.0	0.00	0.00	364.73	385.61	....	....	0.00	0.00	1.00 z	Dp-Grate	10.43	8,640	7,776	7,344

Project File: Ex SD D Analysis.stm | Number of lines: 7 | Date: 3/26/2020

NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 -- Return period = 10 Yrs. ; ** Critical depth

MyReport

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)
D2 to D1	23.994	42	1.25	Cir	....	....	0.013	2.24	523991.82	0.03	....	....	....	42	0.00	42	0.00	0.00	0.00
D4 to D2	213.738	42	4.84	Cir	....	....	0.013	n/a	524173.15	0.25	0.00	0.00	0.00	42	0.00	42	0.00	0.00	0.00
D7 to D4	158.705	42	3.56	Cir	....	....	0.013	n/a	524303.30	0.20	0.00	0.00	0.00	42	0.00	42	0.00	0.00	0.00
D8 to D7	165.929	36	4.79	Cir	....	....	0.013	5.36	524441.10	0.16	0.00	81.52	0.00	36	0.00	36	0.00	0.00	0.00
D9 to D8	88.349	30	3.24	Cir	....	....	0.013	n/a	524528.18	0.17	0.00	43.20	0.00	30	0.00	30	0.00	0.00	0.00
D5 to D4	40.946	18	1.29	Cir	....	....	0.012	0.99	524170.65	0.12	0.00	0.00	0.00	18	0.00	18	0.00	0.00	0.00
D6 to D5	213.219	18	9.79	Cir	....	....	0.012	0.69	523965.11	0.60	0.00	10.43	0.00	18	0.00	18	0.00	0.00	0.00

Project File: Ex SD D Analysis.stm | Number of lines: 7 | Date: 3/26/2020

NOTES: ** Critical depth

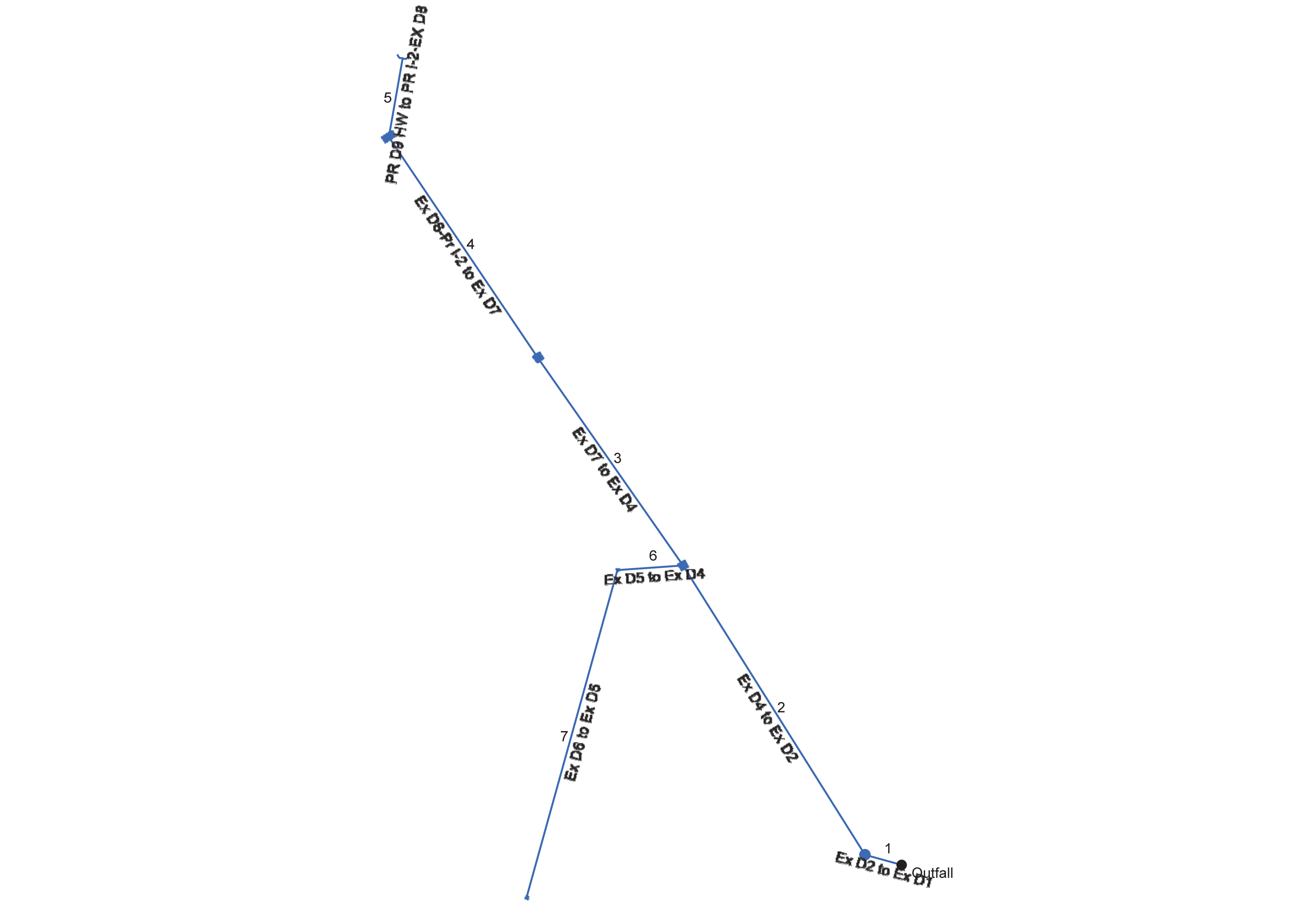
MyReport

Tc (min)	Throat Ht (in)	Total Area (ac)	Total CxA	Total Runoff (cfs)	Vel Ave (ft/s)	Vel Dn (ft/s)	Vel Hd Dn (ft)	Vel Hd Up (ft)	Vel Up (ft/s)	Cover Dn (ft)	Cover Up (ft)	Storage (cft)
1.0	....	0.00	0.00	0.00	14.05	14.05	3.07	3.07	14.05	n/a	4.46	230.80
0.7	....	0.00	0.00	0.00	14.17	14.05	3.07	3.18	14.30	3.93	6.89	2050.01
0.3	....	0.00	0.00	0.00	17.18	21.05	2.76	2.76	13.32	2.57	6.48	1238.97
0.2	....	0.00	0.00	0.00	20.44	23.19	4.87	4.87	17.70	3.65	8.35	1050.74
0.0	....	0.00	0.00	0.00	12.54	15.62	1.39	1.39	9.47	3.81	0.79	328.57
0.6	....	0.00	0.00	0.00	7.41	8.15	0.69	0.69	6.67	4.45	3.93	58.41
0.0	....	0.00	0.00	0.00	8.31	9.94	0.69	0.69	6.67	3.55	3.71	280.75

Project File: Ex SD D Analysis.stm | Number of lines: 7 | Date: 3/26/2020

NOTES: ** Critical depth

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Proposed Ex SD D Analysis.stm	Number of lines: 7	Date: 3/20/2020

Storm Sewers v11.00

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	Ex D2 to Ex D1	163.1	42	Cir	23.723	348.20	348.50	1.265	351.70*	352.33*	3.22	355.54	End	Manhole
2	Ex D4 to Ex D2	163.1	42	Cir	213.713	349.03	359.38	4.843	355.54	362.80	6.11	362.80	1	DropGrate
3	Ex D7 to Ex D4	149.6	42	Cir	158.606	363.70	369.35	3.562	366.04	372.73	n/a	372.73	2	DropGrate
4	Ex D8-Pr I-2 to Ex D7	149.6	42	Cir	166.387	372.18	380.12	4.772	374.30	383.50	n/a	383.50	3	DropGrate
5	PR D9 HW to PR I-2-EX D8	73.58	42	Cir	49.965	384.66	399.00	28.700	385.53	401.68	1.34	401.68	4	OpenHeadwall
6	Ex D5 to Ex D4	13.56	18	Cir	40.967	363.82	364.35	1.294	365.13	365.72	n/a	365.72	2	DropGrate
7	Ex D6 to Ex D5	13.56	18	Cir	212.853	364.73	385.61	9.810	365.72	386.98	n/a	386.98	6	DropGrate

Project File: Proposed Ex SD D Analysis.stm | Number of lines: 7 | Run Date: 3/20/2020

NOTES: Return period = 10 Yrs. ; *Surcharged (HGL above crown).

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	23.723	0.00	0.00	0.00	0.00	0.00	0.0	0.8	0.0	163.1	113.1	16.96	42	1.26	348.20	348.50	351.70	352.33	0.00	356.54	Ex D2 to Ex D1
2	1	213.713	0.00	0.00	0.00	0.00	0.00	0.0	0.6	0.0	163.1	221.4	17.01	42	4.84	349.03	359.38	355.54	362.80	356.54	369.77	Ex D4 to Ex D2
3	2	158.606	0.00	0.00	0.00	0.00	0.00	0.0	0.3	0.0	149.6	189.9	18.78	42	3.56	363.70	369.35	366.04	372.73	369.77	379.34	Ex D7 to Ex D4
4	3	166.387	0.00	0.00	0.00	0.00	0.00	0.0	0.1	0.0	149.6	219.8	20.13	42	4.77	372.18	380.12	374.30	383.50	379.34	393.75	Ex D8-Pr I-2 to Ex
5	4	49.965	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	73.58	539.0	24.24	42	28.70	384.66	399.00	385.53	401.68	393.75	403.29	PR D9 HW to PR I
6	2	40.967	0.00	0.00	0.00	0.00	0.00	0.0	0.5	0.0	13.56	12.94	8.16	18	1.29	363.82	364.35	365.13	365.72	369.77	369.78	Ex D5 to Ex D4
7	6	212.853	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	13.56	35.63	9.50	18	9.81	364.73	385.61	365.72	386.98	369.78	390.81	Ex D6 to Ex D5

Project File: Proposed Ex SD D Analysis.stm | Number of lines: 7 | Run Date: 3/20/2020

NOTES:Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83; Return period =Yrs. 10 ; c = cir e = ellip b = box

MyReport

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross Sl, Sw (ft/ft)	Cross Sl, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	9.62	9.62	n/a	0.20	0.50	0.90	113.14	3.42	....	....	....	-164.438	3.50	3.50	Outfall	0.00	1274097.34	356.17	356.80	0.624
2	9.56	9.56	Sag	0.20	0.50	0.90	221.40	3.42	0.020	0.020	....	42.359	3.50	3.42**	1	0.00	1273983.84	360.02	367.32	5.309
3	6.84	9.52	Sag	0.20	0.50	0.90	189.89	3.38	0.020	0.020	....	-2.730	2.34	3.38**	2	0.00	1273893.30	369.88	376.57	0.000
4	6.09	9.52	Sag	0.20	0.50	0.90	219.78	3.38	0.020	0.020	....	0.863	2.12	3.38**	3	0.00	1273800.38	378.13	387.34	0.000
5	1.88	7.92	n/a	0.20	0.50	0.90	538.98	2.68	....	....	....	43.904	0.87	2.68**	4	0.00	1273809.02	386.88	403.03	0.000
6	1.63	1.69	Sag	0.20	0.50	0.90	12.94	1.37	0.020	0.020	....	-61.964	1.31	1.37**	2	0.00	1273942.97	366.13	366.72	0.000
7	1.23	1.69	Sag	0.20	0.50	0.90	35.63	1.37	0.020	0.020	....	-70.519	0.99	1.37**	6	0.00	1273886.31	366.72	387.98	0.000

Project File: Proposed Ex SD D Analysis.stm	Number of lines: 7	Date: 3/20/2020
NOTES: ** Critical depth		

MyReport

Flow Rate (cfs)	Sf Ave (ft/ft)	Sf Dn (ft/ft)	Grate Area (sqft)	Grate Len (ft)	Grate Width (ft)	Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Gutter Depth (ft)	Gutter Slope (ft/ft)	Gutter Spread (ft)	Gutter Width (ft)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	HGL Jmp Dn (ft)	HGL Jmp Up (ft)	Incr CxA	Incr Q (cfs)	Inlet Depth (ft)
163.13	2.630	2.630	....	....	....	0.00	356.54	....	....	....	....	351.70	352.33	355.54	....	....	0.00	0.00	....
163.13	2.484	2.630	16.00	4.00	4.00	356.54	369.77	0.00	Sag	4.00	2.00	355.54	362.80	362.80	....	....	0.00	0.00	0.00
149.57	0.000	0.000	16.00	4.00	4.00	369.77	379.34	0.00	Sag	4.00	2.00	366.04	372.73	372.73	....	....	0.00	0.00	0.00
149.57	0.000	0.000	15.00	2.50	6.00	379.34	393.75	1.30	Sag	138.47	8.00	374.30	383.50	383.50	....	....	0.00	75.99	1.30
73.58	0.000	0.000	....	....	....	393.75	403.29	....	....	....	....	385.53	401.68	401.68	....	....	0.00	73.58	....
13.56	0.000	0.000	16.00	4.00	4.00	369.77	369.78	0.00	Sag	4.00	2.00	365.13	365.72	365.72	....	....	0.00	0.00	0.00
13.56	0.000	0.000	16.00	4.00	4.00	369.78	390.81	0.43	Sag	47.04	2.00	365.72	386.98	386.98	....	....	0.00	13.56	0.43

Project File: Proposed Ex SD D Analysis.stm | Number of lines: 7 | Date: 3/20/2020

NOTES: ** Critical depth

MyReport

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
....	Ex D2	Sag	....	0.0	0.00	0.00	348.20	348.50	....	....	0.00	0.00	0.72	MH	0.00	1,225	1,103	1,041
0	Ex D4	Sag	4.00	0.0	0.00	0.00	349.03	359.38	....	....	0.00	0.00	1.35 z	Dp-Grate	0.00	15,039	13,535	12,783
0	Ex D7	Sag	4.00	0.0	0.00	0.00	363.70	369.35	....	....	0.00	0.00	0.50 z	Dp-Grate	0.00	10,611	9,550	9,019
100	Pr I-2 - Ex D8	Sag	138.47	0.0	0.00	0.00	372.18	380.12	....	....	0.00	0.00	1.11 z	Dp-Grate	75.99	12,688	11,419	10,785
100	D9 Headwall-Proposed	Sag	....	0.0	0.00	0.00	384.66	399.00	....	....	0.00	0.00	1.00 z	Hdwall	73.58	3,017	2,715	2,564
0	Ex D5	Sag	4.00	0.0	0.00	0.00	363.82	364.35	....	....	0.00	0.00	1.43 z	Dp-Grate	0.00	1,740	1,566	1,479
100	Ex D6	Sag	47.04	0.0	0.00	0.00	364.73	385.61	....	....	0.00	0.00	1.00 z	Dp-Grate	13.56	8,620	7,758	7,327

Project File: Proposed Ex SD D Analysis.stm | Number of lines: 7 | Date: 3/20/2020

NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 -- Return period = 10 Yrs. ; ** Critical depth

MyReport

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)
Ex D2 to Ex D1	23.723	42	1.26	Cir	....	....	0.013	3.22	523992.07	0.02	....	....	....	42	0.00	42	0.00	0.00	0.00
Ex D4 to Ex D2	213.713	42	4.84	Cir	....	....	0.013	6.11	524173.15	0.21	0.00	0.00	0.00	42	0.00	42	0.00	0.00	0.00
Ex D7 to Ex D4	158.606	42	3.56	Cir	....	....	0.013	n/a	524303.37	0.17	0.00	0.00	0.00	42	0.00	42	0.00	0.00	0.00
Ex D8-Pr I-2 to Ex D7	166.387	42	4.77	Cir	....	....	0.013	n/a	524441.40	0.18	0.00	75.99	0.00	42	0.00	42	0.00	0.00	0.00
PR D9 HW to PR I-2-EX D8	49.965	42	28.70	Cir	....	....	0.013	1.34	524490.61	0.11	0.00	73.58	0.00	42	0.00	42	0.00	0.00	0.00
Ex D5 to Ex D4	40.967	18	1.29	Cir	....	....	0.012	n/a	524170.26	0.09	0.00	0.00	0.00	18	0.00	18	0.00	0.00	0.00
Ex D6 to Ex D5	212.853	18	9.81	Cir	....	....	0.012	n/a	523965.09	0.46	0.00	13.56	0.00	18	0.00	18	0.00	0.00	0.00

Project File: Proposed Ex SD D Analysis.stm	Number of lines: 7	Date: 3/20/2020

NOTES: ** Critical depth

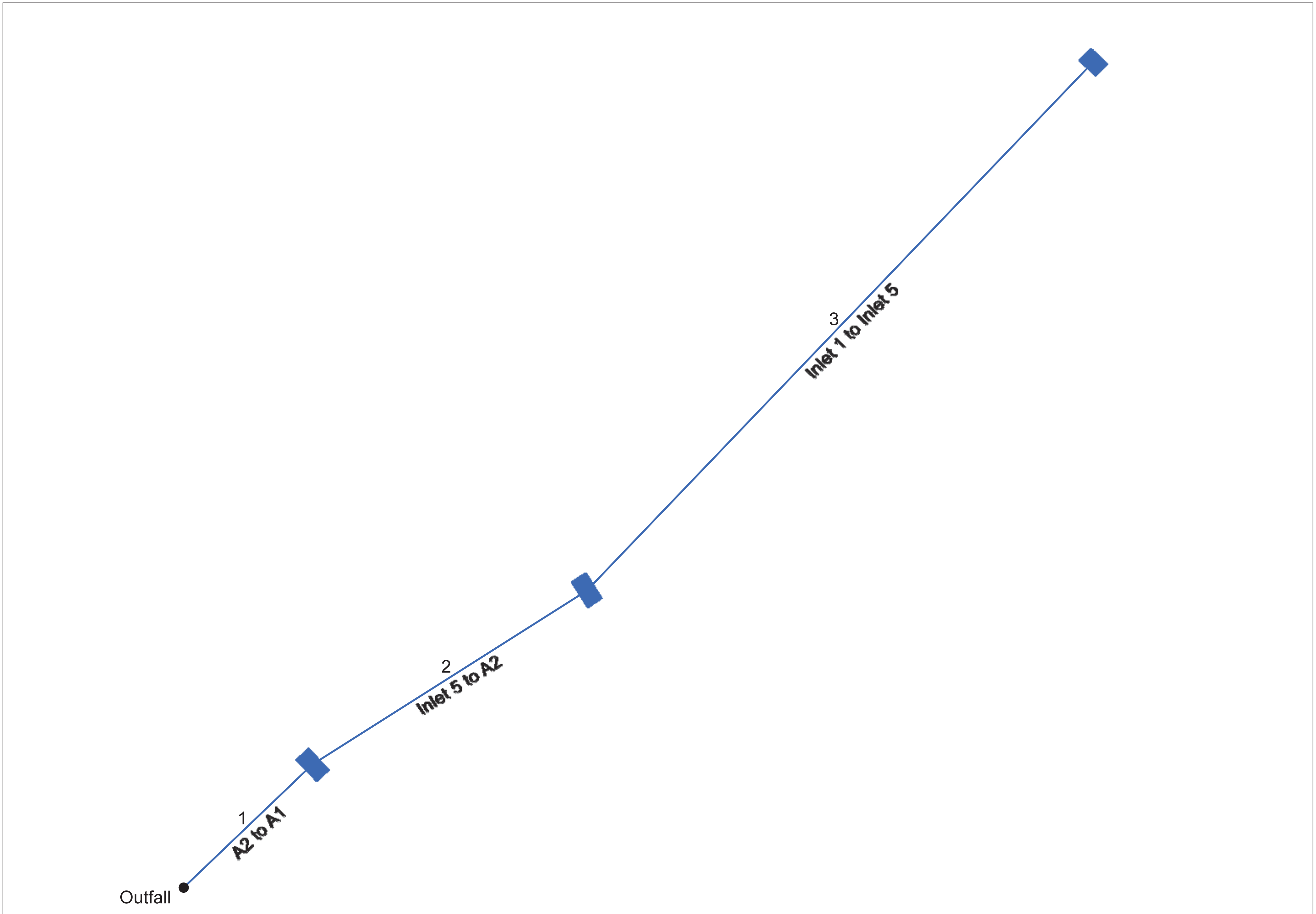
MyReport

Tc (min)	Throat Ht (in)	Total Area (ac)	Total CxA	Total Runoff (cfs)	Vel Ave (ft/s)	Vel Dn (ft/s)	Vel Hd Dn (ft)	Vel Hd Up (ft)	Vel Up (ft/s)	Cover Dn (ft)	Cover Up (ft)	Storage (cft)
0.8	....	0.00	0.00	0.00	16.96	16.96	4.47	4.47	16.96	n/a	4.54	228.19
0.6	....	0.00	0.00	0.00	17.01	16.96	4.47	4.52	17.06	4.01	6.89	2053.67
0.3	....	0.00	0.00	0.00	18.78	21.86	3.83	3.83	15.70	2.57	6.49	1323.54
0.1	....	0.00	0.00	0.00	20.13	24.56	3.83	3.83	15.70	3.66	10.13	1333.05
0.0	....	0.00	0.00	0.00	24.24	39.18	1.34	1.34	9.30	5.59	0.79	245.13
0.5	....	0.00	0.00	0.00	8.16	8.30	1.00	1.00	8.02	4.45	3.93	68.14
0.0	....	0.00	0.00	0.00	9.50	10.98	1.00	1.00	8.02	3.55	3.70	315.05

Project File: Proposed Ex SD D Analysis.stm | Number of lines: 7 | Date: 3/20/2020

NOTES: ** Critical depth

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Inlet 1 to Ex A2 Analysis.stm	Number of lines: 3	Date: 3/20/2020

Storm Sewers v11.00

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	A2 to A1	38.08	30	Cir	46.284	410.19	411.43	2.679	412.69	413.51	n/a	413.51 j	End	DropGrate
2	Inlet 5 to A2	32.32	30	Cir	84.597	411.63	412.47	0.993	413.51	414.40	0.49	414.40	1	DropGrate
3	Inlet 1 to Inlet 5	13.22	18	Cir	190.443	412.67	414.75	1.092	414.40*	417.42*	0.87	418.29	2	DropGrate

Project File: Inlet 1 to Ex A2 Analysis.stm	Number of lines: 3	Run Date: 3/20/2020

NOTES: Return period = 10 Yrs. ; *Surcharged (HGL above crown). ; j - Line contains hyd. jump.

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	46.284	0.00	0.00	0.00	0.00	0.00	0.0	0.6	0.0	38.08	67.13	8.23	30	2.68	410.19	411.43	412.69	413.51	416.52	416.17	A2 to A1
2	1	84.597	0.00	0.00	0.00	0.00	0.00	0.0	0.4	0.0	32.32	40.87	8.04	30	0.99	411.63	412.47	413.51	414.40	416.17	418.00	Inlet 5 to A2
3	2	190.443	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	13.22	10.97	7.48	18	1.09	412.67	414.75	414.40	417.42	418.00	419.81	Inlet 1 to Inlet 5

Project File: Inlet 1 to Ex A2 Analysis.stm | Number of lines: 3 | Run Date: 3/20/2020

NOTES:Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83; Return period =Yrs. 10 ; c = cir e = ellip b = box

MyReport

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross Sl, Sw (ft/ft)	Cross Sl, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	4.37	4.37	Sag	0.20	0.50	0.90	67.13	2.08	0.020	0.020	....	-43.822	2.50	2.08**	Outfall	0.00	1271184.34	413.63	414.69	0.393
2	3.97	4.08	Sag	0.20	0.50	0.90	40.87	1.93	0.020	0.020	....	11.361	1.88	1.93**	1	0.00	1271255.72	414.49	415.38	0.000
3	1.77	1.77	Sag	0.20	0.50	0.90	10.97	1.36	0.010	0.010	....	-13.857	1.50	1.50	2	0.00	1271387.25	415.27	418.29	3.019

Project File: Inlet 1 to Ex A2 Analysis.stm | Number of lines: 3 | Date: 3/20/2020

NOTES: ** Critical depth

MyReport

Flow Rate (cfs)	Sf Ave (ft/ft)	Sf Dn (ft/ft)	Grate Area (sqft)	Grate Len (ft)	Grate Width (ft)	Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Gutter Depth (ft)	Gutter Slope (ft/ft)	Gutter Spread (ft)	Gutter Width (ft)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	HGL Jmp Dn (ft)	HGL Jmp Up (ft)	Incr CxA	Incr Q (cfs)	Inlet Depth (ft)	
38.08	0.850	0.863	15.00	2.50	6.00	416.52	416.17	0.23	Sag	31.35	8.00	412.69	413.51 j	413.51	412.69	412.17	0.00	5.76	0.23	
32.32	0.000	0.000	15.00	2.50	6.00	416.17	418.00	0.52	Sag	59.94	8.00	413.51	414.40	414.40	....	....	0.00	19.10	0.52	
13.22	1.585	1.586	10.00	2.50	4.00	418.00	419.81	0.49	Sag	101.20	4.00	414.40	417.42	418.29	....	....	0.00	13.22	0.49	

Project File: Inlet 1 to Ex A2 Analysis.stm | Number of lines: 3 | Date: 3/20/2020

NOTES: ** Critical depth

MyReport

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
100	A2	Sag	31.35	0.0	0.00	0.00	410.19	411.43	4.63	11.90	0.97	2.26	0.50 z	Dp-Grate	5.76	2,404	2,164	2,043
100	Inlet 5	Sag	59.94	0.0	0.00	0.00	411.63	412.47	....	....	0.00	0.00	0.50 z	Dp-Grate	19.10	4,176	3,758	3,550
100	Inlet 1	Sag	101.20	0.0	0.00	0.00	412.67	414.75	....	....	0.00	0.00	1.00	Dp-Grate	13.22	7,720	6,948	6,562

Project File: Inlet 1 to Ex A2 Analysis.stm | Number of lines: 3 | Date: 3/20/2020

NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 -- Return period = 10 Yrs. ; ** Critical depth

MyReport

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)	Tc (min)
A2 to A1	46.284	30	2.68	Cir	....	....	0.013	n/a	524687.73	0.10	0.00	5.76	0.00	30	0.00	30	0.00	0.00	0.00	0.6
Inlet 5 to A2	84.597	30	0.99	Cir	....	....	0.013	0.49	524733.14	0.21	0.00	19.10	0.00	30	0.00	30	0.00	0.00	0.00	0.4
Inlet 1 to Inlet 5	190.443	18	1.09	Cir	....	....	0.013	0.87	524870.86	0.42	0.00	13.22	0.00	18	0.00	18	0.00	0.00	0.00	0.0

Project File: Inlet 1 to Ex A2 Analysis.stm | Number of lines: 3 | Date: 3/20/2020

NOTES: ** Critical depth

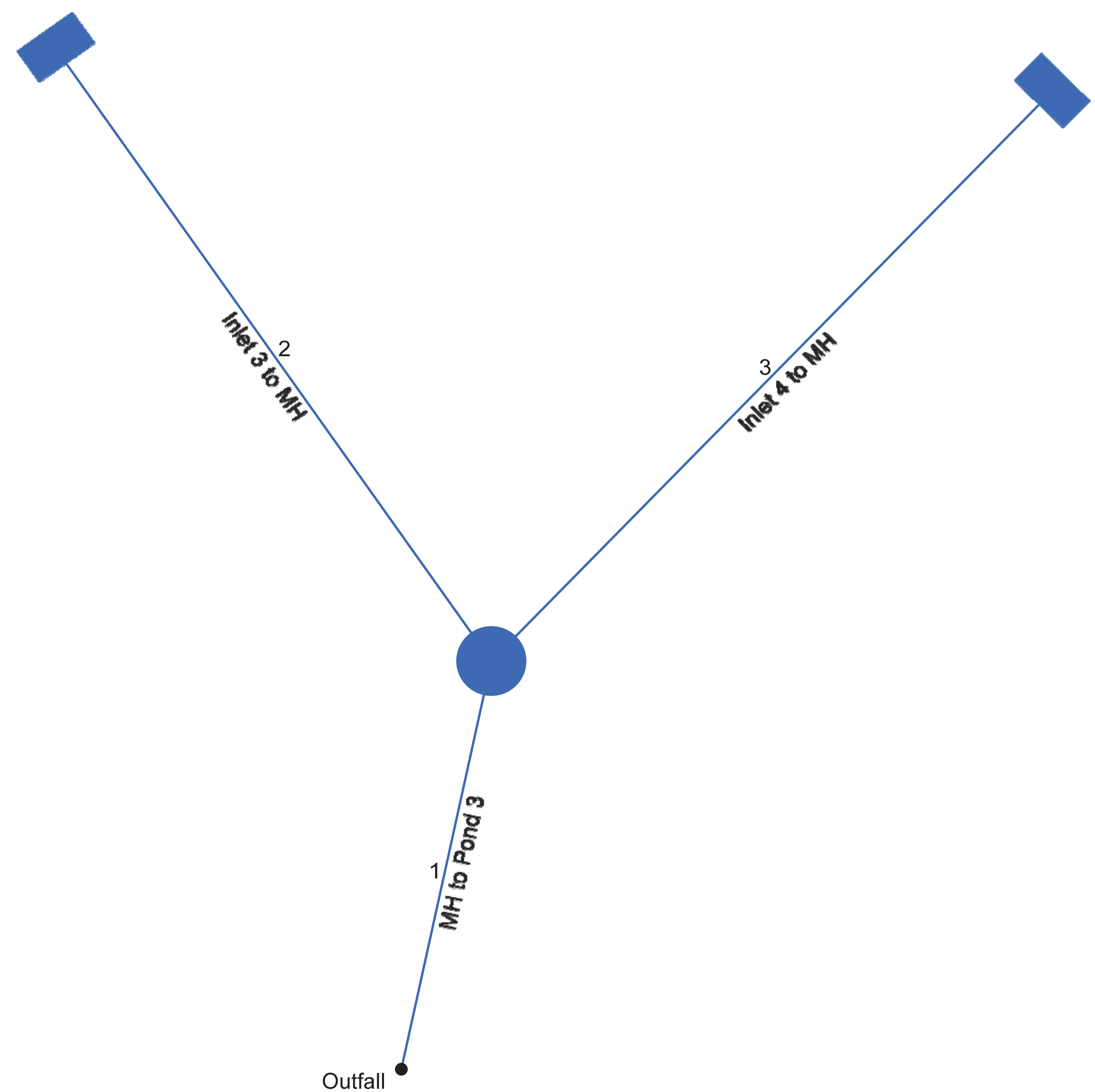
MyReport

Throat Ht (in)	Total Area (ac)	Total CxA	Total Runoff (cfs)	Vel Ave (ft/s)	Vel Dn (ft/s)	Vel Hd Dn (ft)	Vel Hd Up (ft)	Vel Up (ft/s)	Cover Dn (ft)	Cover Up (ft)	Storage (cft)
....	0.00	0.00	0.00	8.23	7.76	0.94	1.18	8.71	3.83	2.24	217.03
....	0.00	0.00	0.00	8.04	8.14	0.98	0.98	7.93	2.04	3.03	340.25
....	0.00	0.00	0.00	7.48	7.48	0.87	0.87	7.48	3.83	3.56	336.47

Project File: Inlet 1 to Ex A2 Analysis.stm | Number of lines: 3 | Date: 3/20/2020

NOTES: ** Critical depth

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: New.stm	Number of lines: 3	Date: 3/20/2020

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	MH to Pond 3	38.20	30	Cir	49.526	408.54	409.00	0.929	411.04	411.43	0.75	412.18	End	Manhole
2	Inlet 3 to MH	6.55	30	Cir	89.116	416.80	423.93	8.001	417.20	424.78	0.31	424.78	1	DropGrate
3	Inlet 4 to MH	31.65	30	Cir	94.564	415.77	420.50	5.002	416.78	422.41	0.96	422.41	1	DropGrate

Project File: New.stm	Number of lines: 3	Run Date: 3/20/2020
NOTES: Return period = 10 Yrs.		

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	49.526	0.00	0.00	0.00	0.00	0.00	0.0	1.1	0.0	38.20	39.52	7.81	30	0.93	408.54	409.00	411.04	411.43	412.47	422.33	MH to Pond 3
2	1	89.116	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	6.55	116.0	8.61	30	8.00	416.80	423.93	417.20	424.78	422.33	431.78	Inlet 3 to MH
3	1	94.564	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	31.65	91.72	12.40	30	5.00	415.77	420.50	416.78	422.41	422.33	426.51	Inlet 4 to MH

Project File: New.stm | Number of lines: 3 | Run Date: 3/20/2020

NOTES:Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83; Return period =Yrs. 10 ; c = cir e = ellip b = box

MyReport

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross Sl, Sw (ft/ft)	Cross Sl, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	4.91	4.87	n/a	0.20	0.50	0.90	39.52	2.09	....	....	....	-77.572	2.50	2.43	Outfall	0.00	1273811.93	411.98	412.39	0.405
2	0.51	1.47	Sag	0.20	0.50	0.90	116.01	0.85	0.020	0.020	....	-47.758	0.40	0.85**	1	0.00	1273760.40	417.51	425.09	0.000
3	1.87	4.03	Sag	0.20	0.50	0.90	91.72	1.91	0.020	0.020	....	31.977	1.01	1.91**	1	0.00	1273878.10	417.74	423.37	0.000

Project File: New.stm	Number of lines: 3	Date: 3/20/2020

NOTES: ** Critical depth

MyReport

Flow Rate (cfs)	Sf Ave (ft/ft)	Sf Dn (ft/ft)	Grate Area (sqft)	Grate Len (ft)	Grate Width (ft)	Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Gutter Depth (ft)	Gutter Slope (ft/ft)	Gutter Spread (ft)	Gutter Width (ft)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	HGL Jmp Dn (ft)	HGL Jmp Up (ft)	Incr CxA	Incr Q (cfs)	Inlet Depth (ft)	
38.20	0.817	0.868	....	....	....	412.47	422.33	....	....	....	....	411.04	411.43	412.18	....	....	0.00	0.00	....	
6.55	0.000	0.000	15.00	2.50	6.00	422.33	431.78	0.25	Sag	33.44	8.00	417.20	424.78	424.78	....	....	0.00	6.55	0.25	
31.65	0.000	0.000	15.00	2.50	6.00	422.33	426.51	0.73	Sag	80.74	8.00	416.78	422.41	422.41	....	....	0.00	31.65	0.73	

Project File: New.stm | Number of lines: 3 | Date: 3/20/2020

NOTES: ** Critical depth

MyReport

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
....	I3 & I4 MH	Sag	....	0.0	0.00	0.00	408.54	409.00	....	....	0.00	0.00	0.78	MH	0.00	3,276	2,948	2,785
100	Inlet 3	Sag	33.44	0.0	0.00	0.00	416.80	423.93	....	....	0.00	0.00	1.00 z	Dp-Grate	6.55	4,970	4,473	4,225
100	Inlet 4	Sag	80.74	0.0	0.00	0.00	415.77	420.50	....	....	0.00	0.00	1.00 z	Dp-Grate	31.65	5,422	4,880	4,609

Project File: New.stm | Number of lines: 3 | Date: 3/20/2020

NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 -- Return period = 10 Yrs. ; ** Critical depth

MyReport

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)	Tc (min)
MH to Pond 3	49.526	30	0.93	Cir	....	....	0.013	0.75	524774.38	0.11	....	....	....	30	0.00	30	0.00	0.00	0.00	1.1
Inlet 3 to MH	89.116	30	8.00	Cir	....	....	0.013	0.31	524847.08	1.11	0.00	6.55	0.00	30	0.00	30	0.00	0.00	0.00	0.0
Inlet 4 to MH	94.564	30	5.00	Cir	....	....	0.013	0.96	524841.93	0.24	0.00	31.65	0.00	30	0.00	30	0.00	0.00	0.00	0.0

Project File: New.stm | Number of lines: 3 | Date: 3/20/2020

NOTES: ** Critical depth

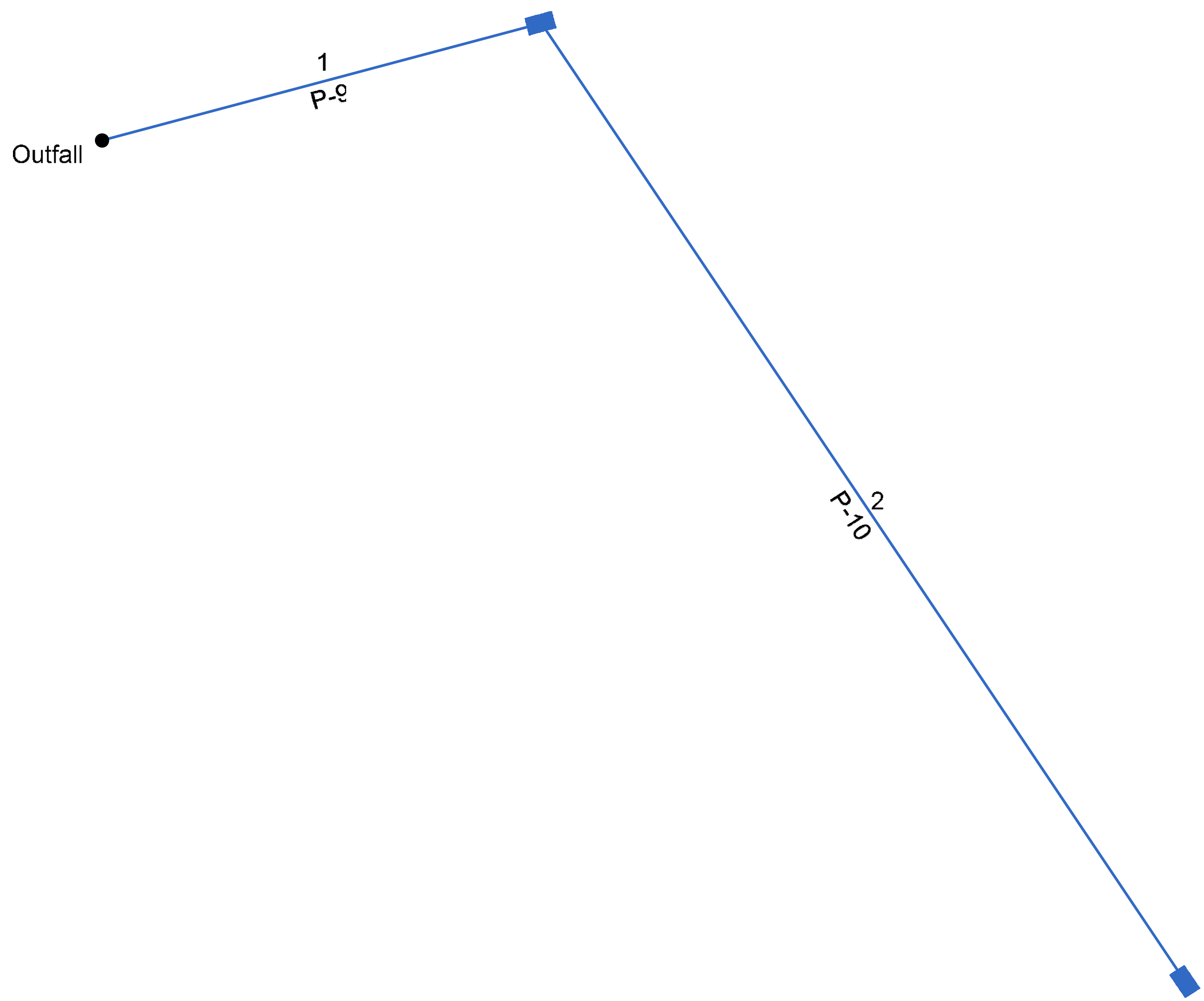
MyReport

Throat Ht (in)	Total Area (ac)	Total CxA	Total Runoff (cfs)	Vel Ave (ft/s)	Vel Dn (ft/s)	Vel Hd Dn (ft)	Vel Hd Up (ft)	Vel Up (ft/s)	Cover Dn (ft)	Cover Up (ft)	Storage (cft)
....	0.00	0.00	0.00	7.81	7.78	0.94	0.96	7.84	1.43	10.83	242.31
....	0.00	0.00	0.00	8.61	12.75	0.31	0.31	4.47	3.03	5.35	86.49
....	0.00	0.00	0.00	12.40	16.95	0.96	0.96	7.85	4.06	3.51	281.30

Project File: New.stm	Number of lines: 3	Date: 3/20/2020

NOTES: ** Critical depth

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Proposed SD Z Analysis.stm	Number of lines: 2	Date: 7/1/2020

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	P-9	12.06	24	Cir	65.085	400.00	400.50	0.768	401.13	401.75	n/a	401.75	End	DropGrate
2	P-10	7.27	24	Cir	166.023	400.50	401.50	0.602	401.75	402.46	n/a	402.46 j	1	DropGrate

Project File: Proposed SD Z Analysis.stm	Number of lines: 2	Run Date: 7/1/2020

NOTES: Return period = 10 Yrs. ; j - Line contains hyd. jump.

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Dn	Up	Dn	Up	Dn	Up	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	65.085	0.00	0.00	0.00	0.00	0.00	0.0	1.2	0.0	12.06	19.82	6.24	24	0.77	400.00	400.50	401.13	401.75	402.75	404.75	P-9
2	1	166.023	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	7.27	17.55	4.21	24	0.60	400.50	401.50	401.75	402.46	404.75	408.00	P-10

Project File: Proposed SD Z Analysis.stm | Number of lines: 2 | Run Date: 7/1/2020

NOTES:Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83; Return period =Yrs. 10 ; c = cir e = ellip b = box

MyReport

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross Sl, Sw (ft/ft)	Cross Sl, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	1.82	2.06	Sag	0.20	0.50	0.90	19.82	1.25	0.020	0.020	....	-15.013	1.13	1.25**	Outfall	0.00	1273957.44	401.66	402.28	0.000
2	1.48	1.48	Sag	0.20	0.50	0.90	17.55	0.96	0.020	0.020	....	71.272	1.25	0.96**	1	0.00	1274049.66	402.12	402.83	0.000

Project File: Proposed SD Z Analysis.stm | Number of lines: 2 | Date: 7/1/2020

NOTES: ** Critical depth

MyReport

Flow Rate (cfs)	Sf Ave (ft/ft)	Sf Dn (ft/ft)	Grate Area (sqft)	Grate Len (ft)	Grate Width (ft)	Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Gutter Depth (ft)	Gutter Slope (ft/ft)	Gutter Spread (ft)	Gutter Width (ft)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	HGL Jmp Dn (ft)	HGL Jmp Up (ft)	Incr CxA	Incr Q (cfs)	Inlet Depth (ft)	
12.06	0.000	0.000	5.06	2.53	2.00	402.75	404.75	0.31	Sag	39.42	8.00	401.13	401.75	401.75	....	....	0.00	4.79	0.31	
7.27	0.000	0.000	5.06	2.53	2.00	404.75	408.00	0.42	Sag	49.51	8.00	401.75	402.46 j	402.46	401.74	401.53	0.00	7.27	0.42	

Project File: Proposed SD Z Analysis.stm | Number of lines: 2 | Date: 7/1/2020

NOTES: ** Critical depth

MyReport

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
100	INLET Z-2	Sag	39.42	0.0	0.00	0.00	400.00	400.50	....	....	0.00	0.00	1.44 z	Dp-Grate	4.79	2,548	2,293	2,166
100	INLET Z-6	Sag	49.51	0.0	0.00	0.00	400.50	401.50	16.60	5.71	0.24	0.44	1.00 z	Dp-Grate	7.27	7,730	6,957	6,571

Project File: Proposed SD Z Analysis.stm | Number of lines: 2 | Date: 7/1/2020

NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 -- Return period = 10 Yrs. ; ** Critical depth

MyReport

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)
P-9	65.085	24	0.77	Cir	....	....	0.013	n/a	524502.49	0.28	0.00	4.79	0.00	24	0.00	24	0.00	0.00	0.00
P-10	166.023	24	0.60	Cir	....	....	0.013	n/a	524364.43	1.20	0.00	7.27	0.00	24	0.00	24	0.00	0.00	0.00

Project File: Proposed SD Z Analysis.stm | Number of lines: 2 | Date: 7/1/2020

NOTES: ** Critical depth

MyReport

Tc (min)	Throat Ht (in)	Total Area (ac)	Total CxA	Total Runoff (cfs)	Vel Ave (ft/s)	Vel Dn (ft/s)	Vel Hd Dn (ft)	Vel Hd Up (ft)	Vel Up (ft/s)	Cover Dn (ft)	Cover Up (ft)	Storage (cft)
1.2	....	0.00	0.00	0.00	6.24	6.62	0.53	0.53	5.86	0.75	2.25	126.35
0.0	....	0.00	0.00	0.00	4.21	3.53	0.37	0.37	4.90	2.25	4.50	294.34

Project File: Proposed SD Z Analysis.stm | Number of lines: 2 | Date: 7/1/2020

NOTES: ** Critical depth

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf		Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf	Ave Sf	Enrgy loss		
	(in)	(cfs)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(%)	(ft)	(K)	(ft)
1	24	12.06	400.00	401.13	1.13	1.82	6.62	0.53	401.66	0.000	65.085	400.50	401.75	1.25**	2.06	5.86	0.53	402.28	0.000	0.000	n/a	1.44	n/a
2	24	7.27	400.50	401.75	1.25	1.48	3.53	0.37	402.12	0.000	166.023	401.50	402.46 j	0.96**	1.48	4.90	0.37	402.83	0.000	0.000	n/a	1.00	n/a

Project File: Proposed SD Z Analysis.stm	Number of lines: 2	Run Date: 7/1/2020

Notes: ; ** Critical depth.; j-Line contains hyd. jump ; c = cir e = ellip b = box

INLET NO.	INCR. AREA (ac)	TOTAL AREA (ac)	C	C*A	∑C*A	T.C (min)	I (in/hr)	BASE FLOW (cfs)	OVER FLOW (cfs)	TOTAL INFLOW* (cfs)	FLOW INTER. (cfs)	FLOW BYPASS cfs	FLOW BYPASS TO	INLET LENGTH COMP. (ft)	INLET LENGTH ACTUAL (ft)	STREET SLOPW (%)	CROSS SLOPE (ft/ft)	CURB HEIGHT (ft)	THROAT DEPRESS (in)	GUTTER FLOW DEPTH (ft)	GUTTER FLOW SPREAD (ft)	NOTES
I-1*	5.28	5.28	0.57	3.01	3.01	19.2	4.46	0	-	13.22	-	-	-	-								Swale 1 Drainage Area
I-5*	6.73	6.73	0.58	3.90	3.90	8.28	6.22	0	-	24.05	19.10	4.95	A-2									Majority of Swale 5 Drainage Area
A-2	0.206	6.94	0.58	4.02	7.93	6	6.78	0	-	5.76	-	-	-									TOTAL Swale 5 Drainage Area
I-3*	2.36	2.36	0.61	1.44	1.44	16.26	4.83	0	-	6.55	-											SWALE 11 Drainage Area
I-4*	9.05	9.03	0.56	5.06	5.06	7.2	6.47	0	-	31.58	-											SWALE 15 Drainage Area
I-2*	33.357	33.357	0.57	19.01	19.01	8.58	6.15	0	-	222.07	70.892	151.178	Ex D7									Swale 10 Area (also picks up Swale 8 and 13)- PR Yard Inlet + Sediment Basin Dishcharge (TEMPORARY)
Ex D7	1.544	1.544	0.53	0.82	0.82	6	6.78	5.548	151.178	156.73	64.866	91.86021	Ex D5									
Ex D5	0.829	0.829	0.51	0.42	0.42	6	6.78	2.867	91.86021	94.73	54.914	39.813	Ex D4									
Ex D4	-	-	-	-	-	6	6.78	0.000	39.812726	39.81	35.104	4.709	Ex D5									
Z-6*	2.095	2.095	0.55	1.15	1.15	6	6.78			7.27												
Z-2	0.963	0.963	0.73	0.70	0.70	6	6.78			4.79												

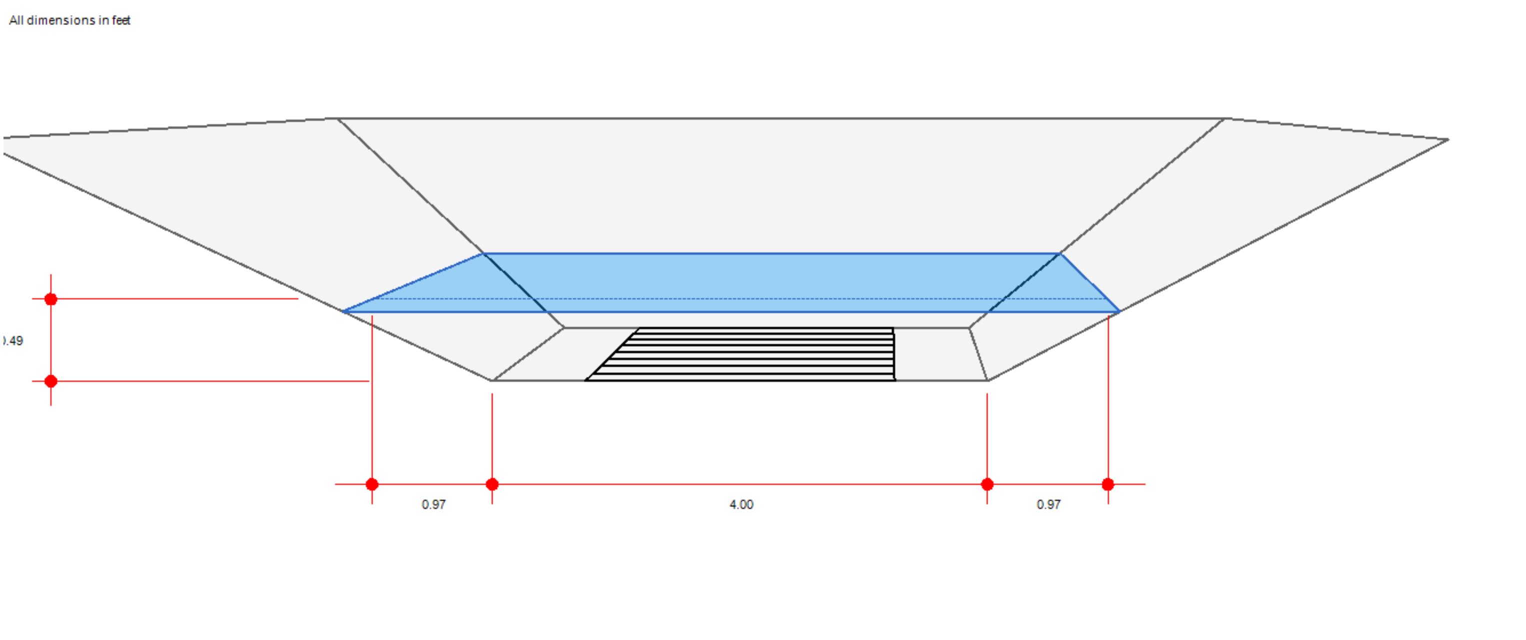
EA ENGINEERING, SCIENCE, AND TECHNOLOGY	**INLET COMPUTATIONS**	**COMPUTED**	LMO	**DATE**
		CHECKED		**Jul-20**
	GUDE LANDFILL REMEDIATION DESIGN	**SHEET NO.**		**PROJECT NO.**
				1564601

*I-1: Total inflow was calculated with TR-55 - located in Swale 1
*I-5: Total inflow was calculated with TR-55 - located in Swale 5
*I-3: Total inflow was calculated with TR-55 - located in Swale 11
*I-4: Total inflow was calculated with TR-55 - located in Swale 15
*I-2: Total inflow was calculated with TR-55 - Sum of Swales 8, 13, and 10 + Temporary Sediment Basin Discharge
*Z-6: Total inflow was calculated with TR-55 - located in Swale 14

Inlet Report

Inlet 1

Drop Grate Inlet		**Calculations**	
Location	= Sag	Compute by:	Known Q
Curb Length (ft)	= -0-	Q (cfs)	= 13.22
Throat Height (in)	= -0-		
Grate Area (sqft)	= 4.00	**Highlighted**	
Grate Width (ft)	= 2.50	Q Total (cfs)	= 13.22
Grate Length (ft)	= 4.00	Q Capt (cfs)	= 13.22
		Q Bypass (cfs)	= -0-
Gutter		Depth at Inlet (in)	= 5.83
Slope, Sw (ft/ft)	= 0.500	Efficiency (%)	= 100
Slope, Sx (ft/ft)	= 0.500	Gutter Spread (ft)	= 5.94
Local Depr (in)	= 24.00	Gutter Vel (ft/s)	= -0-
Gutter Width (ft)	= 4.00	Bypass Spread (ft)	= -0-
Gutter Slope (%)	= -0-	Bypass Depth (in)	= -0-
Gutter n-value	= -0-		



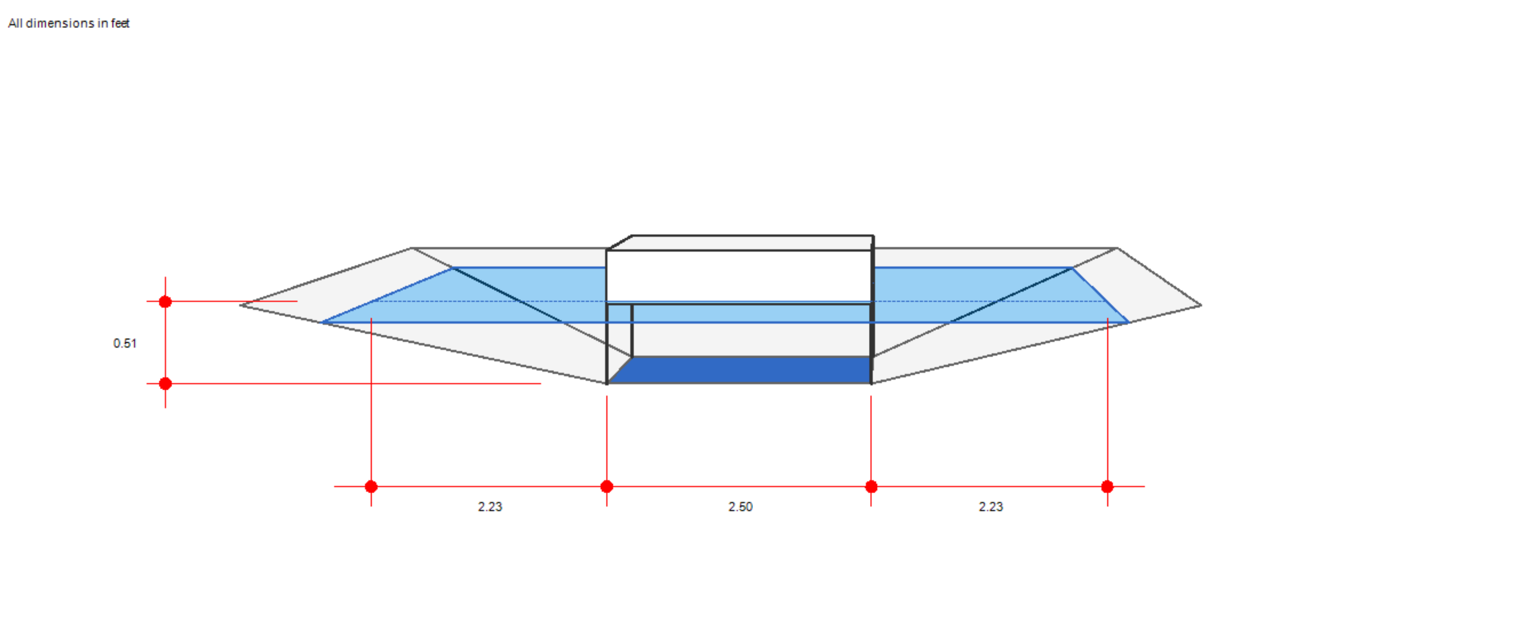
Inlet Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Wednesday, Jul 1 2020

Inlet 2

Drop Curb Inlet		
Location	=	Sag
Curb Length (ft)	=	10.00
Throat Height (in)	=	6.00
Grate Area (sqft)	=	-0-
Grate Width (ft)	=	-0-
Grate Length (ft)	=	-0-
Gutter		
Slope, Sw (ft/ft)	=	0.230
Slope, Sx (ft/ft)	=	0.230
Local Depr (in)	=	-0-
Gutter Width (ft)	=	-0-
Gutter Slope (%)	=	-0-
Gutter n-value	=	-0-

Calculations		
Compute by:		Known Q
Q (cfs)	=	11.00
Highlighted		
Q Total (cfs)	=	11.00
Q Capt (cfs)	=	11.00
Q Bypass (cfs)	=	-0-
Depth at Inlet (in)	=	6.15
Efficiency (%)	=	100
Gutter Spread (ft)	=	2.23
Gutter Vel (ft/s)	=	-0-
Bypass Spread (ft)	=	-0-
Bypass Depth (in)	=	-0-



Inlet Report

Inlet 3

Drop Grate Inlet

Location	=	Sag
Curb Length (ft)	=	-0-
Throat Height (in)	=	-0-
Grate Area (sqft)	=	6.00
Grate Width (ft)	=	6.00
Grate Length (ft)	=	2.50

Gutter

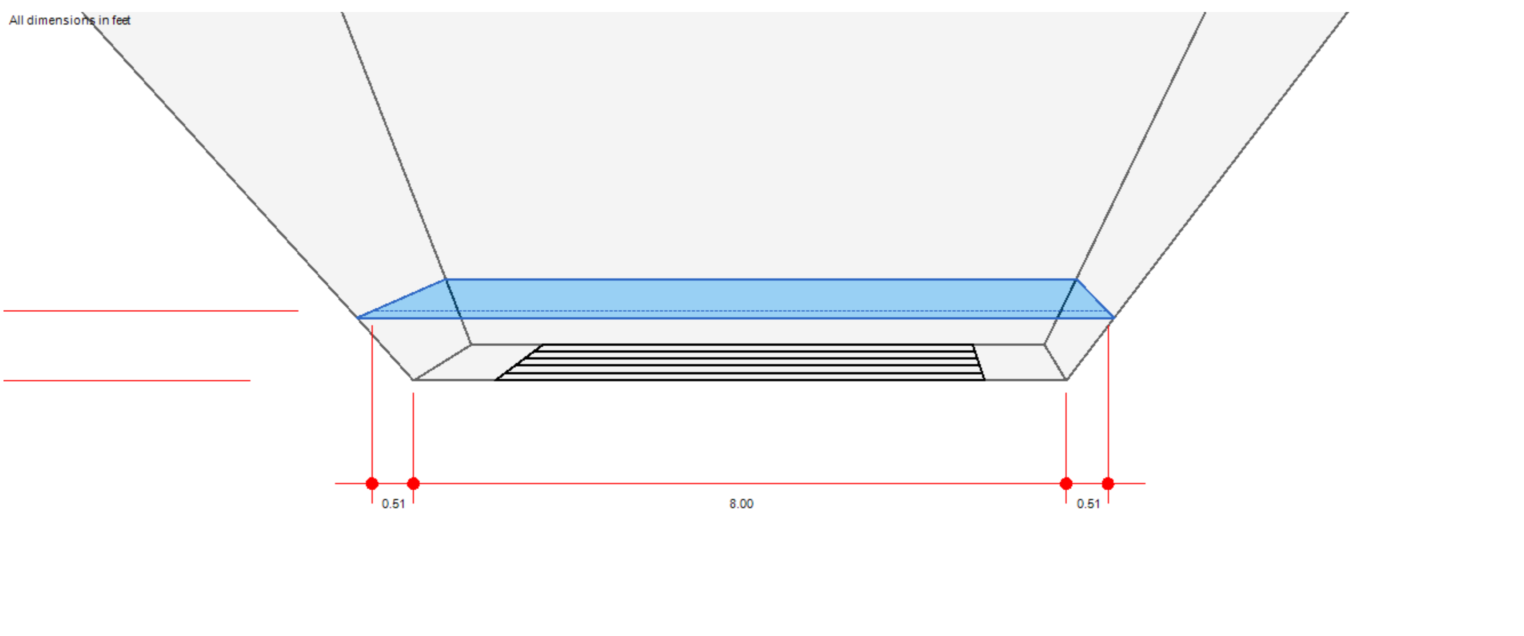
Slope, Sw (ft/ft)	=	0.500
Slope, Sx (ft/ft)	=	0.500
Local Depr (in)	=	24.00
Gutter Width (ft)	=	8.00
Gutter Slope (%)	=	-0-
Gutter n-value	=	-0-

Calculations

Compute by:		Known Q
Q (cfs)	=	6.55

Highlighted

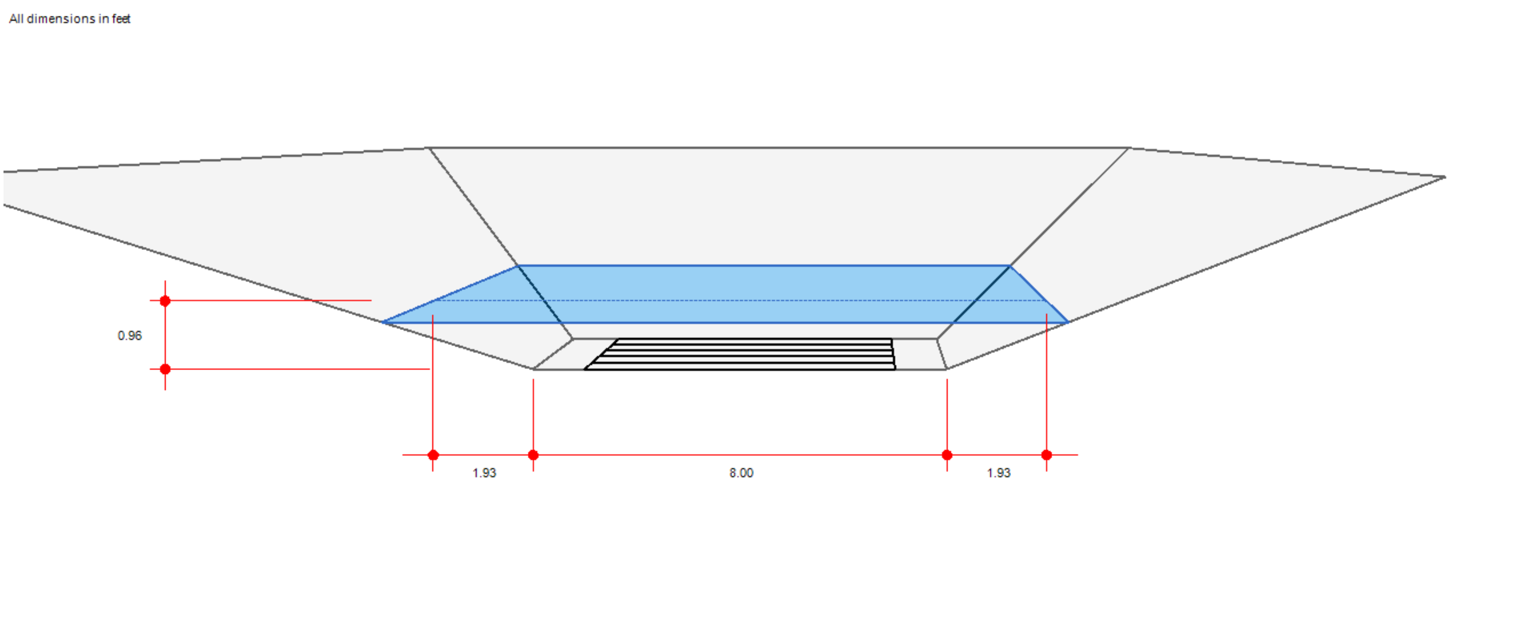
Q Total (cfs)	=	6.55
Q Capt (cfs)	=	6.55
Q Bypass (cfs)	=	-0-
Depth at Inlet (in)	=	3.05
Efficiency (%)	=	100
Gutter Spread (ft)	=	9.02
Gutter Vel (ft/s)	=	-0-
Bypass Spread (ft)	=	-0-
Bypass Depth (in)	=	-0-



Inlet Report

Inlet 4

Drop Grate Inlet		**Calculations**	
Location	= Sag	Compute by:	Known Q
Curb Length (ft)	= -0-	Q (cfs)	= 31.65
Throat Height (in)	= -0-		
Grate Area (sqft)	= 6.00	**Highlighted**	
Grate Width (ft)	= 6.00	Q Total (cfs)	= 31.65
Grate Length (ft)	= 2.50	Q Capt (cfs)	= 31.65
		Q Bypass (cfs)	= -0-
Gutter		Depth at Inlet (in)	= 11.56
Slope, Sw (ft/ft)	= 0.500	Efficiency (%)	= 100
Slope, Sx (ft/ft)	= 0.500	Gutter Spread (ft)	= 11.85
Local Depr (in)	= 24.00	Gutter Vel (ft/s)	= -0-
Gutter Width (ft)	= 8.00	Bypass Spread (ft)	= -0-
Gutter Slope (%)	= -0-	Bypass Depth (in)	= -0-
Gutter n-value	= -0-		



Inlet Report

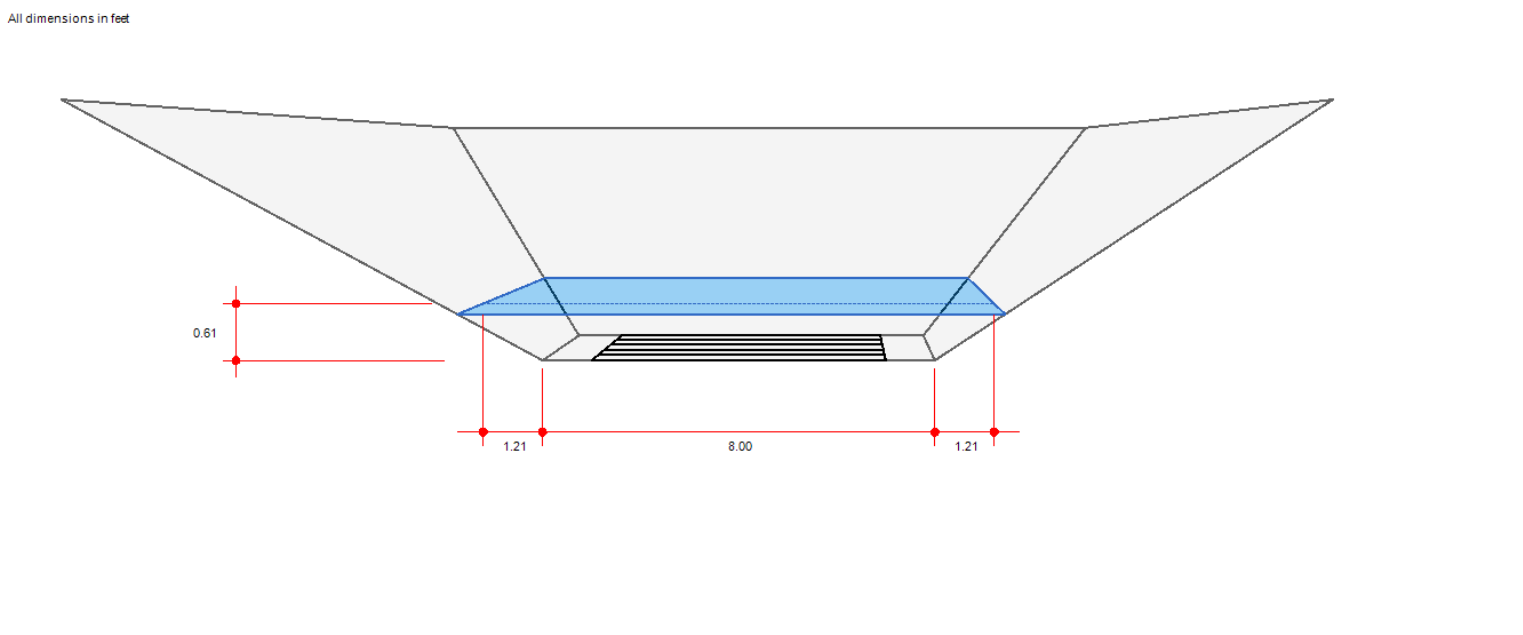
Inlet 5

Drop Grate Inlet	
Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 6.00
Grate Width (ft)	= 6.00
Grate Length (ft)	= 2.50

Gutter	
Slope, Sw (ft/ft)	= 0.500
Slope, Sx (ft/ft)	= 0.500
Local Depr (in)	= 24.00
Gutter Width (ft)	= 8.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

Calculations	
Compute by:	Known Q
Q (cfs)	= 24.05

Highlighted	
Q Total (cfs)	= 24.05
Q Capt (cfs)	= 24.05
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 7.27
Efficiency (%)	= 100
Gutter Spread (ft)	= 10.42
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-



Inlet Report

Inlet A2

Drop Grate Inlet

Location	=	Sag
Curb Length (ft)	=	-0-
Throat Height (in)	=	-0-
Grate Area (sqft)	=	6.00
Grate Width (ft)	=	6.00
Grate Length (ft)	=	2.50

Gutter

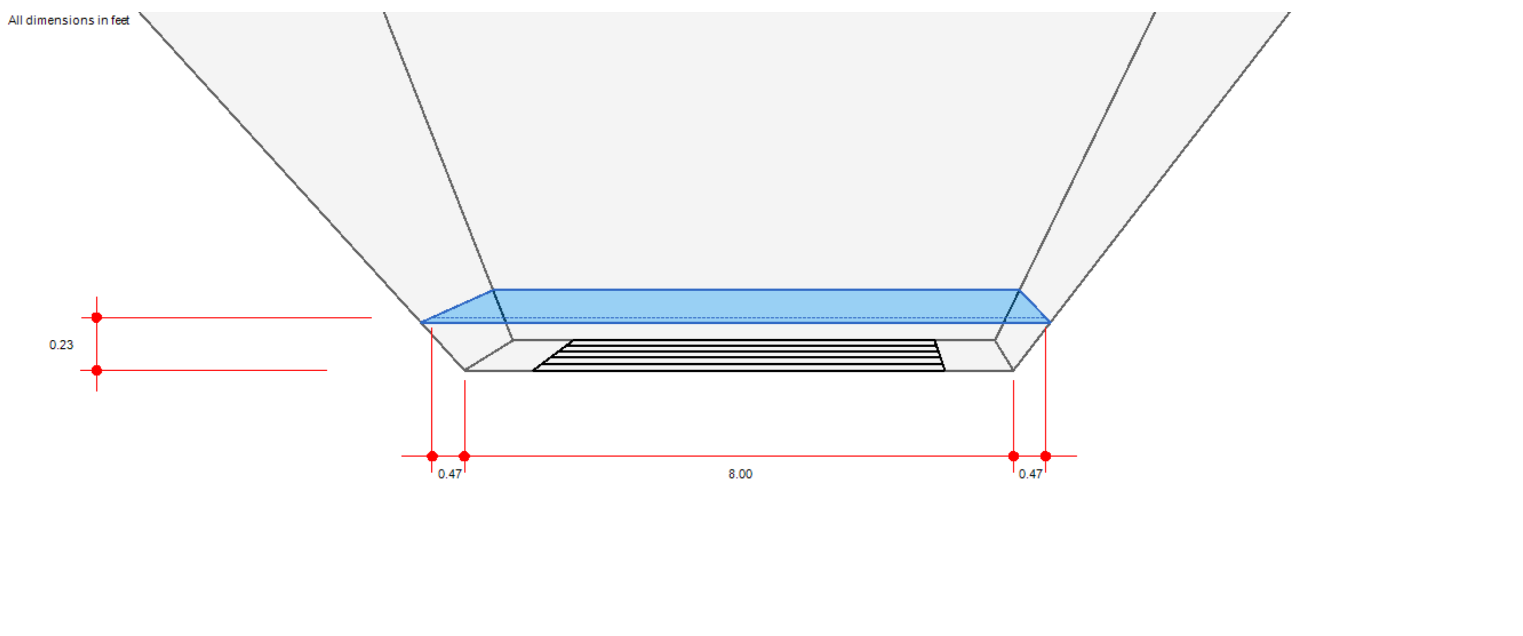
Slope, Sw (ft/ft)	=	0.500
Slope, Sx (ft/ft)	=	0.500
Local Depr (in)	=	24.00
Gutter Width (ft)	=	8.00
Gutter Slope (%)	=	-0-
Gutter n-value	=	-0-

Calculations

Compute by:		Known Q
Q (cfs)	=	5.76

Highlighted

Q Total (cfs)	=	5.76
Q Capt (cfs)	=	5.76
Q Bypass (cfs)	=	-0-
Depth at Inlet (in)	=	2.80
Efficiency (%)	=	100
Gutter Spread (ft)	=	8.93
Gutter Vel (ft/s)	=	-0-
Bypass Spread (ft)	=	-0-
Bypass Depth (in)	=	-0-

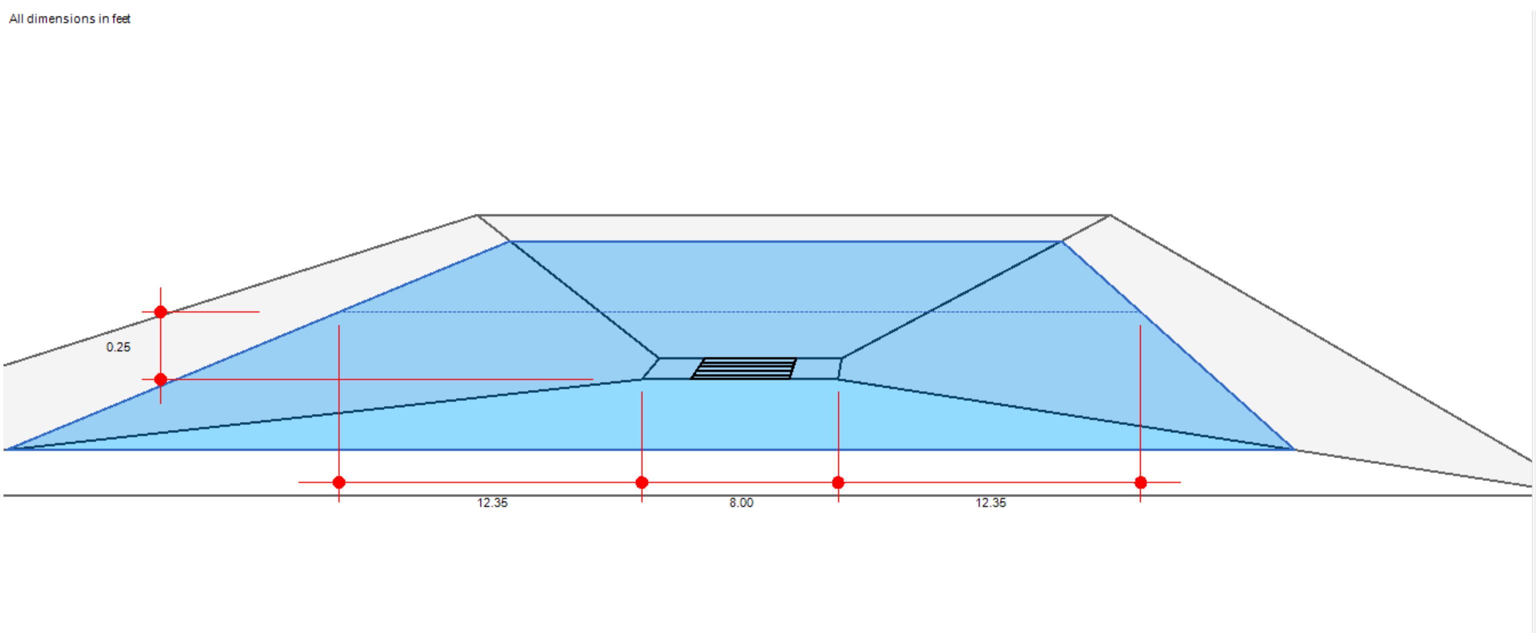


Inlet Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Wednesday, Jul 1 2020

Inlet Z2

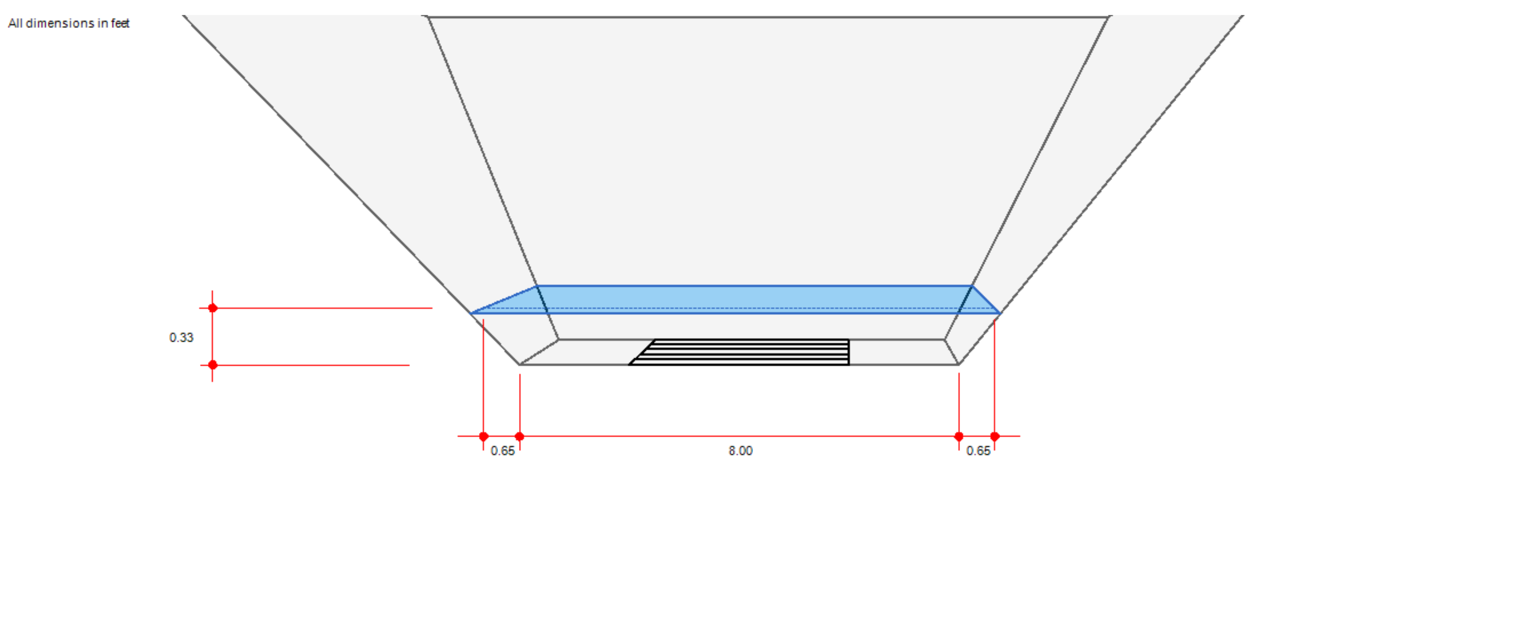
Drop Grate Inlet		**Calculations**	
Location	= Sag	Compute by:	Known Q
Curb Length (ft)	= -0-	Q (cfs)	= 4.79
Throat Height (in)	= -0-		
Grate Area (sqft)	= 4.00	**Highlighted**	
Grate Width (ft)	= 4.00	Q Total (cfs)	= 4.79
Grate Length (ft)	= 2.50	Q Capt (cfs)	= 4.79
		Q Bypass (cfs)	= -0-
Gutter		Depth at Inlet (in)	= 2.96
Slope, Sw (ft/ft)	= 0.020	Efficiency (%)	= 100
Slope, Sx (ft/ft)	= 0.020	Gutter Spread (ft)	= 32.69
Local Depr (in)	= -0-	Gutter Vel (ft/s)	= -0-
Gutter Width (ft)	= 8.00	Bypass Spread (ft)	= -0-
Gutter Slope (%)	= -0-	Bypass Depth (in)	= -0-
Gutter n-value	= -0-		

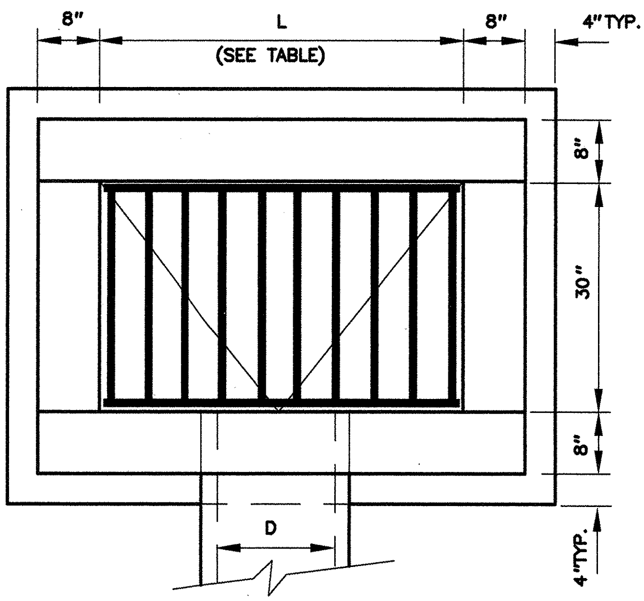


Inlet Report

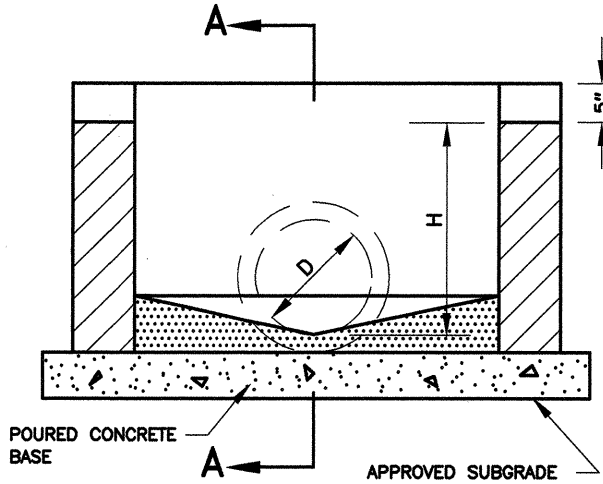
Inlet Z6

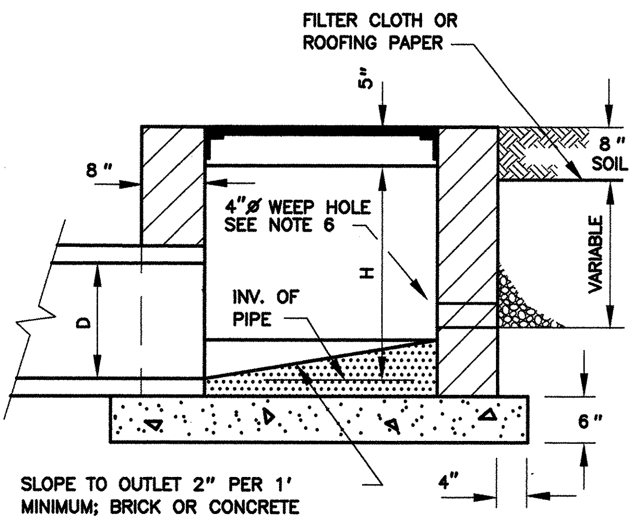
Drop Grate Inlet		**Calculations**	
Location	= Sag	Compute by:	Known Q
Curb Length (ft)	= -0-	Q (cfs)	= 7.27
Throat Height (in)	= -0-		
Grate Area (sqft)	= 4.00	**Highlighted**	
Grate Width (ft)	= 4.00	Q Total (cfs)	= 7.27
Grate Length (ft)	= 2.50	Q Capt (cfs)	= 7.27
		Q Bypass (cfs)	= -0-
Gutter		Depth at Inlet (in)	= 3.91
Slope, Sw (ft/ft)	= 0.500	Efficiency (%)	= 100
Slope, Sx (ft/ft)	= 0.500	Gutter Spread (ft)	= 9.30
Local Depr (in)	= -0-	Gutter Vel (ft/s)	= -0-
Gutter Width (ft)	= 8.00	Bypass Spread (ft)	= -0-
Gutter Slope (%)	= -0-	Bypass Depth (in)	= -0-
Gutter n-value	= -0-		





D	L	H
15"	4' –0"	2' –6"
18"	4' –0"	2' –9"
21"	4' –6"	3' –0"
24"	5' –0"	3' –3"
27"	5' –6"	3' –7"
30"	6' –0"	3' –10"
33"	6' –0"	4' –1"
36"	6' –0"	4' –4"





SECTION A–A

GENERAL NOTES

1. REFER TO MARYLAND STATE HIGHWAY ADMINISTRATION SPECIFICATIONS FOR MATERIALS AND METHODS OF CONSTRUCTION.
2. PROVIDE GRATE PER M.S.H.A. STD. NO. MD–377.02 MODIFIED WITH BARS 3" O.C.; TACK WELD IN PLACE.
3. CONSTRUCTION TO BE OF CONCRETE OR BRICK MASONRY.
4. STEEL VERTICAL 1/2" ø BARS, 6" C.C., HORIZONTAL 1/2" ø BARS, 6" C.C.; BOTTOM 1/2" ø BARS 6" C.C. EACH WALL, 2" MIN. COVER. (WITH CONCRETE CONSTRUCTION)
5. MORTAR SHALL CONFORM TO ASTM SPECIFICATION C270 TYPE M.
6. WEEP HOLES TO BE PLACED IN WALL OPPOSITE OUTLET PIPE 5" ABOVE PIPE INVERT. COVER OPENING WITH 1/2" HARDWARE CLOTH. INSTALL FOUNDATION DRAINAGE MATERIAL AROUND STRUCTURE FROM BOTTOM OF WEEP HOLES TO WITHIN 8" OF SURFACE FOR A THICKNESS OF 12" MINIMUM.
7. BRICK SHALL CONFORM TO AASHTO DESIGNATION M–114 GRADE SW.
8. f'c = 3500 PSI AT 28 DAYS.
9. PARGE OUTSIDE WALLS.

APPROVED JAN 5 /95
DATE

DIRECTOR, DEPT. OF TRANS.

CHIEF, DIV. OF ENG. SERVICES

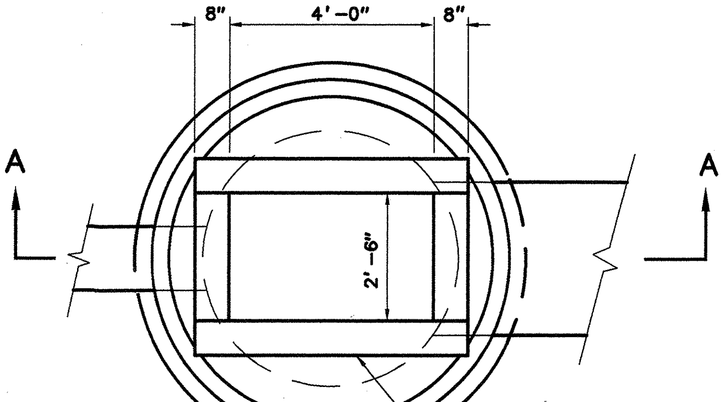
REVISED

MONTGOMERY COUNTY
DEPARTMENT OF TRANSPORTATION

"J" INLET
AS A TERMINUS

STANDARD NO. MC–506.02

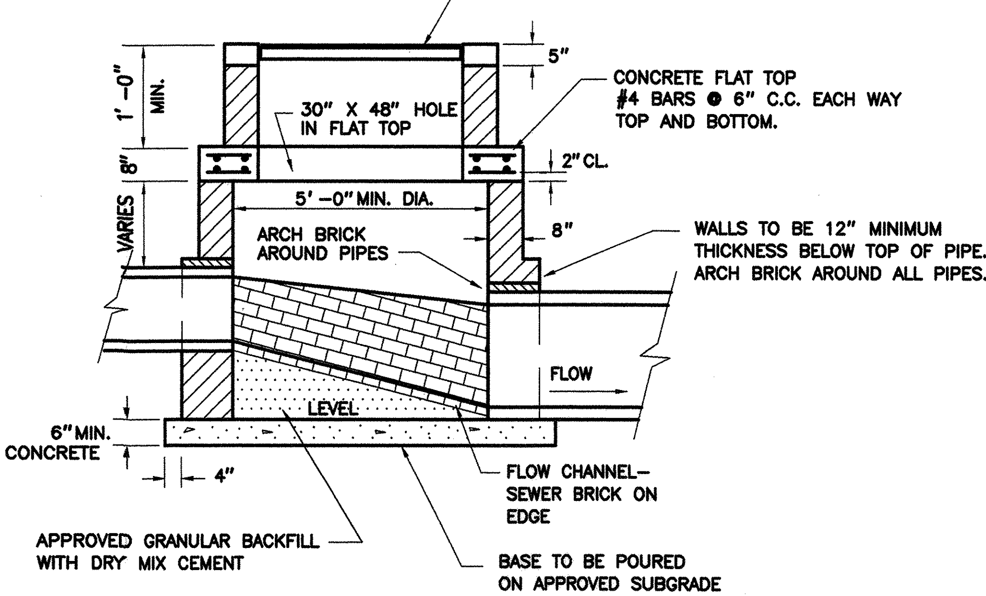
P:\DOTSTD\MC50602 6-24-94 9:42:37 am EST



DEPTH OF STR.	WALL THICKNESS	BASE THICKNESS
1' TO 5'	8"	6"
5' TO 8'	12"	6"
8' TO 12'	16"	8"

NOTE: DEPTH OF STRUCTURE TO BE MEASURED FROM BOTTOM OF FLAT TOP TO INVERT OF OUTGOING PIPE.

OUTGOING PIPE SIZE	STRUCTURE DIAMETER
15" -36"	60"
42" -48"	72"
54" -60"	84"
72"	96"



SECTION A-A

GENERAL NOTES

1. REFER TO MARYLAND STATE HIGHWAY ADMINISTRATION FOR MATERIALS AND METHODS OF CONSTRUCTION.
2. USE SOLID MASONRY (BRICK OR CONCRETE BLOCK) OR POURED CONCRETE FOR WALLS. USE OF M.C.D.O.T. APPROVED PRECAST CONCRETE STRUCTURES MAY BE USED IN PLACE OF BRICK MASONRY.
3. MORTAR SHALL CONFORM TO ASTM SPECIFICATION C270 TYPE M.
4. PROVIDE STEPS IN CHANNELS OF STRUCTURES. REFER TO MC-520.01 FOR DETAILS.
5. $f'c$ = 3,500 P.S.I. AT 28 DAYS.
6. TWO 4"ø WEEP HOLES TO BE PLACED OPPOSITE EACH OTHER AT CROWN OF CHANNEL. COVER OPENING WITH 1/2" HARDWARE CLOTH.
7. INSTALL FOUNDATION DRAINAGE MATERIAL 1' MINIMUM THICKNESS AROUND STRUCTURE FROM BOTTOM OF WEEP HOLES TO WITHIN 8" OF FINISHED GRADE.
8. PARGE OUTSIDE WALLS.

APPROVED JAN 5/96
DATE

DIRECTOR, DEPT. OF TRANS.

CHIEF, DIV. OF ENG. SERVICES

REVISED

MONTGOMERY COUNTY
DEPARTMENT OF TRANSPORTATION

"J" INLET

STANDARD NO. MC-506.01

OBJECTIVE:

Design culvert size is adequate for peak discharge, velocity and depth of flow.

PROCEDURE:

1) Delineate drainage area for each culvert.

2) Use TR-55 to determine peak discharges for 10-year storm events.

Montgomery County Drainage Design Criteria. Montgomery County Department of Transportation, Rockville, Maryland, 10 June 2014.

3) Use HY-8 to design the culverts. The outputs are presented on Culvert Design Form in accordance with Montgomery County Drainage Design Criteria.

CONCLUSION:

Based on HY-8 results, box culverts of Span 3.25 feet and rise 1.5 feet with two barrels have been selected to convey the peak flow for the 10-yr design storm event.

ATTACHMENTS:

Culvert Design Forms
HY-8 Output

PROJECT: Gude Landfill Remediation Design

STATION: SD4
SHEET: 1 **OF** 7

CULVERT DESIGN FORM
DESIGN: SS **DATE:** 3/19/2020
REVIEW: **DATE:** 4/1/2020

SEE ADDITIONAL SHEETS

HYDROLOGIC DATA

METHOD: HY-8

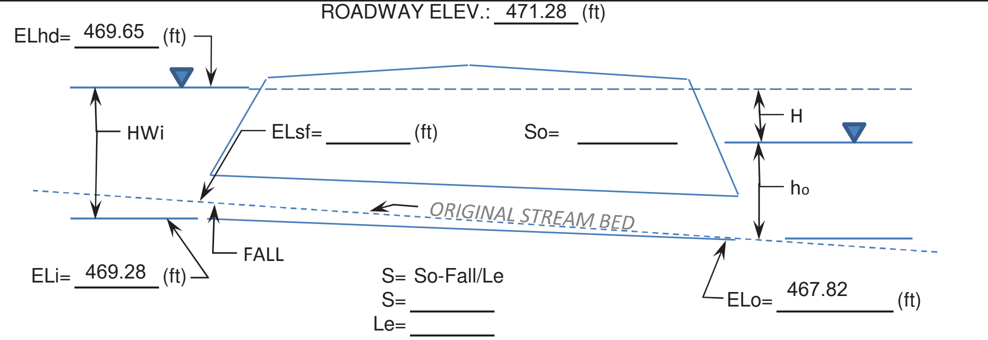
DRAINAGE AREA (AC): 1.35 STREAM SLOPE (FT/FT): 0.015

CHANNEL SHAPE: Trapezoidal

ROUTING: OTHER:

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
10	3.86	0.029



ID NO.	CULVERT DESCRIPTION: Material / Shape	Entrance / Size Span	Rise	TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	INLET CONTROL HW_i/D (2)	HW_i (FT)	FALL (FT) (3)	EL_{hi} (FT) (4)	OUTLET CONTROL TW (FT) (5)	d_C (FT)	$(d_C+D)/2$ (FT)	h_O (FT) (6)	Ke	H (FT) (7)	EL_{ho} (FT) (8)	CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments
1	Reinforced Concrete / Box Culvert	Square Edge / 3.25	1.50	3.86	1.93	NA	0.370		469.65	0.029	0.222	NA	0.029	0.05	0.341	467.82	469.65	16.66	
2																			
3																			
4																			
5																			
6																			

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL - HWi-(ELhd-ELsf): FALL IS ZER0 FOR CULVERTS AT GRADE

(4) ELhi=HWi+ELi (INVERT OF INLET CONTOL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) ho = TW or (Dc+D)/2 (whichever is greater)

(7) $H = [1+Ke+((Ku)(n)^2(L))/R^{1.33}](V^2/2g)$
where Ku = 19.63 (29 IN ENGLISH UNITS)

(8) ELho =ELO+H+ho

SUBSCRIPT DEFINITIONS:

- W = APPROXIMATE
- F = CULVERT FACE
- hd = DESIGN HEADWATER
- hl = HEADWATER IN INLET CONTROL
- ho = HEADWATER IN OUTLET CONTROL
- i = INLET CONTROL SECTION
- O = OUTLET
- sf = STREAMBED AT CULVERT FACE
- tw = TAIL WATER

COMMENTS / DISCUSSION:

MONTGOMERY COUNTY 17 76 MARYLAND GARDEZ BIEN

CULVERT BARREL SELECTED:

SIZE: Span 3.25 FT, Rise 1.5 FT

SHAPE: Box Culvert

MATERIAL: Reinforced Concrete n: 0.012

ENTRANCE: Square Edge

PROJECT: Gude Landfill Remediation Design

STATION: SD8
SHEET: 2 **OF** 7

CULVERT DESIGN FORM
DESIGN: SS **DATE:** 3/19/2020
REVIEW: [signature] **DATE:** 4/1/2020

SEE ADDITIONAL SHEETS

HYDROLOGIC DATA

METHOD: HY-8

DRAINAGE AREA (AC): 4.71 STREAM SLOPE (FT/FT): 0.015

CHANNEL SHAPE: Trapezoidal

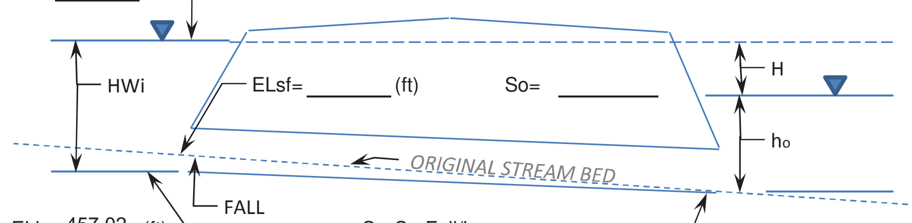
ROUTING: OTHER:

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
10	13.09	0.505

ROADWAY ELEV.: 459.02 (ft)

ELhd= 457.86 (ft)



ELi= 457.02 (ft)

S= So-Fall/Le
S=
Le=

ELo= 456.67 (ft)

ID NO.	CULVERT DESCRIPTION: Material / Shape	Entrance / Size: Span	Rise	TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	INLET CONTROL: HWi/D (2)	HWi (FT)	FALL (FT) (3)	ELhi (FT) (4)	OUTLET CONTROL: TW (FT) (5)	dc (FT)	(dc+D)/2 (FT)	ho (FT) (6)	Ke	H (FT) (7)	ELho (FT) (8)	CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments
1	Reinforced Concrete / Box Culvert	Square Edge / 3.25	1.50	13.09	6.55	NA	0.840		457.86	0.505	0.501	NA	0.505	0.5	0.335	456.67	457.86	6.05	
2																			
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4																			
5																			
6																			

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL - HWi-(ELhd-ELsf): FALL IS ZER0 FOR CULVERTS AT GRADE

(4) ELhi=HWi+ELi (INVERT OF INLET CONTOL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) ho = TW or (Dc+D)/2 (whichever is greater)

(7) $H = [1+Ke+((Ku)(n)^2(L))/R^{1.33}](V^2/2g)$
where Ku = 19.63 (29 IN ENGLISH UNITS)

(8) ELho =ELo+H+ho

SUBSCRIPT DEFINITIONS:

- W = APPROXIMATE
- F = CULVERT FACE
- hd = DESIGN HEADWATER
- hl = HEADWATER IN INLET CONTROL
- ho = HEADWATER IN OUTLET CONTROL
- i = INLET CONTROL SECTION
- O = OUTLET
- sf = STREAMBED AT CULVERT FACE
- tw = TAIL WATER

COMMENTS / DISCUSSION:

MONTGOMERY COUNTY MARYLAND 1776

CULVERT BARREL SELECTED:

SIZE: Span 3.25 FT, Rise 1.5 FT

SHAPE: Box Culvert

MATERIAL: Reinforced Concrete n: 0.012

ENTRANCE: Square Edge

PROJECT: Gude Landfill Remediation Design

STATION: SD8-2
SHEET: 3 **OF** 7

CULVERT DESIGN FORM
DESIGN: SS **DATE:** 3/19/2020
REVIEW: [signature] **DATE:** 4/1/2020

SEE ADDITIONAL SHEETS

HYDROLOGIC DATA

☐ METHOD: HY-8

☐ DRAINAGE AREA (AC): 15.55 ☐ STREAM SLOPE (FT/FT): 0.015

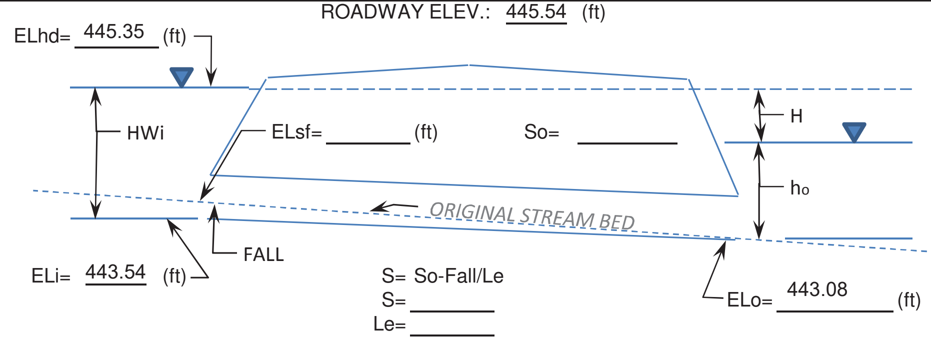
☐ CHANNEL SHAPE: Trapezoidal

☐ ROUTING: ☐ OTHER:

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
10	39.95	0.789

ROADWAY ELEV.: 445.54 (ft)



ID NO.	CULVERT DESCRIPTION: Material / Shape	Entrance / Size: Span	Rise	TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	INLET CONTROL: HW_i/D (2)	HW_i (FT)	FALL (FT) (3)	EL_{hi} (FT) (4)	OUTLET CONTROL: TW (FT) (5)	d_C (FT)	$(d_C+D)/2$ (FT)	h_O (FT) (6)	Ke	H (FT) (7)	EL_{ho} (FT) (8)	CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments
1	Reinforced Concrete Box Culvert	Square Edge 3.25	1.50	39.95	19.98	NA	1.81		445.35	0.789	1.06	NA	0.789	0.5	1.021	443.08	445.35	8.44	
2																			
3																			
4																			
5																			
6																			

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL - HWi-(ELhd-ELsf): FALL IS ZER0 FOR CULVERTS AT GRADE

(4) ELhi=HWi+ELi (INVERT OF INLET CONTOL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) ho = TW or (Dc+D)/2 (whichever is greater)

(7) $H = [1+Ke+((Ku)(n)^2(L))/R^{1.33}](V^2/2g)$
where Ku = 19.63 (29 IN ENGLISH UNITS)

(8) ELho =ELo+H+ho

SUBSCRIPT DEFINITIONS:

- W = APPROXIMATE
- F = CULVERT FACE
- hd = DESIGN HEADWATER
- hl = HEADWATER IN INLET CONTROL
- ho = HEADWATER IN OUTLET CONTROL
- i = INLET CONTROL SECTION
- O = OUTLET
- sf = STREAMBED AT CULVERT FACE
- tw = TAIL WATER

COMMENTS / DISCUSSION:

MONTGOMERY COUNTY MARYLAND 1776 GARDEZ BIEN

CULVERT BARREL SELECTED:

SIZE: Span 3.25 FT, Rise 1.5 FT

SHAPE: Box Culvert

MATERIAL: Reinforced Concrete n: 0.012

ENTRANCE: Square Edge

PROJECT: Gude Landfill Remediation Design

STATION: SD9
SHEET: 4 **OF** 7

CULVERT DESIGN FORM
DESIGN: SS **DATE:** 3/19/2020
REVIEW: [signature] **DATE:** 4/1/2020

HYDROLOGIC DATA

SEE ADDITIONAL SHEETS

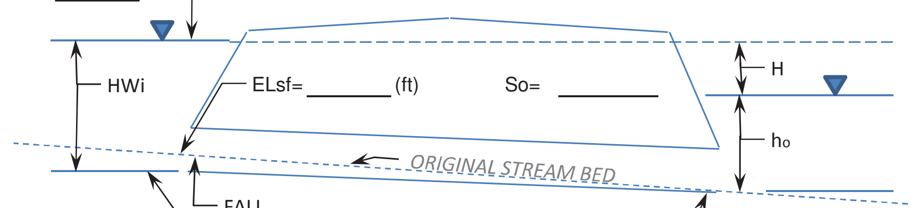
- [ ] METHOD: HY-8
- [ ] DRAINAGE AREA (AC): 1.58
- [ ] STREAM SLOPE (FT/FT): 0.01
- [ ] CHANNEL SHAPE: Trapezoidal
- [ ] ROUTING:
- [ ] OTHER:

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
10	4.87	0.236

ROADWAY ELEV.: 472.00 (ft)

ELhd= 470.44 (ft)



ELi= 470.00 (ft)

S= So-Fall/Le
S=
Le=

ELo= 469.88 (ft)

ID NO.	CULVERT DESCRIPTION: Material / Shape	Entrance / Size: Span	Size: Rise	TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	INLET CONTROL: HW_i/D (2)	HW_i (FT)	FALL (FT) (3)	EL_{hi} (FT) (4)	OUTLET CONTROL: TW (FT) (5)	d_C (FT)	$(d_C+D)/2$ (FT)	h_O (FT) (6)	Ke	H (FT) (7)	EL_{ho} (FT) (8)	CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments
1	Reinforced Concrete / Box Culvert	Square Edge / 3.25	1.50	4.87	2.44	NA	0.440		470.44	0.236	0.259	NA	0.236	0.5	0.204	469.88	470.44	3.12	
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6																			

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL - HWi-(ELhd-ELsf): FALL IS ZER0 FOR CULVERTS AT GRADE

(4) ELhi=HWi+ELi (INVERT OF INLET CONTOL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) ho = TW or (Dc+D)/2 (whichever is greater)

(7) $H = [1+Ke+((Ku)(n)^2(L))/R^{1.33}](V^2/2g)$
where Ku = 19.63 (29 IN ENGLISH UNITS)

(8) ELho =ELo+H+ho

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
F = CULVERT FACE
hd = DESIGN HEADWATER
hI = HEADWATER IN INLET CONTROL
ho = HEADWATER IN OUTLET CONTROL
i = INLET CONTROL SECTION
O = OUTLET
sf = STREAMBED AT CULVERT FACE
tw = TAIL WATER

COMMENTS / DISCUSSION:

MONTGOMERY COUNTY MARYLAND 1776

CULVERT BARREL SELECTED:

SIZE: Span 3.25 FT, Rise 1.5 FT

SHAPE: Box Culvert

MATERIAL: Reinforced Concrete n: 0.012

ENTRANCE: Square Edge

PROJECT: Gude Landfill Remediation Design

STATION: SD12
SHEET: 5 **OF** 7

CULVERT DESIGN FORM
DESIGN: SS **DATE:** 3/19/2020
REVIEW: [signature] **DATE:** 4/1/2020

SEE ADDITIONAL SHEETS

HYDROLOGIC DATA

☐ METHOD: HY-8

☐ DRAINAGE AREA (AC): 3.31 ☐ STREAM SLOPE (FT/FT): 0.020

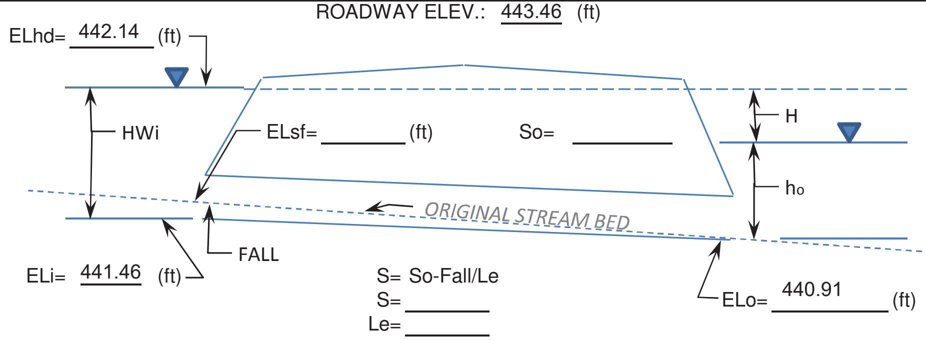
☐ CHANNEL SHAPE: Trapezoidal

☐ ROUTING: ☐ OTHER:

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
10	9.54	0.358

ROADWAY ELEV.: 443.46 (ft)



ID NO.	CULVERT DESCRIPTION: Material / Shape	Entrance / Size Span	Rise	TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	INLET CONTROL: HW_i/D (2)	HW_i (FT)	FALL (FT) (3)	EL_{hi} (FT) (4)	OUTLET CONTROL: TW (FT) (5)	d_C (FT)	$(d_C+D)/2$ (FT)	h_O (FT) (6)	Ke	H (FT) (7)	EL_{ho} (FT) (8)	CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments
1	Reinforced Concrete / Box Culvert	Square Edge / 3.25	1.50	9.54	4.77	NA	0.680		442.14	0.358	0.406	NA	0.358	0.5	0.322	440.91	442.14	5.90	
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6																			

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL - HWi-(ELhd-ELsf): FALL IS ZER0 FOR CULVERTS AT GRADE

(4) ELhi=HWi+ELi (INVERT OF INLET CONTOL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) ho = TW or (Dc+D)/2 (whichever is greater)

(7) $H = [1+Ke+((Ku)(n)^2(L))/R^{1.33}](V^2/2g)$ where Ku = 19.63 (29 IN ENGLISH UNITS)

(8) ELho =ELo+H+ho

SUBSCRIPT DEFINITIONS:

- W = APPROXIMATE
- F = CULVERT FACE
- hd = DESIGN HEADWATER
- hl = HEADWATER IN INLET CONTROL
- ho = HEADWATER IN OUTLET CONTROL
- i = INLET CONTROL SECTION
- O = OUTLET
- sf = STREAMBED AT CULVERT FACE
- tw = TAIL WATER

COMMENTS / DISCUSSION:

MONTGOMERY COUNTY MARYLAND 1776 GARDEZ BIEN

CULVERT BARREL SELECTED:

SIZE: Span 3.25 FT, Rise 1.5 FT

SHAPE: Box Culvert

MATERIAL: Reinforced Concrete n: 0.012

ENTRANCE: Square Edge

PROJECT: Gude Landfill Remediation Design

STATION: SD13
SHEET: 6 **OF** 7

CULVERT DESIGN FORM
DESIGN: SS **DATE:** 3/19/2020
REVIEW: [signature] **DATE:** 4/1/2020

HYDROLOGIC DATA

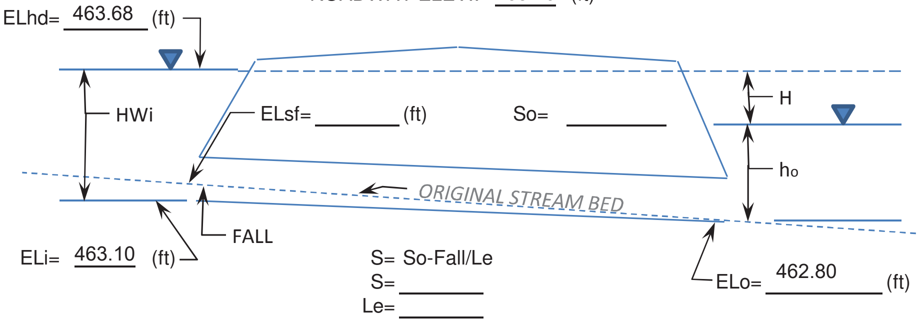
SEE ADDITIONAL SHEETS

- ☐ METHOD: HY-8
- ☐ DRAINAGE AREA (AC): 2.36 ☐ STREAM SLOPE (FT/FT): 0.020
- ☐ CHANNEL SHAPE: Trapezoidal
- ☐ ROUTING: ☐ OTHER:

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
10	7.31	0.075

ROADWAY ELEV.: 465.10 (ft)



ID NO.	CULVERT DESCRIPTION: Material / Shape	Entrance / Size: Span	Size: Rise	TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	INLET CONTROL: HW_i/D (2)	HW_i (FT)	FALL (FT) (3)	EL_{hi} (FT) (4)	OUTLET CONTROL: TW (FT) (5)	d_C (FT)	$(d_C+D)/2$ (FT)	h_O (FT) (6)	Ke	H (FT) (7)	EL_{ho} (FT) (8)	CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments
1	Reinforced Concrete Box Culvert	Square Edge 3.25	1.50	7.31	3.66	NA	0.580		463.68	0.075	0.340	NA	0.075	0.5	0.505	462.80	463.68	4.42	
2																			
3																			
4																			
5																			
6																			

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL - HWi-(ELhd-ELsf): FALL IS ZER0 FOR CULVERTS AT GRADE

(4) ELhi=HWi+ELi (INVERT OF INLET CONTOL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) ho = TW or (Dc+D)/2 (whichever is greater)

(7) $H = [1+Ke+((Ku)(n)^2(L))/R^{1.33}](V^2/2g)$
where Ku = 19.63 (29 IN ENGLISH UNITS)

(8) ELho =ELo+H+ho

SUBSCRIPT DEFINITIONS:

- W = APPROXIMATE
- F = CULVERT FACE
- hd = DESIGN HEADWATER
- hI = HEADWATER IN INLET CONTROL
- ho = HEADWATER IN OUTLET CONTROL
- i = INLET CONTROL SECTION
- O = OUTLET
- sf = STREAMBED AT CULVERT FACE
- tw = TAIL WATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: Span 3.25 FT, Rise 1.5 FT

SHAPE: Box Culvert

MATERIAL: Reinforced Concrete n: 0.012

ENTRANCE: Square Edge

PROJECT: Gude Landfill Remediation Design

STATION: SD13-2
SHEET: 7 **OF** 7

CULVERT DESIGN FORM
DESIGN: SS **DATE:** 3/19/2020
REVIEW: [signature] **DATE:** 4/1/2020

SEE ADDITIONAL SHEETS

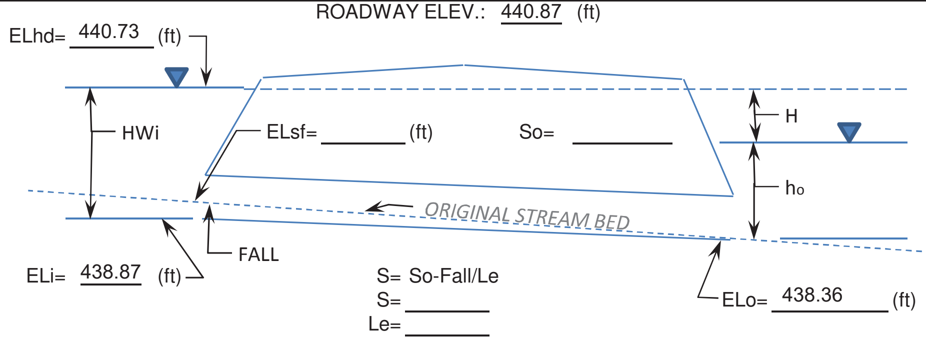
HYDROLOGIC DATA

- [ ] METHOD: HY-8
- [ ] DRAINAGE AREA (AC): 14.35
- [ ] STREAM SLOPE (FT/FT): 0.020
- [ ] CHANNEL SHAPE: Trapezoidal
- [ ] ROUTING:
- [ ] OTHER:

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
10	41.10	0.802

ROADWAY ELEV.: 440.87 (ft)



ID NO.	CULVERT DESCRIPTION: Material	Shape	Entrance	Size Span	Size Rise	TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	INLET CONTROL HW$_i$/D (2)	HW$_i$ (FT)	FALL (FT) (3)	EL$_{hi}$ (FT) (4)	OUTLET CONTROL TW (FT) (5)	d$_C$ (FT)	(d$_C$+D)/2 (FT)	h$_O$ (FT) (6)	Ke	H (FT) (7)	EL$_{ho}$ (FT) (8)	CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments
1	Reinforced Concrete	Box Culvert	Square Edge	3.25	1.50	41.10	20.55	NA	1.86		440.73	0.802	1.075	NA	0.802	0.5	1.058	438.36	440.73	8.62	
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HWi/D = HW/D OR HWi/D FROM DESIGN CHARTS

(3) FALL - HWi-(ELhd-ELsf): FALL IS ZER0 FOR CULVERTS AT GRADE

(4) ELhi=HWi+ELi (INVERT OF INLET CONTOL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) ho = TW or (Dc+D)/2 (whichever is greater)

(7) $H = [1+Ke+((Ku)(n)^2(L))/R^{1.33}](V^2/2g)$
where Ku = 19.63 (29 IN ENGLISH UNITS)

(8) ELho =ELO+H+ho

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
F = CULVERT FACE
hd = DESIGN HEADWATER
hI = HEADWATER IN INLET CONTROL
ho = HEADWATER IN OUTLET CONTROL
i = INLET CONTROL SECTION
O = OUTLET
sf = STREAMBED AT CULVERT FACE
tw = TAIL WATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: Span 3.25 FT, Rise 1.5 FT

SHAPE: Box Culvert

MATERIAL: Reinforced Concrete n: 0.012

ENTRANCE: Square Edge

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 3.86 cfs

Design Flow: 3.86 cfs

Maximum Flow: 3.86 cfs

Table 1 - Summary of Culvert Flows at Crossing: SD4 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	SD4 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
469.65	3.86	3.86	0.00	1
471.28	45.13	45.13	0.00	Overtopping

Rating Curve Plot for Crossing: SD4 (10-YR)

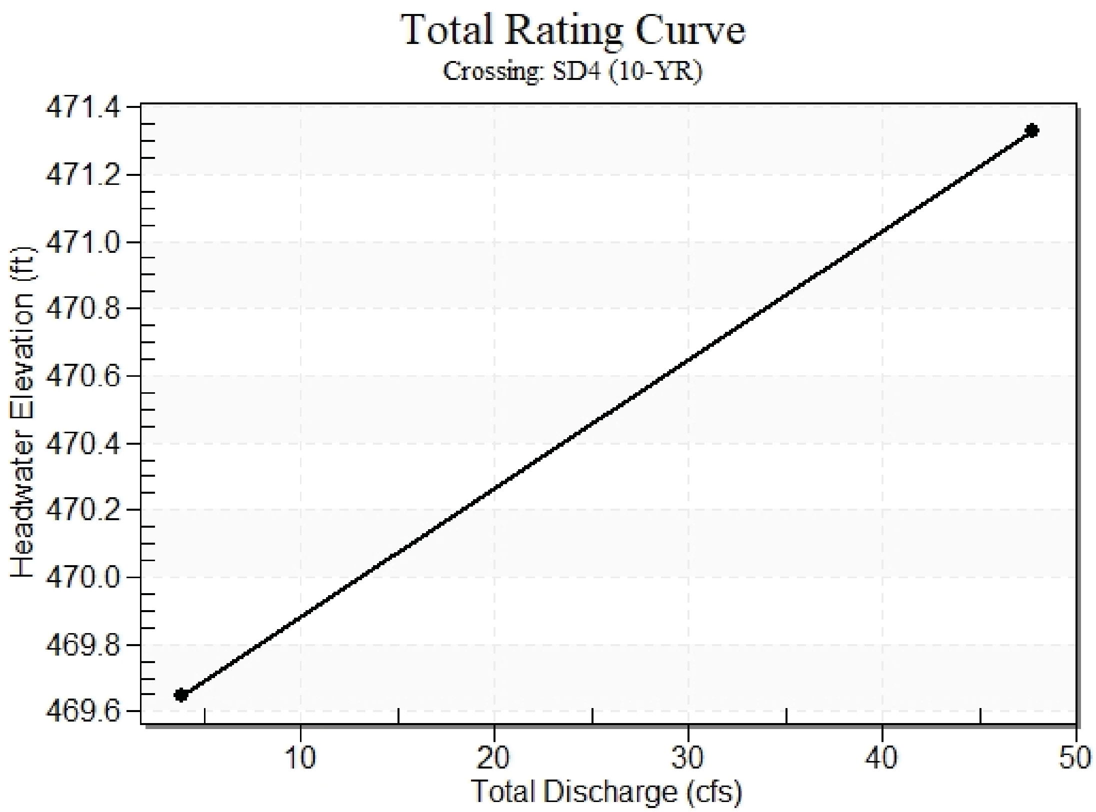


Table 2 - Culvert Summary Table: SD4

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104
3.86	3.86	469.65	0.368	0.0*	1-S2n	0.114	0.222	0.114	0.217	5.227	2.104

* Full Flow Headwater elevation is below inlet invert.

****

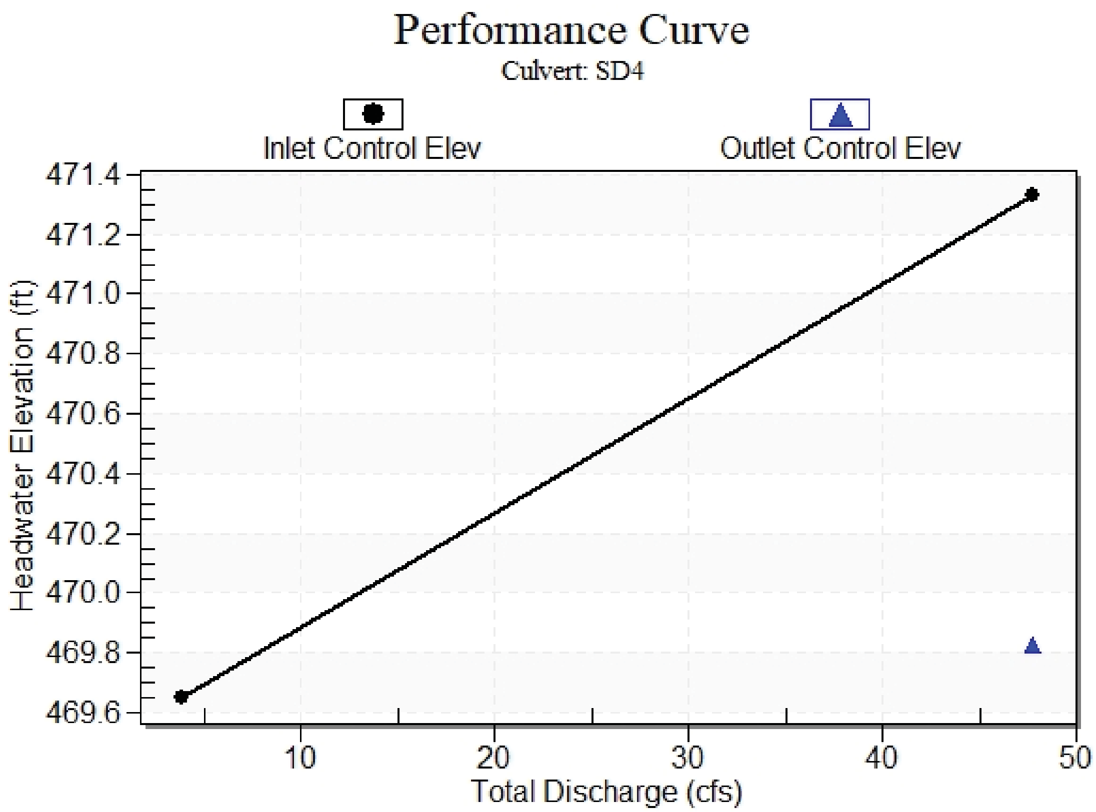
Straight Culvert

Inlet Elevation (invert): 469.28 ft, Outlet Elevation (invert): 467.82 ft

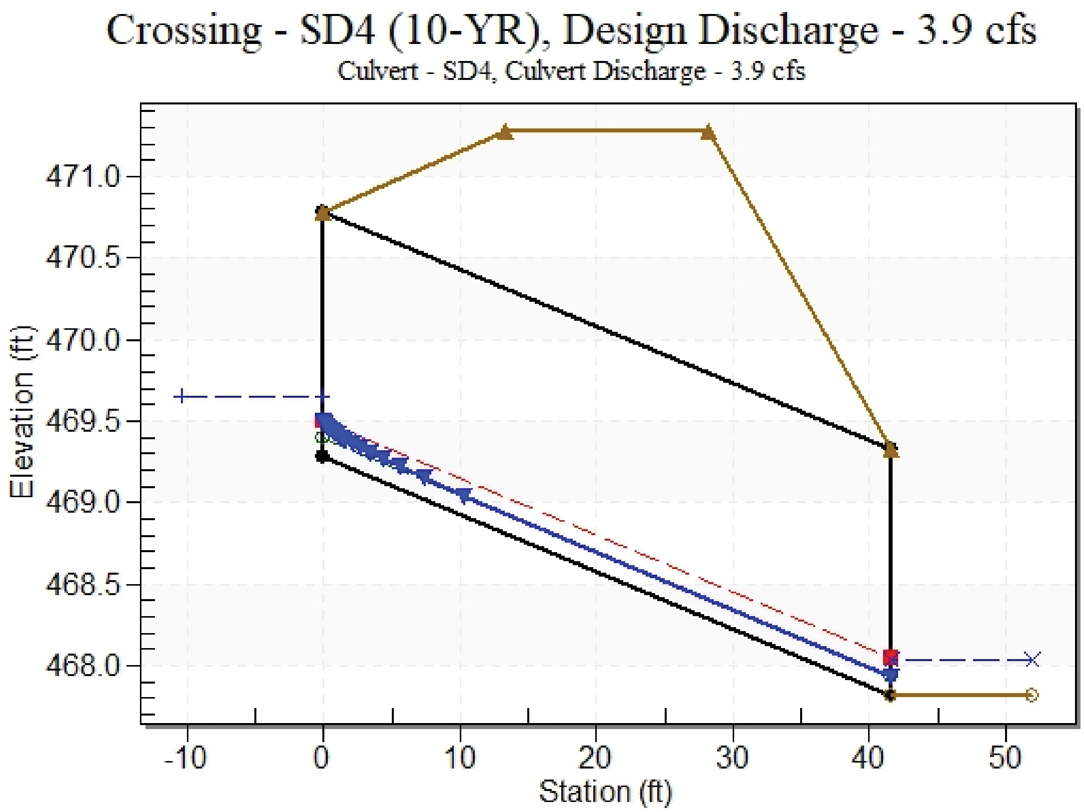
Culvert Length: 41.57 ft, Culvert Slope: 0.0351

****

Culvert Performance Curve Plot: SD4



Water Surface Profile Plot for Culvert: SD4



Site Data - SD4

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 469.28 ft

Outlet Station: 41.55 ft

Outlet Elevation: 467.82 ft

Number of Barrels: 2

Culvert Data Summary - SD4

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: SD4 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82
3.86	468.04	0.22	2.10	0.20	0.82

Tailwater Channel Data - SD4 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0150

Channel Manning's n: 0.0300

Channel Invert Elevation: 467.82 ft

Roadway Data for Crossing: SD4 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 471.28 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 39.95 cfs

Design Flow: 39.95 cfs

Maximum Flow: 39.95 cfs

Table 4 - Summary of Culvert Flows at Crossing: SD8-2 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	SD8-2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.35	39.95	39.95	0.00	1
445.54	44.82	44.82	0.00	Overtopping

Rating Curve Plot for Crossing: SD8-2 (10-YR)

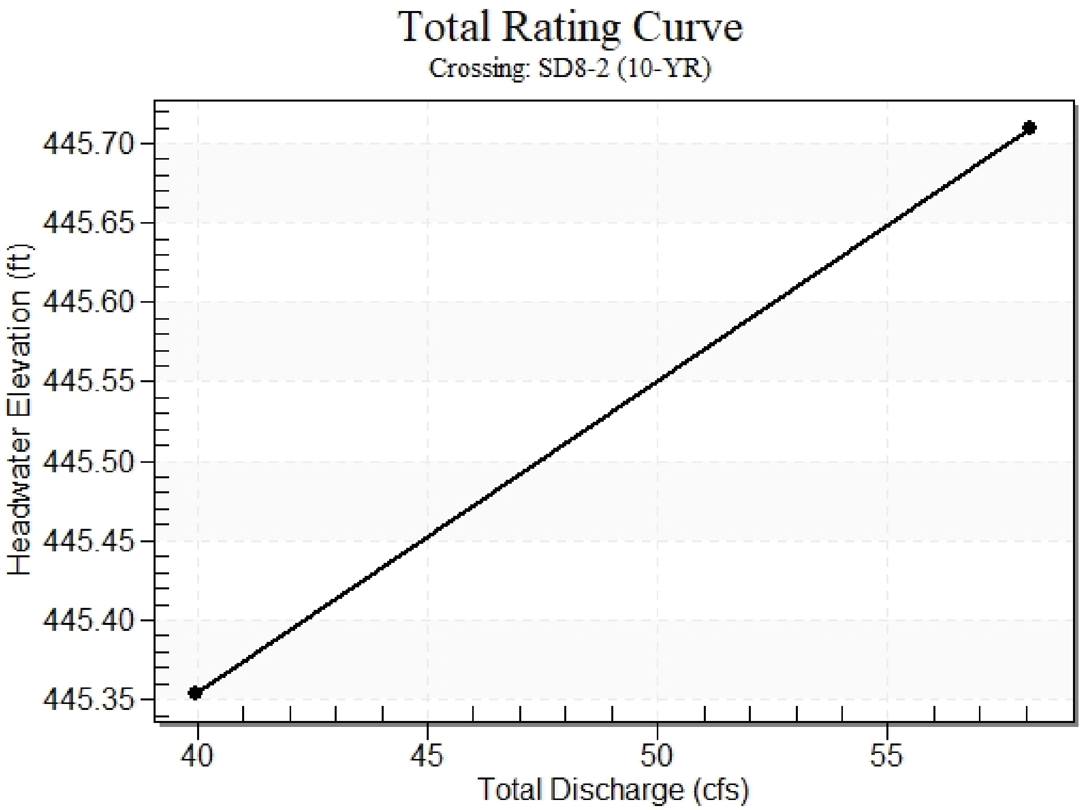


Table 5 - Culvert Summary Table: SD8-2

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799
39.95	39.95	445.35	1.814	1.048	5-S2n	0.609	1.055	0.729	0.857	8.436	4.799

****

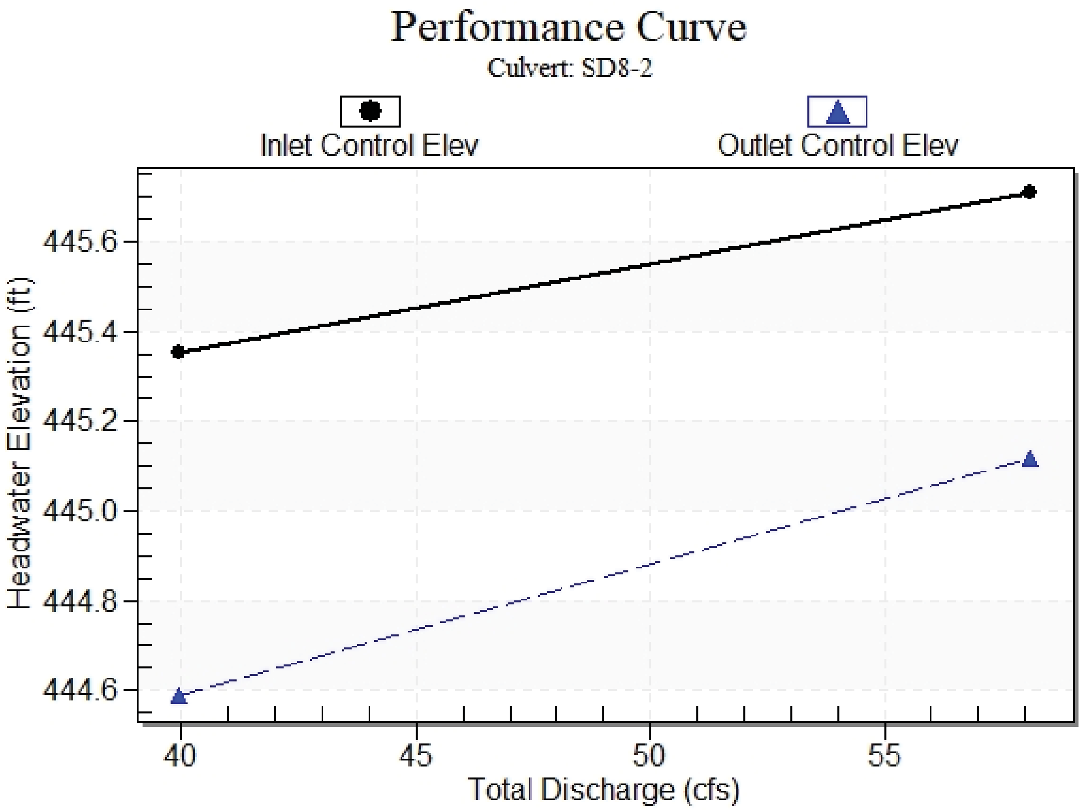
Straight Culvert

Inlet Elevation (invert): 443.54 ft, Outlet Elevation (invert): 443.08 ft

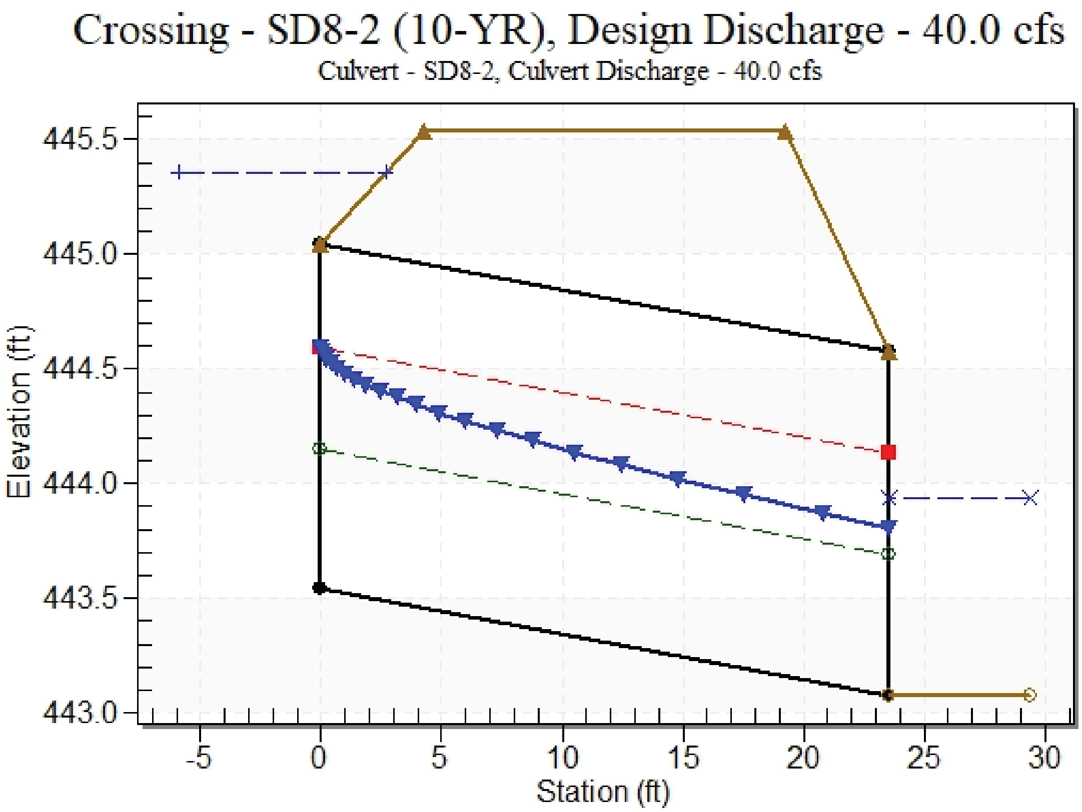
Culvert Length: 23.52 ft, Culvert Slope: 0.0196

****

Culvert Performance Curve Plot: SD8-2



Water Surface Profile Plot for Culvert: SD8-2



Site Data - SD8-2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 443.54 ft

Outlet Station: 23.51 ft

Outlet Elevation: 443.08 ft

Number of Barrels: 2

Culvert Data Summary - SD8-2

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: SD8-2 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99
39.95	443.94	0.86	4.80	0.80	0.99

Tailwater Channel Data - SD8-2 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0150

Channel Manning's n: 0.0300

Channel Invert Elevation: 443.08 ft

Roadway Data for Crossing: SD8-2 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 445.54 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 41.1 cfs

Design Flow: 41.1 cfs

Maximum Flow: 41.1 cfs

Table 7 - Summary of Culvert Flows at Crossing: SD13-2 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	SD13-2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.73	41.10	41.10	0.00	1
440.87	44.82	44.82	0.00	Overtopping

Rating Curve Plot for Crossing: SD13-2 (10-YR)

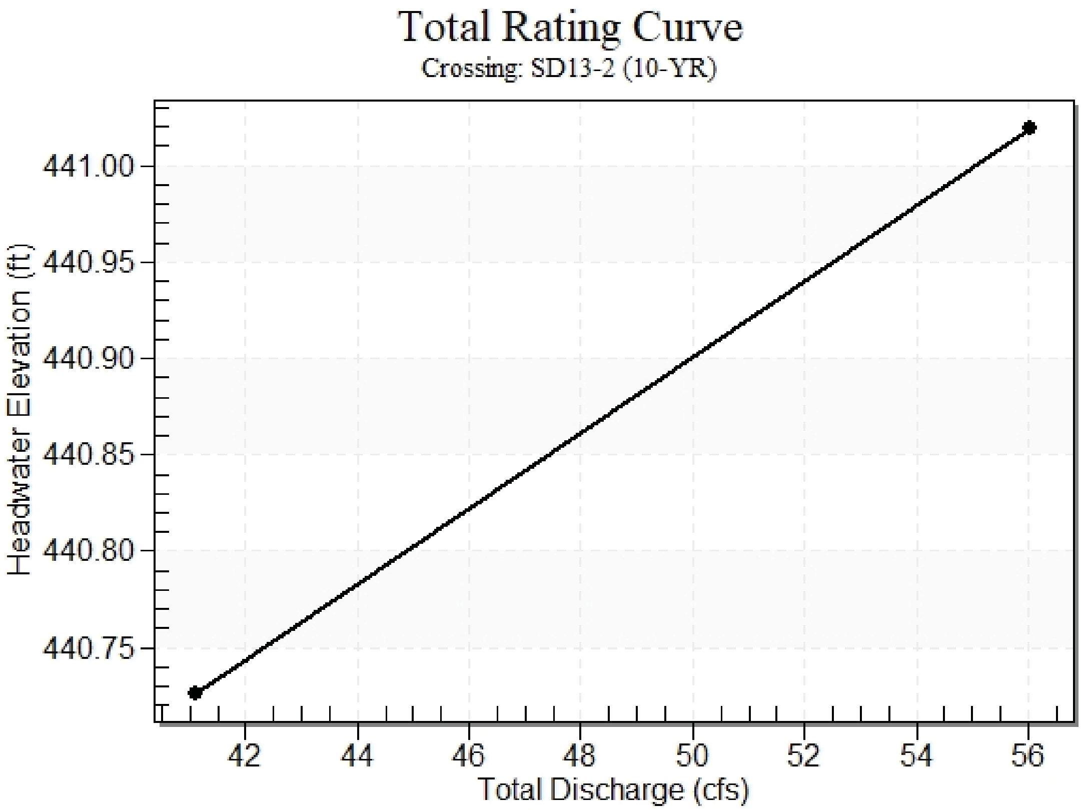


Table 8 - Culvert Summary Table: SD13-2

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336
41.10	41.10	440.73	1.857	1.050	5-S2n	0.617	1.075	0.733	0.802	8.622	5.336

****

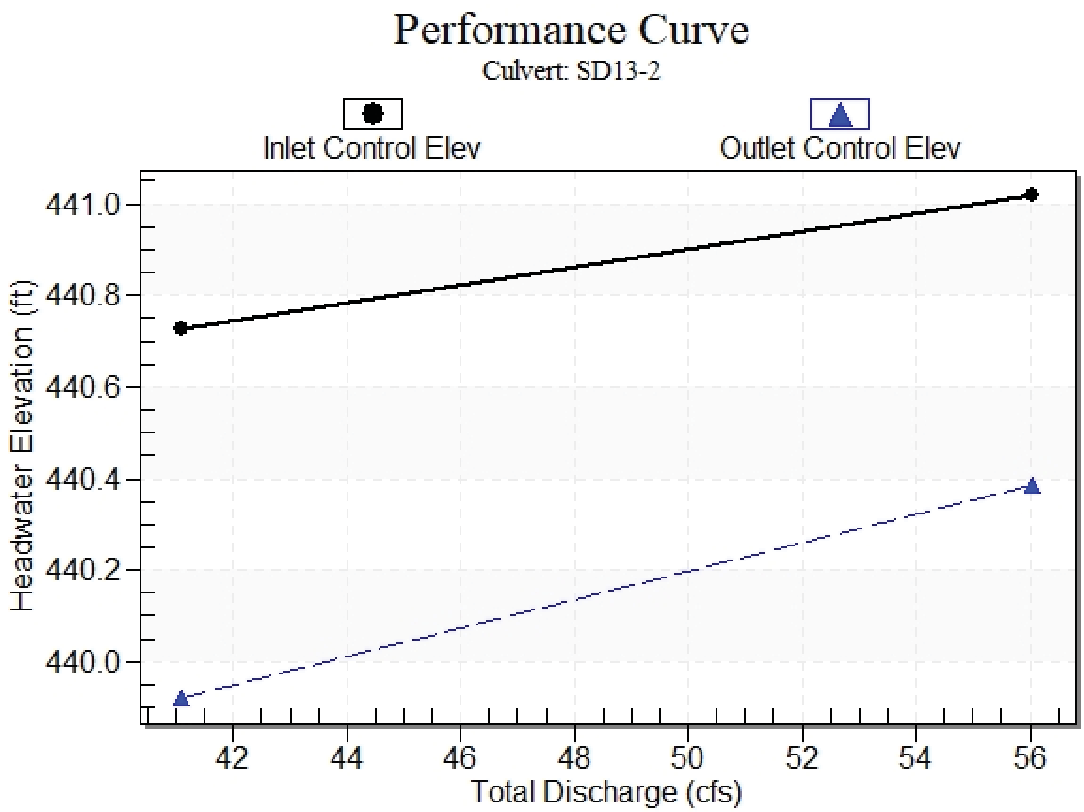
Straight Culvert

Inlet Elevation (invert): 438.87 ft,   Outlet Elevation (invert): 438.36 ft

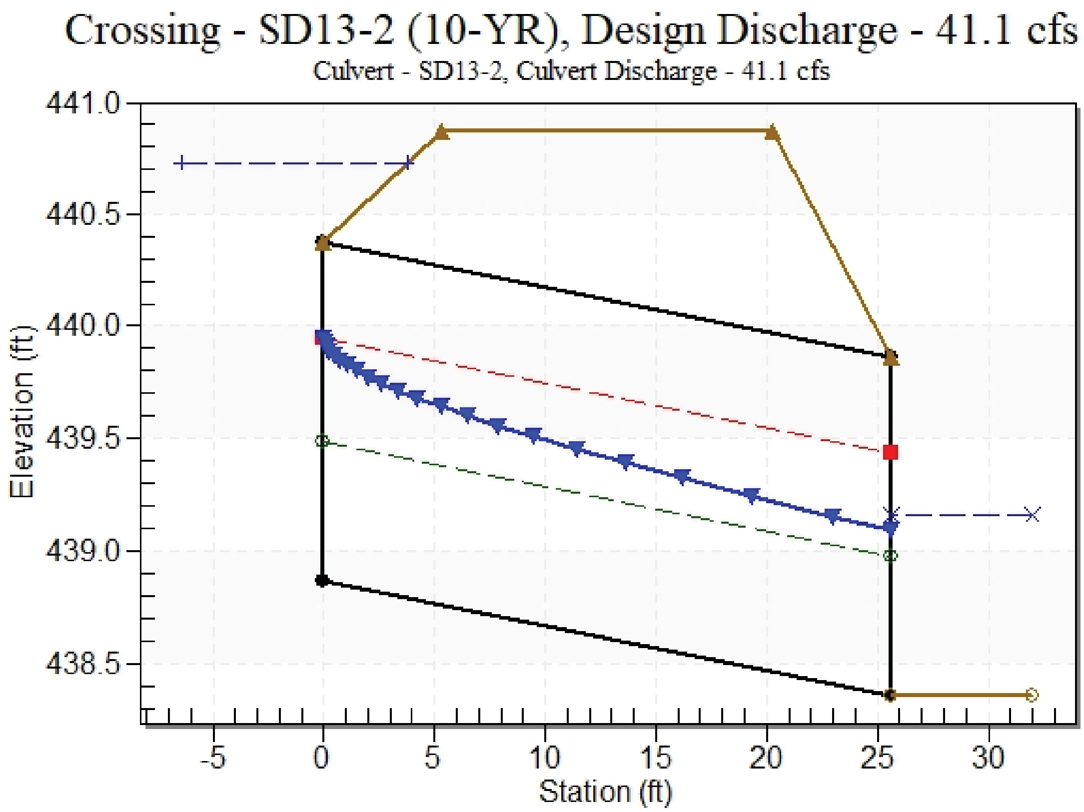
Culvert Length: 25.60 ft,   Culvert Slope: 0.0199

****

Culvert Performance Curve Plot: SD13-2



Water Surface Profile Plot for Culvert: SD13-2



Site Data - SD13-2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 438.87 ft

Outlet Station: 25.59 ft

Outlet Elevation: 438.36 ft

Number of Barrels: 2

Culvert Data Summary - SD13-2

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: SD13-2 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13
41.10	439.16	0.80	5.34	1.00	1.13

Tailwater Channel Data - SD13-2 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 438.36 ft

Roadway Data for Crossing: SD13-2 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 440.87 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 9.54 cfs

Design Flow: 9.54 cfs

Maximum Flow: 9.54 cfs

Table 10 - Summary of Culvert Flows at Crossing: SD12 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	SD12 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
442.14	9.54	9.54	0.00	1
443.46	44.84	44.84	0.00	Overtopping

Rating Curve Plot for Crossing: SD12 (10-YR)

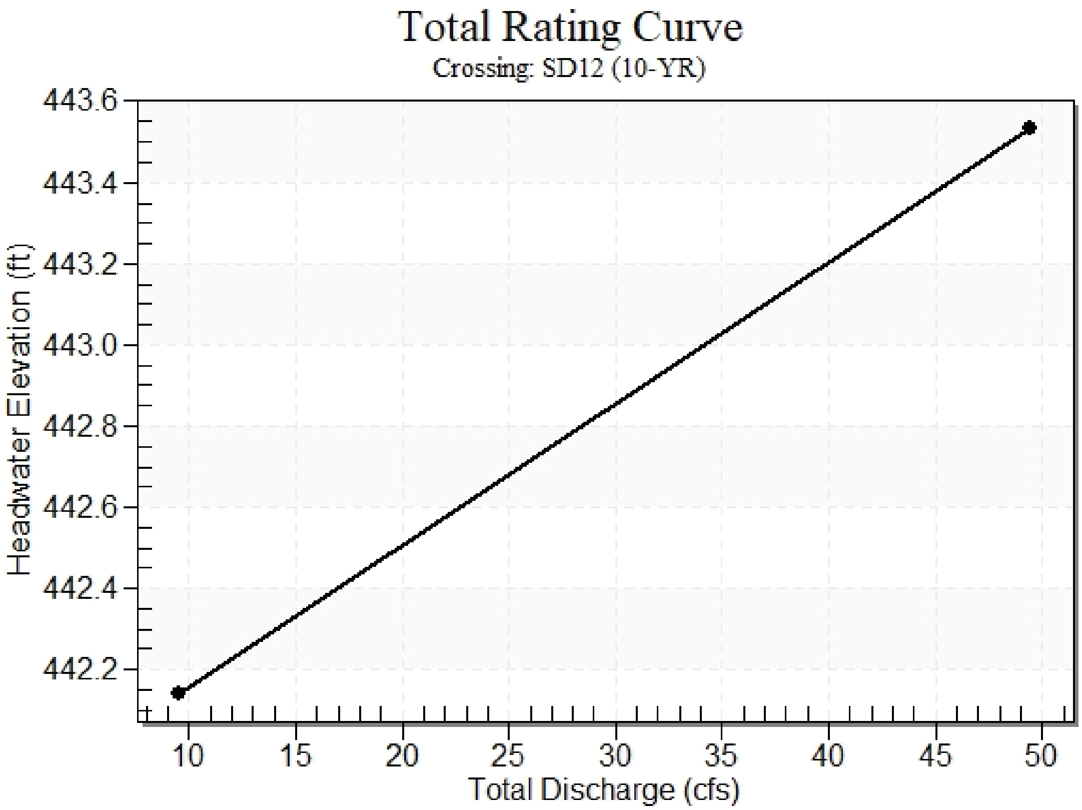


Table 11 - Culvert Summary Table: SD12

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333
9.54	9.54	442.14	0.683	0.0*	1-S2n	0.238	0.406	0.249	0.358	5.897	3.333

* Full Flow Headwater elevation is below inlet invert.

****

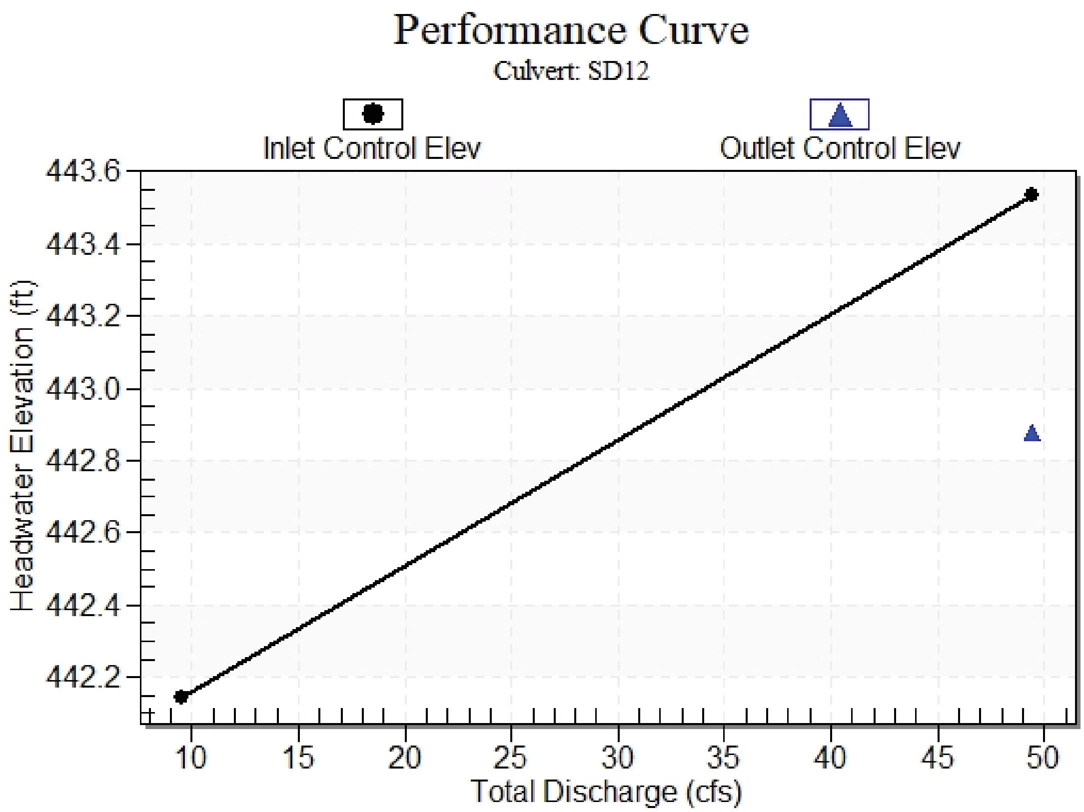
Straight Culvert

Inlet Elevation (invert): 441.46 ft, Outlet Elevation (invert): 440.91 ft

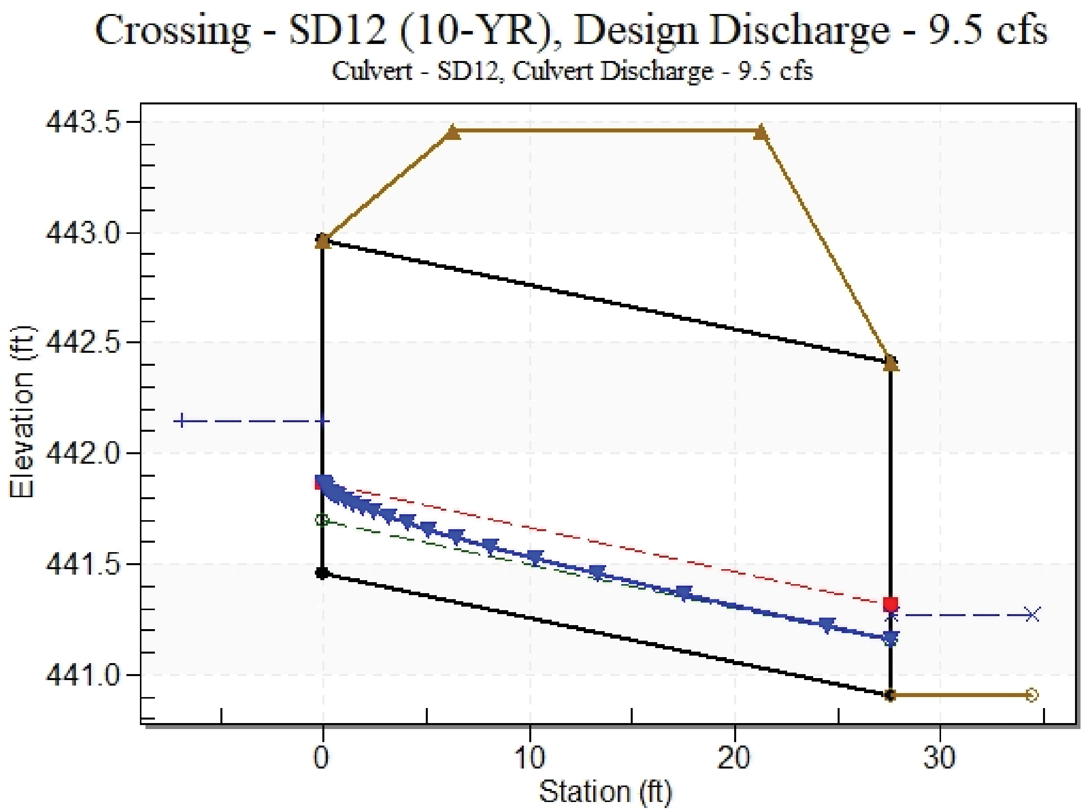
Culvert Length: 27.58 ft, Culvert Slope: 0.0199

****

Culvert Performance Curve Plot: SD12



Water Surface Profile Plot for Culvert: SD12



Site Data - SD12

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 441.46 ft

Outlet Station: 27.57 ft

Outlet Elevation: 440.91 ft

Number of Barrels: 2

Culvert Data Summary - SD12

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: SD12 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98
9.54	441.27	0.36	3.33	0.45	0.98

Tailwater Channel Data - SD12 (10-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 440.91 ft

Roadway Data for Crossing: SD12 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 443.46 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 4.87 cfs

Design Flow: 4.87 cfs

Maximum Flow: 4.87 cfs

Table 13 - Summary of Culvert Flows at Crossing: SD9 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	SD9 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
470.44	4.87	4.87	0.00	1
472.00	44.55	44.55	0.00	Overtopping

Rating Curve Plot for Crossing: SD9 (10-YR)

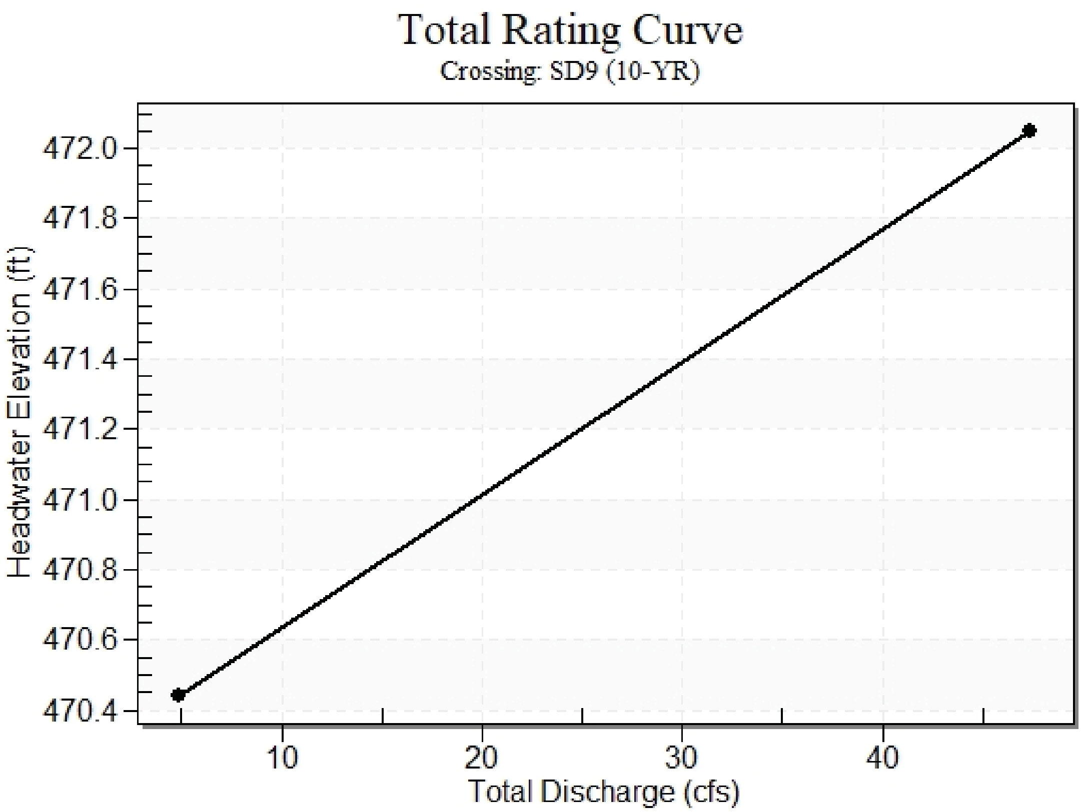


Table 14 - Culvert Summary Table: SD9

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082
4.87	4.87	470.44	0.443	0.179	1-JS1t	0.241	0.259	0.292	0.292	2.562	2.082

****

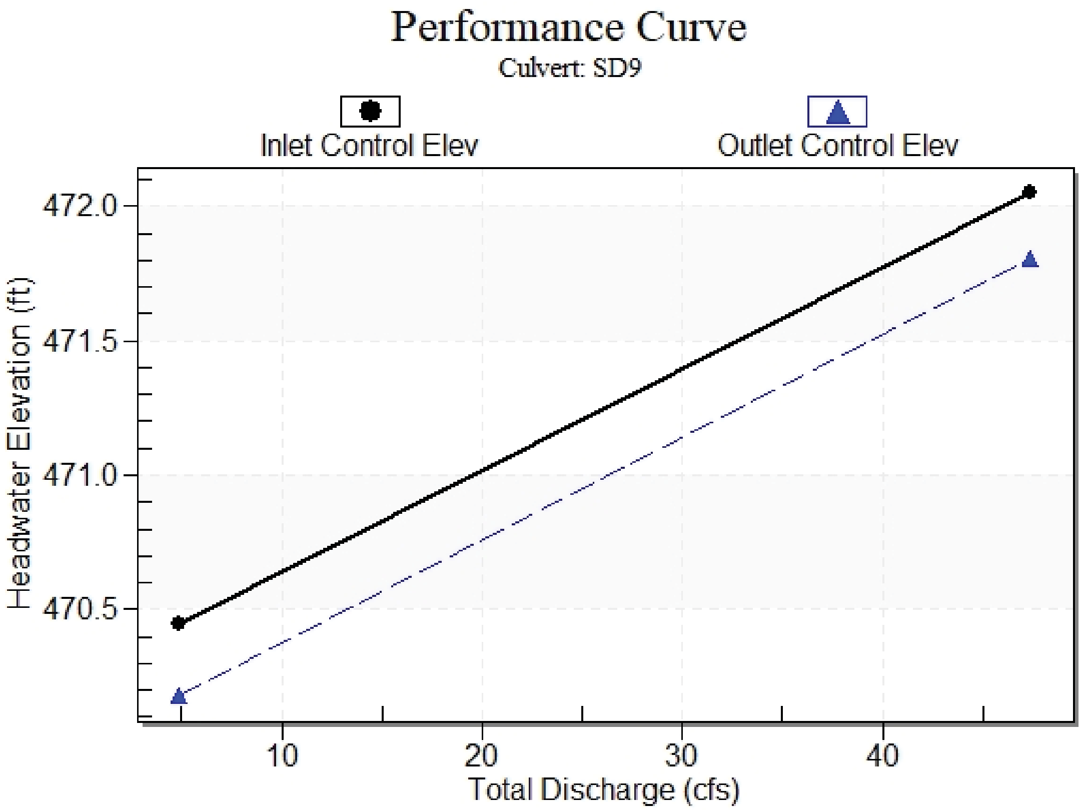
Straight Culvert

Inlet Elevation (invert): 470.00 ft,   Outlet Elevation (invert): 469.88 ft

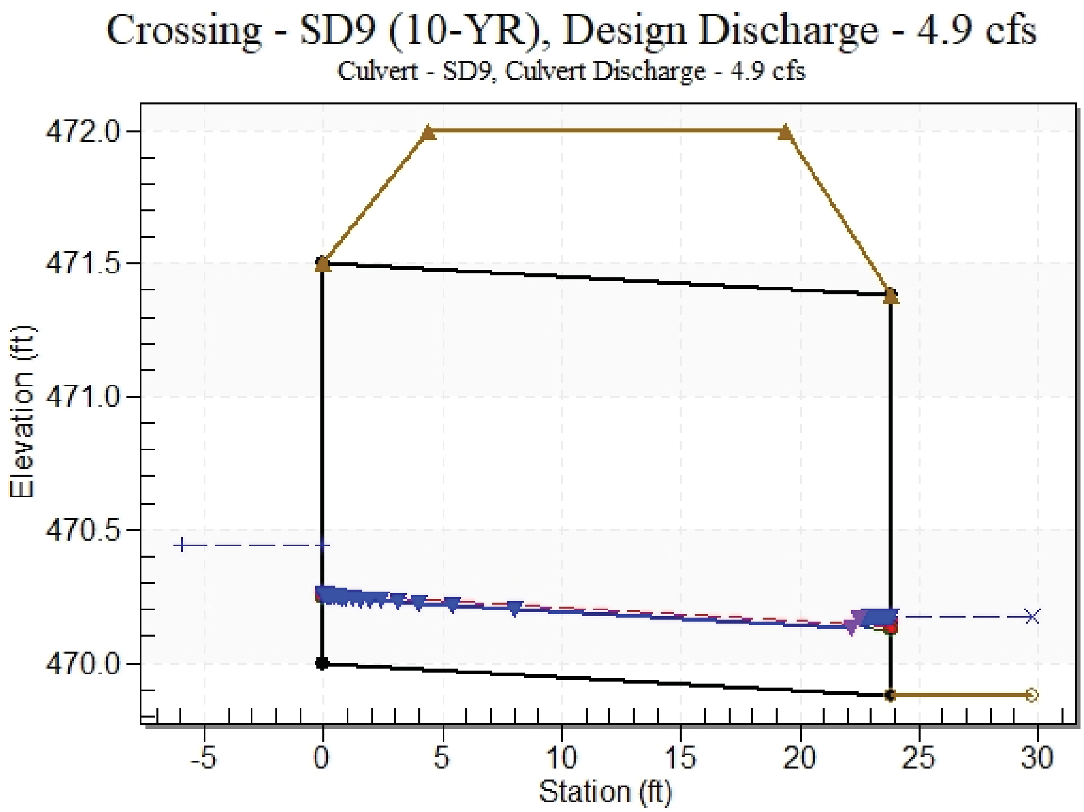
Culvert Length: 23.80 ft,   Culvert Slope: 0.0050

****

Culvert Performance Curve Plot: SD9



Water Surface Profile Plot for Culvert: SD9



Site Data - SD9

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 470.00 ft

Outlet Station: 23.80 ft

Outlet Elevation: 469.88 ft

Number of Barrels: 2

Culvert Data Summary - SD9

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: SD9 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68
4.87	470.17	0.29	2.08	0.18	0.68

Tailwater Channel Data - SD9 (10-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0100

Channel Manning's n: 0.0300

Channel Invert Elevation: 469.88 ft

Roadway Data for Crossing: SD9 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 472.00 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 13.09 cfs

Design Flow: 13.09 cfs

Maximum Flow: 13.09 cfs

Table 16 - Summary of Culvert Flows at Crossing: SD8 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	SD8 upstream Discharge (cfs)	Roadway Discharge (cfs)	Iterations
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
457.86	13.09	13.09	0.00	1
459.02	44.80	44.80	0.00	Overtopping

Rating Curve Plot for Crossing: SD8 (10-YR)

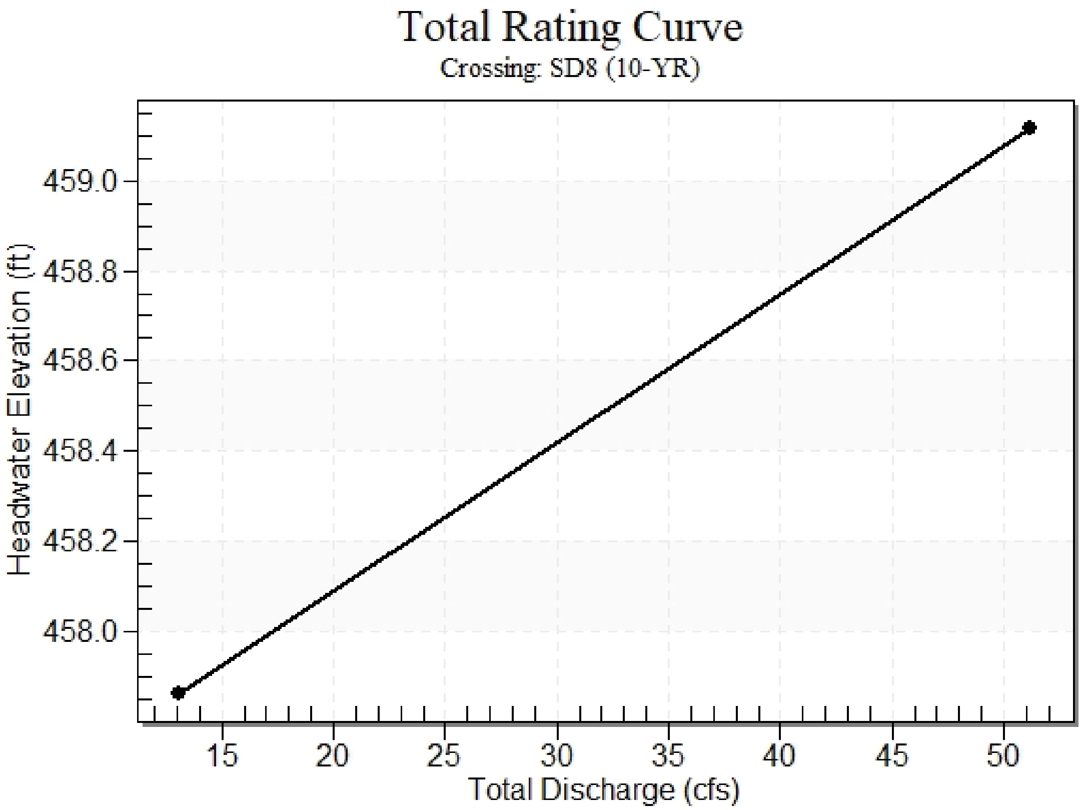


Table 17 - Culvert Summary Table: SD8 upstream

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284
13.09	13.09	457.86	0.844	0.199	1-S2n	0.304	0.501	0.333	0.448	6.050	3.284

****

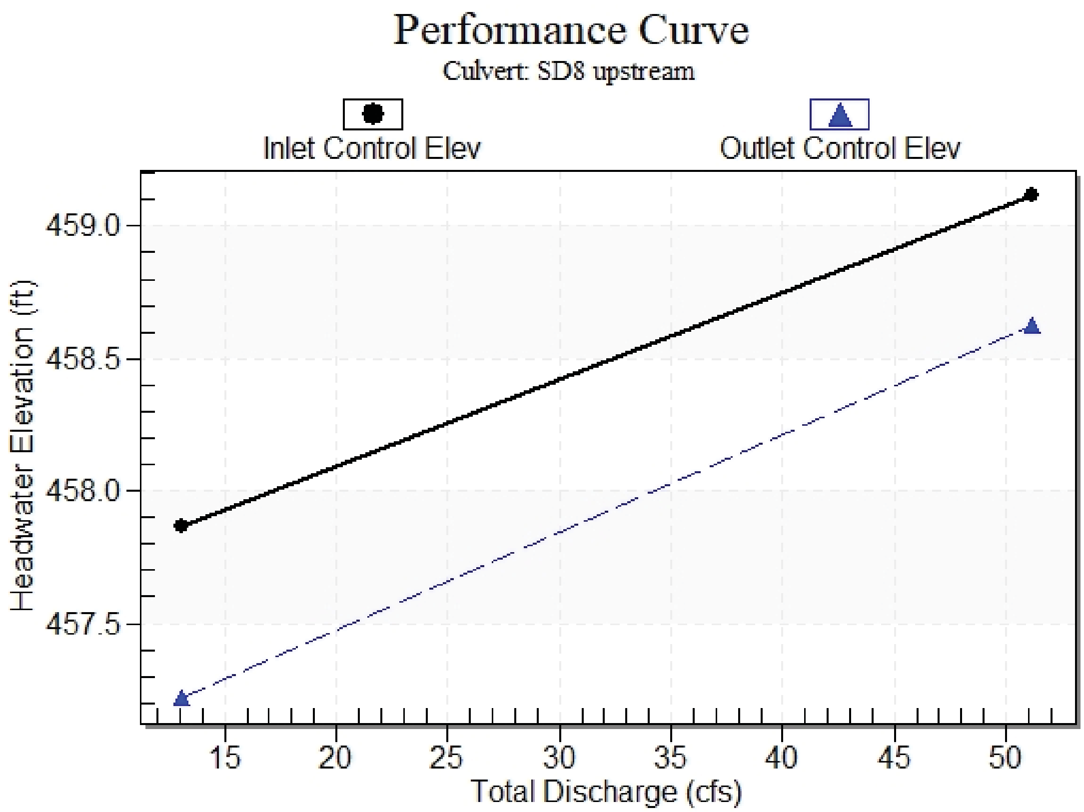
Straight Culvert

Inlet Elevation (invert): 457.02 ft, Outlet Elevation (invert): 456.67 ft

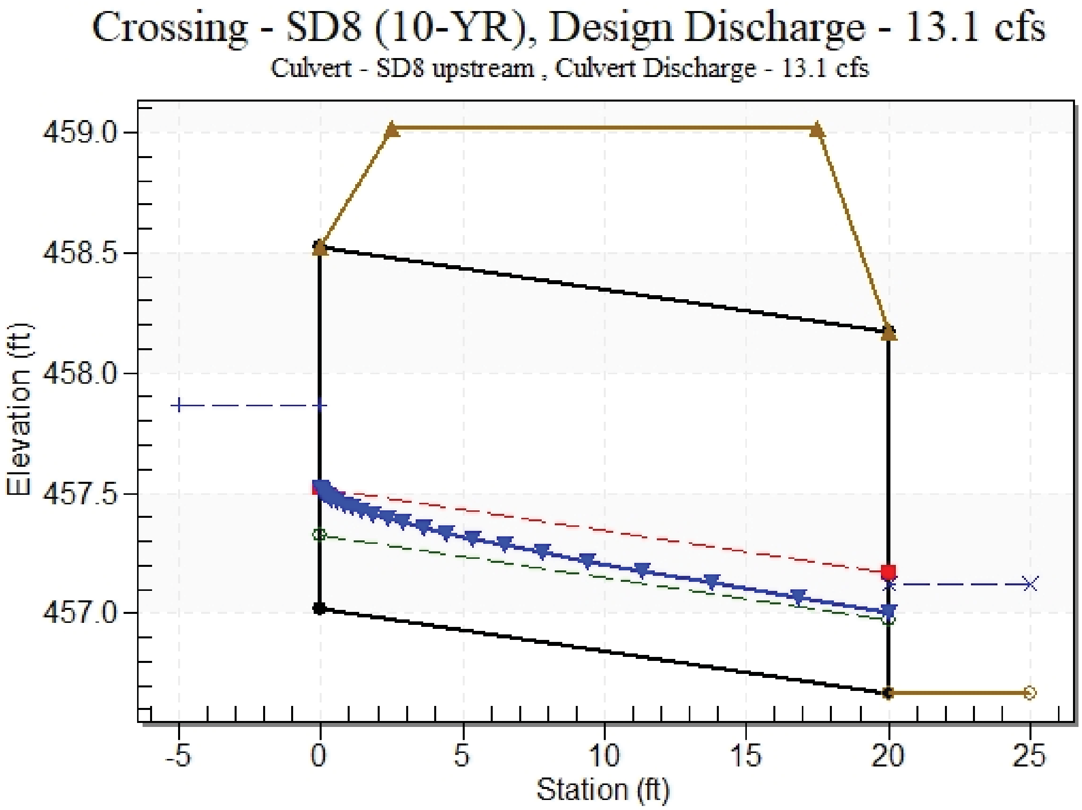
Culvert Length: 20.00 ft, Culvert Slope: 0.0175

****

Culvert Performance Curve Plot: SD8 upstream



Water Surface Profile Plot for Culvert: SD8 upstream



Site Data - SD8 upstream

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 457.02 ft

Outlet Station: 20.00 ft

Outlet Elevation: 456.67 ft

Number of Barrels: 2

Culvert Data Summary - SD8 upstream

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: SD8 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91
13.09	457.12	0.45	3.28	0.42	0.91

Tailwater Channel Data - SD8 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0150

Channel Manning's n: 0.0300

Channel Invert Elevation: 456.67 ft

Roadway Data for Crossing: SD8 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 459.02 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 7.31 cfs

Design Flow: 7.31 cfs

Maximum Flow: 7.31 cfs

Table 19 - Summary of Culvert Flows at Crossing: SD13 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	SD13 upstream Discharge (cfs)	Roadway Discharge (cfs)	Iterations
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
463.68	7.31	7.31	0.00	1
465.10	44.66	44.66	0.00	Overtopping

Rating Curve Plot for Crossing: SD13 (10-YR)

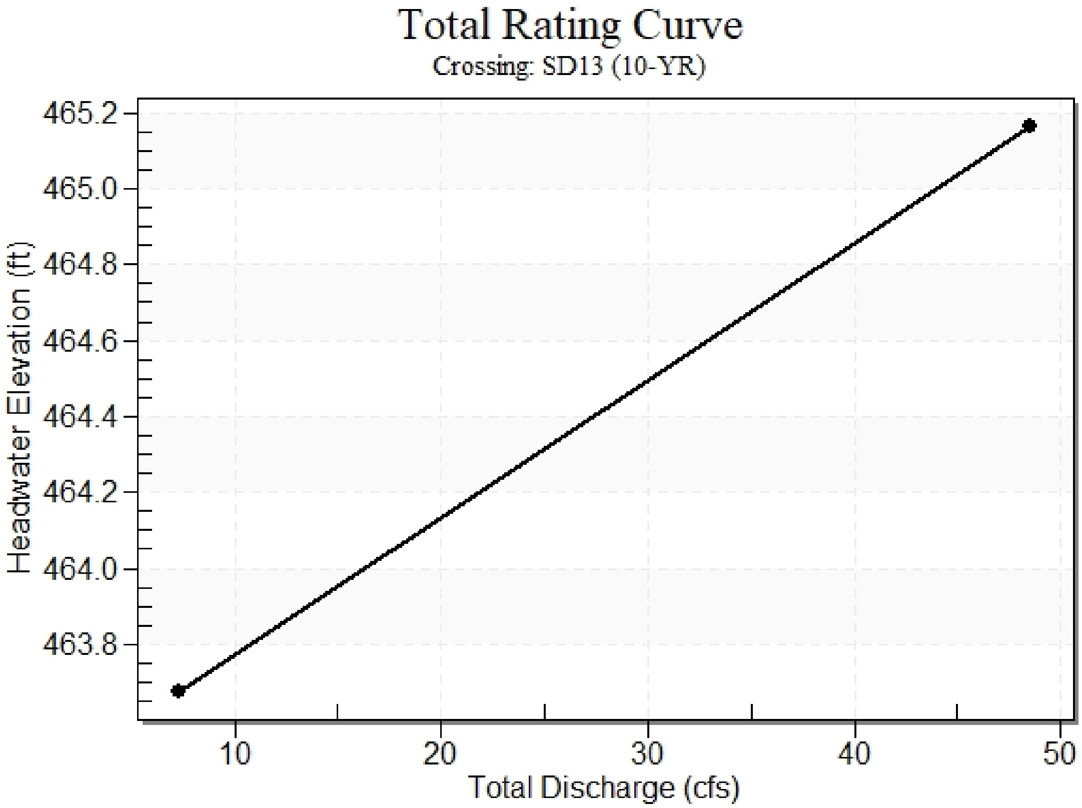


Table 20 - Culvert Summary Table: SD13 upstream

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012
7.31	7.31	463.68	0.578	0.056	1-S2n	0.251	0.340	0.255	0.303	4.416	3.012

****

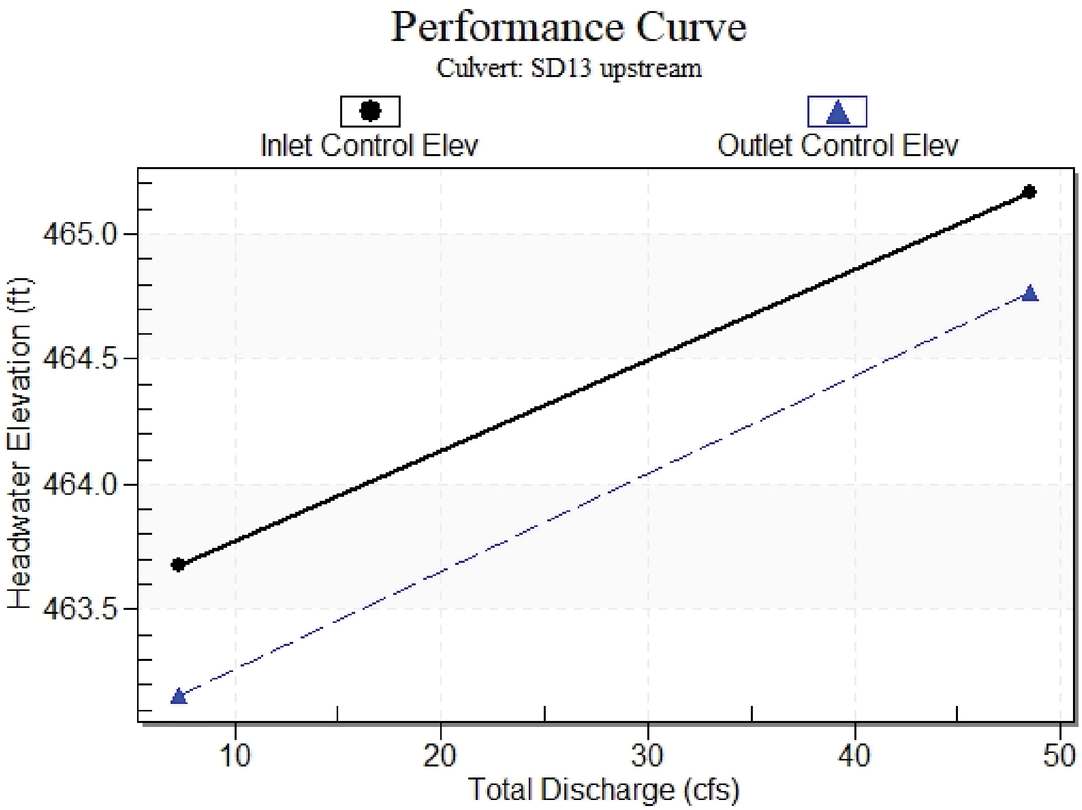
Straight Culvert

Inlet Elevation (invert): 463.10 ft, Outlet Elevation (invert): 462.80 ft

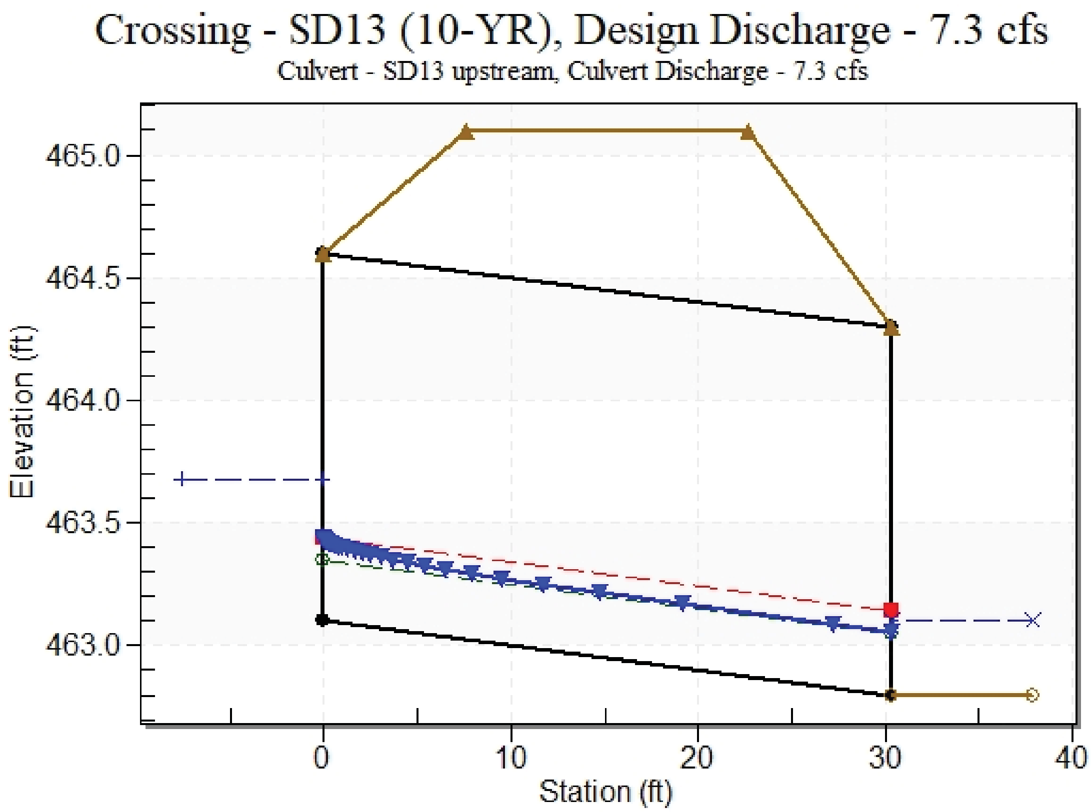
Culvert Length: 30.30 ft, Culvert Slope: 0.0099

****

Culvert Performance Curve Plot: SD13 upstream



Water Surface Profile Plot for Culvert: SD13 upstream



Site Data - SD13 upstream

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 463.10 ft

Outlet Station: 30.30 ft

Outlet Elevation: 462.80 ft

Number of Barrels: 2

Culvert Data Summary - SD13 upstream

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: SD13 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96
7.31	463.10	0.30	3.01	0.38	0.96

Tailwater Channel Data - SD13 (10-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 462.80 ft

Roadway Data for Crossing: SD13 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 465.10 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Attachment H3

H3 – Sediment Control Report

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Gude Landfill Remediation Design
Montgomery County, Maryland

Sediment Control Report

Prepared for

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

Prepared by

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

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: 25 August 2020

July 2020
EA Project No. 15646.01

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Gude Landfill Remediation Design
Montgomery County, Maryland

Sediment Control Report

Prepared for

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

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225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

July 2020
EA Project No. 15646.01

Recycled Paper

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
Ft.	Foot (Feet)
the Landfill	Gude Landfill
M-NCPPC	Maryland-National Capital Park and Planning Commission
MDE	Maryland Department of the Environment
TGOS	Temporary Gabion Outlet Structure
TSOS	Temporary Stone Outlet Structure

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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). This report summarizes the sediment control design requirements for the Gude Landfill site. The stormwater management design is discussed in the *Stormwater Management Design Report* (EA 2020), under separate cover.

1.1 SITE INFORMATION

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, Recycling and Resource Management Division (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 October 21, 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 drainage and conveyance

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2. SEDIMENT CONTROL

Montgomery County Code Chapter 19 requires a permit for any land-disturbing activity with a few exceptions. This project does not meet the criteria for the exceptions and thus a permit is required. The permit must be obtained through the Montgomery County Department of Permitting Services (DPS).

DPS approved the Combined Stormwater Management Concept/Site Development Stormwater Management Plan for this project on March 10, 2020, and noted that an Engineered Sediment Control Plan is required. This report describes the sediment control approach that is detailed on the accompanying plans.

The erosion and sediment control design will include a phased construction approach. Grading will be limited to 20-acre areas based on the limit imposed by the *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control* (MDE 2011).

Two series of phases have been developed for construction. Subgrade construction has been divided into seven phases (S-I through S-VII) as shown on Drawing C-701. Subgrade work consists primarily of stripping clean soil from the soil to be re-used during construction, excavating and relocating waste onsite, and covering the waste with clean soil. Details illustrating this are included on Drawing C-505. The proposed phases have been defined based on balancing cut and fill of onsite material, maintaining positive drainage, and adhering to the regulated 20-acre maximum grading unit requirement for erosion and sediment control.

The second series of phases consist of the closure cap construction which has been divided into six phases (F-I through F-VI) as shown on Drawing C-702. Closure cap construction consists primarily of covering the subgrade with a geosynthetic cap, placing 2 feet of clean soil over the geosynthetics, and establishing permanent vegetation. The proposed phases have been defined based on maintaining positive drainage as much as practical during all phases.

This plan addresses the overall approach for sediment control for the project and the individual sediment controls that will be required for each phase. There is an additional level of detail that will be added to the plan in the next submission once we have obtained feedback on the overall approach and primary sediment controls. Some of the anticipated additions in a future submittal include:

2.1 PHASE S-I

Phase S-I is shown on Drawing C-703 and includes significant excavation of waste on the west and northwest slope of the Landfill to create a buffer between the property line and the limit of waste. The excavated waste will be placed in the western portion of Phase S-I on top of the Landfill. Currently, the waste is adjacent to the property boundary and there is no space at the bottom of the Landfill slope to install sediment traps or basins to provide sediment control for a larger drainage area. The proposed slope is 3H:1V or 33 percent.

The progression of grading on the west and northwest slope is shown on Drawing C-506. Super silt fence will be placed along the existing slope to provide initial controls to the excavation occurring at the top of slope. The excavation will begin at the top of the slope and work downward in stages to prevent slope failure and potential drainage of leachate offsite. The excavation will be performed in a sump condition. If contaminants are found within the sump condition, the standing water will be pumped, collected, and disposed of as waste material, not sediment-laden water. If contaminants are not found within the standing water, the contactor may choose to perform pumping operations and discharge via filter bag within a stabilized conveyance or collected via portable sediment tank. Otherwise, the collected stormwater will be conveyance to the downstream sediment filtering/capturing device. As construction progresses, temporary gabion outlet structures (TGOS) or temporary stone outlet structures will be installed. The first of series of TGOS structures will be placed along the upper slope of the phase with earth dikes to direct flow to it. Discharge from the facility will be directed into pipe slope drains to convey it to the bottom of the slope.

As slope construction progresses downslope, 10-ft benches are proposed along the 3H:1V slope at a maximum interval of 30-ft. Construction will continue approximately 10 horizontal feet downslope of the bench and grading will be tied into existing grade to provide a sump condition. Within the sump conditions, TGOS or TSOS will be installed to provide the necessary erosion and sediment controls. The use of TGOS or TSOS was determined based on the overall drainage area to the structure. See Appendix A for a schedule of TGOS, TSOS, pipe slope drains, and earth berm structures utilized within the project.

Once the TGOS/TSOS are installed and the drainage area is stabilized, the super silt fence installed directly downslope will be removed to permit the next progression of slope construction. This same process as described will continue until the bottom of the slope is reached.

Sediment controls on the northern, eastern, and southern boundaries of Phase S-I will be super silt fence. The slopes that drain to these boundaries are flatter than 10 percent and unlimited slope length is allowed to the super silt fence.

Some sections of the phase boundary are existing drainage divides and super silt fence will be installed along these sections as well. The super silt fence will serve as a visual phase boundary and will control any sediment that flows to these boundaries as grading changes to the subgrade condition. However, in locations where the drainage divide is not present, orange construction fence will be utilized to delineate between phase lines.

As Phase S-I progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete Phase F-I concurrent with Phase S-I.

When Phase S-I is 50 percent stabilized, the contractor may request to begin work in Phase S-II. The Phase S-I drawing C-703 shows Phase S-II in existing conditions and Phase S-I in subgrade conditions for illustrative purposes; however, it is expected that grading in Phase S-II will begin before Phase S-I grading is complete.

2.2 PHASE S-II

Phase S-II is shown on Drawing C-704 and includes significant excavation of waste on the west and northwest slope of the Landfill to create a buffer between the property line and the limit of waste. The excavated waste will be placed in the western portion of Phase S-II on the upper surface of the Landfill. Currently, the waste is adjacent to the property boundary and there is no available space at the bottom of the Landfill slope to install sediment traps or basins to provide sediment control for a larger drainage area. The proposed slope is 3H:1V or 33 percent.

As Phase S-II progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete Phase F-I and F-II concurrent with Phase S-II.

When Phase S-II is 50 percent stabilized, the contractor may request to begin work in Phase S-III. Drawing SC-105 shows Phase S-III in existing conditions and Phase S-II in subgrade conditions for illustrative purposes; however, it is expected that grading in Phase S-III will begin before Phase S-II grading is complete.

2.3 PHASE S-III

Phase S-III is shown on Drawing C-705 and includes significant excavation of waste on the west and northwest slope of the Landfill to create a buffer between the property line and the limit of waste. The excavated waste will be placed in the western portion of Phase S-III on the upper surface of the Landfill. Currently, the waste is adjacent to the property boundary and there is no available space at the bottom of the Landfill slope to install sediment traps or basins to provide sediment control for a larger drainage area. The proposed slope is 3H:1V or 33 percent.

The construction and proposed erosion and sediment controls within this phase closely mimics the conditions found within Phase S-I.

As Phase S-III progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete Phase F-II concurrent with Phase S-III.

When Phase S-III is 50 percent stabilized, the contractor may request to begin work in Phase S-IV or in Phase F-I, depending on how they choose to execute the project. The drawing sequence assumes they will complete Phases S-I, S-II, and S-III before they begin Phase F-I.

2.4 PHASE F-I

Phase F-I is shown on Drawing C-706 and includes capping of the west and northwest slope of the Landfill. The capping consists of the placement of a geosynthetic liner with two feet of cover soil which will conform to the subgrade grading conditions.

Capping of the phase will progress by deploying the geosynthetic liner downslope to the toe of phase slope. Placement of the cover soil will then process from the toe of slope towards the top of the phase to ensure proper placement and compaction of the placed soil can be achieved without sloughing of the material. As soil cover proceeds upslope, 15-in. filter logs will be installed at 50-ft slope length increments. Super silt fence cannot be installed in the cover soil because the soil will be 2 feet thick and the fence posts cannot penetrate the geosynthetics. Therefore, filter logs will be placed on top of the cover soil to control sedimentation until vegetation is established.

Construction of the permanent benches every 30 vertical feet will be performed using same day stabilization and filter logs will be provided at their cross-section downstream elevation and the equivalent upstream elevation.

Perimeter sediment controls on the northern, eastern, and southern boundaries of Phase F-I will be super silt fence. The slopes that drain to these boundaries are flatter than 10 percent and unlimited slope length is allowed to the super silt fence.

When Phase F-I is 50 percent stabilized, the contractor may request to begin work in Phase F-II. It is anticipated that grading in Phase F-II will begin before Phase F-I grading is complete with the approval of the inspector.

2.5 PHASE F-II

Phase F-I is shown on Drawing C-707 and includes capping of the west and northwest slope of the Landfill. The capping consists of the placement of a geosynthetic liner with two feet of cover soil which will conform to the subgrade grading conditions.

Capping of the phase will progress by deploying the geosynthetic liner downslope to the toe of phase slope. Placement of the cover soil will then process from the toe of slope towards the top of the phase to ensure proper placement and compaction of the placed soil can be achieved without sloughing of the material. As soil cover proceeds upslope, 15-in. filter logs will be installed at 50-ft slope length increments. Super silt fence cannot be installed in the cover soil because the soil will be 2 feet thick and the fence posts cannot penetrate the geosynthetics. Therefore, filter logs will be placed on top of the cover soil to control sedimentation until vegetation is established.

Construction of the permanent benches every 30 vertical feet will be performed using same day stabilization and filter logs will be provided at their cross-section downstream elevation and the equivalent upstream elevation.

Perimeter sediment controls on the northern, eastern, and southern boundaries of Phase F-II will be super silt fence. The slopes that drain to these boundaries are flatter than 10 percent and unlimited slope length is allowed to the super silt fence.

When Phase F-II is 50 percent stabilized, the contractor may request to begin work in Phase F-II. It is anticipated that grading in Phase F-II will begin before Phase F-I grading is complete with the approval of the inspector.

2.6 PHASE S-IV

Phase S-IV is shown on Drawing C-708 and includes excavation and placement of waste within the phase to reach subgrade. Phase S-IV resides at the southern portion of the project adjacent to the southern access point to the site. Phase S-IV is generally graded to drain to the east with the primary sediment controls will be super silt fence where slopes are flatter and there is no concentrated flow, an earth dikes to direct flow along the downstream phase boundary, construction of one TGOS, and construction of Sediment Basin No.1 to manage any sediment-laden runoff.

Pond No. 3 will be converted to Sediment Basin No. 1 at the beginning of this phase. It will serve as the primary sediment device for Phases S-V, S-VI, S-VII, F-III, F-IV, F-V, and F-VI. Sediment Basin No. 1 is discussed in greater detail in Section 2.14.

Super silt fence will be the primary sediment control on the southern boundary of Phase S-IV. The slopes that drain to this boundary are flatter than 10 percent and unlimited slope length is allowed to the super silt fence. Earth dike will be the primary sediment control on the northern boundary, containing and directing flow eastward to Sediment Basin No. 1.

While Phase S-IV is draining to Sediment Basin No. 1, the clear water from the remaining subgrade phases will be directed to bypass with clear water diversion pipes to limit the amount of drainage area that is being managed in the basin. Sediment Basin No. 1 to limit the drainage area being managed in the basin.

The initial area of fill will be at the western end of Phase S-IV to raise the grades and begin to direct any runoff to the east. There is limited area along the western slope of the initial infill area to install a sediment trap or basin. As a result, a TGOS is proposed to be installed to capture sediment laden water. The TGOS is proposed to remain in place for use in Phase F-III. The initial grading will be treated with perimeter super silt fence and sump pit with filter bags or portable sediment tank.

Phase S-IV also extends to the east of the site's access road adjacent to Sediment Basin No. 1. The access roadway will be graded to provide access to the future phases of work. In addition, the existing concrete and asphalt pad will be utilized during construction for non-erodible material storage for the project. The installation of the access road and storage pad necessitated that grading and drainage be provided around their perimeter and to allow bypassing of the future Phase S-VI runoff. The resulting drainage swales for these improvements will discharge to proposed storm drainage systems that discharge into Sediment Basin No. 1. Inlet protection is provided for these structures.

As Phase S-IV progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete the final phase concurrent with Phase S-IV.

When Phase S-IV is 50 percent stabilized, the contractor may request to begin work in Phase S-V. However, it is expected that grading in Phase S-V will begin before Phase S-IV grading is complete.

2.7 PHASE S-V

Phase S-V is shown on Drawing C-709 and includes excavation and placement of waste within the phase to reach subgrade elevations. Phase S-V consists of a long narrow portion of the site that is utilized the bridge construction between Phase S-IV downstream and Phase XII upstream. This bridging phase provides means of providing clearwater bypassing in subsequent phases. In addition, the downstream edge of the phase is located at existing inlets that discharge water to Pond #3 which also permits a location to perform bypassing for previous phases.

Due the shape of the land and grading features, Phase S-V provides drainage from the far western extent of the site and from its interface with Phase S-1 along its northern boundary towards the its center and ultimately discharges into Sediment Basin No. 1.

Due to the linearity of the phase, 8-ft wide swales are provided as a means of conveyance the sediment basin. The swales have been sized for the drainage area that they receive while providing a minimum of 6-inches of freeboard for the 10-year storm event.

Super silt fence will be the primary sediment control on the northeastern and southwestern boundary of Phase S-V. Earth dikes are the primary sediment control on the boundary with Phase S-VII, containing and directing flow eastward and southward to Sediment Basin No. 1.

The initial area of fill will be at the western end of Phase S-IV to raise the grades and begin to direct any runoff to the east. There is limited area along the western slope of the initial infill area to install a sediment trap or basin. As a result, a TGOS is proposed to be installed to capture sediment laden water. The TGOS is proposed to remain for use in Phase F-III. The initial grading will be treated with perimeter super silt fence and sump pit with filter bags or portable sediment tank.

As Phase S-V progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete the final phase concurrent with Phase S-V.

When Phase S-V is 50 percent stabilized, the contractor may request to begin work in Phase S-VI. However, it is expected that grading in Phase S-VI will begin before Phase S-V grading is complete.

2.8 PHASE S-VI

Phase S-VI is shown on Drawing C-710 and includes excavation and placement of waste within the phase to reach subgrade elevation. Phase S-VI drains to the south towards the access road and material staging area constructed during Phase S-IV. Runoff from the phase is directed to the conveyances previously installed during Phase IV where it enters the closed storm drainage system and enters Sediment Basin No. 1.

Super silt fence is provided around the project boundary to filter the limited amount of runoff that is directed to project boundary. In addition, and earth dike is provided along the access road to direct runoff toward the south and to storm drainage system.

As Phase S-VI progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete the final phase concurrent with Phase S-VI.

When Phase S-VI is 50 percent stabilized, the contractor may request to begin work in Phase S-VII.

2.9 PHASE S-VII

Phase S-VII is shown on Drawing C-711 and includes excavation and placement of waste within the phase to reach subgrade. Phase S-VII resides in the center of protect and abut against Phases S-I, S-II, S-III, and S-IV. Phase S-VII also resides downgradient of Phases S-I, S-II, and S-III and is the recipient of runoff from those phases. As a result, 8-ft. wide swales are provided to convey both the out-of-phase runoff and runoff from Phase S-VII to Sediment Basin No. 1

Earth dike are provides around the perimeter of the phase in order to direct out-of-phase runoff to clear water diversion pipes that are closely located to the proposed swales. In addition, in-phase earth dikes are proposed along the southern boundary to direct runoff either Sediment Basin No. 1 or to a proposed TGOS adjacent to Swale 8 that is in Phase S-V. This treated runoff will flow within Swale 8 until reaching its discharge point into the bypass channel (Swale 10) of Sediment Basin No. 1.

As excavation and filling occurs throughout the phase, there will likely be some sump conditions and any ponded water can be managed with a sump pit and filter bag or portable sediment tank.

When Phase S-VII is 50 percent stabilized, the contractor may request to begin work in Phase F-III.

2.10 PHASE F-III

Phase F-III is shown on Drawing C-712 and includes capping of the western section of the Landfill. The capping consists of the placement of a geosynthetic liner with two feet of cover soils which will conform to subgrade grading conditions. Any temporary stabilization measures will be removed before placing geosynthetics. Geosynthetics will be rolled out over the area from the higher elevations to the lower elevations. Once the geosynthetics are anchored, soil cover will be placed over the geosynthetics starting upgradient and continue downgradient to prevent the creation of a sump conditions if construction were to be completed downgradient to upgradient.

However, the initial fill areas of Phases S-IV and S-V is the exception to this as there is not a downstream sediment capturing facility to provide sediment controls. Within this area, soil cover placement will be completed similar to Phase F-I and F-II proceeding from the toe of slope to the top of slope with filter logs installed to provide erosion and sediment control.

The majority of the phase will drain to the east to Sediment Basin No. 1 through the proposed Swale 8 which was graded during Phases S-IV and S-V. As the placement of soil cover proceeds from higher elevations to lower elevations, the swale will continue to drain to Sediment Basin No. 1.

The phase has been delineated along ridgelines which results in not needing inter-phase sediment control to direct clear water away from the phase.

While Phase F-III is draining to Sediment Basin No. 1, the clear water from the remaining, stabilized subgrade phases will be directed to bypass Sediment Basin No. 1 to limit the drainage area being managed by the basin.

When Phase F-III is 50 percent stabilized, the contractor may request to begin work in Phase F-IV.

2.11 PHASE F-IV

Phase F-IV is shown on Drawing C-713 and is the next phase in the capping of the Landfill and is located within the center of the site. Similar to Phase F-III, the phase has been delineated to utilize the drainage divides to limit the need of inter-phase controls to direct clean water and sediment laden water.

The majority of the phase will drain to the east to Sediment Basin No. 1 through proposed drainage Swale 13. As the placement of soil cover proceeds from higher elevations to lower elevations, the swale will continue to drain to Sediment Basin No. 1.

Super silt fence will be utilized at the lower limit of the phase where runoff cannot reach the swale for conveyance to the basin. Super silt fence installed at this location will be beyond the limit of the capping system and therefore, will not puncture the geosynthetic liner system.

While Phase F-IV is draining to Sediment Basin No. 1, the clear water from the remaining, stabilized subgrade and final phases will be directed to bypass Sediment Basin No. 1 to limit the drainage area being managed in the basin.

When Phase F-IV is 50 percent stabilized, the contractor may request to begin work in Phase F-V. Drawing SC-114 shows Phase F-V in subgrade conditions and Phase F-IV in final conditions for illustrative purposes; however, it is expected that grading in Phase F-V will begin before Phase F-IV grading is complete.

2.12 PHASE F-V

Phase F-V is shown on Drawing C-714 and is the next phase in the capping of the Landfill and is located to the east of Phase F-IV. Similar to Phase F-III and F-IV, the phase has been delineated to utilize the drainage divides to limit the need of inter-phase controls to direct clean water and sediment laden water. Temporary stabilization measures will be removed before placing geosynthetics. Geosynthetics will be deployed out over the area from the higher elevations to the lower elevations. Once the geosynthetics are anchored, soil cover will be placed over the geosynthetics starting at the top of slope and continuing downslope.

Sediment controls on the east boundary of Phase F-V will be super silt fence.

The majority of the phase will drain to the southeast to Sediment Basin No. 1 through the Swale 11 and 16. As the placement of soil cover proceeds from higher elevations to lower elevations, the swale will continue to drain to Sediment Basin No. 1.

While Phase F-V is draining to Sediment Basin No. 1, the clear water from the remaining stabilized subgrade and final phases will be directed to bypass Sediment Basin No. 1 to limit the drainage area being managed by the basin.

When Phase F-V is 50 percent stabilized, the contractor may request to begin work in Phase F-VI.

2.13 PHASE F-VI

Phase F-VI is shown on Drawing C-715 and includes capping of the Landfill and is located at the southeastern portion of the project. Any temporary stabilization measures will be removed before placing geosynthetics. Geosynthetics will be deployed out over the area from the higher elevations to the lower elevations. Once the geosynthetics are anchored, soil cover will be placed over the geosynthetics.

Sediment controls on the northern and eastern boundaries of Phase F-VI will be super silt fence. The majority of the phase will drain to the south and southwest to Sediment Basin No. 1 via Swales 14 and 18 to their respective storm inlet structures. As the placement of soil cover proceeds from higher elevations to lower elevations, the swale will continue to drain to Sediment Basin No. 1.

While Phase F-VI is draining to Sediment Basin No. 1, the clear water from the remaining, stabilized final phases will be directed to bypass Sediment Basin No. 1 via Swale 10 to limit the drainage area being managed by the basin.

Once the majority of Phase F-VI is stabilized, Sediment Basin No. 1 will be decommissioned and will be returned to its existing function as a dry pond.

2.14 SEDIMENT BASIN NO. 1

Entering Phase S-IV from the south, existing Pond No. 3 resides to the west of the road. Pond No. 3 is an excavated dry pond that received runoff from approximately 52 acres of the landfill. Pond No. 3 has multiple storm pipes entering the facility from the north and east with bypass piping diverting water around the pond in larger storm events. Due to these existing conditions, Pond No. 3 is proposed to be converted to Sediment Basin No. 1 and be utilized as such for the duration of construction. The proposed basin is shown in detail on Drawing C-513 and is the only sediment basin for the project due to the physical constraints of the site.

Sediment Basin No. 1 has been sized to provide sediment capturing for approximately 45 acres of drainage area during either subgrade or final grading phases of the project. As a result, it will accommodate approximately three subgrade phases or two final grade phases to utilize it without performing clearwater bypass via Swale 10. The capacity of Sediment Basin No. 1 provides the contractor with flexibility on how to construct the project while not being overly restrictive. This allows for additional competitiveness in the bids and ultimately will be financially beneficial to the County's project.

Sediment Basin No. 1 does not include an emergency spillway due to the site being a filled as a part of previously landfilling operations. The provision of the emergency spillway being required within native soils is therefore not achievable for this project. As a result, the sediment basin has been designed to provide a minimum of 2-ft of freeboard above the 10-yr. storm event to comply with erosion and sediment control regulation. In addition, the 100-yr storm event is fully contained within the pond with approximately 0.67-ft of freeboard.

Similar to the constraints for the inclusion of an emergency spillway, the required cut-off trench and impervious core for the embankment would likely extend into existing waste material and the structural suitability to tie-in the cut-off trench would be limited. In addition, Sediment Basin No. 1 is partially constructed by extending the existing Pond No. 3 embankment to design elevation. The removal of Pond No. 3's embankment and complete reconstruction is not desired as it has been in a stable and stabilized state for over three decades. Removal of the embankment could introduce potential undesirable instability of soils. As a result, a clay liner within the interior face of the embankment is proposed to prevent the lateral movement of water through the embankment. The clay liner is proposed to be 2-ft. think and extend 4-ft below the bottom of the sediment basin. The limits of clay liner and section of the liner, embankment, outfall pipe, etc. can be found on Sheet C-513.

The supporting calculations for Sediment Basin No. 1 are provided in Appendix B inclusive of the hydrologic and hydraulics calculations, draw-down dewatering device, principal spillway, anti-flotation, and rock outlet protection.

3. REFERENCES

EA Engineering, Science, and Technology, Inc., PBC (EA). 2020. *Stormwater Management Design Report*.

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.

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Figures

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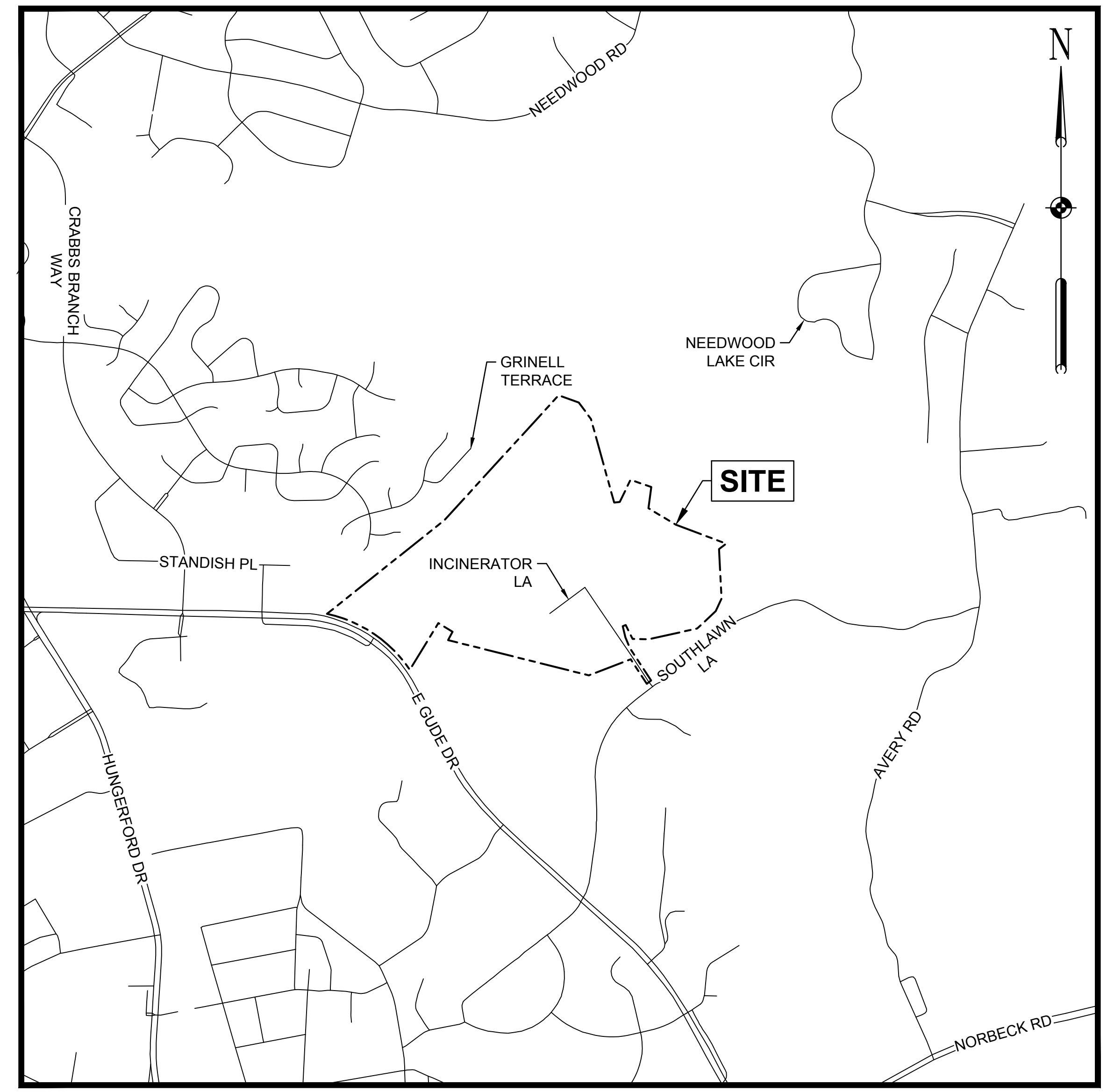
LOCATION MAP - MONTGOMERY COUNTY, MARYLAND
NOT TO SCALE



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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Appendix A

Supporting Documentation and Calculations

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

Pipe Slope Drain Schedule

By:	SCL	Project:	Gude Landfill
Date:	6/26/2020	Job Number:	1564601
Check:		Maryland County:	Montgomery
Date:		Study Area Limits:	N/A
Sheet:	1 of 1	Study Area Designator:	N/A

ID	Phase	Drainage Area (AC.)	Pipe Size (inch)
PSD S-I-1	S-I	1.15	18
PSD S-I-2	S-I	0.68	18
PSD S-I-3	S-I	0.77	18
PSD S-I-4	S-II	1.49	18
PSD S-II-1	S-II	0.58	18
PSD S-II-2	S-II	1.31	18
PSD S-II-3	S-II	0.92	18
PSD S-III-1	S-III	0.44	12
PSD S-III-2	S-III	1.46	18
PSD F-I-1	F-I	1.29	18
PSD-F-I-2	F-I	0.4	12
PSD F-II-1	F-II	0.33	12

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

Earth Dike Schedule

By: SCL
Date: 6/26/2020
Check:
Date:
Sheet: 1 of 2

Project: Gude Landfill
Job Number: 1564601
Maryland County: Montgomery
Study Area Limits: N/A

ID	Phase	Drainage Area (Ac.)	Maximum Slope	Clear / Dirty Water	Class
ED S-I-1	S-I	0.57	2.0%	Dirty	A-1
ED S-I-2	S-I	0.57	2.0%	Dirty	A-1
ED S-I-3	S-I	1.49	1.0%	Dirty	A-1
ED S-I-4	S-I	1.49	3.3%	Dirty	A-2
ED S-II-1	S-II	1.31	5.0%	Dirty	A-2
ED S-II-2	S-II	0.92	8.3%	Dirty	A-2
ED S-II-3	S-II	0.86	1.8%	Dirty	A-1
ED S-II-4	S-II	0.36	2.2%	Dirty	A-2
ED S-II-5	S-II	0.23	3.8%	Dirty	A-2
ED S-II-6	S-II	0.1	1.0%	Dirty	A-1
ED S-II-7	S-II	0.24	8.3%	Dirty	A-2
ED S-II-8	S-II	0.25	3.3%	Dirty	A-2
ED S-III-1	S-III	0.23	8.3%	Dirty	A-2
ED S-III-2	S-III	0.23	3.3%	Dirty	A-2
ED S-III-3	S-III	0.55	5.6%	Dirty	A-2
ED S-III-4	S-III	0.1	4.3%	Dirty	A-2
ED S-III-5	S-III	0.26	2.1%	Dirty	A-1
ED S-III-6	S-III	0.26	2.1%	Dirty	A-1
ED S-IV-1	S-IV	4.02	4.9%	Clear/Dirty	A-2
ED S-IV-2	S-IV	1.95	9.1%	Clear	A-2
ED S-IV-3	S-IV	0.34	3.3%	Clear	A-2
ED S-IV-4	S-IV	0.17	1.0%	Clear	A-2
ED S-IV-5	S-IV	1.16	7.7%	Clear	A-2
ED S-IV-6	S-IV	0.62	15.4%	Clear	A-3
ED S-IV-7	S-IV	0.82	10.0%	Clear	A-2
ED S-V-1	S-V	1.16	8.3%	Clear	A-2
ED S-V-2	S-V	0.36	4.6%	Clear	A-2
ED S-V-3	S-V	0.12	5.0%	Dirty	A-2

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

Earth Dike Schedule

By: SCL
Date: 6/26/2020
Check:
Date:
Sheet: 2 of 2

Project: Gude Landfill
Job Number: 1564601
Maryland County: Montgomery
Study Area Limits: N/A

ID	Phase	Drainage Area (Ac.)	Maximum Slope	Clear / Dirty Water	Class
ED S-V-4	S-V	0.61	8.3%	Clear	A-2
ED S-V-5	S-V	0.05	1.0%	Clear	A-2
ED S-V-6	S-V	0.25	9.5%	Clear	A-2
ED S-V-7	S-V	0.05	10.0%	Clear	A-2
ED S-VI-1	S-VI	1.46	8.7%	Dirty	A-2
ED S-VII-1	S-VII	0.72	5.9%	Clear	A-2
ED S-VII-2	S-VII	0.43	2.0%	Clear	A-2
ED S-VII-3	S-VII	0.16	1.0%	Clear	A-2
ED S-VII-4	S-VII	0.29	3.7%	Clear	A-2
ED S-VII-5	S-VII	0.17	1.0%	Clear	A-2
ED S-VII-6	S-VII	0.29	7.6%	Clear	A-2
ED S-VII-7	S-VII	0.74	2.7%	Clear	A-2
ED S-VII-8	S-VII	0.85	2.9%	Clear	A-2
ED S-VII-9	S-VII	0.82	3.8%	Dirty	A-2
ED S-VII-10	S-VII	0.32	2.8%	Dirty	A-2
ED S-VII-11	S-VII	1.48	4.0%	Dirty	A-2
ED F-I-1	F-I	0.1	9.00%	Dirty	A-2
ED F-I-2	F-I	0.52	2.70%	Dirty	A-2
ED F-I-3	F-I	0.56	2.70%	Dirty	A-2
ED F-II-1	F-II	0.7	7.10%	Dirty	A-2

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

Benching Schedule

By: SCL
Date: 6/26/2020
Check:
Date:
Sheet: 1 of 1

Project: Gude Landfill
Job Number: 1564601
Maryland County: Montgomery
Study Area Limits: N/A
Study Area Designator: N/A

ID	Phase (s)	Maximum Drainage Area (AC.)	Length (Feet)	1' Deep Bench Width (feet)	Q10 (cfs)	V10 (fps)	Flow Depth (feet)	Treatment
Bench 1	S-I / F-I	2.65	718	10	7.16	3.06	0.6	ECM
Bench 2	S-I / S-II / F-I	0.68	873	10	2.14	2.28	0.4	ECM
Bench 3	S-II / S-III / F-1/ F-II	0.77	520	10	2.06	2.59	0.4	ECM
Bench 4	S-IV / F-VI	18.76	418	20	44.35	4.87	0.9	TRM
Bench 5	S-IV / F-III	1.49	365	10	5.61	3.32	0.5	ECM
Bench 6	S-V / F-III	1.15	312	10	4.33	3.15	0.5	ECM

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EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
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Temporary Gabion/Stone Outlet Structure Schedule

By: SCL
Date: 6/26/2020
Check:
Date:
Sheet: 1 of 2

Project: Gude Landfill
Job Number: 1564601
Maryland County: Montgomery
Study Area Limits: N/A
Study Area Designator: N/A

Temporary Gabion Outlet Structure Schedule

ID	Phase	Drainage Area (AC.)	Volume Required	Volume Provided	Channel Bottom Elevation	Weir Elevation
TGOS S-I-1	S-I	0.92	1,656	1,781	426	428
TGOS S-I-2	S-I	0.52	936	3,390	427	429
TGOS S-I-3	S-I	1.15	2,070	2,465	465	468
TGOS S-I-4	S-I	0.69	1,242	6,912	453	455
TGOS S-I-5	S-I	0.77	1,386	4,935	432	434
TGOS S-I-6	S-I	1.49	2,682	7,785	465	467
TGOS S-I-7	S-I	1.42	2,556	2,560	467	469
TGOS S-I-8	S-I	1.34	2,412	2,798	468	470
TGOS S-II-1	S-II	0.58	1,044	3,206	438	440
TGOS S-II-2	S-II	1.31	2,358	4,753	459	461
TGOS S-II-3	S-II	0.91	1,638	2,414	452	454
TGOS S-II-4	S-II	0.54	972	5,400	434	436
TGOS S-II-5	S-II	1.07	1,926	2,664	466.5	467.5
TGOS S-II-6	S-II	2.25	4,050	4,500	459.5	462
TGOS S-III-1	S-III	0.44	792	4,538	451	454
TGOS S-III-2	S-III	1.46	2,628	3,371	451	454
TGOS S-III-3	S-III	1.5	2,700	2,850	463.5	464.8
TGOS S-IV-1	S-IV	1.49	2,682	2,888	450	452
TGOS S-I-15	S-VII	1.15	2,070	3,019	451	452.5
TGOS F-I-1	F-I	1.29	2,322	2,414	454	456
TGOS F-I-2	F-I	1.15	2,070	2,465	429	431
TGOS F-I-3	F-I	1.42	2,556	2,560	469	471
TGOS F-II-1	F-II	1.46	2,628	3,371	453	456
TGOS F-III-1	F-III	0.91	1,638	2,969	452	453

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

Temporary Gabion/Stone Outlet Structure Schedule

By:	SCL	Project:	Gude Landfill
Date:	6/26/2020	Job Number:	1564601
Check:		Maryland County:	Montgomery
Date:		Study Area Limits:	N/A
Sheet:	2 of 2	Study Area Designator:	N/A

Temporary Stone Outlet Structure Schedule						
ID	Phase	Drainage Area (AC.)	Volume Required	Volume Provided	Channel Bottom Elevation	Weir Elevation
TSOS S-I-1	S-I	0.19	342	1,013	450	451
TSOS S-II-1	S-II	0.46	828	1,018	463	464.5
TSOS S-V-1	S-V	0.33	594	1,525	450	451
TSOS F-II-1	F-II	0.32	576	1,109	453	454

Appendix B

Sediment Basin No. 1 Calculations

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA
Project: Gude
SubTitle: DA-1A
State: Maryland
County: Montgomery NOAA-C
Filename: \\lovetonfp\projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Desig

Date: 6/29/2020
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DS-BS-1	Maximum Sediment Basin	Outlet	44.8	81	.371

Total area: 44.80 (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-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)	25-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
DS-BS-1	52.33	104.71	149.33	219.49
REACHES				
OUTLET	52.33	104.71	149.33	219.49

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)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
DS-BS-1	52.33	104.71	149.33	219.49
	12.28	12.26	12.27	12.27
REACHES				
OUTLET	52.33	104.71	149.33	219.49

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DS-BS-1	44.80	0.371	81	Outlet	Maximum Sediment Basin

Total Area: 44.80 (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)
DS-BS-1							
SHEET	100	0.0120	0.240				0.295
SHALLOW	369	0.0380	0.050				0.033
CHANNEL	900	0.0200	0.030	14.04	13.90	7.143	0.035
CHANNEL	418	0.0600	0.030	20.12	15.83	14.514	0.008
						Time of Concentration	.371
							========

DA-1A

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
DS-BS-1	Gravel (w/ right-of-way)		D	2.62	91
	Pasture, grassland or range	(good)	D	42.18	80
	Total Area / Weighted Curve Number			44.8	81
				====	==

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WinTR-20 Printed Page File      Beginning of Input Data List
C:\Users\slemasters\Desktop\Sed Basin 1 scl 48-in lower slope pipe.inp

WinTR-20: version 3.20                  0         0         .1        0
Gude Landfill
Pond 3 - Proposed Conditions

SUB-AREA:
          DA-SB-1   Pond 3              .07       81.       .371


STREAM REACH:
          Pond 3    Outlet              Pond 3                        YY


STORM ANALYSIS:
          2-YR                          3.14      TYPE NO_C 2         3.14
          10-YR                         4.82      TYPE NO_C 2         3.14
          100-YR                        8.32      TYPE NO_C 2         3.14



STRUCTURE RATING:
          Pond 3    398.7
                    398.7     0.        4.44
                    399.      26.3      4.88
                    399.5     74.4      5.33
                    400.      131.7     5.8
                    400.5     139.4     6.28
                    401.      146.1     6.77
                    401.5     152.7     7.29
                    402.      159.3     7.81




GLOBAL OUTPUT:
          1         .1        .1        YY  Y     YY  Y




WinTR-20 Printed Page File      End of Input Data List

                                Gude Landfill
                        Pond 3 - Proposed Conditions

                        Name of printed page file:
    C:\Users\slemasters\Desktop\Sed Basin 1_scl 48-in lower slope pipe.out

                                        STORM 2-YR

Area or    Drainage  Rain Gage     Runoff   ------------ Peak Flow ------------
 Reach       Area     ID or        Amount   Elevation   Time       Rate       Rate
Identifier  (sq mi)   Location      (in)      (ft)      (hr)      (cfs)      (csm)

DA-SB-1       0.070                 1.421               12.28      52.3     747.62

   Line
Start Time   ------------ Flow Values @ time increment of  0.100 hr ------------
      (hr)      (cfs)      (cfs)      (cfs)      (cfs)      (cfs)      (cfs)      (cfs)

     9.600       0.0        0.1        0.2        0.2        0.3        0.4        0.4
    10.300       0.5        0.6        0.7        0.8        0.9        1.1        1.3
    11.000       1.5        1.8        2.2        2.6        3.2        3.8        4.6
    11.700       6.0        8.1       11.1       16.8       29.1       46.5       52.0
    12.400      43.8       33.5       26.4       20.9       16.7       14.0       12.1
    13.100      10.7        9.5        8.5        7.7        7.1        6.5        5.9
    13.800       5.5        5.2        5.0        4.8        4.6        4.5        4.3
    14.500       4.2        4.0        3.9        3.7        3.6        3.4        3.3
    15.200       3.1        3.0        2.9        2.9        2.8        2.8        2.8
    15.900       2.7        2.7        2.6        2.6        2.6        2.5        2.5
```

16.600	2.4	2.4	2.4	2.3	2.3	2.2	2.2
17.300	2.2	2.1	2.1	2.0	2.0	2.0	1.9
18.000	1.9	1.8	1.8	1.8	1.7	1.7	1.7
18.700	1.7	1.7	1.7	1.7	1.7	1.6	1.6
19.400	1.6	1.6	1.6	1.6	1.6	1.6	1.6
20.100	1.6	1.6	1.5	1.5	1.5	1.5	1.5
20.800	1.5	1.5	1.5	1.5	1.4	1.4	1.4
21.500	1.4	1.4	1.4	1.4	1.4	1.4	1.4
22.200	1.3	1.3	1.3	1.3	1.3	1.3	1.3
22.900	1.3	1.3	1.3	1.2	1.2	1.2	1.2
23.600	1.2	1.2	1.2	1.2	1.2	1.2	0.9
24.300	0.5	0.2	0.1	0.0			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Pond 3	0.070	Upstream	1.421		12.28	52.3	747.62

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.600	0.0	0.1	0.2	0.2	0.3	0.4	0.4
10.300	0.5	0.6	0.7	0.8	0.9	1.1	1.3
11.000	1.5	1.8	2.2	2.6	3.2	3.8	4.6
11.700	6.0	8.1	11.1	16.8	29.1	46.5	52.0
12.400	43.8	33.5	26.4	20.9	16.7	14.0	12.1
13.100	10.7	9.5	8.5	7.7	7.1	6.5	5.9
13.800	5.5	5.2	5.0	4.8	4.6	4.5	4.3

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
14.500	4.2	4.0	3.9	3.7	3.6	3.4	3.3
15.200	3.1	3.0	2.9	2.9	2.8	2.8	2.8
15.900	2.7	2.7	2.6	2.6	2.6	2.5	2.5
16.600	2.4	2.4	2.4	2.3	2.3	2.2	2.2
17.300	2.2	2.1	2.1	2.0	2.0	2.0	1.9
18.000	1.9	1.8	1.8	1.8	1.7	1.7	1.7
18.700	1.7	1.7	1.7	1.7	1.7	1.6	1.6
19.400	1.6	1.6	1.6	1.6	1.6	1.6	1.6
20.100	1.6	1.6	1.5	1.5	1.5	1.5	1.5
20.800	1.5	1.5	1.5	1.5	1.4	1.4	1.4
21.500	1.4	1.4	1.4	1.4	1.4	1.4	1.4
22.200	1.3	1.3	1.3	1.3	1.3	1.3	1.3
22.900	1.3	1.3	1.3	1.2	1.2	1.2	1.2
23.600	1.2	1.2	1.2	1.2	1.2	1.2	0.9
24.300	0.5	0.2	0.1	0.0			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Pond 3	0.070	Downstream	1.421	399.19	12.39	44.3	633.15

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.800	0.0	0.1	0.2	0.3	0.3	0.4	0.5
10.500	0.5	0.6	0.7	0.8	1.0	1.2	1.4
11.200	1.6	1.9	2.3	2.8	3.3	4.1	5.3
11.900	7.0	9.7	14.8	24.1	39.2	44.3	40.4
12.600	33.8	27.6	23.7	20.4	17.5	15.1	13.1
13.300	11.5	10.1	9.1	8.2	7.4	6.7	6.2
14.000	5.7	5.4	5.1	4.9	4.7	4.5	4.4
14.700	4.2	4.0	3.9	3.7	3.6	3.4	3.3
15.400	3.2	3.1	3.0	2.9	2.9	2.8	2.8
16.100	2.7	2.7	2.6	2.6	2.6	2.5	2.5
16.800	2.4	2.4	2.4	2.3	2.3	2.2	2.2
17.500	2.2	2.1	2.1	2.0	2.0	2.0	1.9
18.200	1.9	1.8	1.8	1.8	1.8	1.7	1.7
18.900	1.7	1.7	1.7	1.7	1.7	1.6	1.6
19.600	1.6	1.6	1.6	1.6	1.6	1.6	1.6
20.300	1.6	1.6	1.5	1.5	1.5	1.5	1.5
21.000	1.5	1.5	1.5	1.5	1.4	1.4	1.4
21.700	1.4	1.4	1.4	1.4	1.4	1.4	1.4
22.400	1.3	1.3	1.3	1.3	1.3	1.3	1.3
23.100	1.3	1.3	1.3	1.2	1.2	1.2	1.2
23.800	1.2	1.2	1.2	1.2	1.1	0.9	0.7
24.500	0.5	0.3	0.2	0.1	0.0		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.070		1.421		12.39	44.3	633.15

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.800	0.0	0.1	0.2	0.3	0.3	0.4	0.5
10.500	0.5	0.6	0.7	0.8	1.0	1.2	1.4
11.200	1.6	1.9	2.3	2.8	3.3	4.1	5.3
11.900	7.0	9.7	14.8	24.1	39.2	44.3	40.4
12.600	33.8	27.6	23.7	20.4	17.5	15.1	13.1
13.300	11.5	10.1	9.1	8.2	7.4	6.7	6.2
14.000	5.7	5.4	5.1	4.9	4.7	4.5	4.4
14.700	4.2	4.0	3.9	3.7	3.6	3.4	3.3
15.400	3.2	3.1	3.0	2.9	2.9	2.8	2.8
16.100	2.7	2.7	2.6	2.6	2.6	2.5	2.5
16.800	2.4	2.4	2.4	2.3	2.3	2.2	2.2
17.500	2.2	2.1	2.1	2.0	2.0	2.0	1.9
18.200	1.9	1.8	1.8	1.8	1.8	1.7	1.7
18.900	1.7	1.7	1.7	1.7	1.7	1.6	1.6
19.600	1.6	1.6	1.6	1.6	1.6	1.6	1.6
20.300	1.6	1.6	1.5	1.5	1.5	1.5	1.5
21.000	1.5	1.5	1.5	1.5	1.4	1.4	1.4
21.700	1.4	1.4	1.4	1.4	1.4	1.4	1.4
22.400	1.3	1.3	1.3	1.3	1.3	1.3	1.3
23.100	1.3	1.3	1.3	1.2	1.2	1.2	1.2
23.800	1.2	1.2	1.2	1.2	1.1	0.9	0.7
24.500	0.5	0.3	0.2	0.1	0.0		

STORM 10-YR

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
DA-SB-1	0.070		2.826		12.26	104.7	1495.90

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.500	0.0	0.1	0.2	0.2	0.3	0.3	0.4
8.200	0.4	0.5	0.5	0.6	0.6	0.7	0.8
8.900	0.8	0.9	0.9	1.0	1.1	1.2	1.4
9.600	1.5	1.6	1.8	1.9	2.1	2.3	2.5
10.300	2.7	2.9	3.1	3.3	3.6	4.1	4.6
11.000	5.2	5.9	6.7	7.8	9.0	10.4	12.2
11.700	15.4	19.9	26.4	38.1	62.3	95.3	103.3
12.400	85.4	64.3	49.9	39.1	31.1	25.7	22.2
13.100	19.5	17.2	15.4	14.0	12.8	11.7	10.7
13.800	9.9	9.3	8.9	8.5	8.2	8.0	7.7

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
14.500	7.4	7.2	6.9	6.6	6.4	6.1	5.8
15.200	5.6	5.4	5.2	5.1	5.0	4.9	4.9
15.900	4.8	4.7	4.6	4.6	4.5	4.4	4.4
16.600	4.3	4.2	4.1	4.1	4.0	3.9	3.9
17.300	3.8	3.7	3.6	3.6	3.5	3.4	3.3
18.000	3.3	3.2	3.1	3.1	3.0	3.0	3.0
18.700	3.0	2.9	2.9	2.9	2.9	2.9	2.9
19.400	2.8	2.8	2.8	2.8	2.8	2.7	2.7
20.100	2.7	2.7	2.7	2.7	2.6	2.6	2.6
20.800	2.6	2.6	2.5	2.5	2.5	2.5	2.5
21.500	2.5	2.4	2.4	2.4	2.4	2.4	2.3
22.200	2.3	2.3	2.3	2.3	2.3	2.2	2.2
22.900	2.2	2.2	2.2	2.1	2.1	2.1	2.1
23.600	2.1	2.1	2.0	2.0	2.0	2.0	1.5
24.300	0.9	0.4	0.2	0.1	0.0		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Pond 3	0.070	Upstream	2.826		12.26	104.7	1495.90

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.500	0.0	0.1	0.2	0.2	0.3	0.3	0.4
8.200	0.4	0.5	0.5	0.6	0.6	0.7	0.8
8.900	0.8	0.9	0.9	1.0	1.1	1.2	1.4
9.600	1.5	1.6	1.8	1.9	2.1	2.3	2.5
10.300	2.7	2.9	3.1	3.3	3.6	4.1	4.6
11.000	5.2	5.9	6.7	7.8	9.0	10.4	12.2
11.700	15.4	19.9	26.4	38.1	62.3	95.3	103.3
12.400	85.4	64.3	49.9	39.1	31.1	25.7	22.2
13.100	19.5	17.2	15.4	14.0	12.8	11.7	10.7
13.800	9.9	9.3	8.9	8.5	8.2	8.0	7.7
14.500	7.4	7.2	6.9	6.6	6.4	6.1	5.8
15.200	5.6	5.4	5.2	5.1	5.0	4.9	4.9
15.900	4.8	4.7	4.6	4.6	4.5	4.4	4.4
16.600	4.3	4.2	4.1	4.1	4.0	3.9	3.9
17.300	3.8	3.7	3.6	3.6	3.5	3.4	3.3
18.000	3.3	3.2	3.1	3.1	3.0	3.0	3.0
18.700	3.0	2.9	2.9	2.9	2.9	2.9	2.9
19.400	2.8	2.8	2.8	2.8	2.8	2.7	2.7
20.100	2.7	2.7	2.7	2.7	2.6	2.6	2.6
20.800	2.6	2.6	2.5	2.5	2.5	2.5	2.5
21.500	2.5	2.4	2.4	2.4	2.4	2.4	2.3
22.200	2.3	2.3	2.3	2.3	2.3	2.2	2.2
22.900	2.2	2.2	2.2	2.1	2.1	2.1	2.1
23.600	2.1	2.1	2.0	2.0	2.0	2.0	1.5
24.300	0.9	0.4	0.2	0.0			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Pond 3	0.070	Downstream	2.826	399.66	12.36	92.9	1326.51

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.700	0.0	0.1	0.2	0.2	0.3	0.3	0.4
8.400	0.4	0.5	0.5	0.6	0.6	0.7	0.8
9.100	0.8	0.9	1.0	1.0	1.1	1.3	1.4
9.800	1.5	1.6	1.8	1.9	2.1	2.3	2.5
10.500	2.7	2.9	3.1	3.4	3.8	4.2	4.7
11.200	5.4	6.1	7.0	8.1	9.3	11.1	13.7
11.900	17.4	23.1	38.0	63.6	87.8	91.8	79.6
12.600	65.2	52.5	41.8	33.6	27.7	24.6	22.1
13.300	19.8	17.8	16.0	14.5	13.2	12.0	11.1
14.000	10.3	9.7	9.2	8.7	8.4	8.1	7.8
14.700	7.5	7.2	6.9	6.6	6.4	6.1	5.8
15.400	5.6	5.4	5.3	5.2	5.1	5.0	4.9
16.100	4.8	4.7	4.6	4.6	4.5	4.4	4.4
16.800	4.3	4.2	4.1	4.1	4.0	3.9	3.9
17.500	3.8	3.7	3.6	3.6	3.5	3.4	3.3
18.200	3.3	3.2	3.1	3.1	3.1	3.0	3.0
18.900	3.0	2.9	2.9	2.9	2.9	2.9	2.9
19.600	2.8	2.8	2.8	2.8	2.8	2.7	2.7
20.300	2.7	2.7	2.7	2.7	2.6	2.6	2.6
21.000	2.6	2.6	2.5	2.5	2.5	2.5	2.5
21.700	2.5	2.4	2.4	2.4	2.4	2.4	2.3
22.400	2.3	2.3	2.3	2.3	2.3	2.2	2.2
23.100	2.2	2.2	2.2	2.1	2.1	2.1	2.1
23.800	2.1	2.1	2.0	2.0	1.9	1.6	1.2
24.500	0.9	0.6	0.4	0.2	0.1	0.0	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.070		2.826		12.36	92.9	1326.51

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.700	0.0	0.1	0.2	0.2	0.3	0.3	0.4
8.400	0.4	0.5	0.5	0.6	0.6	0.7	0.8
9.100	0.8	0.9	1.0	1.0	1.1	1.3	1.4
9.800	1.5	1.6	1.8	1.9	2.1	2.3	2.5
10.500	2.7	2.9	3.1	3.4	3.8	4.2	4.7
11.200	5.4	6.1	7.0	8.1	9.3	11.1	13.7
11.900	17.4	23.1	38.0	63.6	87.8	91.8	79.6
12.600	65.2	52.5	41.8	33.6	27.7	24.6	22.1
13.300	19.8	17.8	16.0	14.5	13.2	12.0	11.1

Line Start Time (hr)	------------ Flow Values @ time increment of 0.100 hr ------------ (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
14.000	10.3	9.7	9.2	8.7	8.4	8.1	7.8
14.700	7.5	7.2	6.9	6.6	6.4	6.1	5.8
15.400	5.6	5.4	5.3	5.2	5.1	5.0	4.9
16.100	4.8	4.7	4.6	4.6	4.5	4.4	4.4
16.800	4.3	4.2	4.1	4.1	4.0	3.9	3.9
17.500	3.8	3.7	3.6	3.6	3.5	3.4	3.3
18.200	3.3	3.2	3.1	3.1	3.1	3.0	3.0
18.900	3.0	2.9	2.9	2.9	2.9	2.9	2.9
19.600	2.8	2.8	2.8	2.8	2.8	2.7	2.7
20.300	2.7	2.7	2.7	2.7	2.6	2.6	2.6
21.000	2.6	2.6	2.5	2.5	2.5	2.5	2.5
21.700	2.5	2.4	2.4	2.4	2.4	2.4	2.3
22.400	2.3	2.3	2.3	2.3	2.3	2.2	2.2
23.100	2.2	2.2	2.2	2.1	2.1	2.1	2.1
23.800	2.1	2.1	2.0	2.0	1.9	1.6	1.2
24.500	0.9	0.6	0.4	0.2	0.1	0.0	

STORM 100-YR

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	------------ Peak Flow ------------ Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
DA-SB-1	0.070		6.044		12.27	219.5	3135.62

Line Start Time (hr)	------------ Flow Values @ time increment of 0.100 hr ------------ (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
4.900	0.0	0.1	0.2	0.2	0.3	0.3	0.4
5.600	0.5	0.5	0.6	0.6	0.7	0.8	0.8
6.300	0.9	1.0	1.1	1.1	1.2	1.3	1.4
7.000	1.5	1.6	1.7	1.8	1.9	2.1	2.2
7.700	2.3	2.4	2.5	2.7	2.8	2.9	3.1
8.400	3.2	3.3	3.5	3.6	3.8	3.9	4.1
9.100	4.2	4.4	4.7	5.0	5.4	5.7	6.1
9.800	6.5	6.9	7.3	7.7	8.2	8.7	9.1
10.500	9.6	10.2	10.9	12.0	13.4	14.8	16.5
11.200	18.5	21.0	23.9	26.9	31.0	38.4	48.2
11.900	62.3	87.3	137.4	203.1	215.3	175.3	130.3
12.600	100.1	77.7	61.3	50.4	43.3	37.8	33.3
13.300	29.7	27.0	24.6	22.4	20.5	18.9	17.8
14.000	17.0	16.4	15.8	15.2	14.7	14.2	13.7
14.700	13.1	12.6	12.1	11.6	11.1	10.6	10.2
15.400	9.9	9.7	9.5	9.3	9.2	9.1	8.9
16.100	8.8	8.6	8.5	8.4	8.2	8.1	8.0
16.800	7.8	7.7	7.5	7.4	7.3	7.1	7.0
17.500	6.9	6.7	6.6	6.4	6.3	6.2	6.0
18.200	5.9	5.8	5.7	5.7	5.6	5.6	5.5
18.900	5.5	5.5	5.4	5.4	5.4	5.3	5.3
19.600	5.3	5.2	5.2	5.2	5.1	5.1	5.0

Line Start Time (hr)	------------ Flow Values @ time increment of 0.100 hr ------------ (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
20.300	5.0	5.0	4.9	4.9	4.9	4.8	4.8
21.000	4.8	4.7	4.7	4.7	4.6	4.6	4.6
21.700	4.5	4.5	4.5	4.4	4.4	4.4	4.3
22.400	4.3	4.2	4.2	4.2	4.1	4.1	4.1
23.100	4.0	4.0	4.0	3.9	3.9	3.9	3.8
23.800	3.8	3.8	3.8	3.7	2.8	1.6	0.8
24.500	0.4	0.2	0.0				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	------------ Peak Flow ------------ Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Pond 3	0.070	Upstream	6.044		12.27	219.5	3135.62

Line Start Time (hr)	------------ Flow Values @ time increment of 0.100 hr ------------ (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
4.900	0.0	0.1	0.2	0.2	0.3	0.3	0.4
5.600	0.5	0.5	0.6	0.6	0.7	0.8	0.8
6.300	0.9	1.0	1.1	1.1	1.2	1.3	1.4
7.000	1.5	1.6	1.7	1.8	1.9	2.1	2.2
7.700	2.3	2.4	2.5	2.7	2.8	2.9	3.1
8.400	3.2	3.3	3.5	3.6	3.8	3.9	4.1
9.100	4.2	4.4	4.7	5.0	5.4	5.7	6.1
9.800	6.5	6.9	7.3	7.7	8.2	8.7	9.1
10.500	9.6	10.2	10.9	12.0	13.4	14.8	16.5
11.200	18.5	21.0	23.9	26.9	31.0	38.4	48.2
11.900	62.3	87.3	137.4	203.1	215.3	175.3	130.3
12.600	100.1	77.7	61.3	50.4	43.3	37.8	33.3
13.300	29.7	27.0	24.6	22.4	20.5	18.9	17.8
14.000	17.0	16.4	15.8	15.2	14.7	14.2	13.7
14.700	13.1	12.6	12.1	11.6	11.1	10.6	10.2
15.400	9.9	9.7	9.5	9.3	9.2	9.1	8.9
16.100	8.8	8.6	8.5	8.4	8.2	8.1	8.0
16.800	7.8	7.7	7.5	7.4	7.3	7.1	7.0
17.500	6.9	6.7	6.6	6.4	6.3	6.2	6.0
18.200	5.9	5.8	5.7	5.7	5.6	5.6	5.5
18.900	5.5	5.5	5.4	5.4	5.4	5.3	5.3
19.600	5.3	5.2	5.2	5.2	5.1	5.1	5.0
20.300	5.0	5.0	4.9	4.9	4.9	4.8	4.8
21.000	4.8	4.7	4.7	4.7	4.6	4.6	4.6
21.700	4.5	4.5	4.5	4.4	4.4	4.4	4.3
22.400	4.3	4.2	4.2	4.2	4.1	4.1	4.1
23.100	4.0	4.0	4.0	3.9	3.9	3.9	3.8
23.800	3.8	3.8	3.8	3.7	2.8	1.6	0.8
24.500	0.4	0.2	0.0				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Pond 3	0.070	Downstream	6.044	401.27	12.46	149.7	2137.86

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
5.100	0.0	0.1	0.2	0.2	0.3	0.3	0.4
5.800	0.5	0.5	0.6	0.6	0.7	0.8	0.8
6.500	0.9	1.0	1.1	1.2	1.2	1.3	1.4
7.200	1.5	1.6	1.7	1.8	1.9	2.1	2.2
7.900	2.3	2.4	2.5	2.7	2.8	2.9	3.1
8.600	3.2	3.3	3.5	3.6	3.8	3.9	4.1
9.300	4.3	4.5	4.8	5.1	5.4	5.8	6.1
10.000	6.5	6.9	7.3	7.8	8.2	8.7	9.1
10.700	9.7	10.4	11.3	12.4	13.7	15.2	17.0
11.400	19.2	21.6	24.5	29.9	38.1	48.5	64.2
12.100	95.1	134.0	143.4	148.9	149.1	145.6	139.4
12.800	124.5	80.3	59.9	48.3	40.6	35.0	31.0
13.500	27.8	25.6	24.0	22.3	20.7	19.4	18.3
14.200	17.4	16.7	16.0	15.4	14.8	14.3	13.7
14.900	13.2	12.7	12.1	11.6	11.1	10.7	10.3
15.600	10.0	9.8	9.6	9.4	9.2	9.1	8.9
16.300	8.8	8.7	8.5	8.4	8.2	8.1	8.0
17.000	7.8	7.7	7.6	7.4	7.3	7.1	7.0
17.700	6.9	6.7	6.6	6.4	6.3	6.2	6.0
18.400	5.9	5.8	5.7	5.7	5.6	5.6	5.5
19.100	5.5	5.5	5.4	5.4	5.4	5.3	5.3
19.800	5.3	5.2	5.2	5.2	5.1	5.1	5.0
20.500	5.0	5.0	4.9	4.9	4.9	4.8	4.8
21.200	4.8	4.7	4.7	4.7	4.6	4.6	4.6
21.900	4.5	4.5	4.5	4.4	4.4	4.4	4.3
22.600	4.3	4.3	4.2	4.2	4.1	4.1	4.1
23.300	4.0	4.0	4.0	3.9	3.9	3.9	3.8
24.000	3.8	3.8	3.6	3.0	2.3	1.6	1.1
24.700	0.7	0.4	0.3	0.2	0.1	0.0	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
OUTLET	0.070		6.044		12.46	149.7	2137.86

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
5.100	0.0	0.1	0.2	0.2	0.3	0.3	0.4
5.800	0.5	0.5	0.6	0.6	0.7	0.8	0.8
6.500	0.9	1.0	1.1	1.2	1.2	1.3	1.4
7.200	1.5	1.6	1.7	1.8	1.9	2.1	2.2
7.900	2.3	2.4	2.5	2.7	2.8	2.9	3.1

Line Start Time (hr)	------------ Flow Values @ time increment of 0.100 hr ------------ (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.600	3.2	3.3	3.5	3.6	3.8	3.9	4.1
9.300	4.3	4.5	4.8	5.1	5.4	5.8	6.1
10.000	6.5	6.9	7.3	7.8	8.2	8.7	9.1
10.700	9.7	10.4	11.3	12.4	13.7	15.2	17.0
11.400	19.2	21.6	24.5	29.9	38.1	48.5	64.2
12.100	95.1	134.0	143.4	148.9	149.1	145.6	139.4
12.800	124.5	80.3	59.9	48.3	40.6	35.0	31.0
13.500	27.8	25.6	24.0	22.3	20.7	19.4	18.3
14.200	17.4	16.7	16.0	15.4	14.8	14.3	13.7
14.900	13.2	12.7	12.1	11.6	11.1	10.7	10.3
15.600	10.0	9.8	9.6	9.4	9.2	9.1	8.9
16.300	8.8	8.7	8.5	8.4	8.2	8.1	8.0
17.000	7.8	7.7	7.6	7.4	7.3	7.1	7.0
17.700	6.9	6.7	6.6	6.4	6.3	6.2	6.0
18.400	5.9	5.8	5.7	5.7	5.6	5.6	5.5
19.100	5.5	5.5	5.4	5.4	5.4	5.3	5.3
19.800	5.3	5.2	5.2	5.2	5.1	5.1	5.0
20.500	5.0	5.0	4.9	4.9	4.9	4.8	4.8
21.200	4.8	4.7	4.7	4.7	4.6	4.6	4.6
21.900	4.5	4.5	4.5	4.4	4.4	4.4	4.3
22.600	4.3	4.3	4.2	4.2	4.1	4.1	4.1
23.300	4.0	4.0	4.0	3.9	3.9	3.9	3.8
24.000	3.8	3.8	3.6	3.0	2.3	1.6	1.1
24.700	0.7	0.4	0.3	0.2	0.0		

Gude Landfill
Pond 3 - Proposed Conditions

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 2-YR (cfs)	10-YR (cfs)	100-YR (cfs)	(cfs)	(cfs)
DA-SB-1	0.070	52.3	104.7	219.5		
Pond 3	0.070	52.3	104.7	219.5		
DOWNSTREAM		44.3	92.9	149.7		
OUTLET	0.070	44.3	92.9	149.7		

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GUDE LANDFILL REMEDIATION
Sediment Basin No. 1
Stage-Storage Table and Related Design Criteria

Elevation (ft)	Area (sq ft)	Average End Area (sq ft)	Change in Elevation (ft)	Volume (cu ft)	Cumulative Volume (cu ft)	Cumulative Volume (acre-ft)
392.0	22,725				0	0.00
392.5	23,732	23,229	0.5	11,615	11,615	0.27
393.0	24,752	24,242	0.5	12,121	23,736	0.54
393.5	25,798	25,275	0.5	12,638	36,373	0.84
394.0	26,866	26,332	0.5	13,166	49,539	1.14
394.5	27,996	27,431	0.5	13,716	63,255	1.45
395.0	29,067	28,532	0.5	14,266	77,521	1.78
395.2	29,518	29,293	0.2	5,859	83,379	1.91
395.5	30,201	29,634	0.5	14,817	92,338	2.12
396.0	31,354	30,778	0.5	15,389	107,727	2.47
396.5	32,526	31,940	0.5	15,970	123,697	2.84
397.0	33,718	33,122	0.5	16,561	140,258	3.22
397.5	34,930	34,324	0.5	17,162	157,420	3.61
397.7	35,420	35,175	0.2	7,035	164,455	3.78
398.0	36,154	35,787	0.3	10,736	175,191	4.02
398.5	37,404	36,779	0.5	18,390	193,580	4.44
399.0	38,669	38,037	0.5	19,019	212,599	4.88
399.5	39,947	39,308	0.5	19,654	232,253	5.33
400.0	41,242	40,595	0.5	20,298	252,550	5.80
400.5	42,550	41,896	0.5	20,948	273,498	6.28
401.0	43,873	43,212	0.5	21,606	295,104	6.77
401.5	45,221	44,547	0.5	22,274	317,378	7.29
402.0	46,561	45,891	0.5	22,946	340,323	7.81

Principal Spillway Elevation =	398.7	feet
Storage to Principal Spillway =	175,191	cu ft
Drainage Area Capacity =	48.7	acres
Draw-Down Device Invert =	395.2	feet
Wet Storage Volume =	83,379	cu ft
Dry Storage Volume =	117,808	cu ft
Basin Cleanout Elevation =	393.70	feet
Riser Crest to Cleanout =	5.0	feet
Basin Surface Area (at Wet Storage El) =	0.69	acres

Principal Spillway

Stage (ft)	Low Flow Dewatering (Assume Blocked)	Riser (Weir Flow)	Riser (Orifice Flow)	Max Riser Flow (Includes Low Flow Orifice)	48-in. Barrel (HY-8)	Actual	Control Type
392.0	0.000	0.00	0.00	0.00	0.00	0.00	
392.5	0.000	0.00	0.00	0.00	0.00	0.00	
393.0	0.000	0.00	0.00	0.00	0.00	0.00	
393.5	0.000	0.00	0.00	0.00	0.00	0.00	
394.0	0.000	0.00	0.00	0.00	0.00	0.00	
394.5	0.000	0.00	0.00	0.00	0.00	0.00	
395.0	0.000	0.00	0.00	0.00	0.00	0.00	
395.2	0.000	0.00	0.00	0.00	0.00	0.00	
395.5	0.000	0.00	0.00	0.00	1.00	0.00	
396.0	0.000	0.00	0.00	0.00	47.00	0.00	
396.5	0.000	0.00	0.00	0.00	59.92	0.00	
397.0	0.000	0.00	0.00	0.00	72.85	0.00	
397.5	0.000	0.00	0.00	0.00	85.07	0.00	
397.7	0.000	0.00	0.00	0.00	89.54	0.00	
398.0	0.407	0.00	0.00	0.41	96.25	0.00	
398.5	0.664	0.00	0.00	0.66	106.21	0.00	
399.0	0.847	12.23	94.94	13.07	115.42	12.23	Riser (Weir Flow)
399.5	0.996	53.24	155.04	54.23	123.95	53.24	Riser (Weir Flow)
400.0	1.126	110.28	197.64	111.40	131.66	110.28	Riser (Weir Flow)
400.5	1.242	179.67	232.56	180.92	139.37	139.37	48-in. Barrel (HY-8)
401.0	1.349	259.52	262.88	260.87	146.10	146.10	48-in. Barrel (HY-8)
401.5	1.447	348.59	290.05	291.50	152.69	152.69	48-in. Barrel (HY-8)
402.0	1.540	446.01	314.89	316.43	159.28	159.28	48-in. Barrel (HY-8)

<u>Riser (Weir Flow) Discharge</u>

$$Q = CLH^{1.5}$$

where: Q = discharge (cfs)
L = riser crest length (ft)
H = head (ft) = stage - top of riser elevation

<u>Riser (Orifice Flow) Discharge</u>

$$Q = CA\sqrt{2gH}$$

where: Q = discharge (cfs)
C = orifice coefficient
A = cross-sectional area of the riser
g = gravity = 32.2 ft/sec^2
H = head (ft) = stage - top of riser elevation

GUDE LANDFILL REMEDIATION
Sediment Basin No. 1

Stage	Storage	Discharge (cfs)
(ft)	(acre-ft)	(cfs)
392.0	0.00	0.0
392.5	0.27	0.0
393.0	0.54	0.0
393.5	0.84	0.0
394.0	1.14	0.0
394.5	1.45	0.0
395.0	1.78	0.0
395.2	1.91	0.0
395.5	2.12	0.0
396.0	2.47	0.0
396.5	2.84	0.0
397.0	3.22	0.0
397.5	3.61	0.0
397.7	3.78	0.0
398.0	4.02	0.0
398.5	4.44	0.0
399.0	4.88	12.2
399.5	5.33	53.2
400.0	5.80	110.3
400.5	6.28	139.4
401.0	6.77	146.1
401.5	7.29	152.7
402.0	7.81	159.3

Low-Flow Orifice Information:

$$Q = CA\sqrt{2gH}$$

Low-Flow Orifice Invert Elevation =	395.2	ft	where:
Low-Flow Orifice Diameter =	0.8	in	Q = discharge (cfs)
Low-Flow Orifice Coefficient =	0.6		C = orifice coefficient
Dewatering Pipe Diameter	48.0	in	
Height of Riser =	3.5	ft	
Number of Low-Flow Orifices Per Row =	50		A = orifice area (ft^2)
Number of Low-Flow Orifice Rows =	15		g = gravity = 32.2 ft/sec^2
Spacing Between Low-Flow Orifice Rows =	3.0	in	H = head (ft) = stage - orifice centerline elevation
Permittivity of geotextile wrap =	0	s^{-1}	(use "0" for no wrap)
Percent clogging of orifices =	0%		

Principal Spillway Information: see next sheet for calculations

Top of Riser Elevation =	398.7	ft	
Riser Crest Length =	24	ft	
Weir Coefficient, C =	3.1		
Riser Area, A =	36	ft^2	
Barrel Diameter =	4	ft	
Barrel Length =	70	ft	
Manning's Coefficient =	0.013		RCP
K_m =	1		Assume only entrance loss
K_p =	0.003		
Tailwater Elevation =	0		Estimated based on assumed capacity of pipe

Emergency Spillway Information:

$$Q = CLH^{\frac{3}{2}}$$

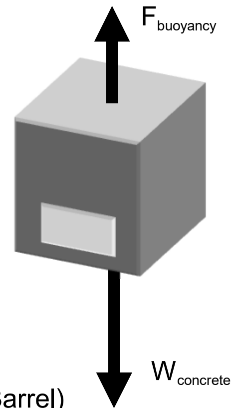
Spillway Weir Crest Elevation =	0.0	ft	
Spillway Weir Length =	0.0	ft	
Spillway Weir Coefficient =	3.0		where:

Q = discharge (cfs)
C = weir coefficient
L = weir length (ft)
H = head (ft) = stage - crest elev.

GUDE LANDFILL REMEDIATION
Sediment Basin No. 1

Stage (ft)	Storage (cu ft)	Dewatering Device Discharge (cfs)	Time to Dewater			CUMULATIVE Time to Dewater		
			(min)	(hr)	(days)	(min)	(hr)	(days)
395.2	83,379	0.00	NA	NA	NA	NA	NA	**NA**
395.3	86,365	0.23	212	3.53	0.15	212	3.53	**0.15**
395.4	89,351	0.33	150	2.50	0.10	362	6.03	**0.25**
395.5	92,338	0.57	90	1.49	0.06	451	7.52	**0.31**
395.6	95,415	0.76	68	1.13	0.05	519	8.65	**0.36**
395.7	98,493	0.90	57	0.95	0.04	576	9.61	**0.40**
395.8	101,571	1.25	41	0.68	0.03	617	10.29	**0.43**
395.9	104,649	1.45	35	0.59	0.02	653	10.88	**0.45**
396.0	107,727	1.79	30	0.50	0.02	683	11.38	**0.47**
396.1	110,921	2.06	26	0.43	0.02	708	11.81	**0.49**
396.2	114,115	2.28	23	0.39	0.02	732	12.20	**0.51**
396.3	117,309	2.71	20	0.33	0.01	751	12.52	**0.52**
396.4	120,503	2.99	18	0.30	0.01	769	12.82	**0.53**
396.5	123,697	3.40	16	0.27	0.01	785	13.09	**0.55**
396.6	127,009	3.74	15	0.25	0.01	800	13.34	**0.56**
396.7	130,321	4.02	14	0.23	0.01	814	13.57	**0.57**
396.8	133,633	4.51	12	0.20	0.01	826	13.77	**0.57**
396.9	136,945	4.85	11	0.19	0.01	838	13.96	**0.58**
397.0	140,258	5.32	11	0.18	0.01	848	14.14	**0.59**
397.1	143,690	5.71	10	0.17	0.01	858	14.31	**0.60**
397.2	147,122	6.05	9	0.16	0.01	868	14.46	**0.60**
397.3	150,555	6.60	9	0.14	0.01	876	14.61	**0.61**
397.4	153,987	6.99	8	0.14	0.01	885	14.74	**0.61**
397.5	157,420	7.50	8	0.13	0.01	892	14.87	**0.62**
397.6	160,937	7.95	7	0.12	0.01	900	15.00	**0.62**
397.7	164,455	8.34	7	0.12	0.00	907	15.12	**0.63**
397.8	168,033	8.94	7	0.11	0.00	914	15.23	**0.63**
397.9	171,612	9.37	6	0.11	0.00	920	15.33	**0.64**
398.0	175,191	9.93	6	0.10	0.00	926	15.44	**0.64**
398.1	178,869	10.42	6	0.10	0.00	932	15.53	**0.65**
398.2	182,546	10.86	6	0.09	0.00	938	15.63	**0.65**
398.3	186,224	11.50	5	0.09	0.00	943	15.72	**0.65**
398.4	189,902	11.97	5	0.09	0.00	948	15.80	**0.66**
398.5	193,580	12.41	5	0.09	0.00	953	15.89	**0.66**
398.6	197,384	12.82	5	0.08	0.00	958	15.97	**0.67**
398.7	201,188	13.22	5	0.08	0.00	963	16.05	**0.67**

Gude Landfill
Sediment Basin No. 1



RISER STRUCTURE FLOTATION COMPUTATIONS

$W_{concrete}$ >= 1.2 x $F_{buoyancy}$

$W_{concrete}$ = $V_{concrete}$ x $\gamma_{concrete}$

		H/W/radius		L		Thickness			
$V_{concrete}$	=	9.00	x	9.00	x	1.50	=	121.50	Bottom slab
	+	8.70	x	7.33	x	0.67	=	42.73	Back wall
	-	2.25	x		x	0.67	=	10.66	54" Opening(48" Barrel)
	-		x		x		=	0.00	
	+	8.70	x	7.33	x	0.67	=	42.73	Front wall
	-		x		x		=	0.00	
	-	0.59	x		x	0.67	=	0.72	14" Opening (10" orifice)
	+	8.70	x	7.33	x	0.67	=	42.73	Side wall
			x		x			0.00	
	+	8.70	x	7.33	x	0.67	=	42.73	Side wall
	-		x		x		=	0.00	
	+		x		x		=	0.00	
	-		x		x		=	0.00	
	+		x		x		=	0.00	
	=							281.03	ft^3

Refer to riser detail in plans for dimensions

$W_{concrete}$ = $V_{concrete}$ x $\gamma_{concrete}$
$W_{concrete}$ = 281.03 ft^3 x 150 lb/ft^3
$W_{concrete}$ = 42,154.51 lb

$F_{buoyancy}$ = V_{riser} x γ_w

V_{riser}	=	8.70	x	7.33	x	7.33	=	467.44	Box
$V_{riser-foot}$	=							467.44	ft^3

$F_{buoyancy}$ = V_{riser} x γ_w
$F_{buoyancy}$ = 467.44 ft^3 x 62.4 lb/ft^3
$F_{buoyancy}$ = 29,168.35 lb

$W_{concrete}$ >= 1.2 x $F_{buoyancy}$
42,154.51 >= 1.2 x 29,168.35
42,154.51 >= 35,002.01

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Table G.6: Temporary Sediment Basin Design Data Sheet
(Refer to instructions on pages G.27 through G.29)

Computed by: SCL Date: 6/25/2020 Checked by:____Date:________________
Project name: Gude Landfill Remediation Basin #: Sediment Basin No. 1
Location: 600 E Gude Drive

Design Volumes and Elevations

1. Total area draining to basin = 44.80 acres (ac)
2. Required total storage volume = 3600 ft^3/ac x 44.80 acre drainage area = 161280 ft^3
3. Required wet storage volume = 1800 ft^3/ac x 44.80 acre drainage area = 80640 ft^3
4. Required dry storage volume = 1800 ft^3/ac x 44.80 acre drainage area = 80640 ft^3
5. Basin bottom elevation = 392 ft
6. Riser or weir crest (total storage) elevation = 398.7 ft
7. Provided total storage volume = 175191 ft^3
8. Wet storage (permanent pool/draw-down) elevation 395.2 ft
9. Provided wet storage volume = 83,528 ft^3
10. Provided dry storage volume = 117808 ft^3
11. Basin cleanout elevation (located at ½ wet storage depth) = 393.7 ft
12. Distance from riser crest elevation to cleanout elevation = 5.0 ft

Surface Area Design

13. Q_{10} = 104.71 cfs (peak inflow from 10-yr, 24-hr storm event; attach computations)
14. Minimum basin surface area ≥ 0.0035 x Q_{10} = 0.37 ac ≤ .68 ac
 required **provided**

Principal Spillway (Q_{ps})
(See Figure G.1)

15. Design Q_{ps} for barrel = 104.71 cfs (min. 10% of Q_{10})
16. Barrel head, H = 5.66 ft; Barrel length, L = 53 ft
17. Barrel dia. = 48 in (min. 10 inch); Q_{ps} = 147 (Q from Table G.7 or G.8) x 1.03 (length correction factor) = 151 cfs. **Note: Q_{ps} must equal or exceed Design Q_{ps}**
18. Riser dia. = _____ in; Riser height = _____ ft; Riser head (h) = _____ ft
19. Trash rack dia. =_____ in; Trash rack height = _____ in

See Calculation Sheets for Custom Riser, Stage-Storage-Discharge, and TR-20 analysis.

Emergency Spillway (Q_{es})
(See Figures G.3 and G.4)

20. Emergency spillway capacity Q_{es} = Q_{10} - Q_{ps} =_____ -_____ =_____ cfs
21. Width, b =_____ ft; Hp = _____ ft
22. Exit channel slope ___________%
23. Emergency Spillway Crest = ________ ft
24. Design High Water = _________ ft
25. Settled top of embankment elevation =__________ ft

100-yr containment is provided in sediment basin, conveyed with principle spillway.

Table G.6: Temporary Sediment Basin Design Data Sheet (continued)

Anti-Seep Collar Design (If Required)
(See Figures G.5 and G.6)

26. y = 5.7 ft; z = 3 :1; pipe slope = 1.87 %; Ls = 52 ft [52ft. determined graphically]
27. Use 2 collars, 8 ft - 0 in. square; projection = 2 ft

Draw-Down Device
(See Table G.10 and Details G-2-6 and G-2-7)

28. $Q_{d\text{-}d}$ = 2.25 cfs
29. Calculated A_o = .27 ft^2
30. Calculated d_o = .58 in
31. Maximum diameter from Table G.10 = 10 in
32. Design d_o = smaller of line 30 or line 31 = .58 in
33. Draw-down device pipe diameter = 48 in
34. Minimum A_t = total area of perforations = $4A_o$ = 1.07 ft^2
35. Perforation diameter = 0.75 in [Perforation size Per Montgomery County Modified Dewatering Device Detail]
36. Minimum number of perforations = 356
37. Number of longitudinal rows = 25 [Based on Montgomery Co. perforation spacing = 6"]
38. Perforated pipe length = 3 ft
39. Actual A_t = (0.0055 ft^2) x (line 37 ÷ 0.5 ft) x (line 38) = 0.45 ft^2 (must be ≥ line 34)

[See Calculation Sheet for Dewatering Calculations - Modification to perforation internals proposed]

Baffle Board Design
(See Detail G-2-4)

40. A = surface area at wet storage elevation = 29,518 ft^2
41. Effective width, $W_e = (A/2)^{1/2}$ = 121.5 ft [We * 2 = 243' (min.)]
42. Flow length from inflow point to outlet = ________ ft [186ft, 179ft, 85ft (west to east inflow points)]
43. If line 42 is less than W_e x 2, provide baffle boards to lengthen flow path
44. Effective flow length, $L_e = L_1 + L_2 + L_3$ = ________ ft (must be ≥ W_e x 2 = ________ ft)

[248ft, 288ft, 425ft (west to east inflow points)]

Attachment H4

H4 – Floodplain Study

[To Be Included - 100 % Design]

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Attachment I

Geosynthetics Calculations

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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.

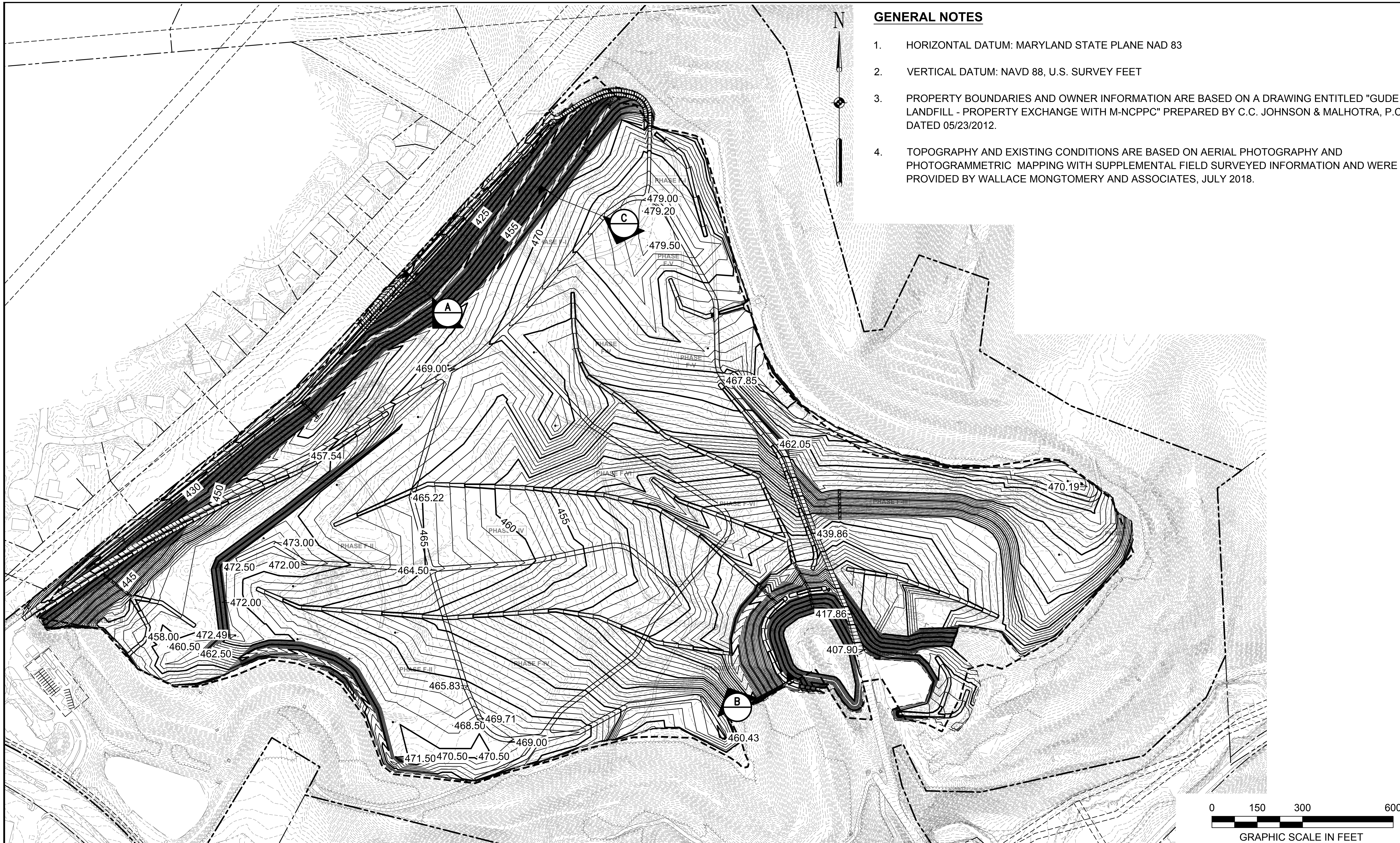
The design method calculates the maximum liquid thickness in the upper and lower slopes. If the liquid thickness is contained within the geocomposite, there is no head in the overlying soil material and the design is acceptable.

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.

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	DRAWN BY: SMB	FIGURE: 1	GUDE LANDFILL REMEDIATION DESIGN NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY BASIS OF DESIGN REPORT MONTGOMERY COUNTY, MARYLAND	FIGURE 1: GEOCOMPOSITE CALCULATION FIGURE
	DATE: JANUARY 2020	CHECKED BY: GAT	PROJECT MGR.: MJG	SHEET NUMBER: -		

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

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, 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 =	3	H:1V	
slope, β =	18.43	°	
length of slope, L =	90	ft	
characteristic parameter, λ =	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:

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

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 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:

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

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, 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	

UPPER SLOPE (FLATTER)			**LOWER SLOPE (STEEPER)**		
slope, z =	4	%	slope, z =	3	H:1V
slope, β =	2.29	°	slope, β =	18.43	°
length of slope, L =	165	ft	length of slope, L =	30	ft
characteristic parameter, λ =	0.020976		characteristic parameter, λ =	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:

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

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

MAX. LIQUID THICKNESS IN LOWER SLOPE:

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

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
β = 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.

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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.

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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, ϕ =	27	°	
slope, z =	3	H:1V	
slope, β =	18.43	°	
length of slope, L =	90	ft	
unit weight of soil, γ =	120	pcf	
depth of soil, D =	2	ft	
pore pressure, μ =	0.25	in. water	
	1.3	psf	
toe soil cohesion, c_s =	0	psf	Silty sand
toe soil friction angle, ϕ_s =	28	°	Silty sand
weight of toe, W_T =	720	lb/ft	

INFINITE SLOPE FACTOR OF SAFETY:

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

F.S. = 1.52

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

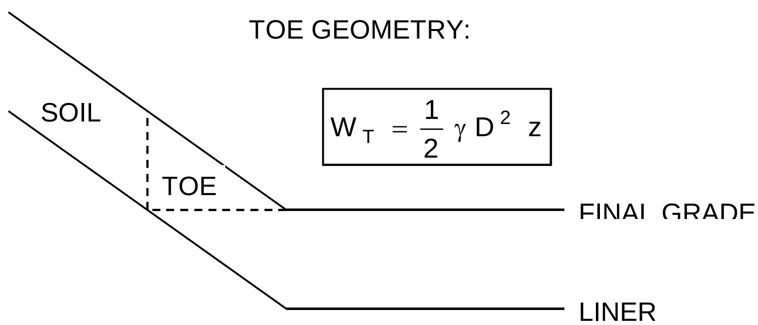
FINITE SLOPE FACTOR OF SAFETY:

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

F.S. = 1.59

TOE GEOMETRY:

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



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
γ = 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)
γ = 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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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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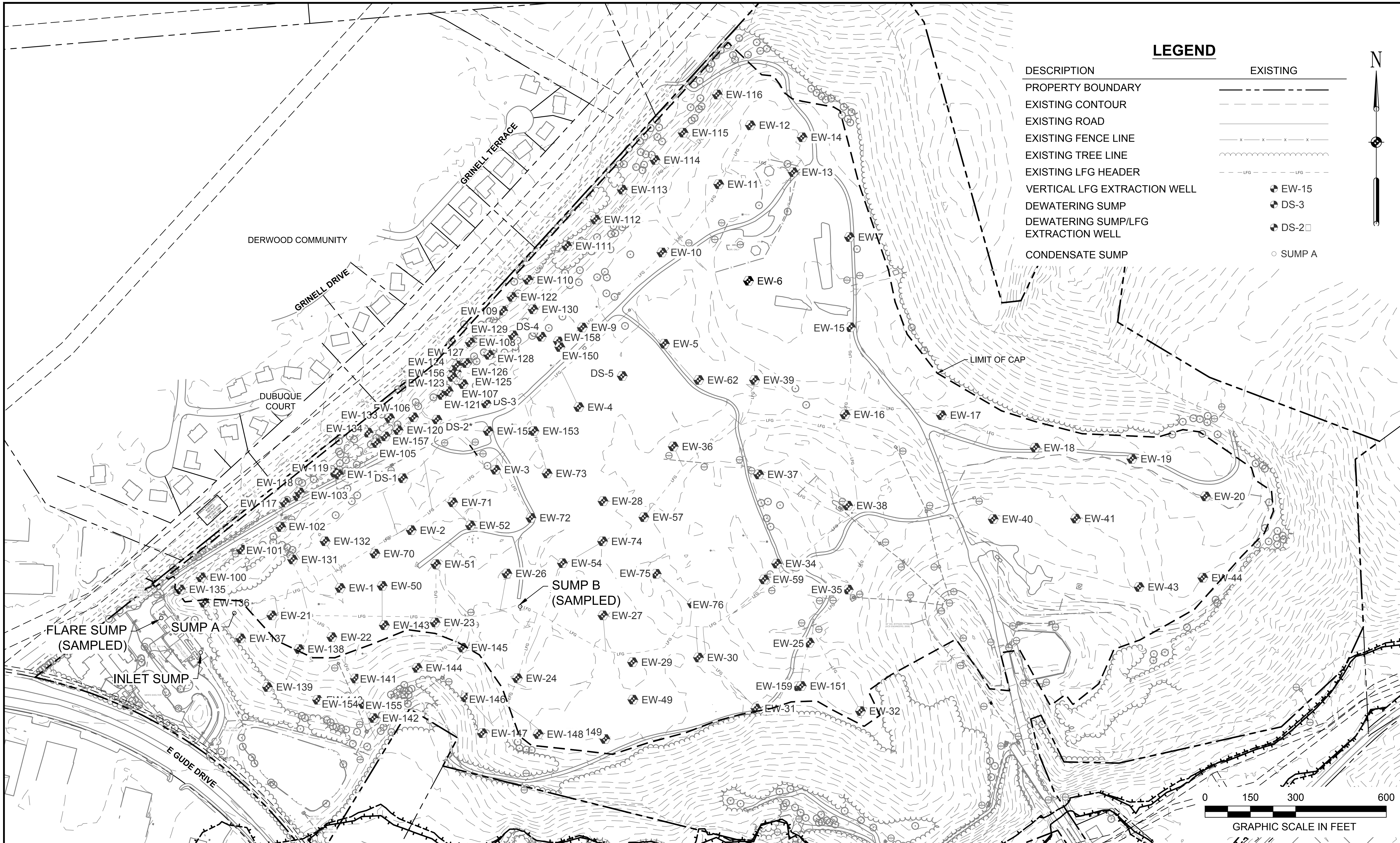
Figure



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: -	DRAWN BY: SS	FIGURE: 1	GUDE LANDFILL REMEDIATION DESIGN NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY MONTGOMERY COUNTY, MARYLAND	FIGURE □□LOCATION OF E□ISTING CONDENSATE SUMPS
	DATE: APRIL 2019	CHECKED BY: GAT	PROJECT MGR.: MJG	SHEET NUMBER: -		

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

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

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.

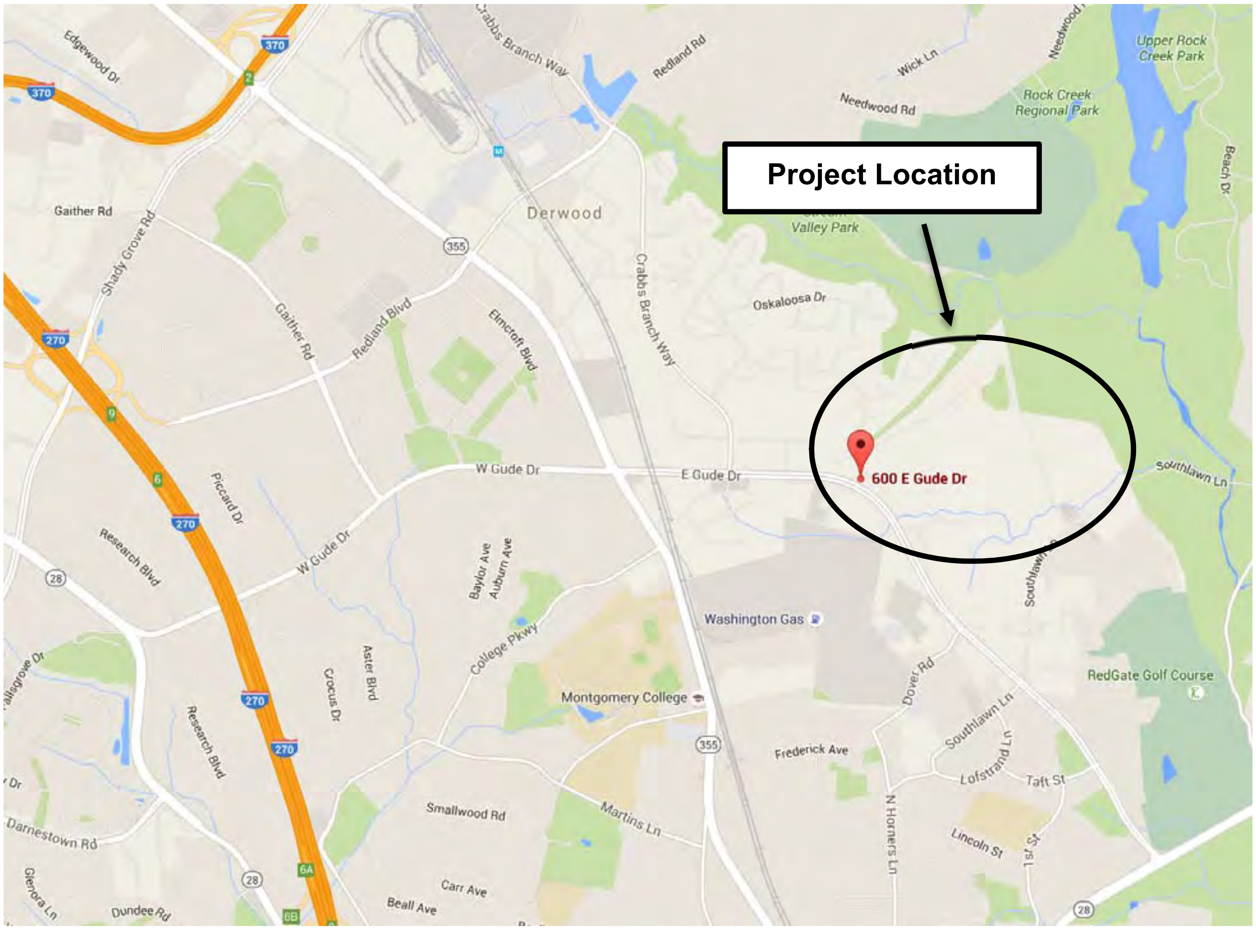
Soil and Land Use Technology Inc.

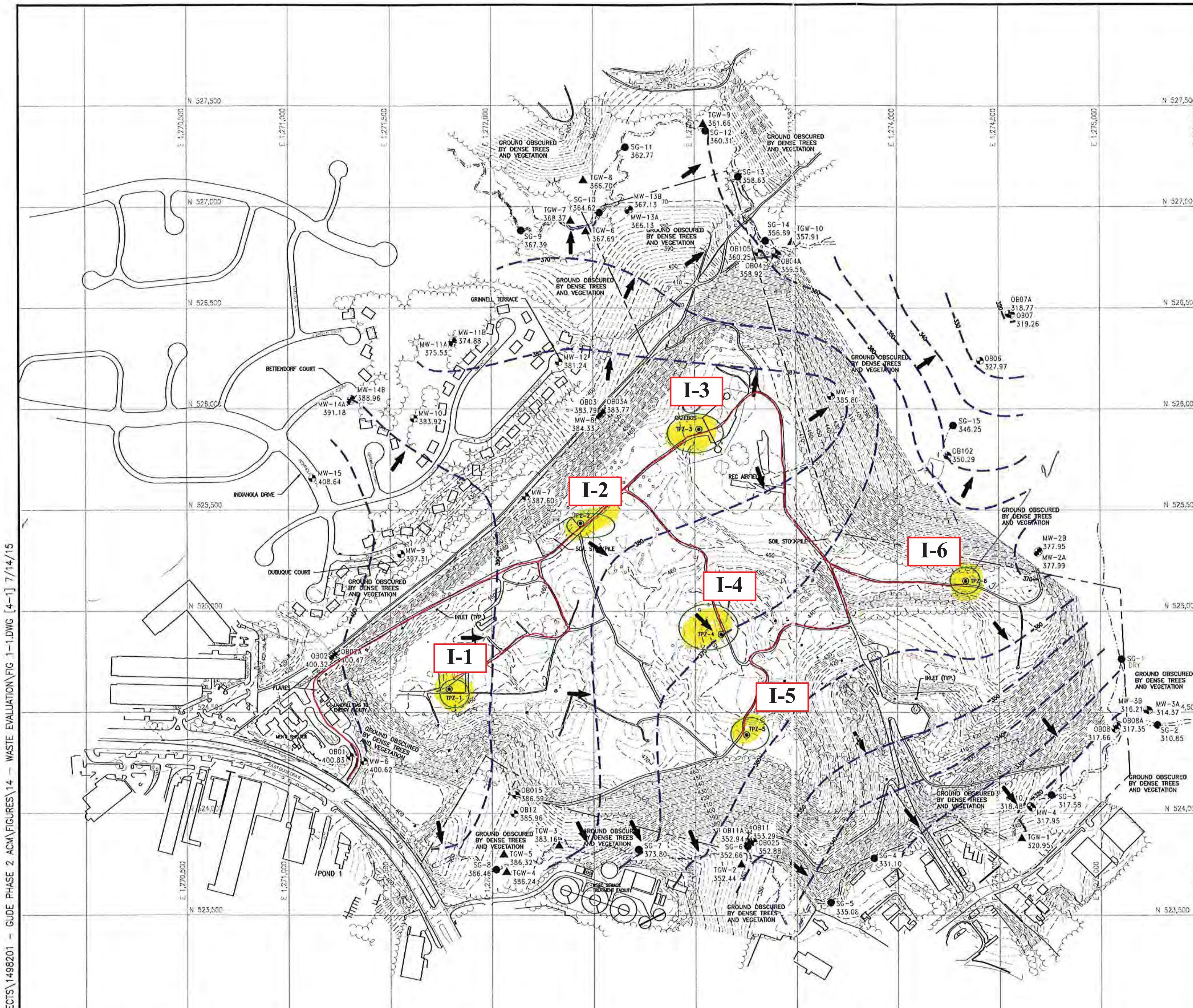
Edward H. Dalton, PE
Vice President

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

- 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
ASSESSMENT OF CORRECTIVE MEASURES
MONTGOMERY COUNTY, MARYLAND

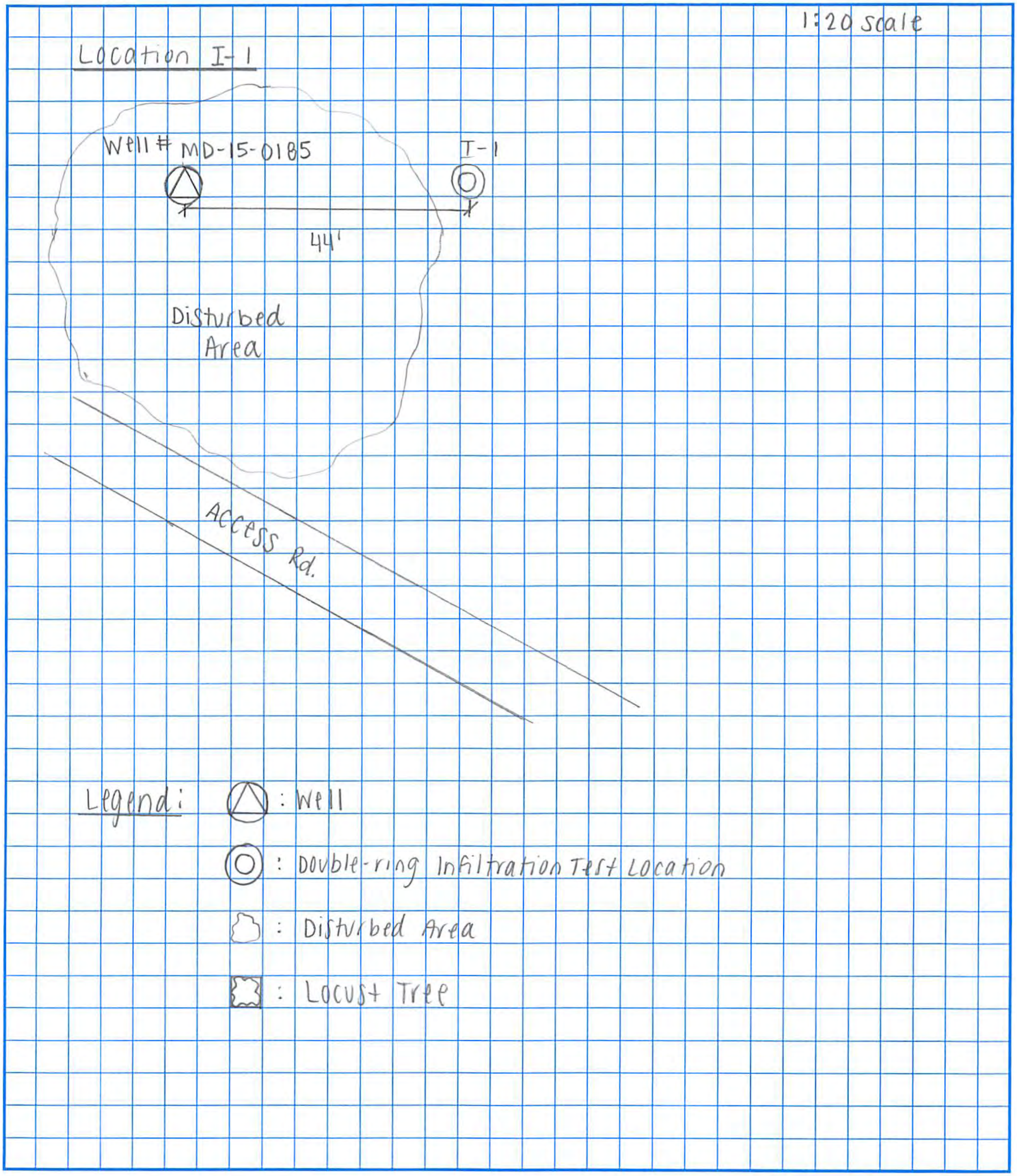
FIGURE A-2
Infiltration Test Location Plan

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.
PL/LJO	TJP	JULY 2015	14982.01
CHECKED BY	PROJECT MGR.	DRAWING NO.	FIGURE
PC	JK	–	A-2

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

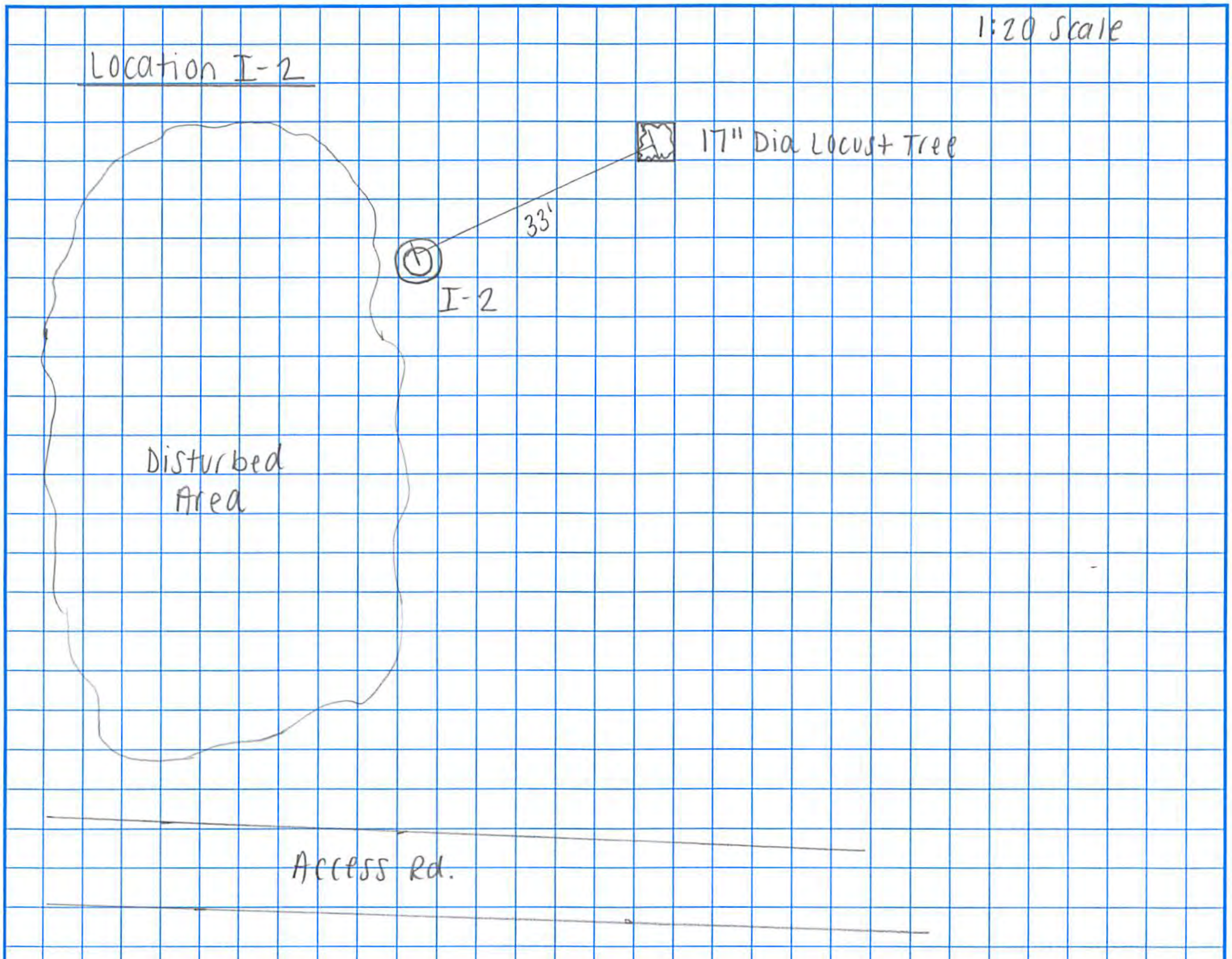
Soil and Land Use Technology Inc. (SaLUT)
Geotechnical Engineers
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

Job: bude 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



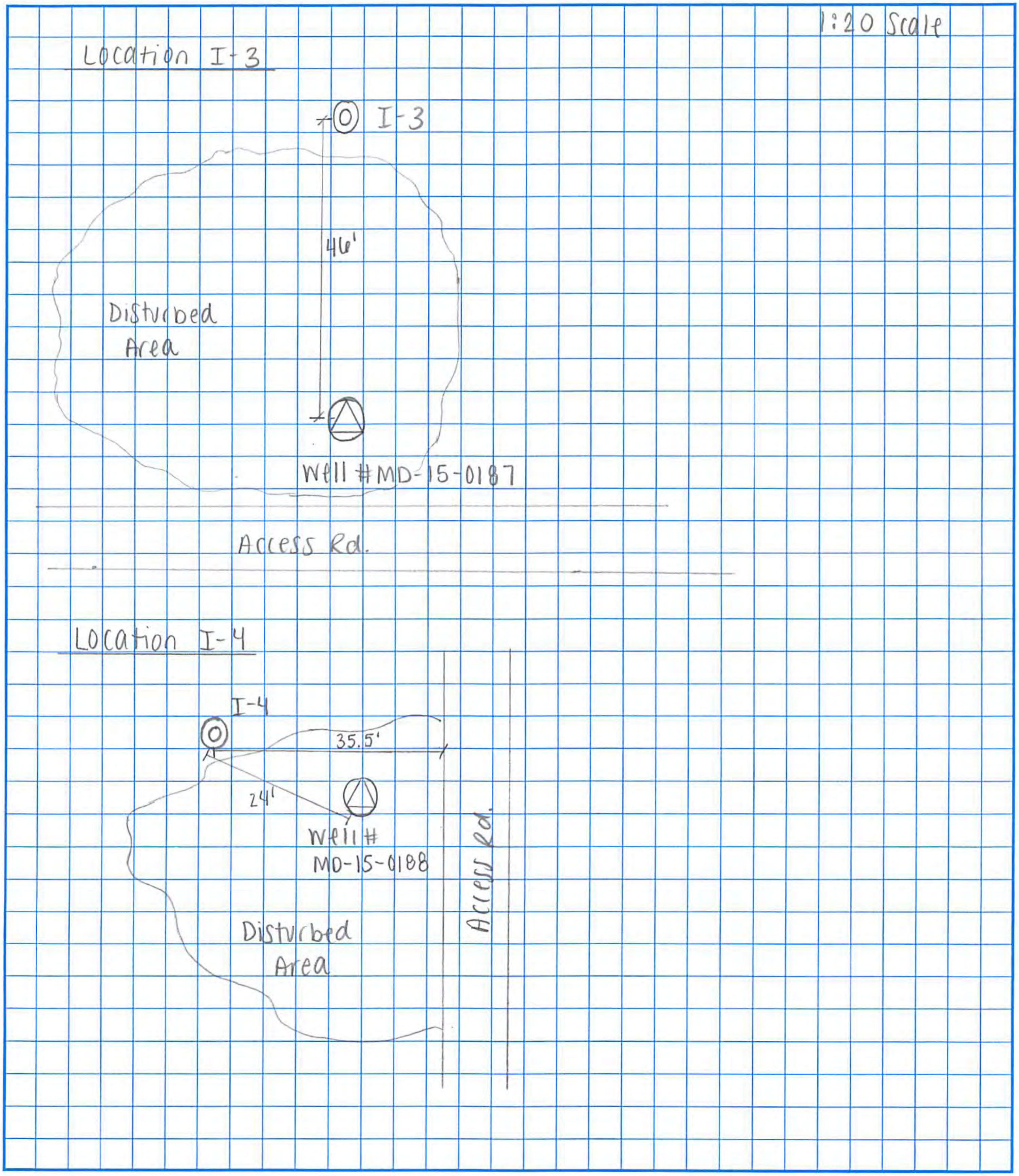
Soil and Land Use Technology Inc. (SaLUT)
Geotechnical Engineers
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

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



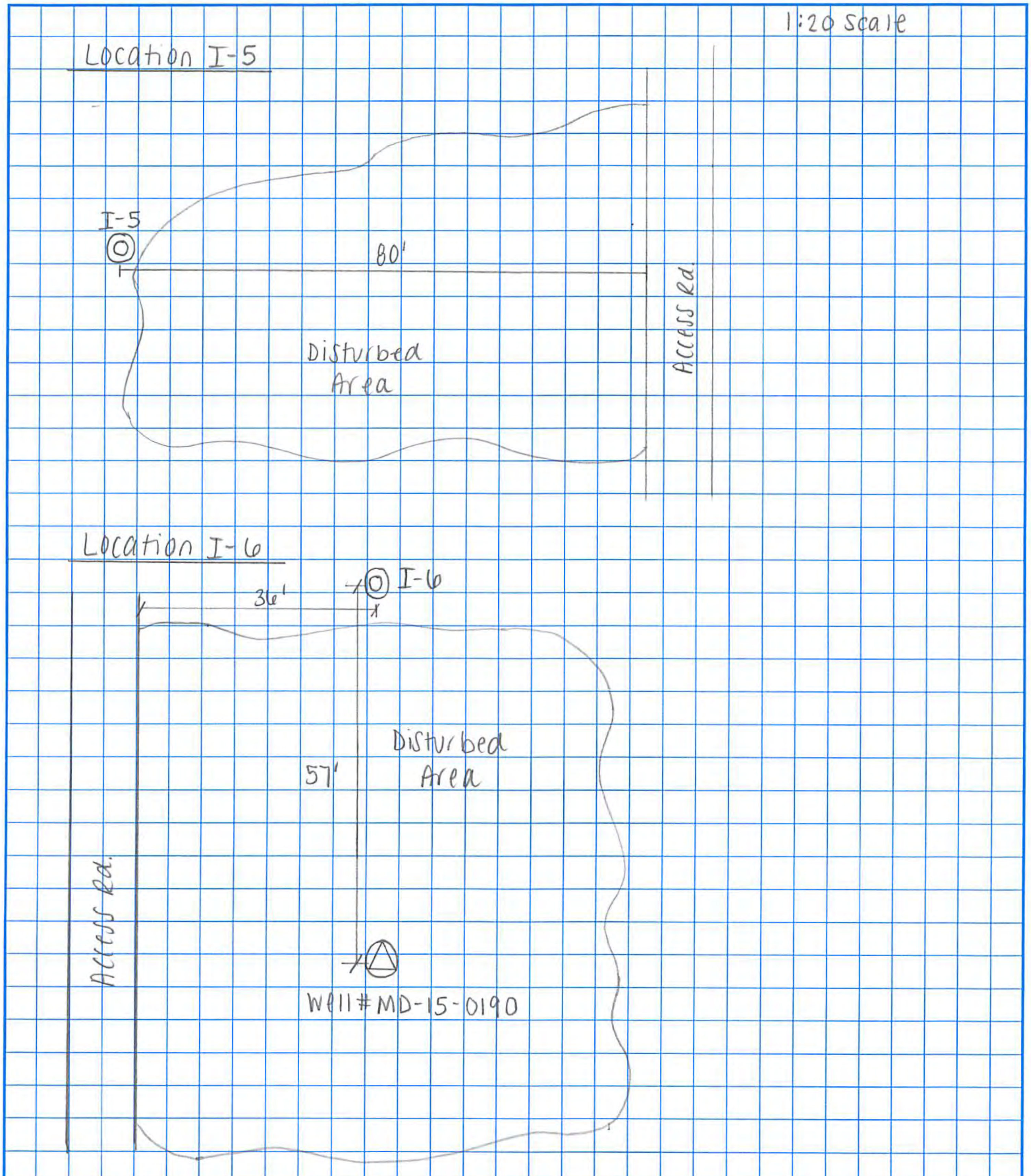
Soil and Land Use Technology Inc. (SaLUT)
Geotechnical Engineers
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

Job: Gude Landfill Double-Ring Infiltrometer
Job No: 15-00047 Sheet No. 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

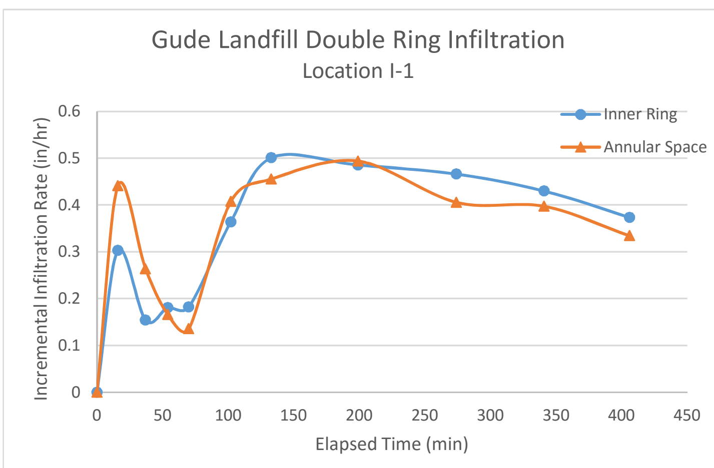
Depth of Water = 8 in
Embedment Depth of Rings = 4 in

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

Ring No. : 3

Location: I-1

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Inner Ring, ΔV_{IR} (in^3)	Annular Space, ΔV_A (mL)	Annular Space, ΔV_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)
ΔV_{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)
ΔV_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

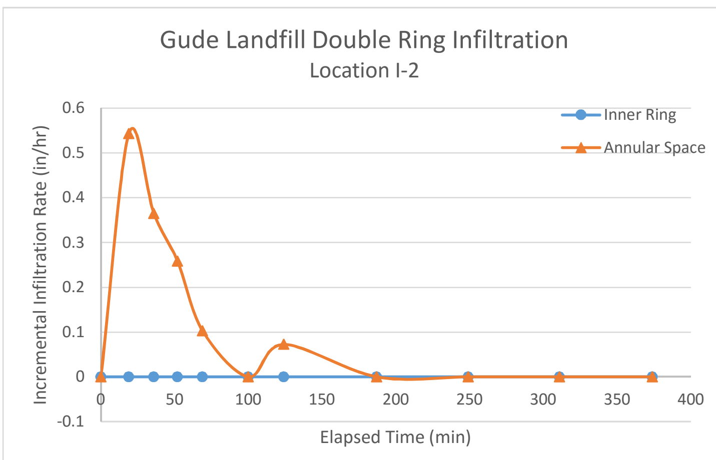
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

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

						Flow/ Water Added						
Reading No.	Date	Time	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Inner Ring, ΔV_{IR} (mL)	Inner Ring, ΔV_{IR} (in^3)	Annular Space, ΔV_A (mL)	Annular Space, ΔV_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)
ΔV_{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)
ΔV_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

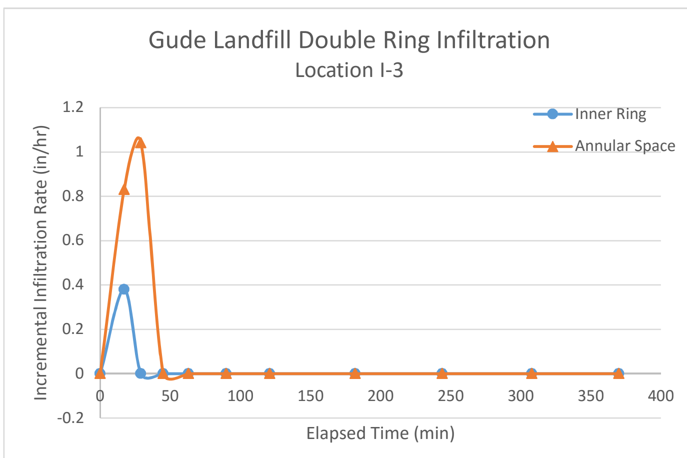
Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Wade
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

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

Ring No. : 2　　Location: I-3　　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, ΔV_{IR} (mL)	Inner Ring, ΔV_{IR} (in^3)	Annular Space, ΔV_A (mL)	Annular Space, ΔV_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)
ΔV_{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)
ΔV_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

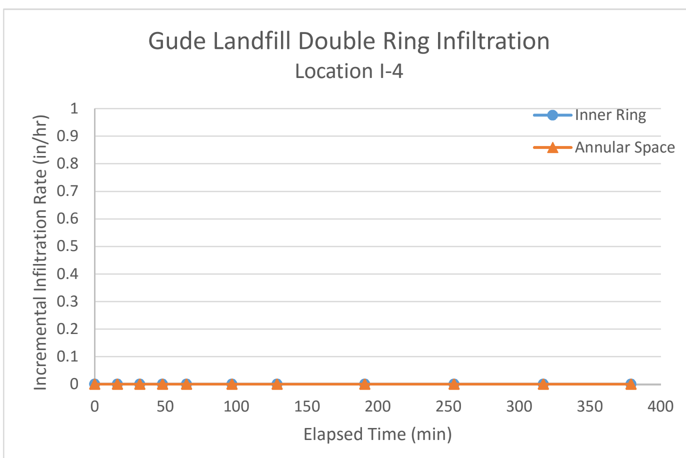
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

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

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Inner Ring, ΔV_{IR} (in^3)	Annular Space, ΔV_A (mL)	Annular Space, ΔV_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)
ΔV_{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)
ΔV_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

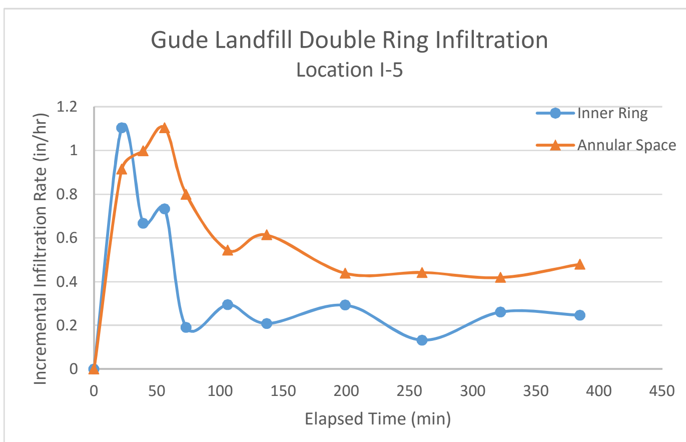
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

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

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Inner Ring, ΔV_{IR} (in^3)	Annular Space, ΔV_A (mL)	Annular Space, ΔV_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)
ΔV_{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)
ΔV_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

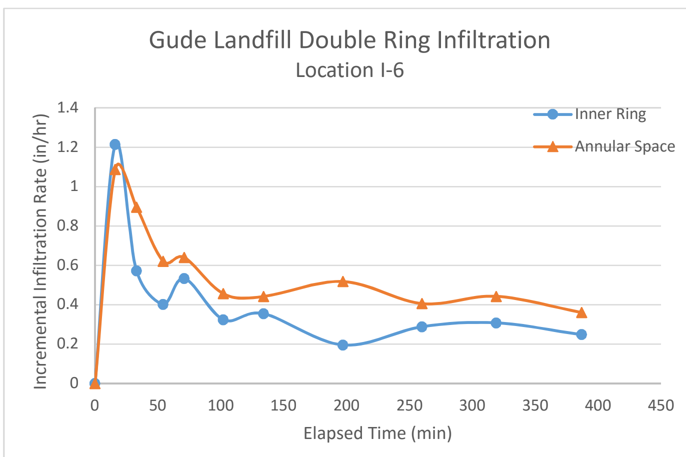
Depth of Water = 8 in
Embedment Depth of Rings = 5 in

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

Ring No. : 1

Location: I-6

						Flow/ Water Added						
Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Inner Ring, ΔV_{IR} (mL)	Inner Ring, ΔV_{IR} (in^3)	Annular Space, ΔV_A (mL)	Annular Space, ΔV_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)
ΔV_{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)
ΔV_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

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:

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.

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              **
**                                                                          **
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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:\GUDESSLP.D10
OUTPUT DATA FILE:            T:\GUDESSLO.OUT


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


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     TITLE:  GUDE SIDE SLOPES

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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   =      0.2138 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

****

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
                                   --------
```

```
                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-
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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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


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


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

     TITLE:  GUDE AVERAGE TOP WITH CAP

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


     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

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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	0.231	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

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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
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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Maryland spectral Services

Analytical Chemistry Services

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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

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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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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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

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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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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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

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

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 CaCO3	**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

Analytical Results

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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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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) (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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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

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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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

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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

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

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

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:

MSS-F001-003

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
	3/6/19		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 pipeline diameter will be calculated using the Darcy-Weisbach Equation of Pressure Loss to ensure that there is adequate flow pressure to convey the gas along each length of pipe in the network. An 8-in. pipe is to be considered for use for the LFG header and a 6-in. pipe is to be used for the LFG laterals.

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 the inner diameter of a trial pipe size and estimated gas flow.

$$v = \frac{Q}{(\frac{\pi d^2}{4})}$$

Waste placement 1964 through 1982 based on historical tonnage report provided to EA.

where:
- Q = Flowrate of gas (cubic feet per minute [ft^3/min]) = 507 ft^3/min total or 5.28 ft^3/min-well for 96 LFG wells.
- d = Inner diameter of pipe (feet [ft])
- v = Mean flow velocity (feet per second [ft/s]).

B. Reynolds Number—Calculate the Reynolds number to estimate friction factor for use in the Darcy-Weisbach Equation. Assume absolute viscosity is $8.0x10^{-6}$ 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) = $8.0x10^{-6}$ 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 $7x10^{-5}$ 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) = $7x10^{-5}$ 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. Using an 8-in. pipe for the LFG header and 6-in. for the laterals, the change in pressure through each pipe is calculated using the following equations:

$$\Delta P = \frac{\rho * f * L * v^2}{144 * d * 2g} * 27.7$$

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: The computed analysis using Excel is presented in the attached table.

CONCLUSION:

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)
- β = 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).

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

Solution: Total gas production from the landfill is estimated at 507 cfm (waste placement 1964 through 1982 based on historical tonnage report provided to EA); 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 96 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. The small pipe sizes are more likely to be affected by landfill settlement; 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 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	5.28	5.28	6	5.80	0.18	0.479736	1743.31	0.00007	0.0001448	0.07064	0.00125
LEB.EC	EB	464.81	EC	466.60	120	-0.015	144	0.061	20.000	0.000008	0	0.00	5.28	8	7.45	0.30	0.290767	1357.21	0.00007	0.0001128	0.07064	0.00025
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	11.18	8	7.45	0.30	0.615345	2872.24	0.00007	0.0001128	0.05624	0.00058
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	17.07	8	7.45	0.30	0.939922	4387.27	0.00007	0.0001128	0.04956	0.00091
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	22.97	8	7.45	0.30	1.2645	5902.29	0.00007	0.0001128	0.04541	0.00055
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	28.86	8	7.45	0.30	1.589077	7417.32	0.00007	0.0001128	0.04248	0.00769
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	34.76	8	7.45	0.30	1.913654	8932.35	0.00007	0.0001128	0.04026	0.00042
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	40.65	8	7.45	0.30	2.238232	10447.37	0.00007	0.0001128	0.03849	0.00225
LEH1.EH2	EH1	471.48	EH2	468.57	127	0.023	152	0.061	20.000	0.000008	0	0.00	40.65	8	7.45	0.30	2.238232	10447.37	0.00007	0.0001128	0.03849	0.00866
LEH2.EI	EH2	468.57	EI	468.91	49	-0.007	59	0.061	20.000	0.000008	0	0.00	40.65	8	7.45	0.30	2.238232	10447.37	0.00007	0.0001128	0.03849	0.00334
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	46.55	8	7.45	0.30	2.562809	11962.40	0.00007	0.0001128	0.03704	0.00086
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	52.44	8	7.45	0.30	2.887387	13477.43	0.00007	0.0001128	0.03581	0.00369
LEJ1.EJ2	EJ1	469.9	EJ2	473.30	76	-0.045	91	0.061	20.000	0.000008	0	0.00	52.44	8	7.45	0.30	2.887387	13477.43	0.00007	0.0001128	0.03581	0.00802
LEJ2.EJ3	EJ2	473.3	EJ3	472.82	28	0.017	34	0.061	20.000	0.000008	0	0.00	52.44	8	7.45	0.30	2.887387	13477.43	0.00007	0.0001128	0.03581	0.00295
LEJ3.EJ4	EJ3	472.82	EJ4	473.82	10	-0.100	12	0.061	20.000	0.000008	0	0.00	52.44	8	7.45	0.30	2.887387	13477.43	0.00007	0.0001128	0.03581	0.00106
LEJ4.EJ5	EJ4	473.82	EJ5	472.35	35	0.042	42	0.061	20.000	0.000008	0	0.00	52.44	8	7.45	0.30	2.887387	13477.43	0.00007	0.0001128	0.03581	0.00370
LEJ5.EK	EJ5	472.35	EK	474.69	41	-0.057	49	0.061	20.000	0.000008	0	0.00	52.44	8	7.45	0.30	2.887387	13477.43	0.00007	0.0001128	0.03581	0.00433
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	58.34	8	7.45	0.30	3.211964	14992.45	0.00007	0.0001128	0.03475	0.01495
L11	EW-189	475.09	EK1	475.00	100	0.001	120	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	0.00089
LEK1.EK2	EK1	472.35	EK2	476.00	175	-0.021	210	0.061	20.000	0.000008	0	0.00	58.34	8	7.45	0.30	3.211964	14992.45	0.00007	0.0001128	0.03475	0.02217
LEK2.EK3	EK2	474.69	EL	476.45	100	-0.018	120	0.061	20.000	0.000008	0	0.00	58.34	8	7.45	0.30	3.211964	14992.45	0.00007	0.0001128	0.03475	0.01267
L12	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	64.23	8	7.45	0.30	3.536542	16507.48	0.00007	0.0001128	0.03383	0.01334
LEL1.EL2	EL1	474.17	EL2	471.78	57	0.042	68	0.061	20.000	0.000008	0	0.00	64.23	8	7.45	0.30	3.536542	16507.48	0.00007	0.0001128	0.03383	0.00853
LEL2.EL3	EL2	471.78	EL3	469.68	76	0.028	91	0.061	20.000	0.000008	0	0.00	64.23	8	7.45	0.30	3.536542	16507.48	0.00007	0.0001128	0.03383	0.01137
LEL3.EM	EL3	469.68	EM	472.26	79	-0.033	95	0.061	20.000	0.000008	0	0.00	64.23	8	7.45	0.30	3.536542	16507.48	0.00007	0.0001128	0.03383	0.01182
L13	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	70.13	8	7.45	0.30	3.861119	18022.51	0.00007	0.0001128	0.03301	0.00905
LEM1.EM2	EM1	469.93	EM2	470.97	20	-0.052	24	0.061	20.000	0.000008	0	0.00	70.13	8	7.45	0.30	3.861119	18022.51	0.00007	0.0001128	0.03301	0.00348
L14	EW-187	466.96	EM2	470.97	100	-0.040	120	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	0.00089
LEM2.EM3	EM2	470.97	EM3	467.69	246	0.013	295	0.061	20.000	0.000008	0	0.00	70.13	8	7.45	0.30	3.861119	18022.51	0.00007	0.0001128	0.03301	0.04278
LEM3.EN	EM3	467.69	EN	462.00	52	0.109	63	0.061	20.000	0.000008	0	0.00	70.13	8	7.45	0.30	3.861119	18022.51	0.00007	0.0001128	0.03301	0.00910
L15	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	76.03	8	7.45	0.30	4.185696	19537.54	0.00007	0.0001128	0.03228	0.01679
LEN1.EO	EN1	463.46	EO	461.56	263	0.007	316	0.061	20.000	0.000008	0	0.00	76.03	8	7.45	0.30	4.185696	19537.54	0.00007	0.0001128	0.03228	0.05255
L16	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	81.92	8	7.45	0.30	4.510274	21052.56	0.00007	0.0001128	0.03162	0.02727
LEO1.EP	EO1	461.00	EP	460.19	57	0.014	68	0.061	20.000	0.000008	0	0.00	87.82	8	7.45	0.30	4.834851	22567.59	0.00007	0.0001128	0.03102	0.01461
L17	EW-178	434.63	EP	460.19	100	-0.256	124	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	0.00092
LEP.EP1	EP	460.19	EP1	458.78	60	0.024	72	0.061	20.000	0.000008	0	0.00	87.82	8	7.45	0.30	4.834851	22567.59	0.00007	0.0001128	0.03102	0.01538
LEP1.EP2	EP1	458.78	EP2	458.75	43	0.001	52	0.061	20.000	0.000008	0	0.00	87.82	8	7.45	0.30	4.834851	22567.59	0.00007	0.0001128	0.03102	0.01102
LEP2.EP3	EP2	458.75	EP3	456.12	48	0.055	58	0.061	20.000	0.000008	0	0.00	87.82	8	7.45	0.30	4.834851	22567.59	0.00007	0.0001128	0.03102	0.01232
LEP3.EQ	EP3	456.12	EQ	455.56	51	0.011	61	0.061	20.000	0.000008	0	0.00	87.82	8	7.45	0.30	4.834851	22567.59	0.00007	0.0001128	0.03102	0.01307
L17	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	93.71	8	7.45	0.30	5.159429	24082.62	0.00007	0.0001128	0.03048	0.03612
L19	EW-183	463.58	EQ1	457.30	100	0.063	120	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	0.00089
LEQ2.EQ3	EQ1	457.30	EQ2	457.30	126	0.000	151	0.061	20.000	0.000008	0	0.00	93.71	8	7.45	0.30	5.159429	24082.62	0.00007	0.0001128	0.03048	0.03612
LEQ3.ER	EQ2	457.30	ER	457.25	104	0.000	125	0.061	20.000	0.000008	0	0.00	93.71	8	7.45	0.30	5.159429	24082.62	0.00007	0.0001128	0.03048	0.02981

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)
L20	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	99.61	8	7.45	0.30	5.484006	25597.64	0.00007	0.0001128	0.02997	0.01256
LER1.ER2	ER1	452.98	ER2	452.18	7	0.119	8	0.061	20.000	0.000008	0	0.00	99.61	8	7.45	0.30	5.484006	25597.64	0.00007	0.0001128	0.02997	0.00216
LER2.ES	ER2	452.18	ES	453.75	66	-0.024	79	0.061	20.000	0.000008	0	0.00	99.61	8	7.45	0.30	5.484006	25597.64	0.00007	0.0001128	0.02997	0.02100
L21	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	105.50	8	7.45	0.30	5.808584	27112.67	0.00007	0.0001128	0.02951	0.01127
LES1.ES2	ES1	453.75	ES2	450.79	36	0.082	43	0.061	20.000	0.000008	0	0.00	105.50	8	7.45	0.30	5.808584	27112.67	0.00007	0.0001128	0.02951	0.01271
LES2.ES3	ES2	453.75	ES3	445.00	100	0.088	120	0.061	20.000	0.000008	0	0.00	105.50	8	7.45	0.30	5.808584	27112.67	0.00007	0.0001128	0.02951	0.03531
LES3.ET	ES3	451.95	ET	443.81	102	0.080	123	0.061	20.000	0.000008	0	0.00	105.50	8	7.45	0.30	5.808584	27112.67	0.00007	0.0001128	0.02951	0.03600
L22	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	111.40	8	7.45	0.30	6.133161	28627.70	0.00007	0.0001128	0.02908	0.02203
L23	EW-184	463.58	ET1	443.65	100	0.199	122	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	0.00091
LET1.ET2	ET1	443.65	ET2	439.92	52	0.072	63	0.061	20.000	0.000008	0	0.00	111.40	8	7.45	0.30	6.133161	28627.70	0.00007	0.0001128	0.02908	0.02015
LET2.EU	ET2	439.92	EU	439.50	85	0.005	102	0.061	20.000	0.000008	0	0.00	111.40	8	7.45	0.30	6.133161	28627.70	0.00007	0.0001128	0.02908	0.03285
L24	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	117.29	8	7.45	0.30	6.457739	30142.72	0.00007	0.0001128	0.02867	0.01660
LEU1.EU2	EU1	439.20	EU2	419.31	155	0.128	188	0.061	20.000	0.000008	0	0.00	117.29	8	7.45	0.30	6.457739	30142.72	0.00007	0.0001128	0.02867	0.06603
LEU2.EU3	EU2	434.68	EU3	430.20	119	0.038	143	0.061	20.000	0.000008	0	0.00	117.29	8	7.45	0.30	6.457739	30142.72	0.00007	0.0001128	0.02867	0.05032
LEU3.EV	EU3	430.20	EV	429.30	119	0.008	143	0.061	20.000	0.000008	0	0.00	117.29	8	7.45	0.30	6.457739	30142.72	0.00007	0.0001128	0.02867	0.05028
L25	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	123.19	8	7.45	0.30	6.782316	31657.75	0.00007	0.0001128	0.02830	0.03772
L26	EW-182	463.58	EV1	429.00	100	0.346	127	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	0.00094
LEV1.EV2	EV1	429.00	EV2	433.56	73	-0.062	88	0.061	20.000	0.000008	0	0.00	123.19	8	7.45	0.30	6.782316	31657.75	0.00007	0.0001128	0.02830	0.03364
LEV2.EV3	EV2	433.56	EV3	434.58	18	-0.057	22	0.061	20.000	0.000008	0	0.00	123.19	8	7.45	0.30	6.782316	31657.75	0.00007	0.0001128	0.02830	0.00829
LEV3.EW	EV3	434.58	EW	435.53	17	-0.056	20	0.061	20.000	0.000008	0	0.00	123.19	8	7.45	0.30	6.782316	31657.75	0.00007	0.0001128	0.02830	0.00783
L27	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	129.08	8	7.45	0.30	7.106893	33172.78	0.00007	0.0001128	0.02795	0.06491
L28	EW-162	445.00	EWL2	448.13	33	-0.095	40	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	0.00029
LEWL2.EW	EWL2	448.13	EW	435.00	130	0.101	156	0.061	20.000	0.000008	0	0.00	134.98	8	7.45	0.30	7.431471	34687.81	0.00007	0.0001128	0.02762	0.07014
LEW.EW1	EW	435.00	EW1	435.50	54	-0.009	65	0.061	20.000	0.000008	0	0.00	134.98	8	7.45	0.30	7.431471	34687.81	0.00007	0.0001128	0.02762	0.02910
LEW1.EW2	EW1	435.50	EW2	437.00	50	-0.030	60	0.061	20.000	0.000008	0	0.00	134.98	8	7.45	0.30	7.431471	34687.81	0.00007	0.0001128	0.02762	0.02696
LEW1.EX	EW2	437.00	EX	437.50	45	-0.011	54	0.061	20.000	0.000008	0	0.00	134.98	8	7.45	0.30	7.431471	34687.81	0.00007	0.0001128	0.02762	0.02425
L29	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	140.87	8	7.45	0.30	7.756048	36202.83	0.00007	0.0001128	0.02730	0.01509
L30	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	146.77	8	7.45	0.30	8.080626	37717.86	0.00007	0.0001128	0.02701	0.01869
L31	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	152.66	8	7.45	0.30	8.405203	39232.89	0.00007	0.0001128	0.02673	0.05071
L32	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	158.56	8	7.45	0.30	8.729781	40747.91	0.00007	0.0001128	0.02646	0.02779
LEZA1.EZA2	EZA1	438.50	EZA2	438.50	31	0.000	37	0.061	20.000	0.000008	0	0.00	158.56	8	7.45	0.30	8.729781	40747.91	0.00007	0.0001128	0.02646	0.02209
LEZA2.EZB	EZA2	438.50	EZB	440.63	16	-0.133	19	0.061	20.000	0.000008	0	0.00	158.56	8	7.45	0.30	8.729781	40747.91	0.00007	0.0001128	0.02646	0.01150
L33	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
L34	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
L35	EW-179	464.23	EZB	438.50	195	0.132	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
LEZB.EZC	EZB	440.63	EZC	440.93	30	-0.010	36	0.061	20.000	0.000008	0	0.00	164.46	8	7.45	0.30	9.054358	42262.94	0.00007	0.0001128	0.02621	0.02277
L36	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	170.35	8	7.45	0.30	9.378935	43777.97	0.00007	0.0001128	0.02596	0.05338
LEZC1.EZC2	EZC1	445.31	EZC2	443.30	10	0.201	12	0.061	20.000	0.000008	0	0.00	170.35	8	7.45	0.30	9.378935	43777.97	0.00007	0.0001128	0.02596	0.00823
LEZC2.EZC3	EZC2	443.30	MH	448.00	450	-0.010	540	0.061	20.000	0.000008	0	0.00	170.35	8	7.45	0.30	9.378935	43777.97	0.00007	0.0001128	0.02596	0.36317
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
L37	EW-180	469.39	EA	465.50	100	0.039	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
LEA.MH1	EA	465.50	MH1	468.00	120	-0.021	144	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	0.00099
MH1.MH2	MH1	468.00	MH2	466.00	130	0.015	156	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	0.00107
L38	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	17.69	8	7.45	0.30	0.973732	4545.08	0.00007	0.0001128	0.04904	0.00269
L39	EW-181	467.04	MH3	466.00	100	0.010	120	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	0.00089
L40	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	23.58	8	7.45	0.30	1.29831	6060.11	0.00007	0.0001128	0.04506	0.00395
LMH4.MH5	MH4	459.35	MH5	461.45	39	-0.054	47	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	0.00104

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)
L41	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	29.48	8	7.45	0.30	1.622887	7575.13	0.00007	0.0001128	0.04222	0.00424
L42	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	35.37	8	7.45	0.30	1.947465	9090.16	0.00007	0.0001128	0.04006	0.01771
L43	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
L44	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	47.16	8	7.45	0.30	2.596619	12120.22	0.00007	0.0001128	0.03690	0.02013
L45	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
L46	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	58.95	8	7.45	0.30	3.245774	15150.27	0.00007	0.0001128	0.03465	0.02438
LMH10.MH11	MH10	464.11	MH11	467.00	151	-0.019	181	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	0.01950
L47	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	64.85	8	7.45	0.30	3.570352	16665.30	0.00007	0.0001128	0.03374	0.02827
L48	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	MH10	464.11	MH6	460.69	87	0.039	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	0.01323
LMH6.MH13	MH6	460.69	MH13	459.99	210	0.003	252	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	0.08954
L49	EW-2	471.47	MH14	467.00	85	0.053	102	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	0.00076
L42	EW-51	467.74	MH14	467.00	15	0.049	18	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	0.00013
LMH14.MH15	MH14	467.00	MH15	463.26	241	0.016	289	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	0.03663
L50	EW-26	463.80	MH15	463.26	15	0.036	18	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	0.00013
LMH15.MH16	MH15	463.26	MH16	461.76	200	0.008	240	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	0.03530
L51	EW-54	462.82	MH16	461.76	20	0.053	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
LMH16.MH17	MH16	461.76	MH17	459.87	155	0.012	186	0.061	20.000	0.000008	0	0.00	182.76	8	7.45	0.30	10.0619	46965.84	0.00007	0.0001128	0.02549	0.14135
LMH17.MH13	MH17	459.87	MH13	459.99	145	-0.001	174	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	0.06727
LMH13.MH18	MH13	459.99	MH18	454.85	95	0.054	114	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	0.01679
L52	EW-75	455.25	MH18	454.85	68	0.006	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
L53	EW-188	464.23	MH19	454.85	100	0.094	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
LMH18.MH19	MH18	454.85	MH19	460.17	118	-0.045	142	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	0.00097
L54	EW-27	460.61	MH19	453.08	314	0.024	377	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	0.00279
LMH12.MH6	MH12	462.78	MH6	460.69	87	0.024	104	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	0.01536
L55	EW-76	460.96	MH19	453.08	20	0.394	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	0.00019
LMH19.MH20	MH19	453.08	MH20	460.17	60	-0.118	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	0.01224
L56	EW-186	464.23	MH20	453.08	100	0.112	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
L57	EW-29	468.25	MH21	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
LMH19.MH20	MH19	464.49	MH20	460.17	60	0.072	72	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	0.00050
L58	EW-30	463.00	MH21	464.49	61	-0.024	73	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	0.00054
LMH21.MH20	MH21	464.49	MH20	460.17	128	0.034	154	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	0.03321
L59	EW-185	464.23	MH20	460.17	100	0.041	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
LMH20.MH22	MH17	460.17	MH19	455.30	172	0.028	206	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	0.04462
LMH22.MH23	MH22	455.3	MH23	448.19	172	0.041	207	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	0.04464
L60	EW-25	450.74	MH23	448.19	20	0.128	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
LMH23.MH	MH23	448.19	MH	447.06	90	0.013	108	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	0.02609
NORTHWEST OF MIDDLE HEADER TO BLOWER-FLARE FACILIY																						
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	463.56	118	0.011	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.WA	EA	463.56	WA	463.49	111	0.001	133	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	0.00028
L61	EW-110	425.18	WA1	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
L62	EW-130	452.40	WA1	450.74	31	0.054	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
LWA1.WA	WA1	450.74	WA	463.49	65	-0.196	79	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	0.00109
LWA.WB	WA	459.54	WB	459.54	20	0.000	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
L63	EW-158	465.19	WB	459.54	75	0.075	90	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	0.00067
LWB.WC	WB	459.54	WC	459.33	55	0.004	66	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	0.00148
L64	EW-122	432.33	WC1	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
L65	EW-109	438.88	WC1	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
LWC1.WD	WC1	438.08	WD	459.00	114	-0.184	139	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	0.00621

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)
LWD.WD2	WD	438.08	WD2	456.19	111	-0.163	135	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	0.00603
LWD2.WD3	WD2	459.00	WD3	456.19	111	0.025	133	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	0.00596
LWD3.WE	WD3	456.19	WE	456.11	25	0.003	29	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	0.00132
L66	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	41.27	8	7.45	0.30	2.272042	10605.19	0.00007	0.0001128	0.03833	0.00561
LWE1.WF	WE1	455.79	WF	455.72	18	0.004	22	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	0.00126
L67	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
L68	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	53.06	8	7.45	0.30	2.921197	13635.24	0.00007	0.0001128	0.03569	0.00507
LWF1.WF2	WF1	455.72	WF2	452.51	27	0.118	33	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	0.00296
LWF2.WG	WF2	452.51	WG	452.55	19	-0.002	23	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	0.00208
L69	EW-152	459.74	WG1	452.55	155	0.046	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
LWG1.WG	WG1	452.55	WG	452.55	162	0.000	194	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	0.02086
LWG.WG2	WG	452.55	WG2	453.24	40	-0.017	48	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	0.00516
LWG2.WH	WG2	453.24	WH	457.04	102	-0.037	122	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	0.01310
L70	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	64.85	8	7.45	0.30	3.570352	16665.30	0.00007	0.0001128	0.03374	0.00441
LWH1.WH2	WH1	457.39	WH2	455.65	103	0.017	124	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	0.01570
LWH2.WH3	WH2	455.65	WH3	455.32	16	0.021	19	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	0.00243
L71	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	70.74	8	7.45	0.30	3.894929	18180.32	0.00007	0.0001128	0.03293	0.00706
LWJ.WJ1	WJ	454.4	WJ1	453.16	32	0.038	39	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	0.00572
LWJ1.WJ2	WJ1	453.16	WJ2	450.26	30	0.097	36	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	0.00532
LWJ2.WJ3	WJ2	450.26	WJ3	448.69	47	0.033	56	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	0.00828
LWJ4.WK	WJ4	448.69	WK	449.64	50	-0.019	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	0.00883
L72	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
L73	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	82.53	8	7.45	0.30	4.544084	21141.06	0.00007	0.0001128	0.03158	0.02157
L74	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	88.43	8	7.45	0.30	4.868662	22651.14	0.00007	0.0001128	0.03099	0.01169
L75	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	94.33	8	7.45	0.30	5.193239	24161.21	0.00007	0.0001128	0.03045	0.03644
LWK4.WK	WK4	459.50	WK	451.14	94	0.089	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	0.02729
LWK.WK5	WK	451.14	WK5	450.26	33	0.027	40	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	0.00955
LWK5.WK6	WK5	450.26	WK6	449.54	20	0.036	24	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	0.00579
LWK6.WK7	WK6	450.26	WK7	447.92	40	0.058	48	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	0.01159
LWK5.WK7	WK7	449.54	WL	442.61	66	0.105	80	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	0.01919
L76	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	100.22	8	7.45	0.30	5.517816	25671.29	0.00007	0.0001128	0.02995	0.02168
LWL1.WM	WL1	437.24	WM	436.79	8	0.058	9	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	0.00251
L77	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	106.12	8	7.45	0.30	5.842394	27181.37	0.00007	0.0001128	0.02949	0.04552
LWM1.WN	WM1	429.33	WN	427.28	40	0.051	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	0.01416
L78	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	112.01	8	7.45	0.30	6.166971	28691.44	0.00007	0.0001128	0.02906	0.01028
LWN1.WN2	WN1	426.36	WN2	424.59	43	0.041	51	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	0.01667
LWN2.WN3	WN2	424.59	WN3	418.04	102	0.064	123	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	0.03990
L79	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	117.91	8	7.45	0.30	6.491549	30201.52	0.00007	0.0001128	0.02866	0.01171
LWN4.WN5	WN4	419.28	WN5	419.43	6	-0.027	7	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	0.00238
LWN5.WN6	WN5	419.43	WN6	420.02	22	-0.026	27	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	0.00953
LWN6.WO	WN6	420.02	WO	421.33	8	-0.170	9	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	0.00332
LWO.WO1	WO	421.33	WO1	423.07	7	-0.249	9	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	0.00307
LWO1.WO2	WO1	423.07	WO2	425.95	12	-0.240	15	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	0.00525
LWO2.WO3	WO2	425.95	WO3	432.20	33	-0.187	41	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	0.01445
LWO3.WO4	WO3	432.20	WO4	435.58	17	-0.198	21	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	0.00741

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)
LWO4.WO5	WO4	435.58	WO5	438.95	22	-0.150	27	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	0.00963
LWO5.WO6	WO5	438.95	WO6	440.70	11	-0.159	13	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	0.00474
LWO6.WO7	WO6	440.70	WO7	449.23	47	-0.181	57	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	0.02032
LWO7.WO8	WO7	440.70	WO8	455.12	35	-0.408	46	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	0.01622
LWO8.WO9	WO8	449.23	WO9	454.72	34	-0.161	41	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	0.01465
LWO9.BF	WO9	454.72	BF	456.62	35	-0.055	42	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	0.01482
Southwest of Middle Header to Blower-Flare Facility																						
LMH.SA	MH	448.00	SA	457.02	145	-0.062	174	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	0.00037
L80	EW-32	459.36	SA1	458.63	56	0.013	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
LSA1.SA2	SA1	458.63	SA2	456.6	59	0.035	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.SA	SA2	456.6	SA	457.02	70	-0.006	84	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	0.00018
LSA.SB	SA	457.02	SB	455.45	80	0.020	96	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	0.00020
L81	EW-159	456.10	SB	455.45	15	0.043	18	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	0.00013
LSB.SC	SB	455.45	SC	457.21	480	-0.004	576	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	0.00396
L82	EW-31	455.10	SC	457.21	25	-0.083	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
LSC.SC1	SC	457.21	SC1	466.35	530	-0.017	636	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	0.00871
LSC1.SC2	SC1	466.35	SC2	467.30	60	-0.016	72	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	0.00099
LSC2.SC3	SC2	467.3	SC3	468.24	82	-0.011	98	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	0.00135
LSC3.SD	SC3	468.24	SD	466.85	100	0.014	120	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	0.00164
L83	EW-149	468.57	SD	466.85	10	0.181	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
LSD.SE	SD	466.85	SE	466.91	232	0.000	278	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	0.00623
LSE.SF	SE	466.91	SF	460.91	200	0.030	240	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	0.00537
L84	EW-24	467.80	SF	460.91	24	0.287	30	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	0.00022
LSF.SG	SF	460.91	SG	460.34	15	0.037	18	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	0.00061
L85	EW-146	428.57	SG	460.34	164	-0.194	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
LSG.SG1	SG	460.34	SG1	456.88	130	0.027	156	0.061	20.000	0.000008	0	5.90	35.37	8	7.45	0.30	1.947465	9090.16	0.00007	0.0001128	0.04006	0.00698
LSG1.SH	SG1	456.88	SH	456.42	73	0.006	88	0.061	20.000	0.000008	0	5.90	35.37	8	7.45	0.30	1.947465	9090.16	0.00007	0.0001128	0.04006	0.00392
L86	EW-145	450.58	SH	456.42	50	-0.118	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
LSH.SH1	SH	456.42	SH1	458.65	72	-0.031	86	0.061	20.000	0.000008	0	5.90	41.27	8	7.45	0.30	2.272042	10605.19	0.00007	0.0001128	0.03833	0.00504
LSH1.SI	SH1	458.65	SI	459.31	50	-0.013	60	0.061	20.000	0.000008	0	5.90	41.27	8	7.45	0.30	2.272042	10605.19	0.00007	0.0001128	0.03833	0.00350
L87	EW-23	428.57	SI	459.31	15	-2.049	41	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	0.00030
LSI.SJ	SI	459.31	SJ	460.13	51	-0.016	61	0.061	20.000	0.000008	0	5.90	47.16	8	7.45	0.30	2.596619	12120.22	0.00007	0.0001128	0.03690	0.00448
L88	EW-144	432.37	SJ	460.13	144	-0.193	176	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
LSJ.SJ1	SJ	460.13	SJ1	460.13	51	0.000	61	0.061	20.000	0.000008	0	5.90	53.06	8	7.45	0.30	2.921197	13635.24	0.00007	0.0001128	0.03569	0.00549
LSJ1.SJ2	SJ1	460.13	SJ2	460.13	51	0.000	61	0.061	20.000	0.000008	0	5.90	53.06	8	7.45	0.30	2.921197	13635.24	0.00007	0.0001128	0.03569	0.00549
LSJ2.SK	SJ2	460.13	SK	463.57	25	-0.138	30	0.061	20.000	0.000008	0	5.90	53.06	8	7.45	0.30	2.921197	13635.24	0.00007	0.0001128	0.03569	0.00272
L89	EW-143	464.55	SK	463.57	15	0.065	18	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	0.00013
LSK.SL	SK	463.57	SL	458.60	29	0.171	35	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	0.00379
LSL.SM	SL	458.6	SM	456.98	78	0.021	94	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	0.01006
L90	EW-22	460.19	SM	456.98	50	0.065	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
LSM.SN	SM	456.98	SN	459.19	54	-0.041	65	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	0.00818
L91	EW-140	461.81	SN	457.83	170	0.023	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
LSN.SN1	SN	457.83	SN1	458.63	50	-0.016	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	0.00883
LSN1.SO	SN1	458.63	SO	459.95	30	-0.044	36	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	0.00530
L92	EW-138	459.11	SO	457.89	15	0.081	18	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	0.00013
LSO.SP	SO	457.89	SP	457.89	58	0.000	70	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	0.01175
L93	EW-139	430.49	SP	457.89	167	-0.164	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	0.00150
LSP.SP1	SP	457.89	SP1	455.84	50	0.041	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	0.01152
LSP1.SQ	SP1	455.84	SQ	457.86	10	-0.202	12	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	0.00265
L94	EW-21	430.49	SQ	457.86	22	-1.244	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
LSQ.BF	SQ	457.86	BF	457.10	68	0.011	82	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	0.01971
CONVERGE AT OUTLET																						
LBF.BF1	BF	457.10	BF1	451.25	45	0.129	55	0.061	20.000	0.000008	0	0.00	507.00	12	11.50	0.72	11.71477	84406.76	0.00007	7.304E-05	0.01973	0.02830
LBF1.BF2	BF1	451.25	BF2	434.93	72	0.228	88	0.061	20.000	0.000008	0	0.00	507.00	12	11.50	0.72	11.71477	84406.76	0.00007	7.304E-05	0.01973	0.04557
LBF2.BF3	BF2	434.93	BF3	417.37	134	0.131	162	0.061	20.000	0.000008	0	0.00	507.00	12	11.50	0.72	11.71477	84406.76	0.00007	7.304E-05	0.01973	0.08369
LBF3.BF4	BF3	417.37	Skid	413.25	23	0.181	28	0.061	20.000	0.000008	0	0.00	507.00	12	11.50	0.72	11.71477	84406.76	0.00007	7.304E-05	0.01973	0.01436

Summary of Pressure Loss Through Pipes and Fittings

Path 1	East of Middle Header to Blower-Flare Station	2.12452	in WC
Path 2	Middle Header to Blower-Flare Station	1.05538	in WC
Path 3	West of Middle Header to Blower-Flare Station	0.75028	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	0.07064	40	7.45	262.394	0.065	18	106.12	0.010	3.44E-04
2	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
2	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
3	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
4	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
5	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
6	0.07064	40	7.45	262.394	0.065	18	1910.09	3.088	1.11E-01
7	0.07064	40	7.45	262.394	0.065	21	2228.44	4.204	1.52E-01
8	0.07064	40	5.80	159.037	0.065	3	318.35	0.234	8.43E-03
9	0.07064	40	5.80	159.037	0.065	4	424.47	0.415	1.50E-02
10	0.07064	40	5.80	159.037	0.065	4	424.47	0.415	1.50E-02
11	0.07064	40	5.80	159.037	0.065	3	318.35	0.234	8.43E-03
12	0.07064	40	5.80	159.037	0.065	3	318.35	0.234	8.43E-03
13	0.07064	40	7.45	262.394	0.065	21	2228.44	4.204	1.52E-01
6	0.07064	40	7.45	262.394	0.065	33	3501.84	10.380	3.75E-01
14	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
15	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
16	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
17	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
6	0.07064	40	7.45	262.394	0.065	33	3501.84	10.380	3.75E-01
6	0.07064	40	7.45	262.394	0.065	33	3501.84	10.380	3.75E-01
18	0.07064	40	5.80	159.037	0.065	2	212.23	0.104	3.75E-03
19	0.07064	40	7.45	262.394	0.065	17	1803.98	2.755	9.95E-02
Skid	0.07064	40	11.50	625.226	0.065	96	10187.16	15.473	5.59E-01

Total	2.29E+00	in WC

TOTAL HEAD LOSS THROUGH PIPES, FITTINGS, AND VALVES	**4.41**	
Reserve	**10**	
Total	**14.41**	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)
γ = 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:

γ = 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% allowable ring deflection.

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/in^2 (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:

$$B' = \frac{1}{1+4e^{(-0.065H)}}$$

<u>Solved:</u>

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.**

Project	Gude Landfill Remediation Design	Project No.	1564601
Subject	LFG Extraction Well Spacing	Sheet No.	1 of 2
		Drawing No.	
Computed by SS 07/02/20	Checked by GAT	Date	7/2/2020

Reference:
NSPS Background Information Document (BID). Appendix E. 1991

U.S. EPA. 1991. Air Emissions from Municipal Solid Waste Landfills: Background Information for Proposed Standards and Guidelines, EPA-450/3-90-011a (NTIS PB91-197061), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, March.

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.

$$R\ (\frac{Q_w DC}{\pi L \rho Q_{gen} \eta})^{1/2}$$

Where:
R = Radius of Influence (ft)
Q_w = Well Flow (scfm)
DC = Design Capacity ($5.16x10^6$ lbs; waste placement 1964 through 1982 based on historical tonnage report)
L = Length of Perforations (feet; varies per well)
ρ = Waste Density (assumed 1400 lb/cyd)
Q_{gen} = LFG generation rate (507 scfm; based on observed gas flow November 2017 through April 2018)
η = Extraction Efficiency (75 percent)

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 96 extraction wells, therefore the Q_w is 5.28 scfm per well. DC of the landfill is estimated as $5.16x10^6$ tons or $1.03x10^{10}$ lbs and ρ is 1400 lb/cyd or 51.85 lb/ft^3. A sample calculation is provided for EW-

130. Total well depth for this well is 45 ft and slotted screen length is 30ft. Completing this calculation yields:

$$R = 131.1\,\left(\frac{5.9 * 1.03E10}{\pi * 30 * 51.85 * 507 * 0.75}\right)^{1/2}$$

$$R = 181\,ft$$

Using the above-mentioned parameters, radius of influence has been calculated for each of the existing and proposed LFG extraction wells. Based on the calculation, radius of influence ranged between 142 ft and 561 ft for the existing extraction wells and between 153 ft and 268 ft for the proposed extraction wells. Well spacing ranged from 246 ft to 972 ft for the existing extraction wells and between 265 ft and 464 ft for the proposed extraction wells. The radius of influence was selected as 150 ft as a conservative estimate to ensure maximum LFG collection coverage. Based on the selected radius of influence, the well spacing yields:

$$spacing = 150 * \sqrt{3}$$
$$spacing = 260\,ft$$

CONCLUSION:

Recognizing that there will be $Q_{w\,total}$ =507 scfm over the entire area of the landfill it can be concluded that the calculation for radius of influence and minimum required well placement distance overestimates the spacing. Therefore, the wells are conservatively spaced at approximately 260 ft to balance the landfill gas extraction capacity with the cost of the system.

NOTE:
RADIUS OF INFLUENCE FOR INDIVIDUAL WELL VARIES FROM 142 FT TO 561 FT. HOWEVER, A CONSERVATIVE RADIUS OF INFLUENCE OF 150 FT IS SHOWN FOR ALL EXTRACTION WELLS.

GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY

MONTGOMERY COUNTY, MARYLAND

FIGURE 4: 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: JULY 2020

PROJECT NUMBER: 1564601

FIGURE 4

SHEET: 1 OF 1

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Attachment L

Environmental Assessment Report

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Gude Landfill Remediation Design
Environmental Assessment
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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July 2020
EA Project No. 15646.01

Recycled Paper

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Environmental Assessment
Montgomery County, Maryland

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July 2020
EA Project No. 15646.01

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LIST OF ACRONYMS AND ABBREVIATIONS

ACM	Assessment of Corrective Measures
CMA	Corrective Measure Alternative
COMAR	Code of Maryland Regulations
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
dBA	A-weighted decibels
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
the Landfill	Gude Landfill
MDE	Maryland Department of the Environment
NSP	Noise Suppression Plan
RAOs	Remedial Action Objectives

1. INTRODUCTION

In 2013, the Maryland Department of the Environment (MDE) and Montgomery County negotiated a consent order to address negative environmental impacts associated with Gude Landfill (the Landfill). EA Engineering, Science, and Technology, Inc., PBC (EA) has been contracted to provide services to achieve compliance with the consent order, which outlines Remedial Action Objectives (RAOs) for the Landfill. After investigation of the site and environmental monitoring data, EA developed a remediation design that involves multiple phases of construction at the Landfill. As part of this work, an Environmental Assessment has been prepared to discuss potential beneficial and adverse effects of these construction activities on the surrounding area and communities. In general, the long-term benefits of the remediation project will result in short-term effects to the community during construction of the project.

This report summarizes the findings of the Environmental Assessment, and includes the identification of potentially impacted communities, identification and quantification of construction phase (temporary) and long-term effects (permanent) of the remediation project, and discussion of potential measures to minimize and mitigate potential adverse effects.

1.1 GUDE LANDFILL REMEDIATION

This section provides background on Gude Landfill and the Gude Landfill Remediation project, including necessary construction activities and expected long-term benefits of the remediation design.

1.1.1 Background

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. 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, Recycling and Resource Management Division (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 and was constructed and operated prior to current U.S. Environmental Protection Agency standards for the design, management, and closure of solid waste disposal facilities. Since 1982, Montgomery County has implemented and maintained Best Management Practices for pre-regulatory era landfills to ensure compliance with Code of Maryland Regulations (COMAR) requirements. Montgomery County currently maintains an active landfill gas collection system including flares, gas extraction wells, and conveyance piping. A network of onsite and offsite groundwater monitoring wells, a network of onsite landfill gas monitoring wells, and environmental monitoring programs for groundwater, surface water, landfill gas, and stormwater are also maintained for the Landfill site.

Due to concerns about the impacts of the Landfill on the environment and human health, the Montgomery County Department of Environmental Protection was required by MDE as part of the 2013 consent order to perform an Assessment of Corrective Measures (ACM) to address specific RAOs (MDE and Montgomery County 2013). The consent order for the Landfill establishes the following RAOs:

- No exceedances of maximum contaminant levels, established by the U.S. Environmental Protection Agency as limits for drinking water, in the groundwater at the Landfill property boundary or between the Landfill and adjacent streams;

- No lower explosive limit exceedances for methane gas at the Landfill property boundary; and

- No non-stormwater discharges (e.g., leachate) to the waters of the State.

To meet these RAOs, EA developed an ACM Report (EA 2016) to identify a recommended Corrective Measure Alternative (CMA), or remediation design, for the County. The CMA was designed to meet regulatory compliance requirements at the Landfill, as discussed in the next section.

1.1.2 Remediation Design

As discussed in the previous section, EA developed the ACM Report (EA 2016) to identify a CMA for the County that would meet the provided RAOs. MDE approved the CMA recommended by EA, which includes the following components:

- Construction of a closure cap over the top of the Landfill as well as the west and northwest Landfill side-slopes; and

- Construction of additional landfill gas collection and conveyance.

The Landfill will be capped on its upper surface and portions of the side-slopes, as outlined in **Figure 1**. According to the design for the CMA developed by EA, the closure cap will include layers of geosynthetic liner material, soil to sustain vegetation, and seeded vegetation. Gravel access roads will also be installed on the upper surface of the closure cap. In order to achieve the grading necessary for the closure cap and future site maintenance, waste will be excavated from the northwest slope and placed on the top surface of the Landfill.

The design also details modifications to the existing landfill gas collection system. Based on spacing requirements, the remediation design includes new landfill gas extraction wells to be installed in addition to some of the existing wells which will remain. New underground landfill gas collection and conveyance piping will be installed.

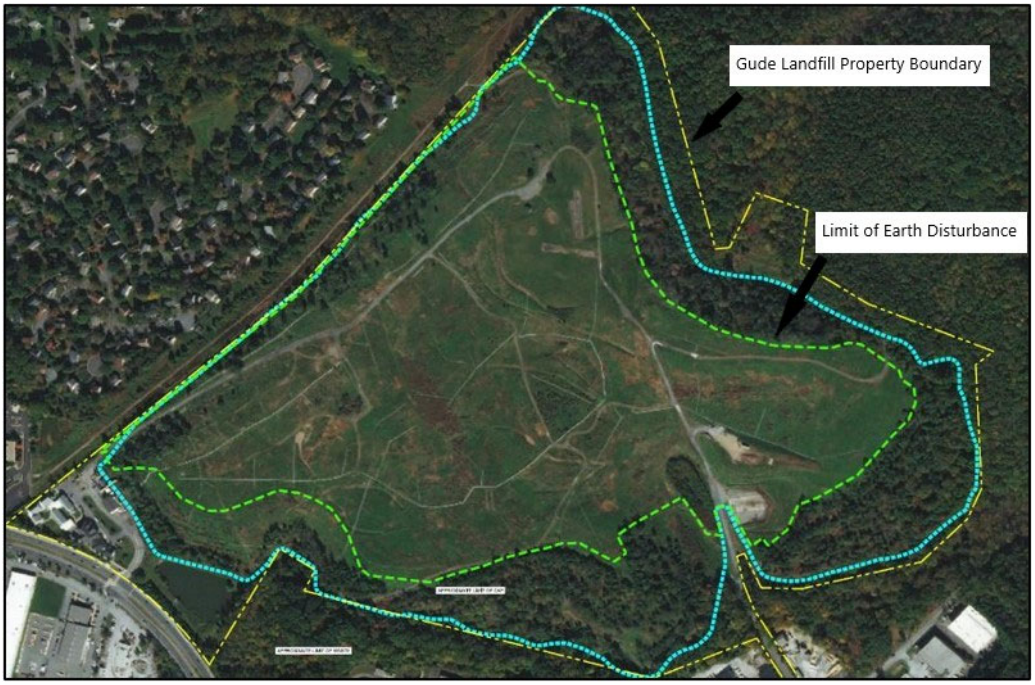

Figure 1 Boundaries of the Landfill and Closure Cap.

1.1.3 Remediation Benefits

The overall objective of the Landfill remediation design is to minimize the impact of the Landfill on the surrounding environment to the greatest extent possible. The design for the CMA was developed by EA to address the RAOs discussed previously, including minimizing maximum contaminant level exceedances in groundwater, non-stormwater discharges (e.g., leachate seeps), and landfill gas migration. Landfill capping will minimize the infiltration of stormwater through the waste and thus reduce the potential for impacts to groundwater and release of non-stormwater discharges. Landfill capping and modifications to the existing landfill gas collection system will minimize the potential for migration of landfill gas off site.

The remediation design will also have benefits for the environment and surrounding community through the development of passive recreational land (parkland) on the upper surface of the capped Landfill. This beneficial land use is expected to include improved site access, new vegetation and wildlife habitat, as well as recreational amenities for the public. In the long-term, this remediation project is intended and expected to benefit the surrounding community.

1.1.4 Construction Activities

This section will discuss construction activities necessary for the closure cap and improvements to the landfill gas collection system. Landfill capping is expected to involve construction activities including:

- Existing vegetation removal;

- Excavation, hauling, and relocation of existing waste from the northwest slope of the Landfill to the top of the Landfill;
- Installation of a geosynthetic closure cap, landfill gas collection system, and cover soil;
- Installation of drainage structures;
- Establishment of a meadow and grassed areas on the closure cap;
- Installation of gravel access roads; and
- Construction of recreational amenities.

The Landfill capping design includes a phased construction approach, with grading limited to 20-acre areas based on the limit imposed by the 2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control. Two series of phases have been developed for closure cap construction. The first series of phases is for subgrade construction, which includes waste excavation and relocation and covering the waste with a compacted layer of soil that serves as a stable base for the closure cap. The second series of phases is for placement of the geosynthetic closure cap, soil cover, and establishing vegetation.

Subgrade construction has been divided into seven phases (S-I through S-VII) as shown on **Figure 2**. The construction of the closure cap itself has been divided into six phases (F-I through F-VI) as shown on **Figure 3**. The phase boundaries shown in these figures are approximate and may change with future design iterations.

Figure 2 Subgrade Construction Phasing

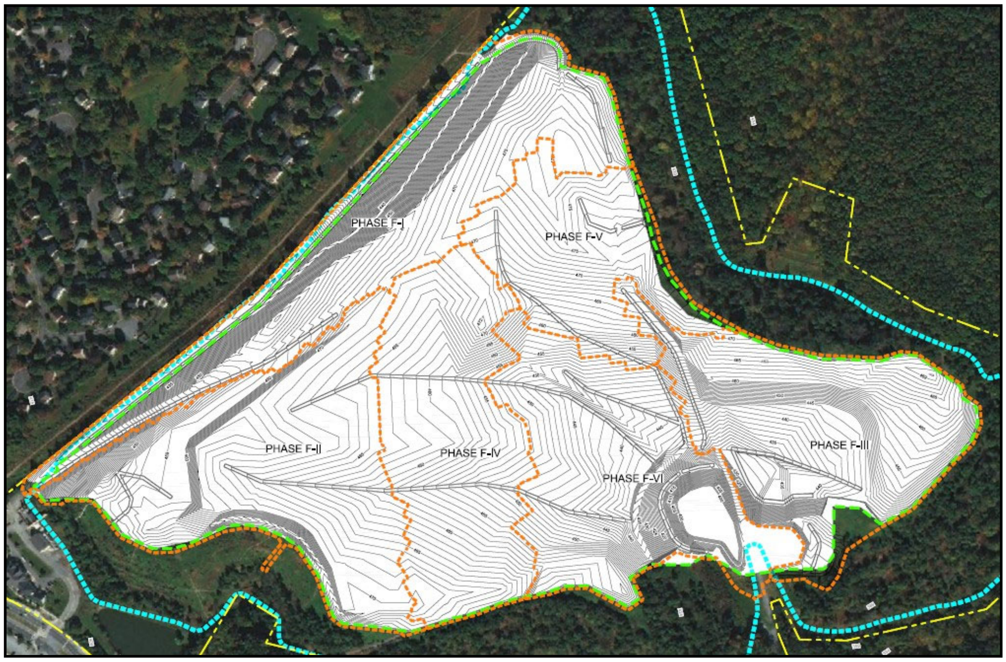

Figure 3 Closure Cap Final Construction Phasing

The landfill gas collection system modifications will also occur in phases so there will be minimal disruption to landfill gas collection during construction.

The construction duration is anticipated to be approximately 4 years. In order to minimize the impact to nearby residential communities, phases of work on the northwest slope will be performed first, and this area will be capped and completed before moving work east.

1.2 SURROUNDING AREA AND COMMUNITY

The surrounding area and properties adjacent to the Landfill have mixed uses including parkland, industrial property, and residential development (**Figure 4**). Communities that may be potentially impacted by remediation activities at the Landfill are expected to include:

- Nearby residential communities including Derwood Station,
- Montgomery County 600 East Gude Drive Campus users,
- Nearby commercial and industrial businesses, and
- Recreational users.

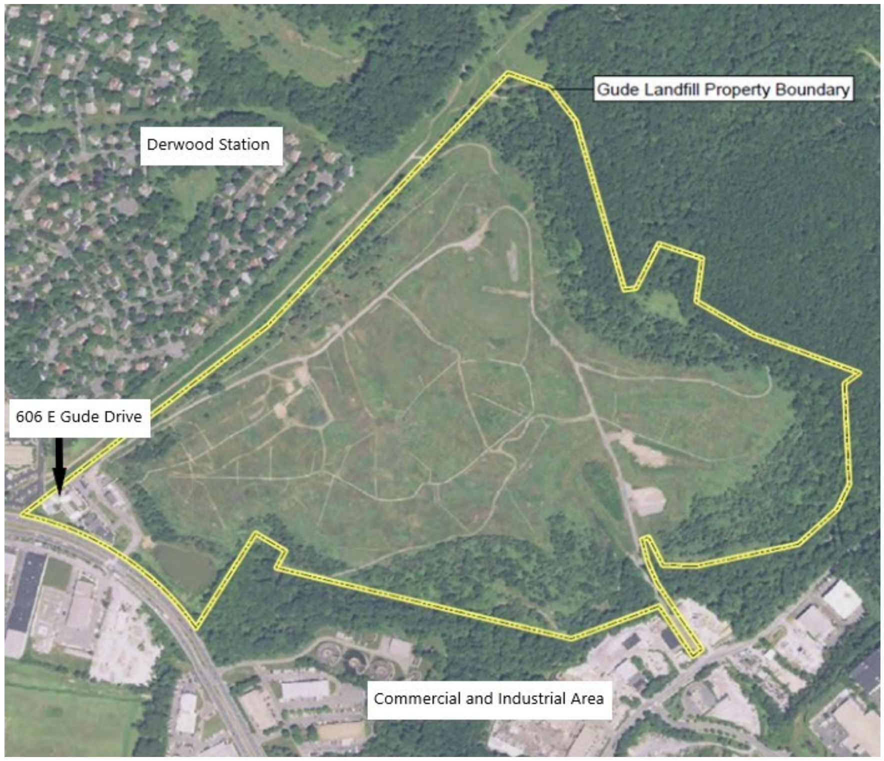

Figure 4 Landfill and Surrounding Area

2. ENVIRONMENTAL EFFECTS

This section describes the construction phase and long-term effects of the remediation project on the surrounding environment and communities. Construction phase effects are temporary and only occur during construction activities. Long-term effects occur post-construction as a result of the completed remediation project. The remediation design meets applicable federal, state, and local regulations to mitigate and minimize construction phase effects. Potential effects and measures to eliminate, minimize, and mitigate these effects are summarized in **Table 1** and are discussed in detail in the following sections.

In general, construction phase nuisances will include changes in traffic, dust, noise, odor, and aesthetics at and around the Landfill site and will only be temporary. However, long-term beneficial effects are expected for groundwater quality, landfill gas migration control, stormwater runoff, site access, habitat and natural resources, recreation, and site aesthetics.

Table 1 Summary of Potential Environmental Effects

Topic	Long-Term Effect*	Environmental Effects	Construction Phase Mitigation Measures
Traffic	0	• Traffic in and out of the site will increase during construction • After construction, traffic levels will return to pre-construction conditions	• Heavy construction traffic will be routed to Southlawn Lane site entrance away from residential areas
Dust	0	• Dust will be generated by construction activities • After construction, dust generation will return to pre-construction levels	• Heavy construction traffic will be routed to Southlawn Lane site entrance away from residential areas • Onsite speed limit will be set • Access roads will be watered • Dump trucks will be covered
Noise	0	• Noise will be generated by construction activities • After construction, noise levels will return to pre-construction levels	• Work will be limited to weekday, daylight hours • Vehicles and equipment will have mufflers • Montgomery County Noise Control Law will be followed • Noise Suppression Plan will be developed
Odor	+	• Odors may be released during waste excavation • Long-term odor levels may be less than pre-construction levels due to closure cap and improved landfill gas collection	• Area of exposed waste will be limited • Odor control measures such as foam over the waste or misting to eliminate odor will be employed if needed
Landfill Gas	+	• Landfill gas capture will be less effective during construction • Modified landfill gas collection system and closure cap will improve control of landfill gas after construction	• Disruption to landfill gas collection will be limited by phasing of work • Landfill gas concentrations will be monitored
Leachate (Non-Stormwater Discharges)	+	• Leachate generation and migration may change during construction activities • Completed closure cap and new vegetation will decrease generation and migration of leachate after construction	• Area of exposed waste will be limited • Any leachate encountered will be controlled • Vegetation removal will be limited at any one time • Exposed waste will be covered at the end of each workday
Hazardous Waste	+	• Hazardous waste could potentially be encountered during waste excavation • Any hazardous waste excavated and removed will reduce the Landfill's impact on the environment	• Any hazardous waste will be handled and disposed of according to state and federal regulations

Topic	Long-Term Effect*	Environmental Effects	Construction Phase Mitigation Measures
Stormwater Runoff	+	• More stormwater runoff with sediment may occur during construction • Completed closure cap, new vegetation, and new stormwater management systems will improve stormwater runoff conditions after construction	• Area of exposed waste will be limited • Vegetation removal will be limited at any one time • Sediment controls that meet MDE and County requirements will limit sediment in the runoff
Fuel Storage	0	• Fuel may be stored at the site during construction • Any fuel storage facility will be removed at the end of construction	• Fuel will be stored according to local, state, and federal regulations • Spill Prevention, Control, and Countermeasure Plan will be developed
Site Access, Safety, and Security	+	• Site access will be restricted during construction for safety reasons • After construction, site access will be improved by new public entrances and walking paths	• Site-specific Health and Safety Plan will be developed to protect construction workers • Construction fencing and clear signage will be implemented to limit access to the site • Closed-circuit television surveillance system will be installed and monitored by the County
Habitat and Natural Resources	+	• Vegetation removal during construction will temporarily reduce habitat • Habitat and natural resources will be improved after construction by planting native species and installing butterfly and bird nesting boxes	• Vegetation removal will be limited at any one time • Native meadow will be seeded as construction is completed in each phase across the site
Recreation	+	• There are currently no recreational opportunities on the Landfill • Recreation will be improved by landscaping the closure cap for recreational use, with features such as walking paths, dog park, mulched play area, and disc golf course	• Access to the Gude Trail will be maintained and no impacts are anticipated
Site Aesthetics	+	• Construction activities and vehicles will be visible from the surrounding area during construction • After construction, site aesthetics will be improved by the vegetated and landscaped closure cap	• Exposed waste will be covered at the end of each workday • Vegetated buffer between Derwood Station and the Landfill will be improved prior to construction
Note: * + = positive effect 0 = no effect			

2.1 TRAFFIC

2.1.1 Construction Phase

Construction associated with the Landfill remediation project will increase vehicle traffic onto the Landfill site. There are two entrances to the Landfill site: (1) East Gude Drive from the south-southwest; and (2) Southlawn Lane at Incinerator Lane from the east-southeast. All construction vehicle traffic will enter and exit the site via the intersection of Southlawn Lane and Incinerator Lane, while the entrance from East Gude Drive will be used only as an administrative entrance that will include parking for construction workers. This traffic pattern is shown in **Figure 5**.

A Traffic Impact Study was performed by T3 Design Corporation to determine the additional traffic generated during construction and its potential impact on the adjacent roadways and intersections. The study indicated all nearby intersections are expected to continue to operate at acceptable levels-of-service (T3 Design Corporation 2019).

Traffic mitigation measures during construction will include limiting the use of the East Gude Drive entrance as an administrative entrance and area and requiring all construction traffic to use the Southlawn Lane/Incinerator Lane entrance to the Landfill. This plan diverts heavy construction traffic from East Gude Drive and acts as a mitigation measure for overall traffic impacts.

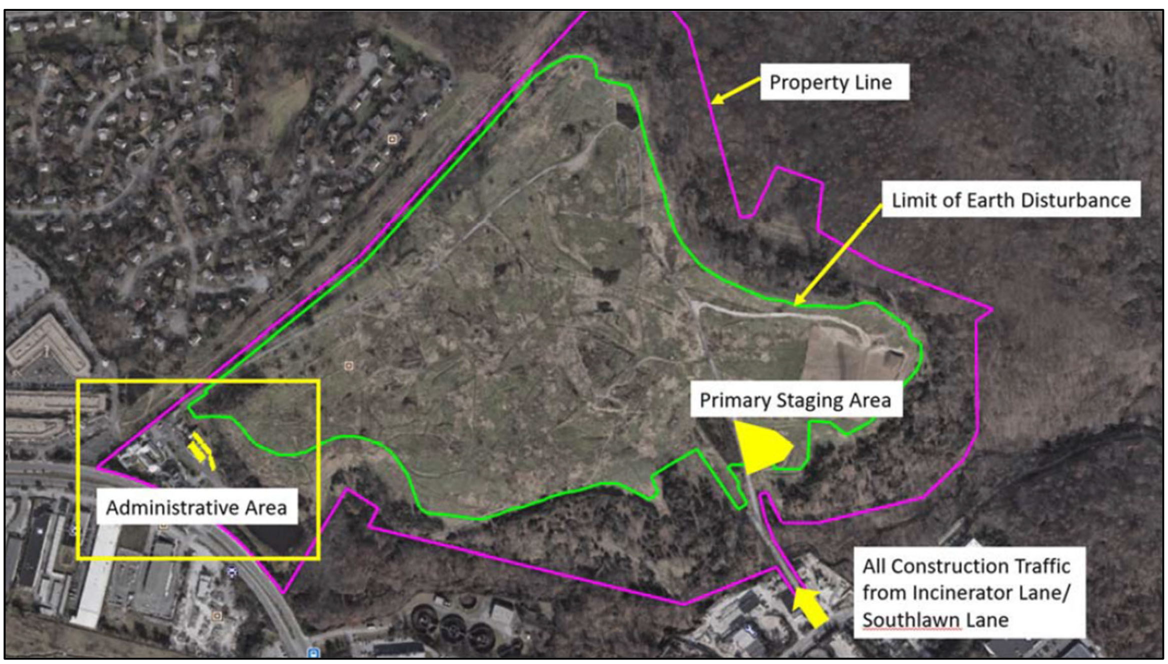

Figure 5 Construction Staging and Routing of Traffic

2.1.2 Long-Term

Long-term traffic patterns are expected to return to pre-construction levels after remediation is complete and construction vehicle traffic is no longer affecting surrounding roadways and intersections.

2.2 DUST

2.2.1 Construction Phase

Construction activities and onsite traffic may generate airborne particulate matter or dust, which could potentially migrate to the surrounding community if not controlled on site. The extent of this migration is dependent on wind speed and direction. Dust, if not mitigated, may negatively affect visibility and air quality in the surrounding community during the construction phase of remediation.

Measures will be implemented during construction to minimize the generation and migration of dust to protect surrounding communities and adhere to requirements outlined in the Montgomery County Department of Environmental Protection Air Quality Ordinance and COMAR 26.11.06.03 Part D: Particulate Matter from Materials Handling and Construction. These regulations require reasonable precautionary measures be taken during construction activities that have the potential to generate dust. These actions include covering open-bodied vehicles transporting materials that could create dust; applying water, foam, or suitable chemicals to roads, open earth, and material stockpiles; and using tarping or other means to cover soil and other construction materials. The contractor for the Landfill remediation project will be required to employ these measures as necessary to control dust on site. Additionally, the contractor will restrict heavy construction vehicle traffic to the Southlawn Lane/Incinerator Lane site entrance, which is further removed from residential communities than the East Gude Drive entrance. The contractor will also limit the speed of onsite traffic in order to minimize dust generation.

2.2.2 Long-Term

Once construction activities are complete, dust generation will return to pre-construction levels. All exposed soil will be seeded and the site will be stabilized. Traffic will be limited to periodic maintenance activities.

2.3 NOISE

2.3.1 Construction Phase

Noise is expected to be generated by construction vehicles and heavy equipment used during construction, potentially increasing noise levels in the surrounding community.

Measures will be taken to minimize and mitigate construction noise in order to limit the nuisance to the surrounding community and adhere to requirements and guidelines outlined in the Montgomery County Noise Control Law. This law outlines the maximum allowable noise levels measured at the receiving location as 75 A-weighted decibels (dBA) from 7 AM to 5 PM on weekdays, 65 dBA during other daytime hours, and 55 dBA during all nighttime hours. As part of these regulations, the development of a Noise Suppression Plan (NSP) by the contractor will be required. The NSP allows an increased maximum noise level of 85 dBA from 7 AM to 5 PM on weekdays and includes a description of noise-suppression strategies and equipment. The NSP also includes the requirement for an informational notice on construction noise levels to be distributed to all nearby residences.

The contractor will be required to limit construction activities to weekdays during daylight hours and limit construction traffic to the Southlawn Lane/Incinerator Lane entrance of the Landfill, which will minimize noise on the northwest side of the Landfill closest to residential communities. Other mitigation methods include source control, such as the selection of equipment that will minimize noise generation. This equipment may include adequate mufflers to control engine noise, localized or directional vehicle backup alarms, white noise vehicle backup alarms, or backup alarms that self-adjust to ambient noise levels. Noise levels will be monitored by the County to ensure that requirements of the Montgomery County Noise Control Law are being met during construction.

Additionally, the vegetated corridor between the Derwood Station community and the northwest property line will be supplemented and improved prior to major construction activities, providing noise screening during the construction phase. Planned improvements to this vegetated buffer include the removal of invasive species and the planting of native trees, shrubs, and other plants, as shown in **Figure 6**.

Figure 6 Derwood Station Vegetated Buffer Improvement Plan

2.3.2 Long-Term

Long-term noise levels are expected to return to pre-construction levels after remediation is complete. There may be slight changes in long-term noise levels or patterns dependent on the use of the remediated Landfill site for recreation. Use of the Landfill for recreation after construction is complete will be limited to daylight hours. Additionally, the improved vegetated corridor between the Derwood Station community and the Landfill will provide a long-term noise buffer.

2.4 ODOR

2.4.1 Construction Phase

As part of the Landfill capping activities, waste on the northwest slope of the Landfill will be excavated, relocated, and regraded onto the upper surface of the Landfill. The exposure of excavated waste may release odors above pre-construction levels at the Landfill site. Depending on wind speeds and direction, these odors have the potential to migrate to the surrounding community. The waste being excavated as part of this remediation project has been in the Landfill for at least 40 years and most organic material should be decomposed, limiting the potential odors. Changes in odor on and off site may also occur due to modifications being made to the landfill gas collection system as part of remediation. As portions of the landfill gas system are temporarily disconnected during construction, there is the potential for temporary increases in landfill gas odors.

The mitigation of odor release and migration to the surrounding community will occur through three main potential strategies: (1) selective timing for waste excavation and landfill gas modifications; (2) waste handling/daily cover of waste; and (3) suppression or masking of odor using misting technology.

Selective timing refers to the contractor adjusting construction activities based on weather and other conditional factors that affect odor migration. For example, odor emission and dispersion are lower when temperatures are colder, so odors will be less likely during colder fall or winter months. Additionally, meteorological conditions, specifically wind speed and direction, have a significant effect on odor migration. The contractor will be required to utilize the existing weather station on site to monitor prevailing wind direction and speed, and will be required to adjust waste excavation activities when odors are more significant and when migration to residential communities is more likely based on meteorological conditions.

The remediation design will be phased to limit the amount of waste that can be exposed to an area that can be covered at the end of the work day. This phasing will minimize odor release, as the entire volume of excavated waste will not be exposed at one time.

Lastly, odors may be neutralized or masked using foam or misting products. These misting products may include deodorizers such as plant and essential oil and water blends, which absorb airborne odor molecules when sprayed onto exposed waste or into the air. Misting products may also include masking agents, which cover landfill odors with a more pleasant fragrance. Use of misters will be a last resort for the project and may be used if odors are significant and the other mitigation measures are not effective.

2.4.2 Long-Term

Long-term odor levels on and off site are expected to be less than pre-construction levels after construction activities are complete. The completed closure cap and improved landfill gas collection system are expected to mitigate the potential release and migration of odors on a long-term basis.

2.5 LANDFILL GAS

2.5.1 Construction Phase

Improvements to the landfill gas collection system will be made as part of the Landfill remediation and will include the installation of new gas extraction wells and new underground collection piping which will connect to the existing landfill gas flare facility. During the abandonment or removal of existing extraction wells and piping, and the installation of new extraction wells and piping, portions of the landfill gas collection system will be temporarily disconnected. This could impact the effectiveness of the landfill gas collection system in controlling the migration and odor of landfill gas during construction activities.

The landfill gas collection system modifications will occur in phases to minimize disruption to landfill gas collection during construction. Existing perimeter landfill gas monitoring wells will be monitored during construction and will be monitored more frequently when portions of the landfill gas system are temporarily disconnected. If landfill gas concentrations exceed 5% by volume in the monitoring wells, the contractor will be required to make adjustments to the system vacuum to reduce migration while modifications are being made to the system.

2.5.2 Long-Term

Long-term effects to the landfill gas collection system are expected to be beneficial. The existing landfill gas collection system is positioned on the surface of the Landfill and has been susceptible to damage by weather and waste settlement. The new collection system piping installed underground within the Landfill closure cap will provide a better solution to landfill gas issues at the site. The revised configuration of gas piping will provide improved flexibility in situations of pipe repair or blockages. New gas extraction wells will also improve the collection and control of landfill gas from the entire site, particularly near the property boundary. The geosynthetic landfill cap will also improve the amount of landfill gas that the system collects, further reducing the amount of gas migrating from the Landfill. Overall, long-term levels of landfill gas migration and odor are expected to be less than pre-construction levels as a result of modifications made during remediation.

2.6 LEACHATE

2.6.1 Construction Phase

Leachate generation and potential for migration off site (non-stormwater discharges) may be impacted by construction activities at the Landfill. Activities of particular concern for leachate effects are the removal of existing vegetation and the exposure of waste during excavation. These activities may lead to stormwater being able to infiltrate into waste more readily, generating increased leachate with the potential for migration during the construction period. Excavating into waste may also expose pockets of existing leachate in the Landfill that must be contained to prevent runoff over the ground surface.

Design aspects and construction measures will minimize and mitigate increased leachate generation and migration at the Landfill. The remediation design includes a closure cap specifically designed so that the heavily vegetated northern, southern, and eastern slopes of the site will not be disturbed, limiting stormwater infiltration and leachate impacts in those areas. Changes in leachate generation in the areas of the site that are being excavated or otherwise disturbed will be largely dependent on waste excavation and handling. The design specifications will require the contractor to cover exposed waste with soil, tarps, or other means at the end of each workday. This will minimize the infiltration of stormwater into areas of disturbance, thus minimizing the generation and migration of leachate during construction. The contractor will also be required to excavate the Landfill in a sump condition, meaning that any existing leachate that is exposed during excavation cannot flow over the ground surface and will be encouraged to drain back into the Landfill or will be pumped from the Landfill and trucked to a leachate treatment facility.

2.6.2 Long-Term

Remediation activities are expected to have a beneficial impact on leachate generation and migration off site in the long term. Installation of the geosynthetic closure cap and new vegetation will reduce the infiltration of stormwater into the waste compared to the existing condition, which will decrease the generation and potential migration of leachate from the Landfill. These remedial actions are expected to ensure that long-term effects of the leachate on the groundwater are beneficial to the site and surrounding community.

2.7 HAZARDOUS WASTE

2.7.1 Construction Phase

The Gude Landfill started accepting waste around 1964 when environmental regulations were minimal. There are no known documents that indicate hazardous waste was placed in the Landfill, but it was not uncommon for some hazardous and industrial wastes to be co-disposed with municipal waste and construction and demolition debris in that era. The remediation design includes requirements for the contractor to stop work if any potential hazardous waste is uncovered based on odor and visual observation and to sample the waste to determine if it is in fact hazardous.

Any hazardous waste excavated will be transported offsite for disposal in accordance with current regulations (COMAR 25.13: Disposal of Controlled Hazardous Substances). Transport and disposal of hazardous waste is heavily regulated to ensure it is performed safely, but there is an increase in potential exposure to the waste compared to it being buried in the Landfill.

2.7.2 Long-Term

In the long-term, the removal of any excavated hazardous waste from the Landfill can only improve groundwater quality and will reduce the Landfill's impact on the environment.

2.8 STORMWATER RUNOFF

2.8.1 Construction Phase

The quantity and quality of stormwater runoff at the Landfill will be potentially impacted by construction activities. Increased generation of stormwater and changes in the quality of that stormwater may occur based on waste excavation and handling, changes in the area of exposed earth, and changes in slopes during the remediation project.

Changes in stormwater runoff quantity and quality will firstly be minimized by the design of the Landfill closure cap, which allows the heavily vegetated northern, southern, and eastern slopes of the site to remain undisturbed, limiting stormwater runoff in those areas to current amounts. During remediation activities, the contractor will take steps to minimize erosion and to control sediment runoff in areas of the site that are being disturbed. The contractor will employ controls during construction as required by the Montgomery County Department of Permitting Services (DPS) and included in MDE's *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*. The construction cannot begin until DPS approves the Sediment Control Plan for the project. A DPS inspector will visit the site during construction to ensure the controls are properly installed and maintained as approved in the Sediment Control Plan.

2.8.2 Long-Term

Long-term stormwater runoff from the Landfill site is expected to be equal to or less than pre-construction quantities after construction activities are complete. Pre-construction runoff characteristics will be maintained as nearly as possible. The final ground surface after remediation will be similar to the pre-construction ground surface; however, the remediated ground surface slope on top of the Landfill will be slightly steeper than the pre-construction slopes to promote drainage and minimize the potential for stormwater ponding on the Landfill closure cap. New vegetation will be planted following remediation activities, which will mimic the existing vegetation and maintain similar stormwater runoff from the Landfill surface and slopes. Overall, the installation of the closure cap, vegetation, and new drainage and stormwater management systems on the Landfill is expected to have a beneficial long-term impact, maintaining or decreasing stormwater quantity and maintaining or improving stormwater quality from the site.

2.9 FUEL STORAGE

2.9.1 Construction Phase

The contractor will have the option to install a temporary fuel tank at the site for construction vehicles and equipment. This may include temporary aboveground fuel storage tanks and other containers. Any time fuel is being stored, there is a risk for potential effects such as fire, spills, and contamination of nearby materials.

In order to minimize potential effects, the contractor will follow regulations and best practices for managing temporary fuel storage for construction activities. Major requirements are outlined by MDE and the Occupational Safety and Health Administration and refer to the National Fire Protection Association Standard 30, Flammable and Combustible Liquids Code, and Title 29, Parts 1910 and 1926, of the Code of Federal Regulations. These resources outline requirements and best practices for the use of temporary fuel storage, including, but not limited to the employment of approved double-walled tanks or containers with proper venting and emergency features; designated fueling locations a distance from property lines, structures, and sources of physical damage; fire extinguishers of proper size and class; proper signage and labeling; and spill prevention, control, and countermeasure plans in place in the case of a fuel spill.

2.9.2 Long-Term

The increase in fuel storage on the Landfill site will be temporary as needed for construction activities; therefore, no long-term effects to the site or surrounding communities are expected. The contractor will be required to use best practices for preventing and addressing any spills that may potentially occur during construction to minimize long-term effects.

2.10 SITE ACCESS, SAFETY, AND SECURITY

2.10.1 Construction Phase

Site access to the Landfill will be restricted during construction for safety reasons. There will be increased personnel, vehicle traffic, and presence and activity of heavy construction equipment during remediation, which can pose a danger to people in the construction area.

Measures will be employed to restrict site access and improve safety and security during construction, such as requiring the contractor to utilize a closed-circuit television surveillance system to promote security at the site. For safety reasons, the contractor will install temporary construction fencing and display clear signage where necessary to restrict access and protect nearby community members. The existing chain-link fencing along the northwest boundary of the Landfill will be maintained in some form during construction. The contractor will also minimize safety hazards by adhering to Occupational Safety and Health Administration regulations and following a site-specific Health and Safety Plan. The contractor must provide a Site Safety Officer during construction activities.

2.10.2 Long-Term

Site access, safety, and security at the Landfill are expected to return to pre-construction levels or better after remediation is complete. Site access will be improved over pre-construction levels, as recreational users will have access to the remediated site and its walking paths via new public entrances from the existing Gude Trail. Additionally, the improved vegetated corridor between the residential community of Derwood Station and the Landfill (discussed in Section 2.3.1) will provide improved access to the remediated site from Derwood Station via a grass access path to the Gude Trail. To minimize long-term safety and security impacts, the chain-link fencing along the Gude Trail will be maintained following construction and site access will be controlled to two locations where Landfill walking paths will intersect the Gude Trail. Additionally, a closed-circuit television surveillance system will be installed permanently for security.

2.11 HABITAT AND NATURAL RESOURCES

2.11.1 Construction Phase

Construction activities at the Landfill will require the removal of vegetation and disturbance to existing habitat at the site. The typical ground cover across the Landfill site is open grassy fields with patches of brushy vegetation with trees on most side slopes and along the perimeter borders of the Landfill. Vegetation removal and disturbance to existing habitat will particularly occur where waste is excavated from the northwest slope and placed and regraded onto the top of the Landfill.

The remediation design includes a closure cap specifically designed so that the heavily vegetated northern, southern, and eastern slopes of the site will not be disturbed, minimizing the loss of vegetation and habitat in those areas. Additionally, the waste excavation and grading will not occur all at one time, but rather will be phased, allowing for areas of the site to be replanted with stabilizing vegetation, replacing and improving natural resources and habitat as construction proceeds.

2.11.2 Long-Term

Remediation is expected to give long-term benefits to onsite habitat and existing natural resources by increasing vegetated habitat on the closure cap, seeding with native plants, and creating wildlife habitat. The Landfill capping activities include the establishment of a meadow environment, with custom seed mixes to incorporate diverse plant species, including grasses and wildflowers. This meadow habitat is expected to support a variety of wildlife, including butterflies, bees, other insects, and avian species. Added features to the site, such as bird and butterfly nesting boxes and avian perches, are also expected to benefit wildlife by providing additional habitat. A vegetated buffer will also be planted along the northwest property line (adjacent to the existing Gude Trail and residential community of Derwood Station). Plantings will include native trees, shrubs, and other species. These improvements to natural resources, habitat, and biodiversity onsite may potentially see accelerated rebound and growth due to the site’s proximity to forested stream valleys, which connect the site to established corridors of movement for a wide variety of species.

2.12 RECREATION

2.12.1 Construction Phase

Recreational use of the Landfill site will be impacted by construction activities. Effects are expected to include restrictions to site access while construction activities are occurring. The Gude Trail, which runs along the northwest side of the Landfill outside of the property boundary, is expected to remain open but may be somewhat impacted by its proximity to the northwest slope of the Landfill, where waste excavation will occur.

Impacts to recreation will be minimized by fencing off construction areas and including clear signage to inform potential recreational users of limited access. The Gude Trail is expected to remain open for recreational use.

2.12.2 Long-Term

Remediation of the Landfill will benefit long-term recreational use of the site. The vegetated closure cap, when completed, will be landscaped for recreational use, and is expected to be open for public use during daylight hours. Entrance for public access to the Landfill will be provided at two gate locations along the northwest property line, accessed from the existing Gude Trail.

Recreational features at the site will potentially include both paved and vegetated walking and running paths, a lookout area, seating areas, a dog park, a disc golf course, a mulched play area, nature play equipment, art installations, and educational signage. Trail markers and informational signage will be installed to direct recreational users of the site.

2.13 SITE AESTHETICS

2.13.1 Construction Phase

Site aesthetics will be impacted during construction activities at the Landfill. Effects to surrounding communities are expected to include disturbance to the existing viewshed by construction fencing and potential views of construction vehicles and remediation activities such as waste excavation, regrading, closure cap installation, and landfill gas system construction.

Measures for mitigating effects to site aesthetics for the surrounding communities include the use of construction fencing, both for safety and aesthetic uses. Excavated waste will be covered at the end of each workday, which will limit the sight of it. Additionally, the improved vegetated buffer between the residential community of Derwood Station and the north side of the existing Gude Trail and Landfill property boundary (discussed in Section 2.3.1) will provide vegetative screening to help block construction activities from view.

2.13.2 Long-Term

Remediation will have long-term benefits to site aesthetics for surrounding communities. The existing viewshed will be improved by the installation of a vegetated closure cap, which will be landscaped for recreational use. The remediated and landscaped site will include walking and running paths, lawns and meadows, a lookout point, recreational areas, and art installations. Additionally, a vegetated buffer will be located on the Landfill site running the entire length of the base of the slope along the northwest property line and adjacent to the south side of the existing Gude Trail and residential community of Derwood Station. This buffer will include both evergreen and deciduous trees and shrubs and will provide aesthetic screening of the remediated site from the surrounding community. Additionally, the improved vegetated buffer between the Derwood Station community and the north side of the existing Gude Trail and Landfill property boundary (discussed in Section 2.3.1) will provide additional long-term screening.

3. REFERENCES

EA Engineering, Science, and Technology, Inc. (EA). 2016. *Gude Landfill Assessment of Corrective Measures*. April.

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. May 28.

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

T3 Design Corporation. 2019. *Final Traffic Impact Study for Gude Landfill Remediation Project.* June.

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Attachment M

Post-Closure Care Plan

Gude Landfill Remediation Design
Post-Closure Care Plan
Montgomery County, Maryland

90% Submission

Prepared for

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

Prepared by

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

July 2020
EA Project No. 15646.01

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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
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

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

July 2020
EA Project No. 15646.01

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TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

COMAR	Code of Maryland Regulations
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
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, Recycling and Resource Management Division (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
- Passive recreational land use elements are maintained.

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.

Post-closure use of the property will be passive recreational land use. Features of this future land use were selected based on the Northeast Maryland Waste Disposal Authority and County's goals and input from stakeholders. EA's subcontractor, Floura Teeter Landscape Architects, developed the passive recreational land use design, which includes elements such as paved and vegetated walking paths, a lookout area, seating areas, a dog park, a disc golf course, a mulched play area, nature play equipment, art installations, trail markers, and educational signage.

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 June 2020 (EA 2020) 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 June 2020 (EA 2020) and all MDE-approved updates.

1.3.3 Landfill Gas Monitoring 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 (APTIM 2020). Key components include the extraction wells, gas collection piping, gas condensate system, blowers, and flares. 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 Landfill Gas Monitoring System

The County will inspect and maintain the landfill gas perimeter monitoring system in accordance with the *Landfill Gas Monitoring Plan,* dated April 2009 (Montgomery County 2009) and all MDE-approved updates. Required repair of the landfill gas monitoring system will be made as soon as possible based on weather conditions and the potential need to procure a contractor to complete the repairs.

1.5.7 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 June 2020 (EA 2020) 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.

1.5.8 Maintenance of the Stormwater Management System

Drainage on the upper surface of the Landfill will be conveyed primarily by a network of open channel swales, box culverts, and storm drains. The County will perform site inspections and perform maintenance of these features as necessary. Maintenance will include the removal of accumulated sediment and repair of visible erosion of the drainage features.

1.5.9 Maintenance of Passive Recreational Land Use Elements

The County will inspect and maintain the passive recreational land use elements as needed. Pet owners will be responsible for their own pet waste. The County will be responsible for routine emptying of trash receptacles.

1.5.10 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.

1.5.11 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

1.5.12 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.

1.5.13 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.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2020. *Groundwater and Surface Water Monitoring Plan.* Maryland. March.

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: ____________________

I. SITE INSPECTION

		GOOD	FAIR	POOR	N/A
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 ______________________________

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Comments ______________________________

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____

	Date Problem Identified	Date Scheduled for Corrective Action	Date Problem Corrected
7. Access Road/Site Security	____________	____________	____________

Description of Corrective Action ______________________________

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Comments ______________________________

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	Date Problem Identified	Date Scheduled for Corrective Action	Date Problem Corrected
8. Other	____________	____________	____________

Description of Corrective Action ______________________________

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Comments ______________________________

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Attachment N

Construction Schedule

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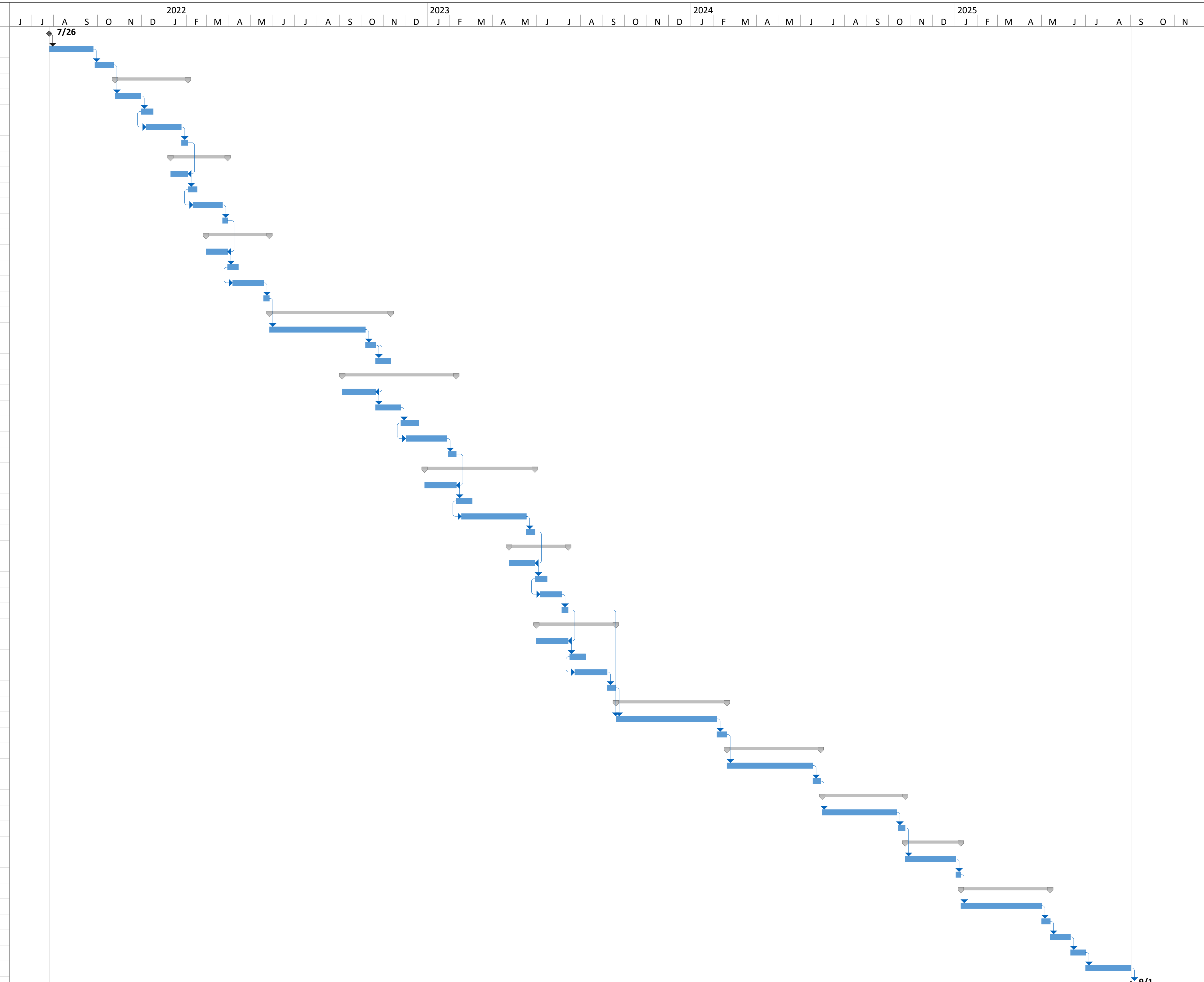
ENGINEER'S OPINION OF GUDE LANDFILL REMEDIATION SCHEDULE
BASED ON 60% REVISED DESIGN

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.

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Attachment O

Passive Recreation Land Use
Basis of Design

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Passive Recreation Land Use
At Gude Landfill
Basis of Design
Montgomery County, Maryland

90% Submission

Prepared for

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

Prepared by

Floura Teeter Landscape Architects, Inc.
800 N. Charles Street, Suite 300
Baltimore, Maryland 21201
(410) 528-8395

Under Contract to

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

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TABLE OF CONTENTS

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LIST OF ACRONYMS AND ABBREVIATIONS

the Authority	Northeast Maryland Waste Disposal Authority
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
M-NCPPC	Maryland-National Capital Park and Planning Commission
DEP	Department of Environmental Protection
EA	EA Engineering, Science, and Technology, Inc., PBC
FTLA	Floura Teeter Landscape Architects, Inc.
GLCC	Gude Landfill Concerned Citizens
the Project Team	EA, FTLA, the County
the Design Team	EA, FTLA
the Landfill	Gude Landfill
the Master Plan	Preferred Conceptual Master Plan
the Summary Report	Passive Recreation Land Use Planning Summary Report
the BODR	Passive Recreation Land Use at Gude Landfill Basis of Design Report

1. EXECUTIVE SUMMARY

The Passive Recreation Land Use Basis of Design Report (BODR) provides an overall understanding for the development of the design of the passive recreation land uses for the Gude Landfill (the Landfill). The BODR is not intended to be a technical document, but rather a comprehensive description of the basis of design, design criteria, and guidelines for how passive recreation land uses are integrated into the remediated landfill. The BODR should be read in conjunction with related reports and documents including Construction Documents and Specifications.

Generally, the design development for passive recreation land uses at the Landfill post remediation implements the Preferred Conceptual Master Plan (the Master Plan) developed with stakeholder engagement during the master planning process. An overview of the process and resulting Master Plan are documented in the Passive Recreation Land Use Planning Summary Report (the Summary Report).

The Northeast Maryland Waste Disposal Authority and Montgomery County Department of Environmental Protection, Recycling and Resource Management Division intends to integrate construction and installation of the passive recreation land uses with the construction of the permanent landfill capping system. All elements of the Master Plan are intended for construction concurrent with the landfill capping system excepting the solar panel array. An area in size, shape, and location identified in the Master Plan will be reserved for future design and installation of a solar panel array, at a date to be determined.

The project schedule required the passive recreation land uses to be reviewed as a separate construction document submittal for the 60% milestone. With the current 90% milestone submission, the construction documents and specifications have been consolidated into one overall Landfill remediation construction document submittal.

2. ACCESS

Montgomery County, Maryland, will remain the owner of the site post construction, with responsibility for day to day operations and maintenance.

Post remediation, the Landfill will continue to have sensitive infrastructure in place to monitor and maintain the Landfill over time. In order to minimize risk to the sensitive infrastructure, the Landfill will be secured with a perimeter fence system in high visibility and activity areas. The County's intention is to provide public access to the site for day use only. Even though public recreation amenities are provided, this site is not part of the Montgomery Parks system. The County may determine the need for temporary closures or adjustments to public access based on available resources.

2.1 COUNTY MAINTENANCE ACCESS

Vehicle access will be restricted to only County employees or representatives. Two gates will accommodate vehicle access; one located adjacent to the existing flare station, and one located at Incinerator Lane. Gravel access roads are planned to provide vehicular access for security, site maintenance and routine monitoring of on-site landfill gas extraction wells located throughout the Landfill. The gravel access roads are anticipated to be approximately fifteen feet in width to accommodate maintenance vehicles.

2.2 PUBLIC RECREATION ACCESS & TRAIL NETWORK

Entrance for public access to the Landfill will be provided at two gate locations along the northwest property line, accessed from the existing Gude Trail. Public use of the Landfill is intended to be by pedestrians only; motorized vehicles, bicycles, or horseback will be restricted at this site.

The gravel access roads, in addition to vehicular access for site maintenance, will function as the primary pedestrian circulation and trail network on the Landfill. The proposed gravel access road width of fifteen-feet is adequate to serve a variety of recreation users moving in both directions on the gravel access roads. Areas adjacent to the gravel access roads will be mowed as needed to maintain a short meadow edge condition.

Grass access paths will be incorporated in select locations to extend access to areas of the Landfill not served by gravel access roads or to provide an alternative trail route or shortcut route that is less physically challenging. Serving as secondary circulation, the proposed grass access paths are anticipated to have a width of fifteen feet total.

3. RECREATION AMENITIES

Recreation proposed at the Landfill include a combination of low impact recreation uses, many of which are complementary in nature. Defined recreation destinations are located and sited on the Landfill in conformance with the Master Plan, while recreation activities such as birdwatching are not location specific and occur throughout the Landfill at the users' determination.

Attachment A includes engineering calculations for determining required size for concrete spread footers and reinforcing steel for various design elements associated with the recreation amenities and signage. Due to the depth limitations of the landfill cap, a typical concrete footer installed below the frost line is not a feasible option.

3.1 HIGHPOINT LOOKOUT

Physically located at the highest elevation of the site, the Highpoint Lookout is a passive use area that affords users a view of the site looking south with the City of Rockville skyline in the distance. Recreational uses envisioned for this destination include walking, dog walking on leash, kite-flying, birdwatching, seating/rest in nature. This area will be maintained as short meadow planting. Seating will be provided.

<u>Site Furnishings /Equipment:</u>
- Chaise Lounge Chair; wooden slats, fixed in place
- Park Bench; custom stump and planed wood bench design
- Trash Receptacle

<u>Signage:</u>
- Educational Sign; timeline of site history, section of landfill to describe capping system, graphic of landfill gas extraction wells.

<u>Fencing:</u>
- Guardrail; located along portions of the leading edge of maintained area, at top of graded slope

<u>Plantings:</u>
- Maintained short meadow/turfgrass
- Tall meadow with owl nesting box

3.2 DOG PLAY OFF LEASH

This destination provides a fenced, designated space for supervised off leash dog play and exercise. Design elements include a double gated entrance to minimize conflicts of incoming and outgoing dogs and separate areas for large and small dogs. The fenced area will be maintained as short meadow planting. Seating will be provided.

<u>Site Furnishings /Equipment:</u>

Outside of Fenced Area:

- Park Bench; custom stump and planed wood bench design
- Trash Receptacle

Inside of Fenced Area:

- Park Bench; custom stump and planed wood bench design
- Terraced Boulder Seating; nested into a sloped grade
- Stump Groupings

Signage:

- Informational Sign; describing rules of use; located outside of the fenced area

Fencing:

- Chain-link fence with wooden posts; five-foot height fence, black powder coated

At Grade Materials:

- Mulched pad inside entrance to large dog area
- Earthen mound; planted with short meadow

Plantings:

- Maintained short meadow/turfgrass

3.3 CHILDREN'S NATURE PLAY

This destination will provide nature inspired play elements and activity areas to foster a connection between children and the natural environment. Nature play spaces encourage creativity and decision-making allowing children to curate their own play experience. Consideration can be given to building play elements and seating from trees removed during the remediation of the Landfill. Signage, bird and butterfly houses, and other educational elements will be incorporated into the design of this destination. A mulched surface will be provided for nature play elements.

Site Furnishings /Equipment:

- Park Bench; custom stump and planed wood bench design
- Balance star; wooden
- Stump climb
- Boulder climb
- Tunnel
- Teeter Totter
- Tic-tac-toe; wooden
- Magnifying lens post
- Butterfly box

Fencing:

- Guardrail to define rear edge of amenity area

At Grade Materials:

- Mulched pad surrounding play elements

Plantings:

- Maintained short meadow/turfgrass

3.4 DISC GOLF

A 9-hole disc golf course will be provided. Disc golf is a sport played in groups of two or more where players stand at a tee box and throw a frisbee-like disc toward a target or basket. This area will be maintained as short meadow planting.

Site Furnishings /Equipment:

- Disc golf basket target; galvanized steel

Signage:

- Informational Sign /Tee Post; located at each tee box; identify par and hole number

Fencing:

- Guardrail; located along leading edge of maintained area, at top of graded slope

At Grade Materials:

- Tee box

Plantings:

- Maintained short meadow/turfgrass

3.5 ENVIRONMENTAL ART INSTALLATION

Environmental art will be used to visually highlight the contours of the Landfill. When viewed from a distance, the art may encourage users to explore the landscape. The artwork will be constructed to function as avian perches giving bird populations a vantage point to hunt or rest.

Site Furnishings /Equipment:

- Park Bench; custom stump and planed wood bench design
- Environmental Art Installation; custom metal avian perch poles, finish: powder-coat bright red

Signage:

- Educational Sign; avian species

Plantings:

- Maintained short meadow/turfgrass
- Tall meadow with owl nesting box

4. SIGN TYPOLOGY

4.1 WAYFINDING

Waystations are proposed at important trail intersections throughout the site. Waystations will be designed to include a consistent set of elements including a trail marker with directional signage and a site map, educational signage, and seating. Waystations are important as they will function as meeting points and will provide orientation for circulation and navigation of the trail network to site amenities.

Trail Markers will serve as the primary wayfinding features. At a height of 10’-0”, the trail markers will be visible from a distance. These are located at trail intersections and decision points along the primary trail network and will indicate trail names, distance to destinations and length of trail, and “you are here” map of the Landfill for general orientation.

Directional Sign Posts will serve as supplemental wayfinding features to be located at intersections of grass access paths with the primary trail network. These will include the trail name and length of trail. Height of directional sign posts will be 4’-6”. Directional sign posts will be used to identify areas of the Landfill not intended for recreation use, such as area designated for the future solar panel array.

4.2 EDUCATIONAL

The history and evolution of the Landfill present opportunities for education on multiple related topics. Integration of educational signage will occur at four waystations and at select locations along the primary trail network. Attachment B includes graphics for educational signage.

Each waystation will have a specific environmental education focus:

Waystation #1 – Evolution of the Landfill; Educational signage will illustrate a timeline of use from landfill to remediation with key facts. Information describing the sensitive infrastructure will be included to illustrate the section of the landfill capping system and a graphic describing the landfill gas extraction wells and capture system.

Waystation #2 – Meteorological Weather Station; A weather station currently located on the Landfill will be relocated to a location accessible to the public to bring awareness to monitoring and data collection. The intent is to coordinate a QR code display that can be scanned with a smart phone for digital access for the public to easily connect to current and historical information collected by the weather station.

Waystation #3 – Avian Habitat; The art installation is an intentional aesthetic intervention in the meadow landscape to punctuate the natural contours of the Landfill. Thirty individual components at a height of 10’-0” and finished with a contrasting red color will be placed to align with and stepping down the contours of the hillside. When viewed from locations of higher elevation throughout the Landfill, such as the Highpoint Lookout, the installation will resemble a flock of birds in flight. Moreover, the individual components of the installation function as perch posts, a vantage point for birds within a meadow landscape void of trees.

Waystation #4 – Pollinator Habitat; As a restored native meadow habitat, the Landfill will support birdwatching activities and will be an opportunity to bring awareness of important meadow ecologies and how open meadow plant communities are important for specific avian species to thrive. Educational signage will focus on highlighting how the meadow ecosystem functions as a food web where specific meadow plants serve as food or host plants for insect and avian species.

Educational Posts are proposed along a portion of the trail adjacent to the disc golf course, twelve posts total. These posts help to imply an edge to the disc golf course separating it from the trail. Content will be focused on meadow plant species growing onsite and avian species that users are likely to encounter.

4.3 INFORMATIONAL

Informational signage is used in areas to provide guidance or instruction for use or recreation amenities located on the Landfill. The two public access entrances to the Landfill from Gude Trail, disc golf course, and dog play area include informational signage.

Each public access entrance will include signage to list the general rules for use of the park and activities that are restricted such as fire, camping, bicycle riding, or horseback riding. Additional information will be posted that describes the nature of the site, potential risks to users, and contact information in case of an emergency.

The disc golf course will include a tee post at each tee box to identify recommended par and hole number.

The dog play area will include a list of general rules and safety recommendations for using the fenced dog play.

.

5. FENCE TYPOLOGY

5.1 PERIMETER FENCING

A 10’0” height galvanized steel chain-link fence will be installed at the perimeter of the Landfill in high visibility and activity. Gates serving pedestrian and vehicles will be incorporated in select locations.

5.2 ENCLOSURE FENCING

The area of the Landfill designated for fenced off-leash dog play will be enclosed with a 5’-0” height black powder coat steel chain-link fence. A double gated entrance will serve pedestrians and pets.

5.3 GUARDRAIL /SAFETY FENCING

A wooden guardrail fence is proposed in select locations where recreation amenity areas are in close proximity to steeply sloped areas of the Landfill. The guardrail will be 3’-0” in height.

6. LANDSCAPE PLANTINGS & HABITAT CREATION

6.1 MEADOW PLANTINGS

Landscapes are living and continually evolving through both natural processes and human influences. That notion is especially relevant to the Landfill as it progresses through remediation and post closure reuse. Due to the limited soil depth available, a meadow ecology is compatible with the Landfill cap construction. A primary goal of the project is to establish a naturalistic meadow environment encouraging the interaction of avian species with the new flora.

Custom meadow seed mixes were developed for the Landfill incorporating a diversity of plant species to provide both host plants and food supply supporting a wide variety of butterflies, bees, and other insects, establishing a food web for birds, bats, and beyond. Plant species included in the custom meadow seed mixes respond to needs of both specialist insect species that may rely on only one type of plant species for their diet and generalist insect species that can feed on a wider variety of plant species. The site is bounded on two sides by forested stream valleys, connecting the site to established corridors of movement for a wide variety of species, possibly contributing to an accelerated rebound in biodiversity of species on the post closure Landfill.

Three custom meadow seed mixes are proposed for permanent stabilization of the Landfill. The proposed locations for the various mixes are based on site conditions such as steep slopes or recreation uses. In addition, species selection considers deer tolerance, seed dormancy, and mature height.

> Meadow Mix #1- Includes thirty different native wildflower and grass species; overall mix is 30% grass species and 70% wildflower species for use in areas of the site unencumbered by steep slopes.
>
> Meadow Mix #2 – Includes three types of turfgrass species for use in recreation amenity areas, grass access trails, and adjacent to gravel access roads.
>
> Meadow Mix #3 - Includes thirty different native wildflower and grass species; overall mix is 65% grass species and 35% wildflower species for use in areas of the site with steep slopes.

Meadows are dynamic plant communities with each species characteristically having differing durations of seed dormancy. To accommodate for succession in the first year of establishment, the meadow areas will be overseeded with an annual cover crop that will quickly germinate, grow, and provide soil stabilization to buffer the time needed for slower to germinate meadow species. Meadows can take three to five years to become fully established. The first one to three years prominent meadow species will include annuals, biennials, and short-lived perennials. These key indicator species include Black-eyed Susan, Wild Bergamot, and Virginia Wild Rye. As the meadow matures between years three to five, long lived perennials will become more prominent as they out compete annuals and other short-lived species. The meadow will continue to evolve over time in response in large part to variations of annual rainfall.

For any areas of the site that may encounter subsidence requiring additional soil and/or grading to maintain positive drainage toward the sides of the Landfill cap, a plant list will be provided identifying appropriate perennial species to be installed as container plantings rather than a seed mix in order to provide fast establishment and soil stabilization. Having a specific group of species for use in these instances create an opportunity to mark a visual record on the site of continued Landfill processes.

Attachment C includes a species list for each meadow mix.

6.2 PERIMETER SCREEN PLANTINGS

A vegetated buffer will be located the entire length of the base of the slope along the northwest property line and adjacent to the existing Gude Trail and residential community of Derwood Station. This will occur on the Landfill site inside the perimeter fence between the fence and the onsite gravel access road. Plantings will include both evergreen and deciduous trees and shrubs.

6.3 NESTING BOXES

To promote a healthy population of breeding pairs of barn owls, *Tyto alba*, nesting boxes will be located within meadow areas of the Landfill. The nesting boxes will be spaced at a maximum density of 1 box per 10 acres.

Nesting box design is an off the shelf model is a molded plastic construction incorporating a double box system which combined with heat reflective pigments and integrated vents reduces heat captured inside the box when located in full sun.

ATTACHMENT A – FOUNDATION DESIGN CALCULATIONS

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OBJECTIVE:

Determine the required dimensions for concrete foundations for the passive recreation elements included in the Passive Recreation Land Use Design as part of the Gude Landfill Remediation Design. Size concrete foundations to provide a minimum factor of safety of 2.0 for overturning and 1.5 for sliding. Size reinforcing steel based on calculated required area of steel.

PROCEDURE:

The required concrete foundation dimensions are calculated using the method for wind load presented in ASCE 7 and the methods for overturning and sliding presented in *Principles of Foundation Engineering* (Das, 2011). Detailed procedure for each passive recreation element is provided in the calculation spreadsheets in Attachment A.

1) Determine the velocity pressure at height of the sign.
   a. Determine velocity pressure based on local conditions.
   b. Determine area of sign.
   c. Determine wind force on sign.
   d. Determine the design wind pressure for the sign.
2) Determine the load on support posts and foundation.
   a. Calculate live loads from wind force.
   b. Calculate dead loads from weight of components.
   c. Calculate load combination.
3) Determine loads to support posts to assess adequacy in deflection.
   a. Analyze load on support posts as point load acting at end of post.
   b. Analyze load on support posts as a uniformly distributed load.

American Society of Civil Engineers (ASCE) (2005). *Standard ASCE 7: Minimum Design Loads for Buildings and Other Structures, 3rd Edition*, American Society of Civil Engineers, Reston, Virginia.

Das, Braja (2011). *Principles of Foundation Engineering, 7th Edition*. Cengage Learning, Stamford, Connecticut.

4) Analyze the load on the foundation and soil.

   a. Calculate load to foundation and load to soil.

   b. Compare load to soil with soil bearing capacity to ensure adequacy.

5) Determine the area of steel required in the foundation.

   a. Calculate reinforcement ratio and area of steel required.

   b. Calculate sizing and spacing of rebar required to satisfy area of steel required.

6) Perform overturning and sliding analysis.

   a. Calculate passive Rankine force from soil.

   b. Calculate overturning and stabilizing forces on sign from front and side. Satisfy factor of safety of 2.0.

   c. Calculate horizontal sliding forces on sign. Satisfy factor of safety of 1.5.

   d. Calculate maximum pressure on geomembrane liner in overturning case.

CONCLUSIONS:

The attached summary table presents foundation and reinforcing steel sizing for the passive recreation elements. All foundations will provide a factor of safety of at least 2.0 against overturning and at least 1.5 against sliding. The loads proposed to be applied to the geomembrane liner do not subject the geomembrane to puncture risk.

ATTACHMENT A

CONCRETE FOUNDATION DESIGN CALCULATIONS

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Concrete Foundation Design Summary Table

Passive Land Use 60% Plans ID	Feature Name	Reinforcing Steel	Foundation Width, W (ft)	Foundation Length, L (ft)	Concrete Volume per Footing (ft^3)	Footing Quantity	Total Concrete Volume (ft^3)
C-3	Dog Play Fence*	#5 @ 12" O.C.	3.00	4.00	12.00	116	1392.00
C-7	Art Installation	#5 @ 6" O.C.	3.00	5.25	15.75	30	473.00
C-14	Butterfly Box	#4 @ 12" O.C.	3.25	3.25	10.56	3	32.00
C-15	Magnifying Lens Post	#4 @ 12" O.C.	2.75	2.75	7.56	2	16.00
C-16	Trash Receptacle	#5 @ 12" O.C.	3.00	3.00	9.00	3	27.00
C-17	Wooden Guardrail*	#4 @ 12" O.C.	3.00	3.00	9.00	30	270.00
C-18	Owl Nesting Box	#5 @ 10" O.C.	3.50	3.75	13.13	3	40.00
C-20	Disc Golf Target Basket	#5 @ 12" O.C.	3.50	3.50	12.25	9	111.00
C-21	Sloped Chaise Lounge Chair^	#5 @ 12" O.C.	3.00	5.00	15.00	10	150.00
S-1	Trail Marker	#5 @ 8" O.C.	3.25	4.25	13.81	6	83.00
S-2	Educational Post	#5 @ 12" O.C.	3.25	3.50	11.38	11	126.00
S-3	Informational Sign (Small)	#5 @ 10" O.C.	3.00	4.25	12.75	5	64.00
S-4	Directional Sign Post	#5 @ 12" O.C.	3.00	3.25	9.75	5	49.00
S-5	Informational Sign (Large)*	#5 @ 10" O.C.	3.00	4.00	12.00	10	120.00
S-6	Disc Golf Tee Post	#4 @ 12" O.C.	2.75	2.75	7.56	9	69.00
						Total (ft^3)	**3030.00**
						Total (yd^3)	**120.00**

*Foundation size calculated for each of two support posts per feature

^Foundation size calculated for both of two supports per feature

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DOG PLAY FENCE

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Dog Play Fence
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft^2)

where:

q_z =	velocity pressure at height z. Height (z) =		6	ft
k_d =	wind directional factor, Table 6-4, where K_d =		0.85	for solid sign
k_z =	velocity pressure exposure coefficient, Table 6-3,			
	for heights of 0 ft to 15 ft, Exposure C, K_h =		0.85	
	for heights of 16 ft to 20 ft, Exposure C, K_h =		0.90	
		Use k_h =	0.85	
k_{zt} =	topographic factor, where $K_{st} = (1 + K_1\ K_2\ K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists.	Use K_{zt} =	1.0	
V =	basic wind speed, from Figure 6-1, where V =		90	mph, for Exposure C (3 second wind gust)

Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.
Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.

I = importance factor Use I = 1.0

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$
q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 6 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1 - Wire Mes	4.71	10	0.00
2- Steel Rail	30.33	0.21	6.32
3 - Post	6	0.5	3.00

A = 9.32 ft^2

Determine Wind Force on the Sign:
F = P x A = q_z x A

F = 14.982 lb/ft^2 x 9.32 ft^2 = 139.62 lb (acting at end of post)
w = 139.62 / 6 lb/ft = 23.27 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft^2)

where:

$q = q_z$	for windward walls at heigth z above the ground.
$q = q_h$	for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.
$q_i = q_z = q_h$ =	1.0
G =	gust effect factor, Use G = 0.85
C_p =	external pressure coefficient. From Figure 6-6, C_p = 0.80 (windward); Cp = -0.50 (leeward)
$(G\ C_{pi})$ =	internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\,G\,C_p - q_i\,(G\,C_{pi}) =$ 0.130 lb/ft^2

$p_{leeward} = q\,G\,C_p - q_i\,(G\,C_{pi}) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 139.62 lb

Uniform Weight/ Post @ Sign = 139.62 lb / 6 ft = 23.27 lb/ ft

Dead Loads:

Section	Material	Area (ft^2)	Unit weight (l	Weight (lb)
1 - Wire Mesh Fencing		47.08	0.21	9.89
		Length (ft)	Unit weight (l	Weight (lb)
2- Rails	2.5" Diam. Steel Pipe	30.33	1.2	36.40
Total				46.29

Sign/Fencing Weight (W_{sign}), = 46.29 lb

Wt_{sign}/ft^2 = 46.3 lb / 9.3 ft^2 = 4.97 lb/ft^2

Uniform Weight @ Sign = 46.29 lb / 6 ft = 7.71 lb/ ft

Number of Posts = 1

Post Length = 7 ft

Sign Weight/ Post ($W_{sign/post}$) = 46.29 lb

Uniform Weight/ Post @ Sign = 46.29 lb / 6 ft = 7.71 lb/ ft

Section	Material	Volume (ft^3)	Density (lb/ft	Weight
3 - Post	Western Red Ced	1.75	23	40.25

Post Weight (Wt_{post}) - 6"x6"x7" Western Red Cedar Timber = 40.25 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 6.71 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\,W_{per\ post} + 1.2\,(Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 139.62 lb + 1.2 x (46 lb + 40.25 lb)

P = 327.24 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\,W + 1.2\,(Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 23.27 lb/ft + 1.2 x (7.71 lb/ft + 6.71 lb/ft)

w = 54.54 lb/ ft = 4.55 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 54.54 lb/ ft x 6 ft / 7 ft = 46.75 lb/ ft = 3.90 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 1,309.0 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 327.2 lb

$M_{maximum} = \frac{PL}{2}$ = 327.2 lb x $\frac{7}{2}$ ft

$M_{maximum}$ = 1,145 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.350 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 1.1E+06 lb/in^2

I = 76.3 in^4

(Δ_{max}) = 0.016 inches (at deflected end)

(Δ_{max}) = 0.016 inches < $\Delta_{allowable}$ = 0.350 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8 w L}{3}$

W_{equil} = 1,018.1 lb/ft = 84.84 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 381.8 lb

$M_{maximum} = \frac{wL^2}{3}$ = 890.8 lb-ft = 10,690 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.350 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E = 1.1E+06 lb/in^2

I = 76.3 in^4

(Δ_{max}) = 0.096 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.096 inches < $\Delta_{allowable}$ = 0.350 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection.
Use minimum 6-inch x 6-inch Western Red Cedar rectangular columns/posts for the fence supports.
Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	4.00	ft =	48	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	12.00	ft^2		
Volume of Footing (V_{ftg}) =	12.00	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,800.00 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 327.2 lb

Uniform Load on Post = 381.8 lb

Load to Soil:

Point Load on Post + W_{ftg}=	2,127.2	lb /	12.00	ft^2 =	177.3	lb/ ft^2 < 2,000 lb/ft^2, ok
Uniform Load on Post + W_{ftg}=	2,181.8	lb /	12.00	ft^2 =	181.8	lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,800.0 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,800.00 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 327.24 lb + 1.2 (1800.00 lb) = 2,487.24 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 2,214.54 lb/ ft = 184.55 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2} = \frac{2,487.2 \text{ lb x } 7}{2}$ ft

$M_{maximum}$ = 8,705 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 36,170.8 lb ft = 434,050 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 8,705 lb ft = 104,464 lb-in (at fixed end at foundation)

Using the following design parameters:

where: $f_y =$	60	ksi	f_y = yield stress or strength of steel
$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
$p_{shear} =$	0.85		
$p_{flexure} =$	0.90		
unit width (w) =	1.0	ft	
footing thickness/depth (d_{ftg})	1.00	ft	

Coefficient of Resistance (Ru)= $M_u / [p_{flexure} (w) (d_{ftg})^2]$= 67.2 psi

$p_{balanced} = (0.85)^2 (f_c' / f_y) [87,000/(87,000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c' / f_y) [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200 / f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85 f_c') =$ 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u / (p_{flexure}) (R_u) =$ 20.03 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d = 9.54 in Use d = 9.50 in

b = 5.30 in Use b = 5.25 in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised} = M_u / (p_{flexure} bd^2) =$ 244.97 psi

$p_{revised} = p_{approx} (R_{u\ revised} / R_u) =$ 0.004566

$A_{steel\ required} = p_{revised} bd =$ 0.23 in^2

Use minimum #4 bars @ 10 inches O/C +/-, Area$_{steel\ provided}$ = 0.24 in^2 ,
or use #5 bars @ 12 inches O/C +/-, Area $_{steel\ provided}$ = 0.31 in^2.

Dog Play Fence
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Wire Mesh	47.08	0.00	4.00	0.00	9.89	2.00	19.78	
2 - Steel Rails	6.32	94.68	4.00	378.71	36.40	2.00	72.80	
3 - Post	3.00	44.95	4.00	179.78	40.25	2.00	80.50	
4 - Concrete Foundation	--	0	--	--	1800.00	2.00	3600.00	
6 - Push/Lean	--	200.00	7.00	1400.00	0	--	--	
7- Passive Rankine		0	--	--	318.08	0.500	159.04	
Total				**1958.50**			**3932.12**	**2.01** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Wire Mesh	47.08	0.00	9.89
2 - Steel Rails	6.32	94.68	36.40
3 - Post	3.00	44.95	40.25
4 - Concrete Foundation	--	0	1800.00
6 - Push/Lean	--	200.00	0
Total		**339.62**	**1886.54**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 $kPa = kN/m^2$

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**339.62**	**753.63**	**2.22** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	$kPa = kN/m^2$
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1886.54	lb
Effective length of Foundation (L') = L - 2e =	1.92	ft
Effective Width of Foundation (B') =	3.00	ft
Moment (M) =	1958.50	lb-ft
Eccentricity (e) = M/Q =	1.04	ft
q_{max} =	1005.61	lb/ft^2
q_{max} =	**6.98**	**psi**

ART INSTALLATION

Art Installation
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\, k_z\, k_{zt}\, k_d\, V^2\, I$ (lb/ft^2)

where:	q_z =	velocity pressure at height z. Height (z) =	10	ft
	k_d =	wind directional factor, Table 6-4, where K_d =	0.85	for solid sign
	k_z =	velocity pressure exposure coefficient, Table 6-3,		
		for heights of 0 ft to 15 ft, Exposure C, K_h =	0.85	
		for heights of 16 ft to 20 ft, Exposure C, K_h =	0.90	
		Use k_h =	0.85	
	k_{zt} =	topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} =	1.0	
	V =	basic wind speed, from Figure 6-1, where V =	90	mph, for Exposure C (3 second wind gust)
		Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.		
		Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.		
	I =	importance factor Use I =	1.0	

$q_z = 0.00256\, k_z\, k_{zt}\, k_d\, V^2\, I$

q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 10 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1 - Bird Sculpture			12
2 - Post	10	0.33	3.33

A = 15.33 ft^2

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

F = 14.982 lb/ft^2 x 15.33 ft^2 = 229.72 lb (acting at end of post)

w = $\frac{229.72 \text{ lb}}{10 \text{ ft}}$ = 22.97 lb/ft (acting over surface of sign)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\, G\, C_p - q_i\, (G\, C_{pi})$ (lb/ft^2)

where: $q = q_z$ for windward walls at heigth z above the ground.

$q = q_h$ for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.

$q_i = q_z = q_h$ = 1.0

G = gust effect factor, Use G = 0.85

C_p = external pressure coefficient. From Figure 6-6,

C_p = 0.80 (windward); Cp = -0.50 (leeward)

$(G\, C_{pi})$ = internal pressure coefficient. From Figure 6-5,

Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\, G\, C_p - q_i\, (G\, C_{pi})$ = 0.130 lb/ft^2

$p_{leeward} = q\, G\, C_p - q_i\, (G\, C_{pi})$ = 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 229.72 lb

Uniform Weight/ Post @ Sign = $\frac{229.72 \text{ lb}}{10 \text{ ft}}$ = 22.97 lb/ ft

Dead Loads:

Section	Material	Volume (ft^3)	Density (lb/f	Weight (lb)
1 - Bird Sculpture	1/2" Galvanized Steel Panel	0.500	487.30	243.65
Total				243.65

Sign Weight (W_{sign}), Galvanized steel sculpture weight = 243.65 lb

Wt_{sign}/ft^2 = $\frac{243.7 \text{ lb}}{15.3 \text{ ft}^2}$ = 15.89 lb/ft^2

Uniform Weight @ Sign = $\frac{243.65 \text{ lb}}{10 \text{ ft}}$ = 24.37 lb/ ft

Number of Posts = 1

Post Length = 11 ft

Sign Weight/ Post ($W_{sign/post}$) = 243.65 lb

Uniform Weight/ Post @ Sign = $\frac{243.65 \text{ lb}}{10 \text{ ft}}$ = 24.37 lb/ ft

Section	Material	Length (ft)	Unit Weight	Weight (lb)
3 - Post	4" Dia., 1/4" t	11.00	10.81	118.90

Post Weight (Wt_{post}), 4" Galvanized Steel Pole = 118.90 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 11.89 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\, W_{per\ post} + 1.2\, (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 229.72 lb + 1.2 x (244 lb + 118.90 lb)

P = 802.62 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\, W + 1.2\, (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 22.97 lb/ft + 1.2 x (24.37 lb/ft + 11.89 lb/ft)

w = 80.26 lb/ ft = 6.69 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 80.26 lb/ ft x $\frac{10 \text{ ft}}{11 \text{ ft}}$ = 72.97 lb/ ft = 6.08 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 3,210.5 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 802.6 lb

$M_{maximum} = \frac{PL}{2}$ = 802.6 lb x $\frac{11}{2}$ ft

$M_{maximum}$ = 4,414 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.550 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 2.9E+07 lb/in^2

I = 201.1 in^4

(Δ_{max}) = 0.002 inches (at deflected end)

(Δ_{max}) = 0.002 inches < $\Delta_{allowable}$ = 0.550 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8\,w\,L}{3}$

W_{equil} = 2,354.3 lb/ft = 196.20 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 882.9 lb

$M_{maximum} = \frac{wL^2}{3}$ = 3,237.2 lb-ft = 38,847 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.550 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E = 2.9E+07 lb/in^2

I = 201.1 in^4

(Δ_{max}) = 0.013 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.013 inches < $\Delta_{allowable}$ = 0.550 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection.
Use minimum 4-inch diameter Galvanized Steel posts with 1/4-inch thickness for the supports.
Use 3/8-inch square base plate with 3/8-inch diameter, 6-inch length anchor bolts.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	5.25	ft =	63	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	15.75	ft^2		
Volume of Footing (V_{ftg}) =	15.75	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 2,362.50 lb

Soil Bearing Capacity = 2,000 $lb/\ ft^2$

Load to Foundation:

Point Load on Post = 802.6 lb

Uniform Load on Post = 882.9 lb

Load to Soil:

Point Load on Post + W_{ftg}=	3,165.1	lb /	15.75	ft^2 =	201.0	$lb/\ ft^2 < 2{,}000\ lb/ft^2$, ok
Uniform Load on Post + W_{ftg}=	3,245.4	lb /	15.75	ft^2 =	206.1	$lb/\ ft^2 < 2{,}000\ lb/ft^2$, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 $lb/\ ft^3$

W_{ftg} = 2,362.5 lb

$W_{ftg/\ thickness\ of\ footing}$ = 2,362.50 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads
to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 802.62 lb + 1.2 (2362.50 lb) = 3,637.62 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 2,915.26 lb/ ft = 242.94 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 3,637.6 lb x $\frac{11}{2}$ ft

$M_{maximum}$ = 20,007 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 117,582.2 lb ft = 1,410,987 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 20,007 lb ft = 240,083 lb-in (at fixed end at foundation)

Using the following design parameters:

where:	f_y =	60	ksi	f_y = yield stress or strength of steel
	$f_{c'}$ =	3,000	psi	f_c = compressive stress or strength of concrete
	p_{shear} =	0.85		
	$p_{flexure}$=	0.90		
	unit width (w) =	1.0	ft	
	footing thickness/depth (	1.00	ft	

Coefficient of Resistance (Ru)= M_u /[$p_{flexure}$ (w) $(d_{ftg})^2$]= 154.4 psi

$p_{balanced} = (0.85)^2(f_c'/f_y)$ [87,000/(87,000+f_y)] = 0.02138

$p_{maximum} = 0.85(f_c'/f_y)$ [1-(1-(2R_u/(0.85f_c'))$^{1/2}$] = 0.01604

$p_{minimum} = 200/f_y$ = 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate}$ = 0.00900

$m = f_y / (0.85 f_c')$ = 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2]$ = 482.82 psi

$bd^2 = M_u / (p_{flexure}) (R_u)$ = 46.04 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

bd^2 = 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure} bd^2)$= 563.00 psi

$p_{revised} = p_{approx} (R_{u\ revised}/R_u)$= 0.010495

$A_{steel\ required} = p_{revised} bd$ = 0.52 in^2

Use minimum #5 bars @ 6 inches O/C +/-, Area$_{steel\ provided}$ = 0.61 in^2 ,

or use #6 bars @ 10 inches O/C +/-, Area$_{steel\ provided}$ = 0.53 in^2 ,

Art Installation
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Bird Sculpture	12.00	179.78	11.00	1977.59	243.65	2.63	639.58	
3 - Post	3.33	49.94	6.00	299.64	118.90	2.63	312.13	
4 - Concrete Foundation	--	0	--	--	2362.50	2.63	6201.56	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine		0	--	--	318.08	0.500	159.04	
Total				**3477.23**			**7312.31**	**2.10** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Bird Sculpture	12.00	0	--	--	243.65	1.50	365.48	
3 - Post	3.33	49.94	6.00	299.64	118.90	1.50	178.36	
4 - Concrete Foundation	15.75	0	--	--	2362.50	1.50	3543.75	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	556.65	0.500	278.32	
Total				**1499.64**			**4365.91**	**2.91** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Bird Sculpture	12.00	179.78	243.65
3 - Post	3.33	49.94	118.90
4 - Concrete Foundation	--	0	2362.50
6 - Push/Lean	--	200.00	0
Total		**429.72**	**2725.05**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$)=	13	degrees
Adhesion between soil and foundation base (c'_a)=	0	kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**429.72**	**947.21**	**2.20** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	2725.05	lb
Effective length of Foundation (L') = L - 2e =	2.70	ft
Effective Width of Foundation (B') =	3.00	ft
Moment (M) =	3477.23	lb-ft
Eccentricity (e) = M/Q =	1.28	ft
q_{max} =	1195.91	lb/ft^2
q_{max} =	**8.30**	**psi**

BUTTERFLY BOX

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Butterfly Box
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft²)

where:	q_z =	velocity pressure at height z. Height (z) =	5	ft
	k_d =	wind directional factor, Table 6-4, where K_d =	0.85	for solid sign
	k_z =	velocity pressure exposure coefficient, Table 6-3,		
		for heights of 0 ft to 15 ft, Exposure C, K_h =	0.85	
		for heights of 16 ft to 20 ft, Exposure C, K_h =	0.90	
		Use k_h =	0.85	
	k_{zt} =	topographic factor, where $K_{st} = (1 + K_1\ K_2\ K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} =	1.0	
	V =	basic wind speed, from Figure 6-1, where V =	90	mph, for Exposure C (3 second wind gust)

Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.

Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.

I = importance factor Use I = 1.0

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$

q_z = 14.98176 lb/ft²

Determine area of sign:

where: h = overall height = 5 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft²)
1 -Butterfly E	2.00	0.50	1.00
2 -			
3 - Post	3.00	0.125	0.38

A = 1.38 ft²

Determine Wind Force on the Sign:

F = P x A = q_z x A

F =	14.982	lb/ft² x	1.38	ft² =	20.60 lb	(acting at end of post)
w =	20.60 / 5	lb / ft =	4.12	lb/ft		(acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft²)

where:	$q = q_z$	for windward walls at heigth z above the ground.	
	$q = q_h$	for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.	
	$q_i = q_z = q_h$ =	1.0	
	G =	gust effect factor, Use G = 0.85	
	C_p =	external pressure coefficient. From Figure 6-6, C_p = 0.80 (windward); Cp = -0.50 (leeward)	
	$(G\ C_{pi})$ =	internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed	

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (\ G\ C_{pi}\ ) =$ 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (\ G\ C_{pi}\ ) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 20.60 lb

Uniform Weight/ Post @ Sign = 20.60 lb / 5 ft = 4.12 lb/ ft

Dead Loads:

Section	Material	Area (ft2)	Unit Weight (	Weight (lb)
1 - Butterfly Box	Wood			3.50
				0.00
Total				3.50

Sign Weight (W_{sign}), 3.50 lb

Wt_{sign}/ft^2 = 3.5 lb / 1.4 ft^2 = 2.55 lb/ft^2

Uniform Weight @ Sign = 3.50 lb / 5 ft = 0.70 lb/ ft

Number of Posts = 1

Post Length = 4.00 ft

Sign Weight/ Post ($W_{sign/post}$) = 3.50 lb

Uniform Weight/ Post @ Sign = 3.50 lb / 5 ft = 0.70 lb/ ft

Section	Material	Volume (ft3)	Density (lb/ft3	Weight
3 - Post	1.5" O.D. Galvanized Steel	0.05	487.30	23.92

Post Weight (Wt_{post}) = 23.92 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 4.78 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 20.60 lb + 1.2 x (4 lb + 23.92 lb)

P = 65.86 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 4.12 lb/ft + 1.2 x (0.70 lb/ft + 4.78 lb/ft)

w = 13.17 lb/ ft = 1.10 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 13.17 lb/ ft x 5.0 ft / 4.0 ft = 16.47 lb/ ft = 1.37 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 263.5 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 65.9 lb

$M_{maximum} = \frac{PL}{2}$ = 65.9 lb x $\frac{4}{2}$ ft

$M_{maximum}$ = 132 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.200 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E =	2.9E+07	lb/in^2	Y = Young's Modulus/M
I =	0.2	in^4	I = Area Moment of Iner

(Δ_{max}) = 0.009 inches (at deflected end)

(Δ_{max}) = 0.009 inches < $\Delta_{allowable}$ = 0.200 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8\,w\,L}{3}$

W_{equil} = 140.5 lb/ft = 11.71 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 52.7 lb

$M_{maximum} = \frac{wL^2}{3}$ = 70.3 lb-ft = 843 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.200 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E =	2.9E+07	lb/in^2
I =	0.2	in^4

(Δ_{max}) = 0.052 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.052 inches < $\Delta_{allowable}$ = 0.200 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 1.5-inch diameter galvanized steel columns/posts for the supports. Use 3/8-inch square base plate with 3/8-inch diameter, 6-inch length anchor bolts.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.25	ft =	39	inches
Length of Footing =	3.25	ft =	39	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	10.56	ft^2		
Volume of Footing (V_{ftg}) =	10.56	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,584.38 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 65.9 lb

Uniform Load on Post = 52.7 lb

Load to Soil:

Point Load on Post + W_{ftg}=	1,650.2	lb /	10.56	ft^2 =	156.2	lb/ ft^2 < 2,000 lb/ft^2, ok
Uniform Load on Post + W_{ftg}=	1,637.1	lb /	10.56	ft^2 =	155.0	lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,584.4 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,584.38 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 W $_{per\ post}$ + 1.2 (Wt $_{sign/post}$ + Wt $_{post@\ sign}$ + W_{ftg})

P = 65.86 lb + 1.2 (1584.38 lb) = 1,967.11 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 (Wt $_{sign/post}$ + Wt $_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 1,914.42 lb/ ft = 159.54 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 1,967.1 $\frac{\text{lb x } 4}{2}$ ft

$M_{maximum}$ = 3,934 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 10,210.3 lb ft = 122,523 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 3,934 lb ft = 47,211 lb-in (at fixed end at foundation)

Using the following design parameters:

where: $f_y =$	60	ksi	f_y = yield stress or strength of steel
$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
$p_{shear} =$	0.85		
$p_{flexure} =$	0.90		
unit width (w) =	1.0	ft	
footing thickness/depth (d_{ftg}) =	1.00	ft	

Coefficient of Resistance (Ru)= M_u /[$p_{flexure}$ (w) (d_{ftg})^2]= 30.4 psi

$p_{balanced} = (0.85)^2(f_c'/ f_y)\ [87{,}000/(87{,}000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c'/ f_y)\ [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85f_c') =$ 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u/ (p_{flexure}) (R_u) =$ 9.05 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure} bd^2) =$ 110.71 psi

$p_{revised} = p_{approx} (R_{u\ revised}/R_u) =$ 0.002064

$A_{steel\ required} = p_{revised} bd =$ 0.10 in^2

Use minimum #4 bars @ 12 inches O/C +/-, Area $_{steel\ provided}$ = 0.20 in^2.
or use #5 bars @ 12 inches O/C +/-, Area$_{steel\ provided}$ = 0.31 in^2 ,

Butterfly Box
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Butterfly Box	1.00	14.98	5.00	74.91	3.50	1.63	5.69	
3 - Post	0.38	5.62	2.50	14.05	23.92	1.63	38.87	
4 - Concrete Foundation	--	0	--	--	1584.38	1.63	2574.61	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine		0	--	--	344.59	0.500	172.30	
Total				**1288.95**			**2791.46**	**2.17** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Butterfly Box	1.00	14.98	5.00	74.91	3.50	1.63	5.69	
3 - Post	0.38	5.62	2.50	14.05	23.92	1.63	38.87	
4 - Concrete Foundation	--	0	--	--	1584.38	1.63	2574.61	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	344.59	0.500	172.30	
Total				**1288.95**			**2791.46**	**2.17** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Butterfly Box	1.00	14.98	3.50
3 - Post	0.38	5.62	23.92
4 - Concrete Foundation	--	0	1584.38
6 - Push/Lean	--	200.00	0
Total		**220.60**	**1611.80**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (
$\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 $kPa = kN/m^2$

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**220.60**	**716.70**	**3.25** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	$kPa = kN/m^2$
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1611.80	lb
Effective length of Foundation (L') = L - 2e =	1.65	ft
Effective Width of Foundation (B') =	3.25	ft
Moment (M) =	1288.95	lb-ft
Eccentricity (e) = M/Q =	0.80	ft
q_{max} =	744.05	lb/ft^2
q_{max} =	**5.17**	**psi**

MAGNIFYING LENS POST

Magnifying Lens Post
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft²)

where:	q_z =	velocity pressure at height z. Height (z) =	3	ft
	k_d =	wind directional factor, Table 6-4, where K_d =	0.85	for solid sign
	k_z =	velocity pressure exposure coefficient, Table 6-3,		
		for heights of 0 ft to 15 ft, Exposure C, K_h =	0.85	
		for heights of 16 ft to 20 ft, Exposure C, K_h =	0.90	
		Use k_h =	0.85	
	k_{zt} =	topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} =	1.0	
	V =	basic wind speed, from Figure 6-1, where V =	90	mph, for Exposure C (3 second wind gust)
		Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.		
		Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.		
	I =	importance factor Use I =	1.0	

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$

q_z = 14.98176 lb/ft²

Determine area of sign:

where: h = overall height = 4.5 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft²)
1 -			0.00
2 -			
3 - Post	3.00	0.500	1.50

A = 1.50 ft²

Determine Wind Force on the Sign:

F = P x A = q_z x A

F =	14.982	lb/ft² x	1.50	ft² =	22.47	lb	(acting at end of post)
w =	22.47 / 5	lb / ft =	4.99	lb/ft			(acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft²)

where:	$q = q_z$	for windward walls at heigth z above the ground.
	$q = q_h$	for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.
	$q_i = q_z = q_h$ =	1.0
	G =	gust effect factor, Use G = 0.85
	C_p =	external pressure coefficient. From Figure 6-6, C_p = 0.80 (windward); Cp = -0.50 (leeward)
	$(G\ C_{pi})$ =	internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (\ G\ C_{pi}\ ) =$ 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (\ G\ C_{pi}\ ) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 22.47 lb

Uniform Weight/ Post @ Sign = 22.47 lb / 4.5 ft = 4.99 lb/ ft

Dead Loads:

Number of Posts = 1

Post Length = 4.00 ft

Section	Material	Volume (ft3)	Density (lb/ft3	Weight
Post	Western Red Cedar	1.00	23	23.00

Post Weight (Wt_{post}) - 8" x 8" Western Red Cedar = 23.00 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 5.11 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 22.47 lb + 1.2 x (0 lb + 23.00 lb)

P = 63.56 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 4.99 lb/ft + 1.2 x (0.00 lb/ft + 5.11 lb/ft)

w = 14.12 lb/ ft = 1.18 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 14.12 lb/ ft x 4.5 ft / 4.0 ft = 15.89 lb/ ft = 1.32 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 254.2 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 63.6 lb

$M_{maximum} = \frac{PL}{2}$ = 63.6 lb x $\frac{4}{2}$ ft

$M_{maximum}$ = 127 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.200 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 1.1E+06 lb/in^2

I = 76.3 in^4

(Δ_{max}) = 0.0006 inches (at deflected end)

(Δ_{max}) = 0.0006 inches < $\Delta_{allowable}$ = 0.200 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8\,w\,L}{3}$

W_{equil} = 150.7 lb/ft = 12.55 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 56.5 lb

$M_{maximum} = \frac{wL^2}{3}$ = 75.3 lb-ft = 904 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.200 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E = 1.1E+06 lb/in^2

I = 76.3 in^4

(Δ_{max}) = 0.003 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.003 inches < $\Delta_{allowable}$ = 0.200 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection.
Use minimum 6-inch x 6-inch Western Red Cedar rectangular columns/posts for the sign supports.
Use Simpson Strong-Tie Post Base Model MPB66Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	2.75	ft =	33	inches
Length of Footing =	2.75	ft =	33	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	7.56	ft^2		
Volume of Footing (V_{ftg}) =	7.56	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,134.38 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 63.6 lb

Uniform Load on Post = 56.5 lb

Load to Soil:

Point Load on Post + W_{ftg}=	1,197.9	lb /	7.56	ft^2 =	158.4	lb/ ft^2 < 2,000 lb/ft^2, ok
Uniform Load on Post + W_{ftg}=	1,190.9	lb /	7.56	ft^2 =	157.5	lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,134.4 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,134.38 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 63.56 lb + 1.2 (1134.38 lb) = 1,424.81 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 1,375.37 lb/ ft = 114.61 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2} = \frac{1{,}424.8 \text{ lb x } 4 \text{ ft}}{2}$

$M_{maximum}$ = 2,850 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 7,335.3 lb ft = 88,024 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 2,850 lb ft = 34,195 lb-in (at fixed end at foundation)

Using the following design parameters:

where:	$f_y =$	60	ksi
	$f_{c'} =$	3,000	psi
	$p_{shear} =$	0.85	
	$p_{flexure} =$	0.90	
	unit width (w) =	1.0	ft
	footing thickness/depth (d_{ftg}	1.00	ft

f_y = yield stress or strength of steel

f_c = compressive stress or strength of concrete

Coefficient of Resistance (Ru)= $M_u /[p_{flexure} (w) (d_{ftg})^2]$= 22.0 psi

$p_{balanced} = (0.85)^2(f_c^{'} / f_y)$ [87,000/(87,000+f_y)] = 0.02138

$p_{maximum} = 0.85(f_c^{'} / f_y)$ [1-(1-(2R_u/(0.85$f_c^{'}$))$^{1/2}$] = 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate}$ = 0.00900

$m = f_y / (0.85 f_c^{'})$ = 23.53

$R_u = p_{approx} f_y[1 - (p_{approx})(m) / 2]$ = 482.82 psi

$bd^2 = M_u/ (p_{flexure}) (R_u)$ = 6.56 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

bd^2 = 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure} bd^2)$= 80.19 psi

$p_{revised} = p_{approx} (R_{u\ revised}/R_u)$= 0.001495

$A_{steel\ required} = p_{revised} bd$ = 0.07 in^2

Use minimum #4 bars @ 12 inches O/C +/-, $Area_{steel\ provided}$ = 0.20 in^2 ,
or use #5 bars @ 12 inches O/C +/-, $Area_{steel\ provided}$ = 0.31 in^2 ,

Magnifying Lens Post
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	**Area (ft^2)**	**Overturning Force (lb)**	**Overturning Moment Arm (ft)**	**Overturning Moment (lb-ft)**	**Stabilizing Force (lb)**	**Stabilizing Moment Arm (ft)**	**Stabilizing Moment (lb-ft)**	**Factor of Safety (must be > 2)**
1 - Post	1.50	22.47	2.50	56.18	23.00	1.38	31.63	
2 - Concrete Foundation	--	0	--	--	1134.38	1.38	1559.77	
3 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
4- Passive Rankine		0	--	--	291.58	0.500	145.79	
Total				**856.18**			**1737.18**	**2.03** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	**Area (ft^2)**	**Overturning Force (lb)**	**Overturning Moment Arm (ft)**	**Overturning Moment (lb-ft)**	**Stabilizing Force (lb)**	**Stabilizing Moment Arm (ft)**	**Stabilizing Moment (lb-ft)**	**Factor of Safety (must be > 2)**
1 - Post	1.50	22.47	2.50	56.18	23.00	1.38	31.63	
2 - Concrete Foundation	--	0	--	--	1134.38	1.38	1559.77	
3 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
4- Passive Rankine	--	0	--	--	291.58	0.500	145.79	
Total				**856.18**			**1737.18**	**2.03** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	**Area (ft^2)**	**Driving Horizontal Force (lb)**	**Resisting Vertical Force (lb)**
1 - Post	1.50	22.47	23.00
2 - Concrete Foundation	--	0	1134.38
3 - Push/Lean	--	200.00	0
Total		**222.47**	**1157.38**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (
$\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	**Resisting Force (lb)**	**Factor of Safety (must be >1.5)**
Total Horizontal Force	**222.47**	**558.78**	**2.51** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1157.38	lb
Effective length of Foundation (L') = L - 2e =	1.27	ft
Effective Width of Foundation (B') =	2.75	ft
Moment (M) =	856.18	lb-ft
Eccentricity (e) = M/Q =	0.74	ft
q_{max} =	865.93	lb/ft^2
q_{max} =	**6.01**	**psi**

TRASH RECEPTACLE

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Trash Receptacle
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft^2)

where:
- q_z = velocity pressure at height z. Height (z) = 4.17 ft
- k_d = wind directional factor, Table 6-4, where K_d = 0.85 for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3,
  for heights of 0 ft to 15 ft, Exposure C, K_h = 0.85
  for heights of 16 ft to 20 ft, Exposure C, K_h = 0.90
  Use k_h = 0.85
- k_{zt} = topographic factor, where $K_{st} = (1 + K_1\ K_2\ K_3)^2$
  and $K_{1,}$ $K_{2\ and}$ K_3 are given in Figure 6-4.
  Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} = 1.0
- V = basic wind speed, from Figure 6-1, where V = 90 mph, for Exposure C (3 second wind gust)

  Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.
  Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.
- I = importance factor Use I = 1.0

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$
q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 4.1667 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
2 - Receptacle	3.5	1.58	5.54

A = 5.54 ft^2

Determine Wind Force on the Sign:
F = P x A = q_z x A

F = 14.982 lb/ft^2 x 5.54 ft^2 = 83.02 lb (acting at end of post)

w = 83.02 lb / 4 ft = 19.93 lb/ft (acting over surface of sign)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft^2)

where:
- $q = q_z$ for windward walls at heigth z above the ground.
- $q = q_h$ for leeward walls, where sides are at heigth h above the ground.
  Neglect q_h for the sign.
- $q_i = q_z = q_h$ = 1.0
- G = gust effect factor, Use G = 0.85
- C_p = external pressure coefficient. From Figure 6-6,
  C_p = 0.80 (windward); Cp = -0.50 (leeward)
- $(G\ C_{pi})$ = internal pressure coefficient. From Figure 6-5,
  Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward}$ = q G C_p - q_i (G C_{pi}) = 0.130 lb/ft^2

$p_{leeward}$ = q G C_p - q_i (G C_{pi}) = 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 83.02 lb

Uniform Weight/ Post @ Sign = $\frac{83.02 \text{ lb}}{4.1667 \text{ ft}}$ = 19.93 lb/ ft

Dead Loads:

Number of Receptacles/Pos	1	
Post Length =	4.167	ft

Section	Material	Weight (lb)
Receptacle/P	Recycled Solid Steel Bar	120.00

Post Weight (Wt_{post}), 4" Galvanized Steel Pole = 120.00 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 28.80 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$)

P = 1.6 x 83.02 lb + 1.2 x (0 lb + 120.00 lb)

P = 276.84 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$)

w = 1.6 x 19.93 lb/ft + 1.2 x (0.00 lb/ft + 28.80 lb/ft)

w = 66.44 lb/ ft = 5.54 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 66.44 lb/ ft x $\frac{4 \text{ ft}}{4 \text{ ft}}$ = 66.44 lb/ ft = 5.54 lb/ in

Note:

Surface mount according to manufacturer specifications.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	3.00	ft =	36	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	9.00	ft^2		
Volume of Footing (V_{ftg}) =	9.00	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,350.00 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 276.8 lb

Uniform Load on Post = 276.8 lb

Load to Soil:

Point Load on Post + W_{ftg}=	1,626.8	lb /	9.00	ft^2 =	180.8	lb/ ft^2 < 2,000 lb/ft^2, ok
Uniform Load on Post + W_{ftg}=	1,626.8	lb /	9.00	ft^2 =	180.8	lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,350.0 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,350.00 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads
to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 276.84 lb + 1.2 (1350.00 lb) = 1,896.84 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 1,686.44 lb/ ft = 140.54 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = $\frac{1{,}896.8 \text{ lb x } 4.166667}{2}$ ft

$M_{maximum}$ = 3,952 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 9,759.5 lb ft = 117,114 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 3,952 lb ft = 47,421 lb-in (at fixed end at foundation)

Using the following design parameters:

where:	$f_y =$	60	ksi	f_y = yield stress or strength of steel
	$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
	$p_{shear} =$	0.85		
	$p_{flexure} =$	0.90		
	unit width (w) =	1.0	ft	
	footing thickness/depth (	1.00	ft	

Coefficient of Resistance (Ru)= $M_u /[p_{flexure}\ (w)\ (d_{ftg}\ )^2]$= 30.5 psi

$p_{balanced} = (0.85)^2(f_c'/ f_y)\ [87{,}000/(87{,}000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c'/ f_y)\ [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85f_c') =$ 23.53

$R_u = p_{approx}f_y[1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u/ (p_{flexure}) (R_u) =$ 9.09 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure}bd^2) =$ 111.20 psi

$p_{revised} = p_{approx}\ (R_{u\ revised}/R_u) =$ 0.002073

$A_{steel\ required} = p_{revised}bd =$ 0.10 in^2

Use minimum #4 bars @ 12 inches O/C +/-, $Area_{steel\ provided} = 0.20\ in^2$,
or use #5 bars @ 12 inches O/C +/-, $Area_{steel\ provided} = 0.31\ in^2$,

Trash Receptacle
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Receptacle	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Receptacle/Post	5.54	83.02	2.75	228.32	120.00	1.50	180.00	
2 - Concrete Foundation	--	0	--	--	1350.00	1.50	2025.00	
3 - Push/Lean	--	200.00	4.50	900.00	0	--	--	
4- Passive Rankine		0	--	--	318.08	0.500	159.04	
Total				**1128.32**			**2364.04**	**2.10** acceptable

Overturning

Section from Front - Wind Force on Side of Receptacle	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Receptacle/Post	5.54	83.02	2.75	228.32	120.00	1.50	180.00	
2 - Concrete Foundation	9.00	0	--	--	1350.00	1.50	2025.00	
3 - Push/Lean	--	200.00	4.50	900.00	0	--	--	
4- Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				**1128.32**			**2364.04**	**2.10** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Receptacle/Post	5.54	83.02	120.00
2 - Concrete Foundation	--	0	1350.00
3 - Push/Lean	--	200.00	0
Total		**283.02**	**1470.00**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (δ' = (1/2)ϕ'$_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_2) + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**283.02**	**657.46**	**2.32** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1470.00	lb
Effective length of Foundation (L') = L - 2e =	1.46	ft
Effective Width of Foundation (B') =	3.00	ft
Moment (M) =	1128.32	lb-ft
Eccentricity (e) = M/Q =	0.77	ft
q_{max} =	848.00	lb/ft^2
q_{max} =	**5.89**	**psi**

WOODEN GUARDRAIL

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Wooden Guardrail
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft^2)

where:	q_z =	velocity pressure at height z. Height (z) =	3	ft
	k_d =	wind directional factor, Table 6-4, where K_d =	0.85	for solid sign
	k_z =	velocity pressure exposure coefficient, Table 6-3,		
		for heights of 0 ft to 15 ft, Exposure C, K_h =	0.85	
		for heights of 16 ft to 20 ft, Exposure C, K_h =	0.90	
		Use k_h =	0.85	
	k_{zt} =	topographic factor, where $K_{st} = (1 + K_1\ K_2\ K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} =	1.0	
	V =	basic wind speed, from Figure 6-1, where V =	90	mph, for Exposure C (3 second wind gust)
		Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70. Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.		
	I =	importance factor Use I =	1.0	

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$

q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 6 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1 - Rail	0.50	8.00	4.00
2 - Post	3	0.6667	2.00

A = 6.00 ft^2

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

F = 14.982 lb/ft^2 x 6.00 ft^2 = 89.89 lb (acting at end of post)

w = 89.89 / 6 lb / ft = 14.98 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft^2)

where:	$q = q_z$	for windward walls at heigth z above the ground.		
	$q = q_h$	for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.		
	$q_i = q_z = q_h$ =	1.0		
	G =	gust effect factor, Use G =	0.85	
	C_p =	external pressure coefficient. From Figure 6-6, C_p = 0.80 (windward); Cp =	-0.50	(leeward)
	$(G\ C_{pi})$ =	internal pressure coefficient. From Figure 6-5, Use 0.55 and	-0.55	partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (G\ C_{pi}) =$ 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (G\ C_{pi}) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 89.89 lb

Uniform Weight/ Post @ Sign = 89.89 lb / 6 ft = 14.98 lb/ ft

Dead Loads:

Section	Material	Voume	Desnity (lb/ft:	Weight (lb)
1- Rail	Western Red Cedar	0.67	23	15.33
Total				15.33

Sign/Fencing Weight (W_{sign}), = 15.33 lb

Wt_{sign}/ft^2 = 15.3 lb / 6.0 ft^2 = 2.56 lb/ft^2

Uniform Weight @ Sign = 15.33 lb / 6 ft = 2.56 lb/ ft

Number of Posts = 1

Post Length = 4.00 ft

Sign Weight/ Post ($W_{sign/post}$) = 15.33 lb

Uniform Weight/ Post @ Sign = 15.33 lb / 6 ft = 2.56 lb/ ft

Section	Material	Volume (ft^3)	Density (lb/ft:	Weight
2 - Post	Western Red Cedar	1.78	23	40.89

Post Weight (Wt_{post}) - 6"x6"x7" Western Red Cedar Timber = 40.89 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 6.82 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 89.89 lb + 1.2 x (15 lb + 40.89 lb)

P = 211.30 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 14.98 lb/ft + 1.2 x (2.56 lb/ft + 6.82 lb/ft)

w = 35.22 lb/ ft = 2.93 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 35.22 lb/ ft x 6 ft / 4 ft = 52.82 lb/ ft = 4.40 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 845.2 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 211.3 lb

$M_{maximum} = \frac{PL}{2}$ = 211.3 lb x $\frac{4}{2}$ ft

$M_{maximum}$ = 423 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.200 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 1.1E+06 lb/in^2

I = 263.7 in^4

(Δ_{max}) = 0.001 inches (at deflected end)

(Δ_{max}) = 0.001 inches < $\Delta_{allowable}$ = 0.200 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8 w L}{3}$

W_{equil} = 375.6 lb/ft = 31.30 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 140.9 lb

$M_{maximum} = \frac{wL^2}{3}$ = 187.8 lb-ft = 2,254 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.200 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E = 1.1E+06 lb/in^2

I = 263.7 in^4

(Δ_{max}) = 0.003 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.003 inches < $\Delta_{allowable}$ = 0.200 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection.
Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the fence supports.
Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	3.00	ft =	36	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	9.00	ft^2		
Volume of Footing (V_{ftg}) =	9.00	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,350.00 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 211.3 lb

Uniform Load on Post = 140.9 lb

Load to Soil:

Point Load on Post + W_{ftg}=	1,561.3	lb /	9.00	ft^2 =	173.5	lb/ ft^2 < 2,000 lb/ft^2, ok
Uniform Load on Post + W_{ftg}=	1,490.9	lb /	9.00	ft^2 =	165.7	lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,350.0 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,350.00 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 211.30 lb + 1.2 (1350.00 lb) = 1,831.30 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 1,655.22 lb/ ft = 137.93 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 1,831.3 $\frac{\text{lb x } 4}{2}$ ft

$M_{maximum}$ = 3,663 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 8,827.8 lb ft = 105,934 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 3,663 lb ft = 43,951 lb-in (at fixed end at foundation)

Using the following design parameters:

where: $f_y =$	60	ksi	f_y = yield stress or strength of steel
$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
$p_{shear} =$	0.85		
$p_{flexure} =$	0.90		
unit width (w) =	1.0	ft	
footing thickness/depth (d_{ftg})	1.00	ft	

Coefficient of Resistance (Ru)= $M_u /[p_{flexure} (w) (d_{ftg})^2]=$ 28.3 psi

$p_{balanced} = (0.85)^2(f_c'/ f_y) [87,000/(87,000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c'/ f_y) [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85f_c') =$ 23.53

$R_u = p_{approx} f_y[1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u/ (p_{flexure}) (R_u) =$ 8.43 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d = 9.54 in Use d = 9.50 in

b = 5.30 in Use b = 5.25 in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure} bd^2) =$ 103.07 psi

$p_{revised} = p_{approx} (R_{u\ revised}/R_u) =$ 0.001921

$A_{steel\ required} = p_{revised} bd =$ 0.10 in^2

Use minimum #4 bars @ 12 inches O/C +/-, $Area_{steel\ provided} = 0.20\ in^2$,
or use #5 bars @ 12 inches O/C +/-, $Area_{steel\ provided} = 0.31\ in^2$.

Wooden Guardrail
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Rail	4.00	59.93	3.08	184.78	15.33	1.50	23.00	
2 - Post	2.00	29.97	2.50	74.91	40.89	1.50	61.34	
3 - Concrete Foundation	--	0	--	--	1350.00	1.50	2025.00	
4 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
5- Passive Rankine		0	--	--	318.08	0.500	159.04	
Total				**1059.69**			**2268.38**	**2.14** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Rail	4.00	59.93	15.33
2 - Post	2.00	29.97	40.89
3 - Concrete Foundation	--	0	1350.00
4 - Push/Lean	--	200.00	0
Total		**289.89**	**1406.23**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**289.89**	**642.74**	**2.22** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1406.23	lb
Effective length of Foundation (L') = L - 2e =	1.49	ft
Effective Width of Foundation (B') =	3.00	ft
Moment (M) =	1059.69	lb-ft
Eccentricity (e) = M/Q =	0.75	ft
q_{max} =	787.21	lb/ft^2
q_{max} =	**5.47**	**psi**

OWL NESTING BOX

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Owl Nesting Box
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft²)

where:	q_z =	velocity pressure at height z. Height (z) =	10.25	ft
	k_d =	wind directional factor, Table 6-4, where K_d =	0.85	for solid sign
	k_z =	velocity pressure exposure coefficient, Table 6-3,		
		for heights of 0 ft to 15 ft, Exposure C, K_h =	0.85	
		for heights of 16 ft to 20 ft, Exposure C, K_h =	0.90	
		Use k_h =	0.85	
	k_{zt} =	topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} =	1.0	
	V =	basic wind speed, from Figure 6-1, where V =	90	mph, for Exposure C (3 second wind gust)

Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.
Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.

I =	importance factor	Use I =	1.0

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$

q_z = 14.98176 lb/ft²

Determine area of sign:

where: h = overall height = 10.25 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft²)
1 -Owl Nesti	2.25	1.46	3.28
2 -			
3 - Post	8.00	0.250	2.00

A = 5.28 ft²

Determine Wind Force on the Sign:
F = P x A = q_z x A

F =	14.982	lb/ft² x	5.28	ft² =	79.12 lb	(acting at end of post)
w =	79.12 / 10	lb / ft =	7.72	lb/ft		(acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft²)

where:	$q = q_z$	for windward walls at heigth z above the ground.
	$q = q_h$	for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.
	$q_i = q_z = q_h$ =	1.0
	G =	gust effect factor, Use G = 0.85
	C_p =	external pressure coefficient. From Figure 6-6, C_p = 0.80 (windward); Cp = -0.50 (leeward)
	$(G\ C_{pi})$ =	internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\,G\,C_p - q_i\,(G\,C_{pi}) =$ 0.130 lb/ft^2

$p_{leeward} = q\,G\,C_p - q_i\,(G\,C_{pi}) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 79.12 lb

Uniform Weight/ Post @ Sign = 79.12 lb / 10.25 ft = 7.72 lb/ ft

Dead Loads:

Section	Material	Area (ft2)	Unit Weight (	Weight (lb)
1 - Owl Nest Plastic				12.00
2-				
				0.00
Total				12.00

Sign Weight (W_{sign}), 12.00 lb

Wt_{sign}/ft^2 = 12.0 lb / 5.3 ft^2 = 2.27 lb/ft^2

Uniform Weight @ Sign = 12.00 lb / 10.25 ft = 1.17 lb/ ft

Number of Posts = 1

Post Length = 9.00 ft

Sign Weight/ Post ($W_{sign/post}$) = 12.00 lb

Uniform Weight/ Post @ Sign = 12.00 lb / 10.25 ft = 1.17 lb/ ft

Section	Material	Length (ft)	Unit Weight (	Weight
3 - Post	1.5" O.D. Galvanized Steel	9.00	3.00	27.00

Post Weight (Wt_{post})= 27.00 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 2.63 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\,W_{per\ post} + 1.2\,(Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 79.12 lb + 1.2 x (12 lb + 27.00 lb)

P = 173.40 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\,W + 1.2\,(Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 7.72 lb/ft + 1.2 x (1.17 lb/ft + 2.63 lb/ft)

w = 16.92 lb/ ft = 1.41 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 16.92 lb/ ft x 10.3 ft / 9.0 ft = 19.27 lb/ ft = 1.61 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 693.6 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 173.4 lb

$M_{maximum} = \frac{PL}{2}$ = 173.4 lb x $\frac{9}{2}$ ft

$M_{maximum}$ = 780 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.450 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 2.9E+07 lb/in^2

I = 3.9 in^4

(Δ_{max}) = 0.013 inches (at deflected end)

(Δ_{max}) = 0.013 inches < $\Delta_{allowable}$ = 0.450 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 3-inch diameter galvanized steel columns/posts for the supports. Use 3/8-inch square base plate with 6-inch length anchor bolts.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.50	ft =	42	inches
Length of Footing =	3.75	ft =	45	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	13.13	ft^2		
Volume of Footing (V_{ftg}) =	13.13	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,968.75 lb

Soil Bearing Capacity = 2,000 lb/ft^2

Load to Foundation:

Point Load on Post = 173.4 lb

Uniform Load on Post = 152.3 lb

Load to Soil:

Point Load on Post + W_{ftg}=	2,142.1	lb /	13.13	ft^2 =	163.2	$lb/ft^2 < 2,000\ lb/ft^2$, ok
Uniform Load on Post + W_{ftg}=	2,121.0	lb /	13.13	ft^2 =	161.6	$lb/ft^2 < 2,000\ lb/ft^2$, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,968.8 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,968.75 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 173.40 lb + 1.2 (1968.75 lb) = 2,535.90 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 2,379.42 lb/ ft = 198.28 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 2,535.9 lb x 9 ft / 2

$M_{maximum}$ = 11,412 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 64,244.3 lb ft = 770,931 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 11,412 lb ft = 136,938 lb-in (at fixed end at foundation)

Using the following design parameters:

where:	$f_y =$	60	ksi
	$f_{c'} =$	3,000	psi
	$p_{shear} =$	0.85	
	$p_{flexure} =$	0.90	
	unit width (w) =	1.0	ft
	footing thickness/depth (d_{ftg}) =	1.00	ft

f_y = yield stress or strength of steel

f_c = compressive stress or strength of concrete

Coefficient of Resistance (Ru)= $M_u / [p_{flexure} (w) (d_{ftg})^2] =$ 88.1 psi

$p_{balanced} = (0.85)^2 (f_c' / f_y) [87{,}000/(87{,}000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c' / f_y) [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85 f_c') =$ 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u / (p_{flexure}) (R_u) =$ 26.26 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\,revised} = M_u / (p_{flexure} bd^2) =$ 321.13 psi

$p_{revised} = p_{approx} (R_{u\,revised} / R_u) =$ 0.005986

$A_{steel\,required} = p_{revised} bd =$ 0.30 in^2

Use minimum #4 bars @ 6 inches O/C +/-, Area $_{steel\,provided}$ = 0.39 in^2.
Or use #5 bars @ 10 inches O/C +/-, Area$_{steel\,provided}$ = 0.37 in^2 ,

Owl Nesting Box
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Owl Nesting Box	3.28	49.16	10.17	499.80	12.00	1.88	22.50	
3 - Post	1.00	14.98	5.00	74.91	47.84	1.88	89.70	
4 - Concrete Foundation	--	0	--	--	1968.75	1.88	3691.41	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine		0	--	--	371.10	0.500	185.55	
Total				**1774.71**			**3989.16**	**2.25** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Owl Nesting Box	3.28	49.16	10.17	499.80	12.00	1.75	21.00	
3 - Post	1.00	14.98	5.00	74.91	47.84	1.75	83.72	
4 - Concrete Foundation	--	0	--	--	1968.75	1.75	3445.31	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	397.61	0.500	198.80	
Total				**1774.71**			**3748.84**	**2.11** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Owl Nesting Box	3.28	49.16	12.00
3 - Post	1.00	14.98	47.84
4 - Concrete Foundation	--	0	1968.75
6 - Push/Lean	--	200.00	0
Total		**264.14**	**2028.59**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**264.14**	**839.44**	**3.18** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	2028.59	lb
Effective length of Foundation (L') = L - 2e =	2.00	ft
Effective Width of Foundation (B') =	3.50	ft
Moment (M) =	1774.71	lb-ft
Eccentricity (e) = M/Q =	0.87	ft
q_{max} =	724.31	lb/ft^2
q_{max} =	**5.03**	**psi**

DISC GOLF TARGET BASKET

Disc Golf Target Basket
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft^2)

where:

q_z = velocity pressure at height z. Height (z) = 4.2 ft

k_d = wind directional factor, Table 6-4, where K_d = 0.85 for solid sign

k_z = velocity pressure exposure coefficient, Table 6-3,
for heights of 0 ft to 15 ft, Exposure C, K_h = 0.85
for heights of 16 ft to 20 ft, Exposure C, K_h = 0.90
Use k_h = 0.85

k_{zt} = topographic factor, where $K_{st} = (1 + K_1\ K_2\ K_3)^2$
and K_1, K_2 and K_3 are given in Figure 6-4.
Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} = 1.0

V = basic wind speed, from Figure 6-1, where V = 90 mph, for Exposure C (3 second wind gust)

Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.
Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.

I = importance factor Use I = 1.0

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$

q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 4.2 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1- Disc Golf	3	2	6
2-			
3 - Post	2	0.167	0.333

A = 6.33 ft^2

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

F = 14.982 lb/ft^2 x 6.33 ft^2 = 94.88 lb (acting at end of post)

w = $\frac{94.88\ lb}{4\ ft}$ = 22.77 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft^2)

where:

$q = q_z$ for windward walls at heigth z above the ground.

$q = q_h$ for leeward walls, where sides are at heigth h above the ground.
Neglect q_h for the sign.

$q_i = q_z = q_h$ = 1.0

G = gust effect factor, Use G = 0.85

C_p = external pressure coefficient. From Figure 6-6,
C_p = 0.80 (windward); Cp = -0.50 (leeward)

$(G\ C_{pi})$ = internal pressure coefficient. From Figure 6-5,
Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (G\ C_{pi}) =$ 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (G\ C_{pi}) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 94.88 lb

Uniform Weight/ Post @ Sign = 94.88 lb / 4.167 ft = 22.77 lb/ ft

Dead Loads:

Section	Material	Weight (lb)
1 - Disc Golf Target Basket		20
Total		20

Basket Weight (W_{sign}) = 20.00 lb

Wt_{sign}/ft^2 = 20.0 lb / 6.3 ft^2 = 3.16 lb/ft^2

Uniform Weight @ Sign = 20.00 lb / 4.167 ft = 4.80 lb/ ft

Number of Posts = 1

Post Length = 5 ft

Sign Weight/ Post ($W_{sign/post}$) = 20.00 lb

Uniform Weight/ Post @ Sign = 20.00 lb / 4.167 ft = 4.80 lb/ ft

Section	Material	Length (ft)	Unit Weight (	Weight (lb)
3 - Post	Galvanized Steel Pipe 2" O.D., 1.5" I.D.	4.00	3.5	14.00

Post Weight (Wt_{post}) - Galvanized Steel Pipe = 14.00 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 3.36 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 94.88 lb + 1.2 x (20 lb + 14.00 lb)

P = 192.62 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 22.77 lb/ft + 1.2 x (4.80 lb/ft + 3.36 lb/ft)

w = 46.22 lb/ ft = 3.85 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 46.22 lb/ ft x 4.2 ft / 5.00 ft = 38.52 lb/ ft = 3.21 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 770.5 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 192.6 lb

$M_{maximum} = \frac{PL}{2}$ = 192.6 lb x $\frac{5}{2}$ ft

$M_{maximum}$ = 482 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.250 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 2.9E+07 lb/in^2

I = 0.5 in^4

(Δ_{max}) = 0.019 inches (at deflected end)

(Δ_{max}) = 0.019 inches < $\Delta_{allowable}$ = 0.250 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8\,w\,L}{3}$

W_{equil} = 616.3 lb/ft = 51.36 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 231.1 lb

$M_{maximum} = \frac{wL^2}{3}$ = 385.2 lb-ft = 4,622 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.250 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E = 2.9E+07 lb/in^2

I = 0.5 in^4

(Δ_{max}) = 0.111 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.111 inches < $\Delta_{allowable}$ = 0.250 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 2-inch O.D. 1.5-inch I.D. galvanized steel poles for the supports. Use 3/8-inch square base plate with 3/8-inch diameter, 6-inch length anchor bolts.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.50	ft =	42	inches
Length of Footing =	3.50	ft =	42	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	12.25	ft^2		
Volume of Footing (V_{ftg}) =	12.25	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,837.50 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 192.6 lb

Uniform Load on Post = 231.1 lb

Load to Soil:

Point Load on Post + W_{ftg}=	2,030.1	lb /	12.25	ft^2 =	165.7	$lb/ ft^2 < 2,000\ lb/ft^2$, ok
Uniform Load on Post + W_{ftg}=	2,068.6	lb /	12.25	ft^2 =	168.9	$lb/ ft^2 < 2,000\ lb/ft^2$, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,837.5 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,837.50 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads
to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 W $_{per\ post}$ + 1.2 (Wt $_{sign/post}$ + Wt $_{post@\ sign}$ + W_{ftg})

P = 192.62 lb + 1.2 (1837.50 lb) = 2,397.62 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 (Wt $_{sign/post}$ + Wt $_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 2,251.22 lb/ ft = 187.60 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2} = \frac{2,397.6 \text{ lb x } 5}{2}$ ft

$M_{maximum}$ = 5,994 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3} =$ 18,760.2 lb ft = 225,122 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 5,994 lb ft = 71,928 lb-in (at fixed end at foundation)

Using the following design parameters:

where: $f_y =$	60	ksi	f_y = yield stress or strength of steel
$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
$p_{shear} =$	0.85		
$p_{flexure} =$	0.90		
unit width (w) =	1.0	ft	
footing thickness/depth (d_{ftg}) =	1.00	ft	

Coefficient of Resistance (Ru)= $M_u / [p_{flexure}\ (w)\ (d_{ftg})^2]$= 46.3 psi

$p_{balanced} = (0.85)^2 (f_c' / f_y)\ [87{,}000/(87{,}000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c' / f_y)\ [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85f_c') =$ 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u / (p_{flexure}) (R_u) =$ 13.79 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d = 9.54 in Use d = 9.50 in

b = 5.30 in Use b = 5.25 in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure} bd^2) =$ 168.68 psi

$p_{revised} = p_{approx} (R_{u\ revised}/R_u) =$ 0.003144

$A_{steel\ required} = p_{revised} bd =$ 0.16 in^2

Use minimum #4 bars @ 12 inches O/C +/-, $Area_{steel\ provided} = 0.20\ in^2$,
or use #5 bars @ 12 inches O/C +/-, Areasteel provided = 0.31 in^2 ,

Disc Golf Target Basket
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Disc Golf Target Basket	6.00	89.89	4.00	359.56	20.00	1.75	35.00	
3 - Post	0.33	4.99	3.08	15.40	14.00	1.75	24.50	
4 - Concrete Foundation	--	0	--	--	1837.50	1.75	3215.63	
6 - Push/Lean	--	200.00	5.17	1033.40	0	--	--	
7- Passive Rankine		0	--	--	371.10	0.500	185.55	
Total				**1408.36**			**3460.67**	**2.46** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Disc Golf Target Basket	6.00	89.89	4.00	359.56	20.00	1.75	35.00	
3 - Post	0.33	4.99	3.08	15.40	14.00	1.75	24.50	
4 - Concrete Foundation	--	0	--	--	1837.50	1.75	3215.63	
6 - Push/Lean	--	200.00	5.17	1033.40	0	--	--	
7- Passive Rankine	--	0	--	--	371.10	0.500	185.55	
Total				**1408.36**			**3460.67**	**2.46** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Disc Golf Target Basket	6.00	89.89	20.00
3 - Post	0.33	4.99	14.00
4 - Concrete Foundation	--	0	1837.50
6 - Push/Lean	--	200.00	0
Total		**294.88**	**1871.50**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (
$\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_2) + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**294.88**	**803.17**	**2.72** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1871.50	lb
Effective length of Foundation (L') = L - 2e =	1.99	ft
Effective Width of Foundation (B') =	3.50	ft
Moment (M) =	1408.36	lb-ft
Eccentricity (e) = M/Q =	0.75	ft
q_{max} =	613.81	lb/ft^2
q_{max} =	**4.26**	**psi**

SLOPED CHAISE LOUNGE CHAIR

Sloped Chaise Lounge Chair
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft^2)

where:

q_z =	velocity pressure at height z. Height (z) =	3.83	ft
k_d =	wind directional factor, Table 6-4, where K_d =	0.85	for solid sign
k_z =	velocity pressure exposure coefficient, Table 6-3,		
	for heights of 0 ft to 15 ft, Exposure C, K_h =	0.85	
	for heights of 16 ft to 20 ft, Exposure C, K_h =	0.90	
	Use k_h =	0.85	
k_{zt} =	topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} =	1.0	
V =	basic wind speed, from Figure 6-1, where V =	90	mph, for Exposure C (3 second wind gust)
	Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.		
	Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.		
I =	importance factor Use I =	1.0	

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$

q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 3.83 ft

Area A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1 - Lounge C	7.5	3	22.5
3 - Posts	1	2	2.0

A = 24.50 ft^2

Determine Wind Force on the Sign:

F = P x A = q_z x A

F =	14.982	lb/ft^2 x	24.50	ft^2 =	367.05	lb	(acting at end of post)
w =	367.05 / 4	lb = / ft	95.84	lb/ft			(acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft^2)

where:

$q = q_z$ for windward walls at heigth z above the ground.

$q = q_h$ for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.

$q_i = q_z = q_h$ = 1.0

G = gust effect factor, Use G = 0.85

C_p = external pressure coefficient. From Figure 6-6,

C_p = 0.80 (windward); Cp = -0.50 (leeward)

$(G\ C_{pi})$ = internal pressure coefficient. From Figure 6-5,

Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (G\ C_{pi})$ = 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (G\ C_{pi})$ = 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 367.05 lb

Uniform Weight/ Post @ Sign = 367.05 lb / 3.83 ft = 95.84 lb/ ft

Dead Loads:

Section	Material	Weight (lb)
1 - Lounge Chair	FSC Hardwood + Galvanized Steel	581.00
2- User		250.00
Total		831.00

Sign Weight (W_{sign}) = 831.00 lb

Wt_{sign}/ft^2 = 831.0 lb / 24.5 ft^2 = 33.92 lb/ft^2

Uniform Weight @ Sign = 831.00 lb / 3.83 ft = 216.97 lb/ ft

Number of Posts = 2

Post Length = 2 ft

Sign Weight/ Post ($W_{sign/post}$) = 415.50 lb

Uniform Weight/ Post @ Sign = 415.50 lb / 3.83 ft = 108.49 lb/ ft

Section	Material	Area (ft^2)	Density (lb/ft^2	Weight (lb)
3 - Post	Galvanized Steel	8.00	10	80.00

Post Weight ($Wt_{post)}$ = 80.00 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 20.89 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 367.05 lb + 1.2 x (415.50 lb + 80.00 lb)

P = 1,181.88 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 95.84 lb/ft + 1.2 x (108.49 lb/ft + 20.89 lb/ft)

w = 308.59 lb/ ft = 25.72 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 308.59 lb/ ft x 4 ft / 2 ft = 590.94 lb/ ft = 49.25 lb/ in

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	5.00	ft =	60	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	15.00	ft^2		
Volume of Footing (V_{ftg}) =	15.00	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 2,250.00 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 1,181.9 lb

Uniform Load on Post = 617.2 lb

Load to Soil:

Point Load on Post + W_{ftg}=	3,431.9	lb /	15.00	ft^2 =	228.8	lb/ ft^2 < 2,000 lb/ft^2, ok
Uniform Load on Post + W_{ftg}=	2,867.2	lb /	15.00	ft^2 =	191.1	lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 2,250.0 lb

$W_{ftg/\ thickness\ of\ footing}$ = 2,250.00 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads
to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 1,181.88 lb + 1.2 (2250.00 lb) = 3,881.88 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 3,008.59 lb/ ft = 250.72 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 3,881.9 $\frac{\text{lb x}}{2}$ 2 ft

$M_{maximum}$ = 3,882 lb ft (at fixed end foundation)

Recalculated moment for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 4,011.4 lb ft = 48,137 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 3,882 lb ft = 46,583 lb-in (at fixed end at foundation)

Using the following design parameters:

where:	$f_y =$	60	ksi	f_y = yield stress or strength of steel
	$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
	$p_{shear} =$	0.85		
	$p_{flexure} =$	0.90		
	unit width (w) =	1.00	ft	
	footing thickness/depth (d_{ftg}	1.00	ft	

Coefficient of Resistance (Ru)= M_u /[$p_{flexure}$ (w) $(d_{ftg})^2$]= 30.0 psi

$p_{balanced} = (0.85)^2(f_c'/f_y)$ [87,000/(87,000+f_y)] = 0.02138

$p_{maximum} = 0.85(f_c'/f_y)$ [1-(1-(2R_u/(0.85f_c'))$^{1/2}$] = 0.01604

$p_{minimum} = 200/f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85 f_c') =$ 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u / (p_{flexure})(R_u) =$ 8.93 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure} bd^2) =$ 109.24 psi

$p_{revised} = p_{approx} (R_{u\ revised}/R_u) =$ 0.002036

$A_{steel\ required} = p_{revised} bd =$ 0.10 in^2

Use minimum #4 bars @ 12 inches O/C +/-, Area$_{steel\ provided}$ = 0.20 in^2 ,
or use minimum #5 bars @ 12 inches O/C +/-, Areasteel provided = 0.31 in^2 ,

Sloped Chaise Lounge Chair
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Lounge Chair	22.50	337.09	2.50	842.72	581.00	2.50	1452.50	
3 - Post	2.00	29.96	1.50	44.95	80.00	2.50	200.00	
4 - Concrete Foundation	--	0	--	--	2250.00	2.50	5625.00	
6 - Push/Lean	--	200.00	4.83	966.00	0	--	--	
7- Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				**1853.67**			**7436.54**	**4.01** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Lounge Chair	0	0	--	--	581.00	1.50	871.50	
3 - Post	7.66	114.76	1.50	172.14	80.00	1.50	120.00	
4 - Concrete Foundation	--	0	--	--	2250.00	1.50	3375.00	
6 - Push/Lean	--	200.00	4.83	966.00	0	--	--	
7- Passive Rankine	--	0	--	--	530.14	0.500	265.07	
Total				**1138.14**			**4631.57**	**4.07** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Lounge Chair	22.50	337.09	581.00
3 - Post	2.00	29.96	80.00
4 - Concrete Foundation	--	0	2250.00
6 - Push/Lean	--	200.00	0
Total		**567.05**	**2911.00**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 $kPa = kN/m^2$

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Sliding Horizontal Force	**567.05**	**990.14**	**1.75** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	$kPa = kN/m^2$
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	2911.00	lb
Effective length of Foundation (L') = L - 2e =	3.73	ft
Effective Width of Foundation (B') =	3.00	ft
Moment (M) =	1853.67	lb-ft
Eccentricity (e) = M/Q =	0.64	ft
q_{max} =	592.02	lb/ft^2
q_{max} =	**4.11**	**psi**

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TRAIL MARKER

Trail Marker
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft²)

where:

q_z =	velocity pressure at height z. Height (z) =	10	ft
k_d =	wind directional factor, Table 6-4, where K_d =	0.85	for solid sign
k_z =	velocity pressure exposure coefficient, Table 6-3,		
	for heights of 0 ft to 15 ft, Exposure C, K_h =	0.85	
	for heights of 16 ft to 20 ft, Exposure C, K_h =	0.90	
	Use k_h =	0.85	
k_{zt} =	topographic factor, where $K_{st} = (1 + K_1\ K_2\ K_3)^2$ and $K_{1,}$ $K_{2\ and}$ K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} =	1.0	
V =	basic wind speed, from Figure 6-1, where V =	90	mph, for Exposure C (3 second wind gust)

Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.

Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.

I = importance factor Use I = 1.0

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$

q_z = 14.98176 lb/ft²

Determine area of sign:

where: h = overall height = 10 ft

Area A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft²)
1 - Upper Sign	2	2	4.0
2 - Lower Sign	2	2.5	5.0
3 - Post	6	0.6667	4.0

A = 13.00 ft²

Determine Wind Force on the Sign:

F = P x A = q_z x A

F =	14.982	lb/ft² x	13.00	ft² =	194.77 lb	(acting at end of post)
w =	194.77 / 10	lb / ft =	19.48	lb/ft		(acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft²)

where:

$q = q_z$ for windward walls at heigth z above the ground.

$q = q_h$ for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.

$q_i = q_z = q_h$ = 1.0

G = gust effect factor, Use G = 0.85

C_p = external pressure coefficient. From Figure 6-6,

C_p = 0.80 (windward); Cp = -0.50 (leeward)

$(G\ C_{pi})$ = internal pressure coefficient. From Figure 6-5,

Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (\ G\ C_{pi}\ ) =$ 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (\ G\ C_{pi}\ ) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 194.77 lb

Uniform Weight/ Post @ Sign = $\frac{194.77\ lb}{10\ ft}$ = 19.48 lb/ ft

Dead Loads:

Section	Material	Area (ft^2)	Unit Weight (	Weight (lb)
1 - Upper Sign	Corten Steel	8	5.00	40.00
2 - Lower Sign	Corten Steel	5	5.00	25.00
End Cap	Corten Steel	1.33	5.00	6.67
Total				71.67

Sign Weight (W_{sign}) = 71.67 lb

Wt_{sign}/ft^2 = $\frac{71.7\ lb}{13.0\ ft^2}$ = 5.51 lb/ft^2

Uniform Weight @ Sign = $\frac{71.67\ lb}{10\ ft}$ = 7.17 lb/ ft

Number of Posts = 1

Post Length = 11 ft

Sign Weight/ Post ($W_{sign/post}$) = 71.67 lb

Uniform Weight/ Post @ Sign = $\frac{71.67\ lb}{10\ ft}$ = 7.17 lb/ ft

Section	Material	Volume (ft^3)	Density (lb/ft^3	Weight (lb)
3 - Post	Western Red Cedar	4.89	23	112.46

Post Weight (Wt_{post}) = 112.46 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 11.25 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 194.77 lb + 1.2 x (71.67 lb + 112.46 lb)

P = 532.57 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 19.48 lb/ft + 1.2 x (7.17 lb/ft + 11.25 lb/ft)

w = 53.26 lb/ ft = 4.44 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 53.26 lb/ ft x $\frac{10\ ft}{11\ ft}$ = 48.42 lb/ ft = 4.03 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 2,130.3 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 532.6 lb

$M_{maximum} = \frac{PL}{2}$ = 532.6 lb x $\frac{11}{2}$ ft

$M_{maximum}$ = 2,929 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.550 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E =	1.1E+06	lb/in^2
I =	263.7	in^4

(Δ_{max}) = 0.029 inches (at deflected end)

(Δ_{max}) = 0.029 inches < $\Delta_{allowable}$ = 0.550 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8\ w\ L}{3}$

W_{equil} = 1,562.2 lb/ft = 130.18 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 585.8 lb

$M_{maximum} = \frac{wL^2}{3}$ = 2,148.0 lb-ft = 25,777 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.550 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E =	1.1E+06	lb/in^2
I =	263.7	in^4

(Δ_{max}) = 0.176 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.176 inches < $\Delta_{allowable}$ = 0.550 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection.
Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the sign supports.
Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.25	ft =	39	inches
Length of Footing =	4.25	ft =	51	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	13.81	ft^2		
Volume of Footing (V_{ftg}) =	13.81	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 2,071.88 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 532.6 lb

Uniform Load on Post = 585.8 lb

Load to Soil:

Point Load on Post + W_{ftg}=	2,604.4	lb /	13.81	ft^2 =	188.6	lb/ ft^2 < 2,000 lb/ft^2, ok
Uniform Load on Post + W_{ftg}=	2,657.7	lb /	13.81	ft^2 =	192.4	lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 2,071.9 lb

$W_{ftg/\ thickness\ of\ footing}$ = 2,071.88 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 532.57 lb + 1.2 (2071.88 lb) = 3,018.82 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 2,539.51 lb/ ft = 211.63 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 3,018.8 lb x $\frac{11}{2}$ ft

$M_{maximum}$ = 16,604 lb ft (at fixed end foundation)

Recalculated moment for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 102,426.8 lb ft = 1,229,122 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 16,604 lb ft = 199,242 lb-in (at fixed end at foundation)

Using the following design parameters:

where: f_y =	60	ksi	f_y = yield stress or strength of steel
$f_{c'}$ =	3,000	psi	f_c = compressive stress or strength of concrete
p_{shear} =	0.85		
$p_{flexure}$=	0.90		
unit width (w) =	1.00	ft	
footing thickness/depth (d_{ftg})	1.00	ft	

Coefficient of Resistance (Ru)= M_u /[$p_{flexure}$ (w) (d_{ftg})^2]= 128.1 psi

$p_{balanced}$= $(0.85)^2(f_c'/ f_y)$ [87,000/(87,000+f_y)] = 0.02138

$p_{maximum}$ = $0.85(f_c'/ f_y)$ [1-(1-(2R_u/(0.85f_c'))$^{1/2}$] = 0.01604

$p_{minimum}$ = 200/ f_y = 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate}$ = 0.00900

$m = f_y / (0.85 f_c')$ = 23.53

$R_u = p_{approx} f_y$[1 - (p_{approx})(m) / 2] = 482.82 psi

bd^2 = M_u/ ($p_{flexure}$) (R_u) = 38.21 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

bd^2 = 473.81 in^3

$R_{u\ revised}$=M_u/($p_{flexure}bd^2$)= 467.23 psi

$p_{revised}$= p_{approx} ($R_{u\ revised}$/R_u)= 0.008709

$A_{steel\ required}$ = $p_{revised}$bd = 0.43 in^2

Use minimum #5 bars @ 8 inches O/C +/-, Area$_{steel\ provided}$ = 0.47 in^2 ,
or use #6 bars @ 12 inches O/C +/-, Area $_{steel\ provided}$ = 0.44 in^2.

Trail Marker
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Upper Sign	4.00	59.93	9.00	539.34	40.00	2.13	85.00	
2 - Lower Sign	5.00	74.91	4.50	337.09	25.00	2.13	53.13	
3 - Post	4.00	59.93	6.00	359.58	119.12	2.13	253.14	
4 - Concrete Foundation	--	0	--	--	2071.88	2.13	4402.73	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	344.59	0.500	172.30	
Total				**2436.01**			**4966.29**	**2.04** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Upper Sign	0	0	--	--	40.00	1.63	65.00	
2 - Lower Sign	0	0	--	--	25.00	1.63	40.63	
3 - Post	6.67	99.88	6.00	599.30	119.12	1.63	193.57	
4 - Concrete Foundation	--	0	--	--	2071.88	1.63	3366.80	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	450.62	0.500	225.31	
Total				**1799.30**			**3891.31**	**2.16** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Upper Sign	4.00	59.93	40.00
2 - Lower Sign	5.00	74.91	25.00
3 - Post	4.00	59.93	119.12
4 - Concrete Foundation	--	0	2071.88
6 - Push/Lean	--	200.00	0
Total		**394.77**	**2256.00**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 $kPa = kN/m^2$

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Sliding Horizontal Force	**394.77**	**865.43**	**2.19** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	$kPa = kN/m^2$
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	2256.00	lb
Effective length of Foundation (L') = L - 2e =	1.70	ft
Effective Width of Foundation (B') =	3.25	ft
Moment (M) =	2436.01	lb-ft
Eccentricity (e) = M/Q =	1.08	ft
q_{max} =	1223.78	lb/ft^2
q_{max} =	**8.50**	**psi**

EDUCATIONAL POST

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Educational Post
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft²)

where:

q_z =	velocity pressure at height z. Height (z) =		4.5	ft
k_d =	wind directional factor, Table 6-4, where K_d =		0.85	for solid sign
k_z =	velocity pressure exposure coefficient, Table 6-3,			
	for heights of 0 ft to 15 ft, Exposure C, K_h =		0.85	
	for heights of 16 ft to 20 ft, Exposure C, K_h =		0.90	
		Use k_h =	0.85	
k_{zt} =	topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists.	Use K_{zt} =	1.0	
V =	basic wind speed, from Figure 6-1, where V =		90	mph, for Exposure C (3 second wind gust)
	Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70. Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.			
I =	importance factor	Use I =	1.0	

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$

q_z = 14.98176 lb/ft²

Determine area of sign:

where: h = overall height = 4.5 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft²)
1 - Educatior	1.00	1.5	1.50
2 -			
3 - Post	3.50	1.50	5.25

A = 6.75 ft²

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

F = 14.982 lb/ft² x 6.75 ft² = 101.13 lb (acting at end of post)

w = $\frac{101.13 \text{ lb}}{5 \text{ ft}}$ = 22.47 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft²)

where:

$q = q_z$	for windward walls at heigth z above the ground.
$q = q_h$	for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.
$q_i = q_z = q_h$ =	1.0
G =	gust effect factor, Use G = 0.85
C_p =	external pressure coefficient. From Figure 6-6, C_p = 0.80 (windward); Cp = -0.50 (leeward)
$(G\ C_{pi})$ =	internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (G\ C_{pi}) =$ 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (G\ C_{pi}) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 101.13 lb

Uniform Weight/ Post @ Sign = 101.13 lb / 4.5 ft = 22.47 lb/ ft

Dead Loads:

Section	Material	Area (ft2)	Unit Weight (	Weight (lb)
1 - Educational Sign	Corten Steel	1.50	10.2	15.30
Total				15.30

Sign Weight (W_{sign}), Corten Steel Sign Weight = 15.30 lb

Wt_{sign}/ft^2 = 15.3 lb / 6.8 ft^2 = 2.27 lb/ft^2

Uniform Weight @ Sign = 15.30 lb / 4.5 ft = 3.40 lb/ ft

Number of Posts = 1

Post Length = 5.50 ft

Sign Weight/ Post ($W_{sign/post}$) = 15.30 lb

Uniform Weight/ Post @ Sign = 15.30 lb / 4.5 ft = 3.40 lb/ ft

Section	Material	Area (ft2)	Unit Weight (	Weight (lb)
3 - Post	Corten Steel	5.25	10.2	53.55

Post Weight (Wt_{post}) - Corten Steel = 53.55 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 11.90 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 101.13 lb + 1.2 x (15 lb + 53.55 lb)

P = 244.42 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 22.47 lb/ft + 1.2 x (3.40 lb/ft + 11.90 lb/ft)

w = 54.32 lb/ ft = 4.53 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 54.32 lb/ ft x 4.5 ft / 5.5 ft = 44.44 lb/ ft = 3.70 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 977.7 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 244.4 lb

$M_{maximum} = \frac{PL}{2}$ = $\frac{244.4 \text{ lb} \times 5.5 \text{ ft}}{2}$

$M_{maximum}$ = 672 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.275 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 3.0E+07 lb/in^2

I = 0.188 in^4

(Δ_{max}) = 0.0868 inches (at deflected end)

(Δ_{max}) = 0.0868 inches < $\Delta_{allowable}$ = 0.275 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 1/2 inch Corten Steel for the sign support.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.25	ft =	39	inches
Length of Footing =	3.50	ft =	42	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	11.38	ft^2		
Volume of Footing (V_{ftg}) =	11.38	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,706.25 lb

Soil Bearing Capacity = 2,000 lb/ft^2

Load to Foundation:

Point Load on Post = 244.4 lb

Uniform Load on Post = 298.7 lb

Load to Soil:

Point Load on Post + W_{ftg}= 1,950.7 lb / 11.38 ft^2 = 171.5 lb/ft^2 < 2,000 lb/ft^2, ok

Uniform Load on Post + W_{ftg}= 2,005.0 lb / 11.38 ft^2 = 176.3 lb/ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,706.3 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,706.25 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 244.42 lb + 1.2 (1706.25 lb) = 2,291.92 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 2,101.82 lb/ ft = 175.15 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 2,291.9 lb x $\frac{5.5}{2}$ ft

$M_{maximum}$ = 6,303 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 21,193.3 lb ft = 254,320 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 6,303 lb ft = 75,633 lb-in (at fixed end at foundation)

Using the following design parameters:

where: f_y =	60	ksi	f_y = yield stress or strength of steel
$f_{c'}$ =	3,000	psi	f_c = compressive stress or strength of concrete
p_{shear} =	0.85		
$p_{flexure}$=	0.90		
unit width (w) =	1.0	ft	
footing thickness/depth (d_{ftg}) =	1.00	ft	

Coefficient of Resistance (Ru)= M_u /[$p_{flexure}$ (w) (d_{ftg})^2]= 48.6 psi

$p_{balanced}$= $(0.85)^2(f_c'/ f_y)$ [87,000/(87,000+f_y)] = 0.02138

$p_{maximum}$ = $0.85(f_c'/ f_y)$ [1-(1-(2R_u/(0.85f_c'))$^{1/2}$] = 0.01604

$p_{minimum}$ = 200/ f_y = 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate}$ = 0.00900

$m = f_y / (0.85f_c')$ = 23.53

$R_u = p_{approx}f_y[1 - (p_{approx})(m) / 2]$ = 482.82 psi

$bd^2 = M_u/ (p_{flexure}) (R_u)$ = 14.50 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d = 9.54 in Use d = 9.50 in

b = 5.30 in Use b = 5.25 in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

bd^2 = 473.81 in^3

$R_{u\ revised}=M_u/(p_{flexure}bd^2)$= 177.36 psi

$p_{revised}= p_{approx} (R_{u\ revised}/R_u)$= 0.003306

$A_{steel\ required} = p_{revised}bd$ = 0.16 in^2

Use minimum #4 bars @ 12 inches O/C +/-, $Area_{steel\ provided}$ = 0.20 in^2 ,
or use #5 bars @ 12 inches O/C +/-, $Area_{steel\ provided}$ = 0.31 in^2 ,

Educational Post
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Educational Sign	1.50	22.47	5.00	112.36	15.30	1.75	26.78	
3 - Post	5.25	78.65	2.75	216.30	53.55	1.75	93.71	
4 - Concrete Foundation	--	0	--	--	1706.25	1.75	2985.94	
6 - Push/Lean	--	200.00	5.50	1100.00	0	--	--	
7- Passive Rankine		0	--	--	344.59	0.500	172.30	
Total				**1428.66**			**3278.72**	**2.29** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Educational Sign	1.50	0	--	--	15.30	1.63	24.86	
3 - Post	5.25	78.65	2.75	216.30	53.55	1.63	87.02	
4 - Concrete Foundation	--	0	--	--	1706.25	1.63	2772.66	
6 - Push/Lean	--	200.00	5.50	1100.00	0	--	--	
7- Passive Rankine	--	0	--	--	371.10	0.500	185.55	
Total				**1316.30**			**3070.09**	**2.33** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Educational Sign	1.50	22.47	15.30
3 - Post	5.25	78.65	53.55
4 - Concrete Foundation	--	0	1706.25
6 - Push/Lean	--	200.00	0
Total		**301.13**	**1775.10**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (
$\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**301.13**	**754.41**	**2.51** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1775.10	lb
Effective length of Foundation (L') = L - 2e =	1.89	ft
Effective Width of Foundation (B') =	3.25	ft
Moment (M) =	1428.66	lb-ft
Eccentricity (e) = M/Q =	0.80	ft
q_{max} =	718.25	lb/ft^2
q_{max} =	**4.99**	**psi**

INFORMATIONAL SIGN (SMALL)

Information Sign (Small)
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\, k_z\, k_{zt}\, k_d\, V^2\, I$ (lb/ft^2)

where:
- q_z = velocity pressure at height z. Height (z) = 8.2 ft
- k_d = wind directional factor, Table 6-4, where K_d = 0.85 for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3,
  - for heights of 0 ft to 15 ft, Exposure C, K_h = 0.85
  - for heights of 16 ft to 20 ft, Exposure C, K_h = 0.90
  - Use k_h = 0.85
- k_{zt} = topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4.
  Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} = 1.0
- V = basic wind speed, from Figure 6-1, where V = 90 mph, for Exposure C (3 second wind gust)

  Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.
  Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.
- I = importance factor Use I = 1.0

$q_z = 0.00256\, k_z\, k_{zt}\, k_d\, V^2\, I$
q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 8.167 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1 - Info Sign (	4.00	2.00	8.00
2 -			
3 - Post	4.17	0.667	2.78

A = 10.78 ft^2

Determine Wind Force on the Sign:
F = P x A = q_z x A

F = 14.982 lb/ft^2 x 10.78 ft^2 = 161.47 lb (acting at end of post)

w = 161.47 lb / 8 ft = 19.77 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\, G\, C_p - q_i\, (G\, C_{pi})$ (lb/ft^2)

where:
- $q = q_z$ for windward walls at heigth z above the ground.
- $q = q_h$ for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h$ = 1.0
- G = gust effect factor, Use G = 0.85
- C_p = external pressure coefficient. From Figure 6-6,
  C_p = 0.80 (windward); Cp = -0.50 (leeward)
- $(G\, C_{pi})$ = internal pressure coefficient. From Figure 6-5,
  Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\,G\,C_p - q_i\,(G\,C_{pi}) =$ 0.130 lb/ft^2

$p_{leeward} = q\,G\,C_p - q_i\,(G\,C_{pi}) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 161.47 lb

Uniform Weight/ Post @ Sign = 161.47 lb / 8.167 ft = 19.77 lb/ ft

Dead Loads:

Section	Material	Area (ft2)	Unit Weight (l	Weight (lb)
1 - Info Sign (	Corten Steel	8.00	2.575	20.60
End Cap	Corten Steel	1.33	2.575	3.43
Total				24.03

Sign Weight (W_{sign}), Corten Steel Sign Weight = 24.03 lb

Wt_{sign}/ft^2 = 24.0 lb / 10.8 ft^2 = 2.23 lb/ft^2

Uniform Weight @ Sign = 24.03 lb / 8.167 ft = 2.94 lb/ ft

Number of Posts = 1

Post Length = 9.17 ft

Sign Weight/ Post ($W_{sign/post}$) = 24.03 lb

Uniform Weight/ Post @ Sign = 24.03 lb / 8.167 ft = 2.94 lb/ ft

Section	Material	Volume (ft3)	Density (lb/ft3	Weight
3 - Post	Western Red Cedar	4.07	23	93.72

Post Weight (Wt_{post}) - 8" x 8" Western Red Cedar = 93.72 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 11.48 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\,W_{per\ post} + 1.2\,(Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 161.47 lb + 1.2 x (24 lb + 93.72 lb)

P = 399.66 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\,W + 1.2\,(Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 19.77 lb/ft + 1.2 x (2.94 lb/ft + 11.48 lb/ft)

w = 48.94 lb/ ft = 4.08 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 48.94 lb/ ft x 8.2 ft / 9.2 ft = 43.60 lb/ ft = 3.63 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 1,598.6 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 399.7 lb

$M_{maximum} = \frac{PL}{2}$ = 399.7 lb x $\frac{9.167}{2}$ ft

$M_{maximum}$ = 1,832 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.458 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E =	1.1E+06	lb/in^2
I =	263.7	in^4

(Δ_{max}) = 0.013 inches (at deflected end)

(Δ_{max}) = 0.013 inches < $\Delta_{allowable}$ = 0.458 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8wL}{3}$

W_{equil} = 1,196.2 lb/ft = 99.69 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 448.6 lb

$M_{maximum} = \frac{wL^2}{3}$ = 1,370.8 lb-ft = 16,449 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.458 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E =	1.1E+06	lb/in^2
I =	263.7	in^4

(Δ_{max}) = 0.076 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.076 inches < $\Delta_{allowable}$ = 0.458 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection.
Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the sign supports.
Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	4.25	ft =	51	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	12.75	ft^2		
Volume of Footing (V_{ftg}) =	12.75	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,912.50 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 399.7 lb

Uniform Load on Post = 448.6 lb

Load to Soil:

Point Load on Post + W_{ftg}=	2,312.2	lb /	12.75	ft^2 =	181.3	lb/ ft^2 < 2,000 lb/ft^2, ok
Uniform Load on Post + W_{ftg}=	2,361.1	lb /	12.75	ft^2 =	185.2	lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,912.5 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,912.50 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads
to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 399.66 lb + 1.2 (1912.50 lb) = 2,694.66 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 2,343.94 lb/ ft = 195.33 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 2,694.7 lb x 9.167 ft / 2

$M_{maximum}$ = 12,351 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 65,656.7 lb ft = 787,880 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 12,351 lb ft = 148,212 lb-in (at fixed end at foundation)

Using the following design parameters:

where:	$f_y =$	60	ksi	f_y = yield stress or strength of steel
	$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
	$p_{shear} =$	0.85		
	$p_{flexure} =$	0.90		
	unit width (w) =	1.0	ft	
	footing thickness/depth (d_{ftg}) =	1.00	ft	

Coefficient of Resistance (Ru)= $M_u /[p_{flexure} (w) (d_{ftg})^2]=$ 95.3 psi

$p_{balanced} = (0.85)^2(f_c'/ f_y) [87,000/(87,000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c'/ f_y) [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85f_c') =$ 23.53

$R_u = p_{approx}f_y[1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u/ (p_{flexure}) (R_u) =$ 28.42 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised}=M_u/(p_{flexure}bd^2)=$ 347.56 psi

$p_{revised}= p_{approx} (R_{u\ revised}/R_u)=$ 0.006479

$A_{steel\ required} = p_{revised}bd =$ 0.32 in^2

Use minimum #4 bars @ 7 inches O/C +/-, Area $_{steel\ provided}$ = 0.34 in^2.

or use #5 bars @ 10 inches O/C +/-, Area$_{steel\ provided}$ = 0.37 in^2 ,

Information Sign (Small)
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Info Sign (small)	8.00	119.85	6.00	719.12	20.60	2.13	43.78	
3 - Post	2.78	41.62	5.17	215.05	97.15	2.13	206.44	
4 - Concrete Foundation	--	0	--	--	1912.50	2.13	4064.06	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				**2134.17**			**4473.32**	**2.10** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Info Sign (small)	8.00	0	--	--	20.60	1.50	30.90	
3 - Post	2.78	41.62	5.17	215.05	97.15	1.50	145.72	
4 - Concrete Foundation	--	0	--	--	1912.50	1.50	2868.75	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	450.62	0.500	225.31	
Total				**1415.05**			**3270.68**	**2.31** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Info Sign (small)	8.00	119.85	20.60
3 - Post	2.78	41.62	97.15
4 - Concrete Foundation	--	0	1912.50
6 - Push/Lean	--	200.00	0
Total		**361.47**	**2030.25**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**361.47**	**786.81**	**2.18** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	2030.25	lb
Effective length of Foundation (L') = L - 2e =	2.15	ft
Effective Width of Foundation (B') =	3.00	ft
Moment (M) =	2134.17	lb-ft
Eccentricity (e) = M/Q =	1.05	ft
q_{max} =	977.61	lb/ft^2
q_{max} =	**6.79**	**psi**

DIRECTIONAL SIGN POST

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Directional Sign Post
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\, k_z\, k_{zt}\, k_d\, V^2\, I$ (lb/ft^2)

where:

q_z =	velocity pressure at height z. Height (z) =		4.5	ft
k_d =	wind directional factor, Table 6-4, where K_d =		0.85	for solid sign
k_z =	velocity pressure exposure coefficient, Table 6-3,			
	for heights of 0 ft to 15 ft, Exposure C, K_h =		0.85	
	for heights of 16 ft to 20 ft, Exposure C, K_h =		0.90	
		Use k_h =	0.85	
k_{zt} =	topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists.	Use K_{zt} =	1.0	
V =	basic wind speed, from Figure 6-1, where V =		90	mph, for Exposure C (3 second wind gust)

Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.

Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.

I =	importance factor	Use I =	1.0	

$q_z = 0.00256\, k_z\, k_{zt}\, k_d\, V^2\, I$

q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 4.5 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1 - Direction	0.667	2	1.33
2 -			
3 - Post	3.83	0.667	2.56

A = 3.89 ft^2

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

F =	14.982	lb/ft^2 x	3.89	ft^2 =	58.26 lb	(acting at end of post)
w =	58.26 / 5	lb / ft =	12.95	lb/ft		(acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\, G\, C_p - q_i\, (G\, C_{pi})$ (lb/ft^2)

where:

$q = q_z$	for windward walls at heigth z above the ground.	
$q = q_h$	for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.	
$q_i = q_z = q_h$ =	1.0	
G =	gust effect factor, Use G =	0.85
C_p =	external pressure coefficient. From Figure 6-6,	
	C_p = 0.80 (windward); Cp = -0.50 (leeward)	
(G C_{pi}) =	internal pressure coefficient. From Figure 6-5,	
	Use 0.55 and -0.55 partially enclosed	

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (G\ C_{pi}) =$ 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (G\ C_{pi}) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 58.26 lb

Uniform Weight/ Post @ Sign = 58.26 lb / 4.5 ft = 12.95 lb/ ft

Dead Loads:

Section	Material	Area (ft2)	Unit Weight (	Weight (lb)
1 - Upper Sig	Corten Steel	2.67	2.575	6.87
End Cap	Corten Steel	1.33	2.575	3.43
Total				10.30

Sign Weight (W_{sign}), Corten Steel Sign Weight = 10.30 lb

Wt_{sign}/ft^2 = 10.3 lb / 3.9 ft^2 = 2.65 lb/ft^2

Uniform Weight @ Sign = 10.30 lb / 4.5 ft = 2.29 lb/ ft

Number of Posts = 1

Post Length = 5.5 ft

Sign Weight/ Post ($W_{sign/post}$) = 10.30 lb

Uniform Weight/ Post @ Sign = 10.30 lb / 4.5 ft = 2.29 lb/ ft

Section	Material	Volume (ft3)	Density (lb/ft3	Weight
3 - Post	Western Red Cedar	2.44	23	56.23

Post Weight (Wt_{post}) - 8" x 8" Western Red Cedar = 56.23 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 12.50 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 58.26 lb + 1.2 x (10 lb + 56.23 lb)

P = 173.06 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 12.95 lb/ft + 1.2 x (2.29 lb/ft + 12.50 lb/ft)

w = 38.46 lb/ ft = 3.20 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 38.46 lb/ ft x 4.5 ft / 5.5 ft = 31.46 lb/ ft = 2.62 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 692.2 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 173.1 lb

$M_{maximum} = \frac{PL}{2}$ = 173.1 lb x 5.5 ft / 2

$M_{maximum}$ = 476 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.275 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 1.1E+06 lb/in^2

I = 263.7 in^4

(Δ_{max}) = 0.001 inches (at deflected end)

(Δ_{max}) = 0.001 inches < $\Delta_{allowable}$ = 0.275 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8 w L}{3}$

W_{equil} = 564.0 lb/ft = 47.00 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 211.5 lb

$M_{maximum} = \frac{wL^2}{3}$ = 387.8 lb-ft = 4,653 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.275 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E = 1.1E+06 lb/in^2

I = 263.7 in^4

(Δ_{max}) = 0.007 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.007 inches < $\Delta_{allowable}$ = 0.275 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the sign supports. Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	3.25	ft =	39	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	9.75	ft^2		
Volume of Footing (V_{ftg}) =	9.75	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,462.50 lb

Soil Bearing Capacity = 2,000 lb/ft^2

Load to Foundation:

Point Load on Post = 173.1 lb

Uniform Load on Post = 211.5 lb

Load to Soil:

Point Load on Post + W_{ftg}=	1,635.6	lb /	9.75	ft^2 =	167.7	$lb/ft^2 < 2{,}000\ lb/ft^2$, ok
Uniform Load on Post + W_{ftg}=	1,674.0	lb /	9.75	ft^2 =	171.7	$lb/ft^2 < 2{,}000\ lb/ft^2$, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,462.5 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,462.50 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads
to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 173.06 lb + 1.2 (1462.50 lb) = 1,928.06 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 1,793.46 lb/ ft = 149.45 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2} = \frac{1{,}928.1\ lb\ x\ 5.5}{2}$ ft

$M_{maximum}$ = 5,302 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 18,084.0 lb ft = 217,008 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 5,302 lb ft = 63,626 lb-in (at fixed end at foundation)

Using the following design parameters:

where:	$f_y =$	60	ksi	f_y = yield stress or strength of steel
	$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
	$p_{shear} =$	0.85		
	$p_{flexure} =$	0.90		
	unit width (w) =	1.0	ft	
	footing thickness/depth (d_{ftg}) =	1.00	ft	

Coefficient of Resistance (Ru)= $M_u / [p_{flexure}\ (w)\ (d_{ftg})^2]$= 40.9 psi

$p_{balanced} = (0.85)^2 (f_c'/ f_y)\ [87{,}000/(87{,}000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c'/ f_y)\ [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85f_c') =$ 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u / (p_{flexure})(R_u) =$ 12.20 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure} bd^2) =$ 149.21 psi

$p_{revised} = p_{approx} (R_{u\ revised}/R_u) =$ 0.002781

$A_{steel\ required} = p_{revised} bd =$ 0.14 in^2

Use minimum #4 bars @ 12 inches O/C +/-, $Area_{steel\ provided}$ = 0.20 in^2 ,
or use #5 bars @ 12 inches O/C +/-, $Area_{steel\ provided}$ = 0.31 in^2 ,

Directional Sign Post
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	**Area (ft^2)**	**Overturning Force (lb)**	**Overturning Moment Arm (ft)**	**Overturning Moment (lb-ft)**	**Stabilizing Force (lb)**	**Stabilizing Moment Arm (ft)**	**Stabilizing Moment (lb-ft)**	**Factor of Safety (must be > 2)**
1 - Directional Sign	1.33	19.98	4.17	83.24	6.87	1.63	11.16	
3 - Post	2.56	38.29	3.25	124.44	59.66	1.63	96.95	
4 - Concrete Foundation	--	0	--	--	1462.50	1.63	2376.56	
6 - Push/Lean	--	200.00	5.50	1100.00	0	--	--	
7- Passive Rankine		0	--	--	318.08	0.500	159.04	
Total				**1307.68**			**2643.71**	**2.02** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	**Area (ft^2)**	**Overturning Force (lb)**	**Overturning Moment Arm (ft)**	**Overturning Moment (lb-ft)**	**Stabilizing Force (lb)**	**Stabilizing Moment Arm (ft)**	**Stabilizing Moment (lb-ft)**	**Factor of Safety (must be > 2)**
1 - Directional Sign	1.33	0	--	--	6.87	1.50	10.30	
3 - Post	2.56	38.29	3.25	124.44	59.66	1.50	89.49	
4 - Concrete Foundation	--	0	--	--	1462.50	1.50	2193.75	
6 - Push/Lean	--	200.00	5.50	1100.00	0	--	--	
7- Passive Rankine	--	0	--	--	344.59	0.500	172.30	
Total				**1224.44**			**2465.84**	**2.01** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	**Area (ft^2)**	**Driving Horizontal Force (lb)**	**Resisting Vertical Force (lb)**
1 - Directional Sign	1.33	19.98	6.87
3 - Post	2.56	38.29	59.66
4 - Concrete Foundation	--	0	1462.50
6 - Push/Lean	--	200.00	0
Total		**258.26**	**1529.03**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 $kPa = kN/m^2$

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x $c'_a + P_p$

	Driving Force (lb)	**Resisting Force (lb)**	**Factor of Safety (must be >1.5)**
Total Horizontal Force	**258.26**	**671.09**	**2.60** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	$kPa = kN/m^2$
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1529.03	lb
Effective length of Foundation (L') = L - 2e =	1.54	ft
Effective Width of Foundation (B') =	3.00	ft
Moment (M) =	1307.68	lb-ft
Eccentricity (e) = M/Q =	0.86	ft
q_{max} =	897.33	lb/ft^2
q_{max} =	**6.23**	**psi**

INFORMATIONAL SIGN (LARGE)

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Information Sign (Large)
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\, k_z\, k_{zt}\, k_d\, V^2\, I$ (lb/ft^2)

where:

q_z =	velocity pressure at height z. Height (z) =		8.167	ft
k_d =	wind directional factor, Table 6-4, where K_d =		0.85	for solid sign
k_z =	velocity pressure exposure coefficient, Table 6-3,			
	for heights of 0 ft to 15 ft, Exposure C, K_h =		0.85	
	for heights of 16 ft to 20 ft, Exposure C, K_h =		0.90	
		Use k_h =	0.85	
k_{zt} =	topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} =		1.0	
V =	basic wind speed, from Figure 6-1, where V =		90	mph, for Exposure C (3 second wind gust)
	Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.			
	Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.			
I =	importance factor	Use I =	1.0	

$q_z = 0.00256\, k_z\, k_{zt}\, k_d\, V^2\, I$

q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 8.167 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1 - Info Sign	4.00	6.33	25.33
2 -			
3 - Post	8.33	0.667	5.56

A = 30.89 ft^2

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

F = 14.982 lb/ft^2 x 30.89 ft^2 = 462.75 lb (acting at end of post)

w = 462.75 lb / 8 ft = 56.66 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\, G\, C_p - q_i\, (G\, C_{pi})$ (lb/ft^2)

where:

$q = q_z$	for windward walls at heigth z above the ground.				
$q = q_h$	for leeward walls, where sides are at heigth h above the ground. Neglect q_h for the sign.				
$q_i = q_z = q_h$ =	1.0				
G =	gust effect factor, Use G =	0.85			
C_p =	external pressure coefficient. From Figure 6-6,				
	C_p =	0.80	(windward); Cp =	-0.50	(leeward)
$(G\, C_{pi})$ =	internal pressure coefficient. From Figure 6-5,				
	Use	0.55	and	-0.55	partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\,G\,C_p - q_i\,(G\,C_{pi}) =$ 0.130 lb/ft^2

$p_{leeward} = q\,G\,C_p - q_i\,(G\,C_{pi}) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 462.75 lb

Uniform Weight/ Post @ Sign = 462.75 lb / 8.167 ft = 56.66 lb/ ft

Dead Loads:

Section	Material	Area (ft^2)	Unit Weight (	Weight (lb)
1 - Info Sign	Corten Steel	25.33	2.575	65.23
End Caps	Corten Steel	2.67	2.575	6.87
Total				72.10

Sign Weight (W_{sign}), Corten Steel Sign Weight = 72.10 lb

Wt_{sign}/ft^2 = 72.1 lb / 30.9 ft^2 = 2.33 lb/ft^2

Uniform Weight @ Sign = 72.10 lb / 8.167 ft = 8.83 lb/ ft

Number of Posts = 2

Post Length = 9.17 ft

Sign Weight/ Post ($W_{sign/post}$) = 36.05 lb

Uniform Weight/ Post @ Sign = 36.05 lb / 8.167 ft = 4.41 lb/ ft

Section	Material	Volume (ft^3)	Density (lb/ft^3	Weight
3 - Post	Western Red Cedar	4.07	23	93.72

Post Weight (Wt_{post}) - Western Red Cedar = 93.72 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 11.48 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\,W_{per\ post} + 1.2\,(Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 462.75 lb + 1.2 x (36 lb + 93.72 lb)

P = 896.11 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\,W + 1.2\,(Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 56.66 lb/ft + 1.2 x (4.41 lb/ft + 11.48 lb/ft)

w = 109.72 lb/ ft = 9.14 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 109.72 lb/ ft x 8.2 ft / 9.2 ft = 97.75 lb/ ft = 8.15 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 3,584.4 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 896.1 lb

$M_{maximum} = \frac{PL}{2}$ = 896.1 lb x $\frac{9.167}{2}$ ft

$M_{maximum}$ = 4,107 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.458 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E = 1.1E+06 lb/in^2

I = 263.7 in^4

(Δ_{max}) = 0.029 inches (at deflected end)

(Δ_{max}) = 0.029 inches < $\Delta_{allowable}$ = 0.458 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8 w L}{3}$

W_{equil} = 2,682.2 lb/ft = 223.52 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 1,005.8 lb

$M_{maximum} = \frac{wL^2}{3}$ = 3,073.5 lb-ft = 36,882 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.458 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E = 1.1E+06 lb/in^2

I = 263.7 in^4

(Δ_{max}) = 0.171 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.171 inches < $\Delta_{allowable}$ = 0.458 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection.
Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the sign supports.
Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	4.00	ft =	48	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	12.00	ft^2		
Volume of Footing (V_{ftg}) =	12.00	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,800.00 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 896.1 lb

Uniform Load on Post = 1,005.8 lb

Load to Soil:

Point Load on Post + W_{ftg}=	2,696.1	lb /	12.00	ft^2 =	224.7	$lb/ ft^2 < 2,000\ lb/ft^2$, ok
Uniform Load on Post + W_{ftg}=	2,805.8	lb /	12.00	ft^2 =	233.8	$lb/ ft^2 < 2,000\ lb/ft^2$, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,800.0 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,800.00 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign} + W_{ftg})$

P = 896.11 lb + 1.2 (1800.00 lb) = 3,056.11 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign} + W_{ftg/\ depth\ of\ footing})$

w = 2,269.72 lb/ ft = 189.14 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2} = \frac{3,056.1\ lb\ x\ 9.167\ ft}{2}$

$M_{maximum}$ = 14,008 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 63,577.9 lb ft = 762,935 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 14,008 lb ft = 168,092 lb-in (at fixed end at foundation)

Using the following design parameters:

where:	$f_y =$	60	ksi	f_y = yield stress or strength of steel
	$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
	$p_{shear} =$	0.85		
	$p_{flexure} =$	0.90		
	unit width (w) =	1.0	ft	
	footing thickness/depth (d_{ftg}) =	1.00	ft	

Coefficient of Resistance (Ru)= $M_u / [p_{flexure} (w) (d_{ftg})^2]$= 108.1 psi

$p_{balanced} = (0.85)^2 (f_c'/ f_y) [87{,}000/(87{,}000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c'/ f_y) [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85f_c') =$ 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u / (p_{flexure}) (R_u) =$ 32.24 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\,revised} = M_u/(p_{flexure} bd^2) =$ 394.18 psi

$p_{revised} = p_{approx} (R_{u\,revised}/R_u) =$ 0.007348

$A_{steel\,required} = p_{revised} bd =$ 0.37 in^2

Use minimum #5 bars @ 10 inches O/C +/-, $Area_{steel\,provided} = 0.37\ in^2$,
or use #6 bars @ 12 inches O/C +/-, $Area_{steel\,provided} = 0.44\ in^2$.

Information Sign (Large)
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Info Sign (Large)	12.67	189.76	6.00	1138.55	32.61	2.00	65.23	
3 - Posts	2.78	41.61	5.17	215.02	100.58	2.00	201.17	
4 - Concrete Foundation	--	0	--	--	1800.00	2.00	3600.00	
6 - Push/Lean	--	100.00	6.00	600.00	0	--	--	
7- Passive Rankine		0	--	--	318.08	0.500	159.04	
Total				**1953.58**			**4025.44**	**2.06** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Info Sign (Large)	12.67	0	--	--	32.61	1.50	48.92	
3 - Posts	2.78	41.61	5.17	215.02	100.58	1.50	150.87	
4 - Concrete Foundation	--	0	--	--	1800.00	1.50	2700.00	
6 - Push/Lean	--	100.00	6.00	600.00	0	--	--	
7- Passive Rankine	--	0	--	--	424.11	0.500	212.06	
Total				**815.02**			**3111.85**	**3.82** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Info Sign (Large)	12.67	189.76	65.23
3 - Post	2.78	41.61	100.58
4 - Concrete Foundation	--	0	1800.00
6 - Push/Lean	--	100.00	0
Total		**331.37**	**1965.81**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (δ' = (1/2)ϕ'_2)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_2) + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**331.37**	**771.93**	**2.33** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1933.20	lb
Effective length of Foundation (L') = L - 2e =	1.98	ft
Effective Width of Foundation (B') =	3.00	ft
Moment (M) =	1953.58	lb-ft
Eccentricity (e) = M/Q =	1.01	ft
q_{max} =	983.76	lb/ft^2
q_{max} =	**6.83**	**psi**

DISC GOLF TEE POST

Disc Golf Tee Post
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$ (lb/ft^2)

where:

q_z = velocity pressure at height z. Height (z) = 3 ft

k_d = wind directional factor, Table 6-4, where K_d = 0.85 for solid sign

k_z = velocity pressure exposure coefficient, Table 6-3,
for heights of 0 ft to 15 ft, Exposure C, K_h = 0.85
for heights of 16 ft to 20 ft, Exposure C, K_h = 0.90
Use k_h = 0.85

k_{zt} = topographic factor, where $K_{st} = (1 + K_1\ K_2\ K_3)^2$
and K_1, K_2 and K_3 are given in Figure 6-4.
Assuming general limited changes in topography, no ridge area, escarpment or axisymetrical hill exists. Use K_{zt} = 1.0

V = basic wind speed, from Figure 6-1, where V = 90 mph, for Exposure C (3 second wind gust)

Exposure B consists of urban and surburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where k_z = 0.70.
Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where k_z = 0.90. Use Exposure C.

I = importance factor Use I = 1.0

$q_z = 0.00256\ k_z\ k_{zt}\ k_d\ V^2\ I$
q_z = 14.98176 lb/ft^2

Determine area of sign:

where: h = overall height = 4.5 ft

A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft^2)
1 - Post	3.00	0.500	1.50

A = 1.50 ft^2

Determine Wind Force on the Sign:
$F = P \times A = q_z \times A$

F = 14.982 lb/ft^2 x 1.50 ft^2 = 22.47 lb (acting at end of post)

w = 22.47 lb / 5 ft = 4.99 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$p = q\ G\ C_p - q_i\ (G\ C_{pi})$ (lb/ft^2)

where:

$q = q_z$ for windward walls at heigth z above the ground.

$q = q_h$ for leeward walls, where sides are at heigth h above the ground.
Neglect q_h for the sign.

$q_i = q_z = q_h$ = 1.0

G = gust effect factor, Use G = 0.85

C_p = external pressure coefficient. From Figure 6-6,
C_p = 0.80 (windward); Cp = -0.50 (leeward)

$(G\ C_{pi})$ = internal pressure coefficient. From Figure 6-5,
Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$p_{windward} = q\ G\ C_p - q_i\ (\ G\ C_{pi}\ ) =$ 0.130 lb/ft^2

$p_{leeward} = q\ G\ C_p - q_i\ (\ G\ C_{pi}\ ) =$ 0.125 lb/ft^2

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 22.47 lb

Uniform Weight/ Post @ Sign = $\frac{22.47\ \text{lb}}{4.5\ \text{ft}}$ = 4.99 lb/ ft

Dead Loads:

Number of Posts = 1

Post Length = 4.00 ft

Section	Material	Volume (ft3)	Density (lb/ft3)	Weight
1 - Post	Western Red Cedar	1.00	23	23.00

Post Weight (Wt_{post}) - 8" x 8" Western Red Cedar = 23.00 lb

Uniform Weight/ Post @ Sign = Wt/ ft = 5.11 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6\ W_{per\ post} + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

P = 1.6 x 22.47 lb + 1.2 x (0 lb + 23.00 lb)

P = 63.56 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6\ W + 1.2\ (Wt_{sign/post} + Wt_{post@\ sign})$

w = 1.6 x 4.99 lb/ft + 1.2 x (0.00 lb/ft + 5.11 lb/ft)

w = 14.12 lb/ ft = 1.18 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 14.12 lb/ ft x $\frac{4.5\ \text{ft}}{4.0\ \text{ft}}$ = 15.89 lb/ ft = 1.32 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = 4P

W_{equil} = 254.2 lb/ft

Axial Load (R) = Shear (V) = P

R = V = P = 63.6 lb

$M_{maximum} = \frac{PL}{2}$ = 63.6 lb x $\frac{4}{2}$ ft

$M_{maximum}$ = 127 lb ft (at both ends)

Total Allowable Deflection = L/240 = 0.200 inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

E =	1.1E+06	lb/in^2
I =	76.3	in^4

(Δ_{max}) = 0.0006 inches (at deflected end)

(Δ_{max}) = 0.0006 inches < $\Delta_{allowable}$ = 0.200 inches, ok

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8\,w\,L}{3}$

W_{equil} = 150.7 lb/ft = 12.55 lb/ in

Axial Load (R) = Shear (V) = wL

R = V = wL = 56.5 lb

$M_{maximum} = \frac{wL^2}{3}$ = 75.3 lb-ft = 904 lb-in (at fixed end)

Total Allowable Deflection = L/240 = 0.200 inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

E =	1.1E+06	lb/in^2
I =	76.3	in^4

(Δ_{max}) = 0.003 inches (at deflected end, adjusted over length of post)

(Δ_{max}) = 0.003 inches < $\Delta_{allowable}$ = 0.200 inches, ok

Note: Based on the preceeding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection.
Use minimum 6-inch x 6-inch Western Red Cedar rectangular columns/posts for the sign supports.
Use Simpson Strong-Tie Post Base Model MPB66Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	2.75	ft =	33	inches
Length of Footing =	2.75	ft =	33	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	7.56	ft^2		
Volume of Footing (V_{ftg}) =	7.56	ft^3		

Dead Load of Footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ft^3

W_{ftg} = 1,134.38 lb

Soil Bearing Capacity = 2,000 lb/ ft^2

Load to Foundation:

Point Load on Post = 63.6 lb

Uniform Load on Post = 56.5 lb

Load to Soil:

Point Load on Post + W_{ftg}= 1,197.9 lb / 7.56 ft^2 = 158.4 lb/ ft^2 < 2,000 lb/ft^2, ok

Uniform Load on Post + W_{ftg}= 1,190.9 lb / 7.56 ft^2 = 157.5 lb/ ft^2 < 2,000 lb/ft^2, ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = A_{ftg} x L x $p_{concrete}$

where: $p_{concrete}$ = 150.00 lb/ ft^3

W_{ftg} = 1,134.4 lb

$W_{ftg/\ thickness\ of\ footing}$ = 1,134.38 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

P = 1.6 $W_{per\ post}$ + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ + W_{ftg})

P = 63.56 lb + 1.2 (1134.38 lb) = 1,424.81 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 ($Wt_{sign/post}$ + $Wt_{post@\ sign}$ +$W_{ftg/\ depth\ of\ footing}$)

w = 1,375.37 lb/ ft = 114.61 lb/ in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2}$ = 1,424.8 lb x $\frac{4}{2}$ ft

$M_{maximum}$ = 2,850 lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3}$ = 7,335.3 lb ft = 88,024 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$M_{maximum} = M_u =$ 2,850 lb ft = 34,195 lb-in (at fixed end at foundation)

Using the following design parameters:

where: $f_y =$	60	ksi	f_y = yield stress or strength of steel
$f_{c'} =$	3,000	psi	f_c = compressive stress or strength of concrete
$p_{shear} =$	0.85		
$p_{flexure} =$	0.90		
unit width (w) =	1.0	ft	
footing thickness/depth (d_{ftg}	1.00	ft	

Coefficient of Resistance (Ru)= $M_u /[p_{flexure} (w) (d_{ftg})^2]=$ 22.0 psi

$p_{balanced} = (0.85)^2(f_c'/ f_y) [87,000/(87,000+f_y)] =$ 0.02138

$p_{maximum} = 0.85(f_c'/ f_y) [1-(1-(2R_u/(0.85f_c'))^{1/2}] =$ 0.01604

$p_{minimum} = 200/ f_y =$ 0.00333

The approximate reinforcement ratio (p_{approx}) =0.18(fc'/ fy) = 0.00900

Use $p_{approximate} =$ 0.00900

$m = f_y / (0.85f_c') =$ 23.53

$R_u = p_{approx} f_y [1 - (p_{approx})(m) / 2] =$ 482.82 psi

$bd^2 = M_u/ (p_{flexure}) (R_u) =$ 6.56 in^3

b = width of stem/web of concrete cross section

d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

d =	9.54	in	Use d =	9.50	in
b =	5.30	in	Use b =	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$ 473.81 in^3

$R_{u\ revised} = M_u/(p_{flexure} bd^2) =$ 80.19 psi

$p_{revised} = p_{approx} (R_{u\ revised}/R_u) =$ 0.001495

$A_{steel\ required} = p_{revised} bd =$ 0.07 in^2

Use minimum #4 bars @ 12 inches O/C +/-, $Area_{steel\ provided} = 0.20\ in^2$,
or use #5 bars @ 12 inches O/C +/-, $Area_{steel\ provided} = 0.31\ in^2$,

Disc Golf Tee Post

Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Post	1.50	22.47	2.50	56.18	23.00	1.38	31.63	
2 - Concrete Foundation	--	0	--	--	1134.38	1.38	1559.77	
3 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
4- Passive Rankine	--	0	--	--	291.58	0.500	145.79	
Total				**856.18**			**1737.18**	**2.03** acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft^2)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Post	1.50	22.47	2.50	56.18	23.00	1.38	31.63	
2 - Concrete Foundation	--	0	--	--	1134.38	1.38	1559.77	
3 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
4- Passive Rankine	--	0	--	--	291.58	0.500	145.79	
Total				**856.18**			**1737.18**	**2.03** acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft^2)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Post	1.50	22.47	23.00
2 - Concrete Foundation	--	0	1134.38
3 - Push/Lean	--	200.00	0
Total		**222.47**	**1157.38**

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (
$\delta' = (1/2)\phi'_2$)= 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m^2

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	**222.47**	**558.78**	**2.51** acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \Upsilon_2 \times D^2) + 2(c'_2) \times \sqrt{(K_p \times D)}$

Soil cohesion (c'_2) =	0	kPa = kN/m^2
Effective Soil Friction angle (ϕ'_2) =	26	degrees
Unit weight of soil (Υ_2) =	82.8	lbf/ft^3
Depth to base of concrete (D) =	1.00	ft
$K_p = \tan^2(45 + (\phi'_2/2))$ =	2.56	
P_p =	**106.03**	**lb/ft**

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) =	1157.38	lb
Effective length of Foundation (L') = L - 2e =	1.27	ft
Effective Width of Foundation (B') =	2.75	ft
Moment (M) =	856.18	lb-ft
Eccentricity (e) = M/Q =	0.74	ft
q_{max} =	865.93	lb/ft^2
q_{max} =	**6.01**	**psi**

ATTACHMENT B

CONCRETE FOUNDATION DETAIL

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ATTACHMENT B – SIGNAGE TEXT & GRAPHICS

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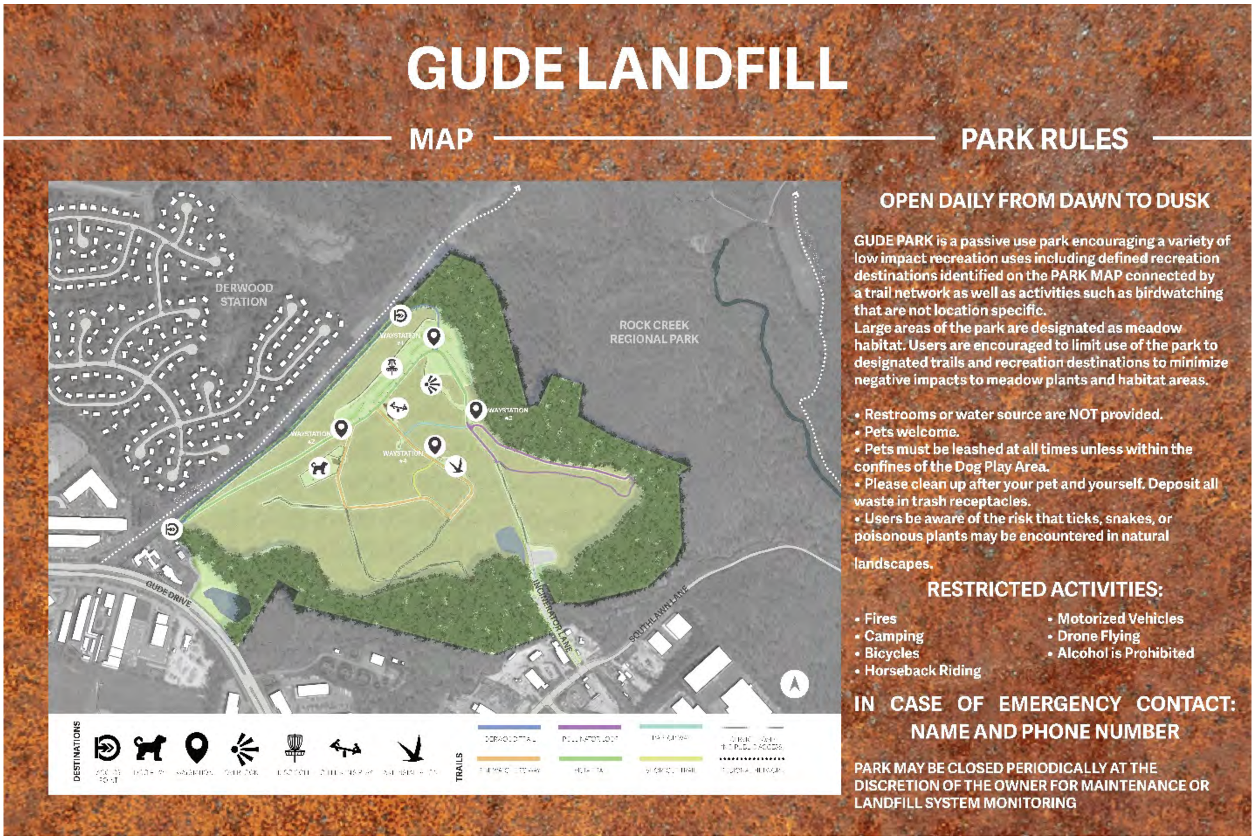
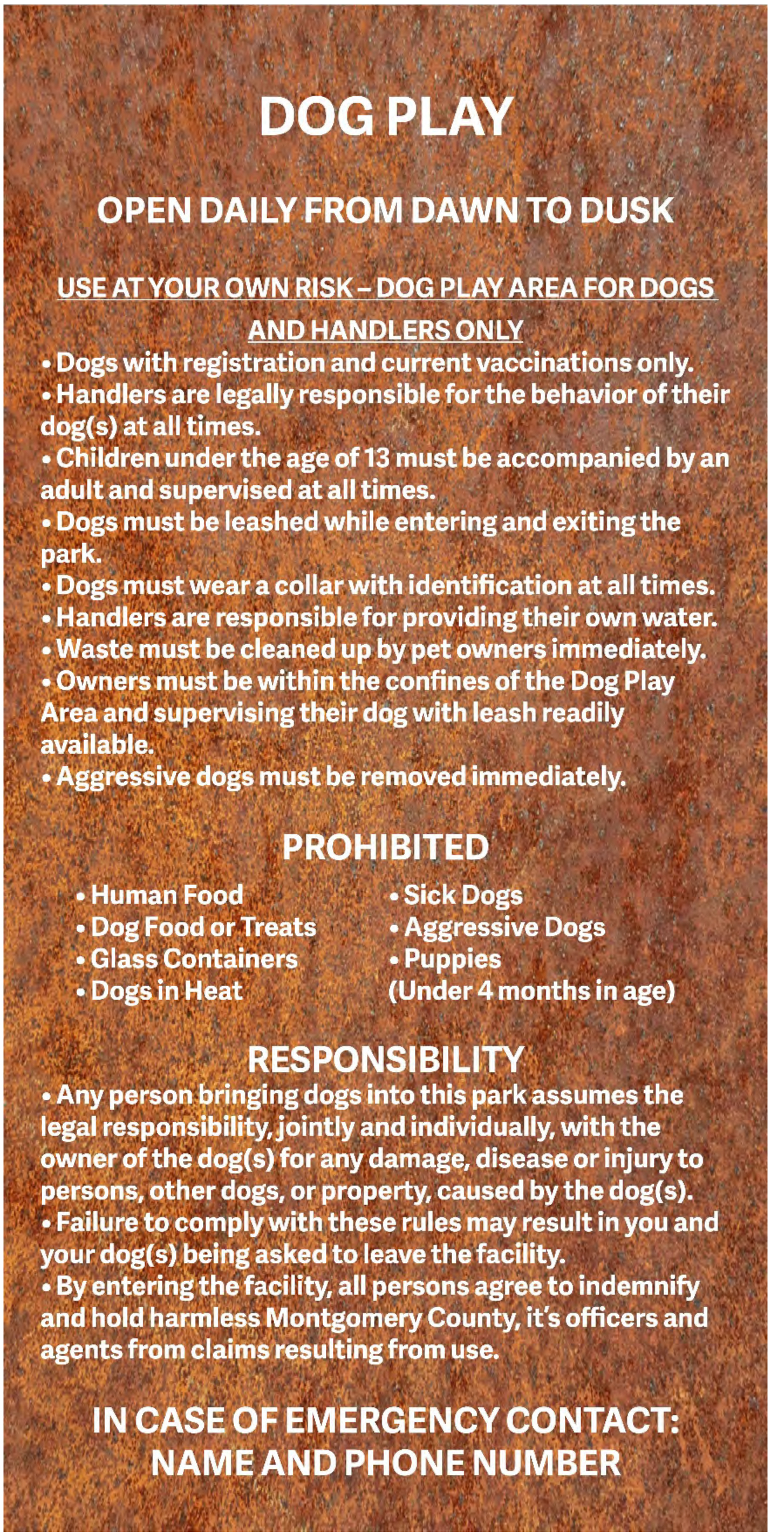
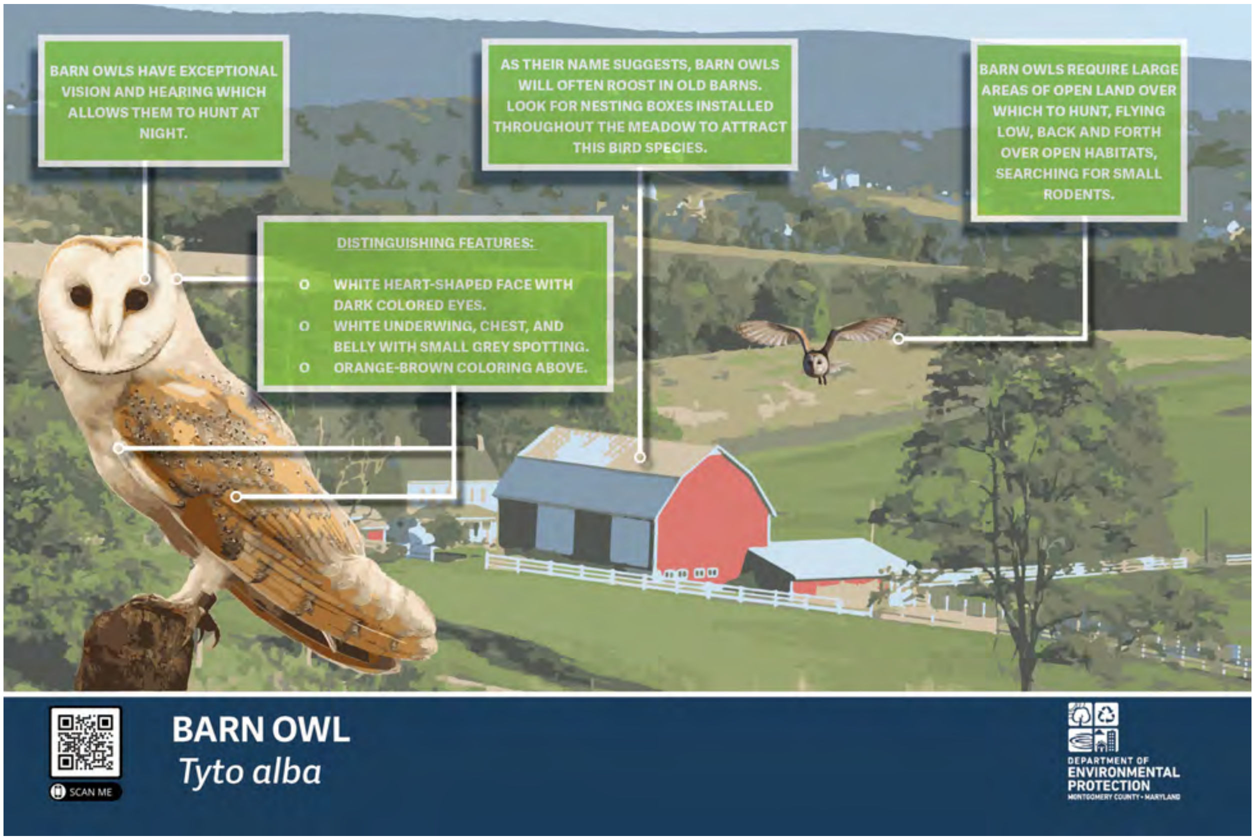
Informational Sign (Large) – Public Access Entry Points



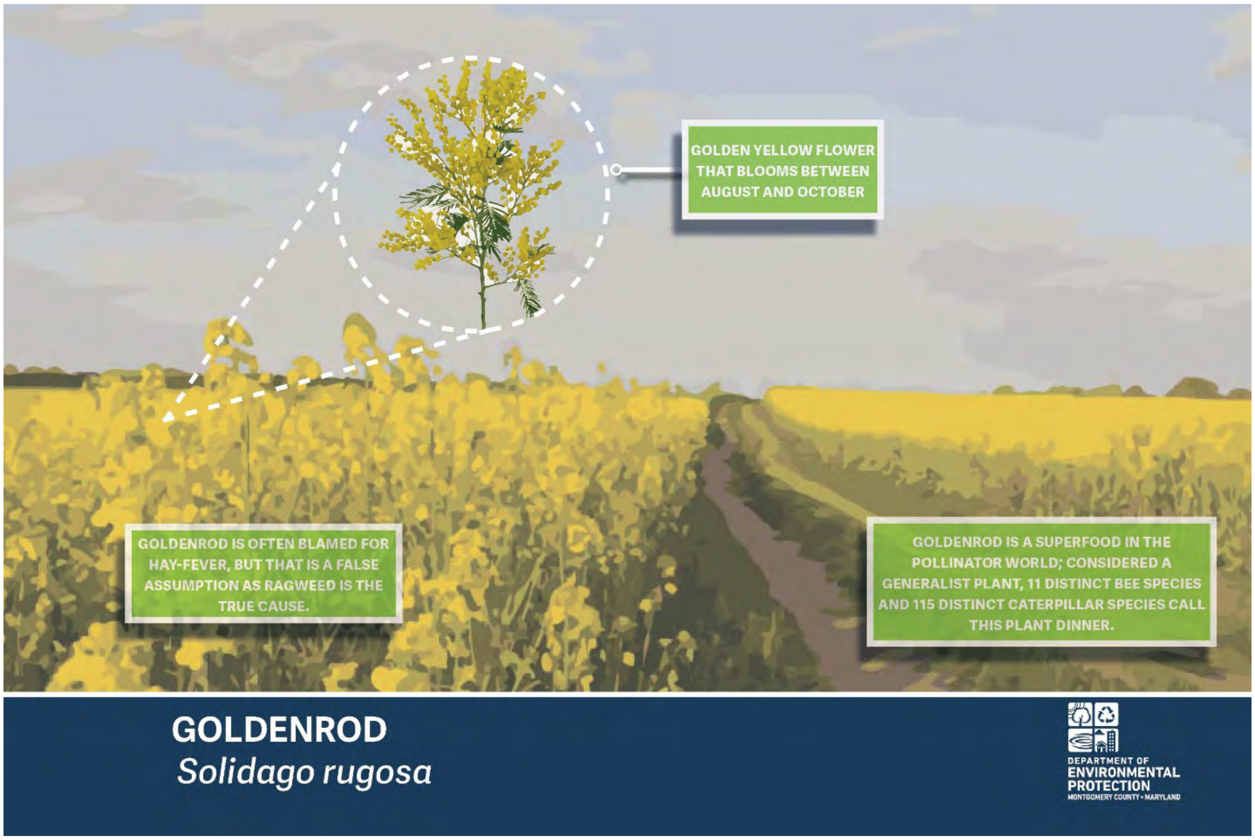
Informational Sign (Small) – Dog Play Area



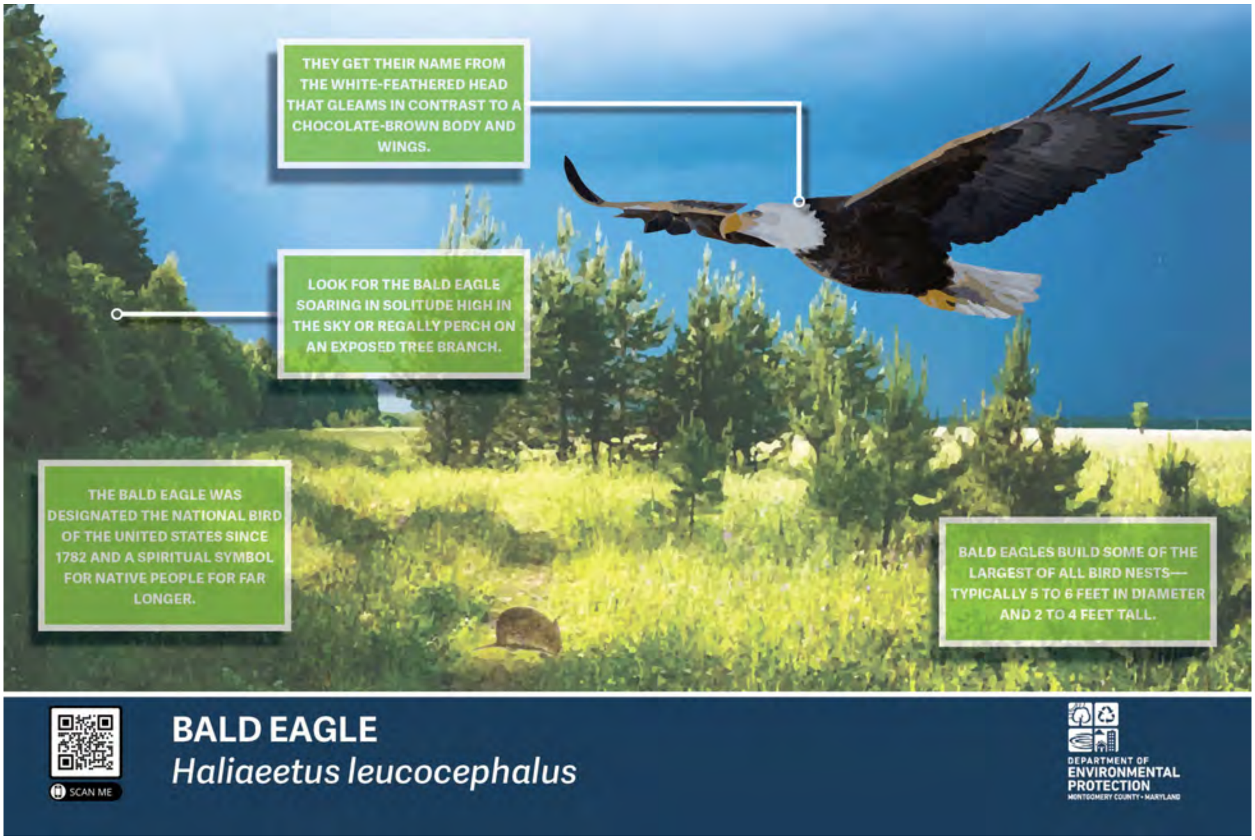
Educational Post #1 – Barn Owl



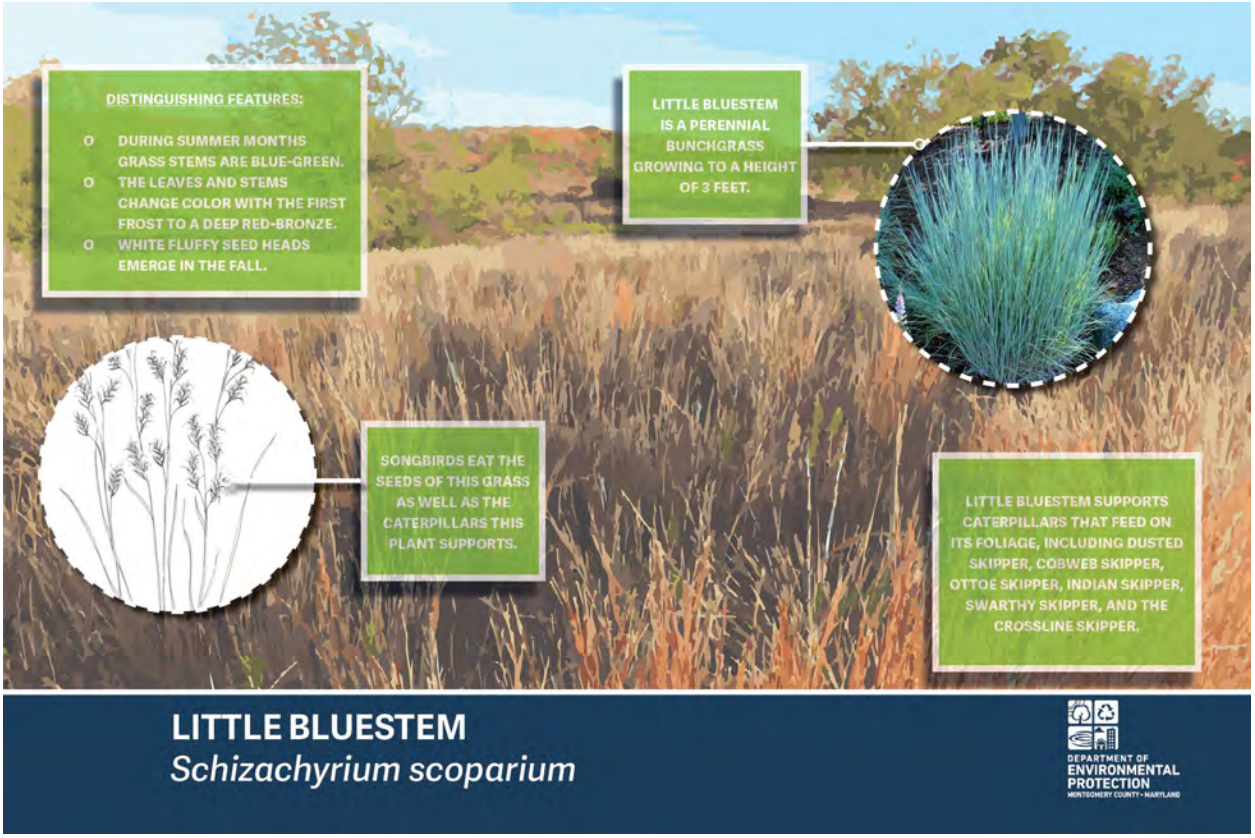
Educational Post #2 – Goldenrod



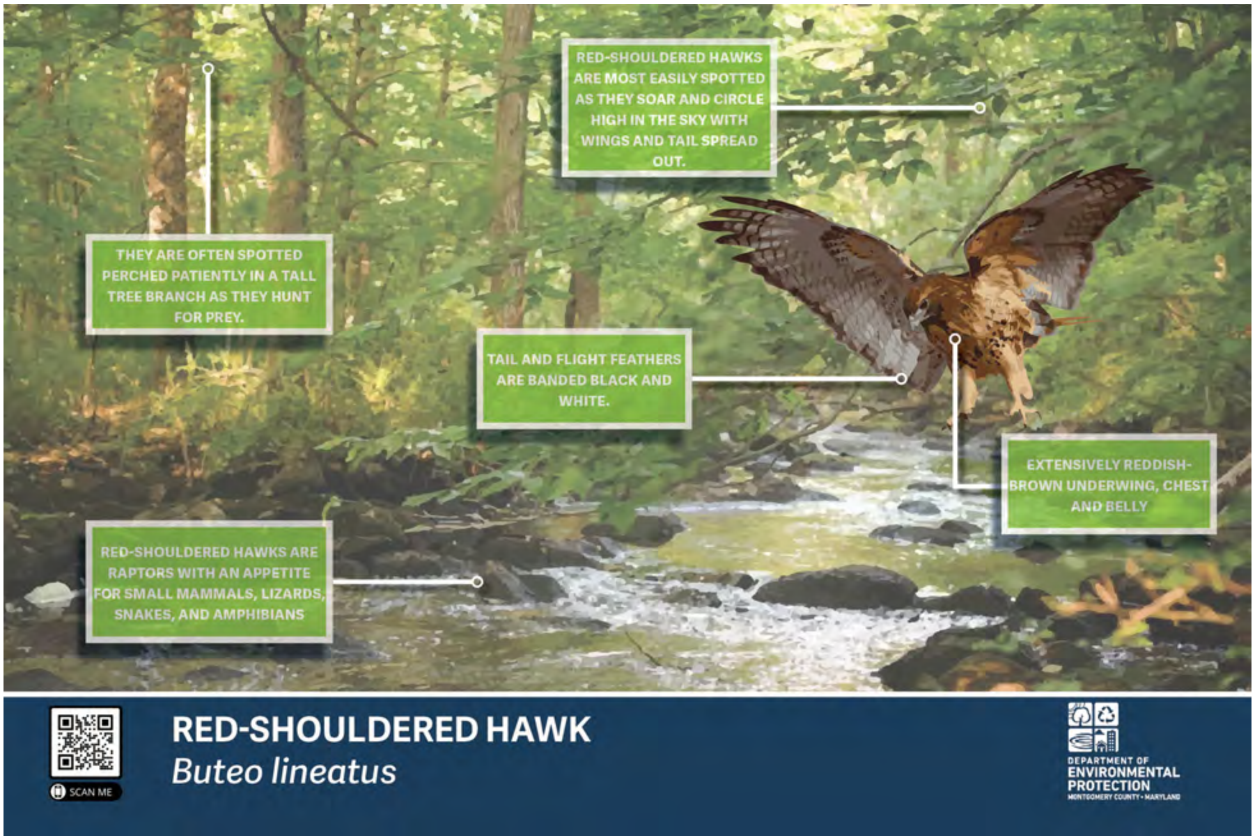
Educational Post #3 – Bald Eagle



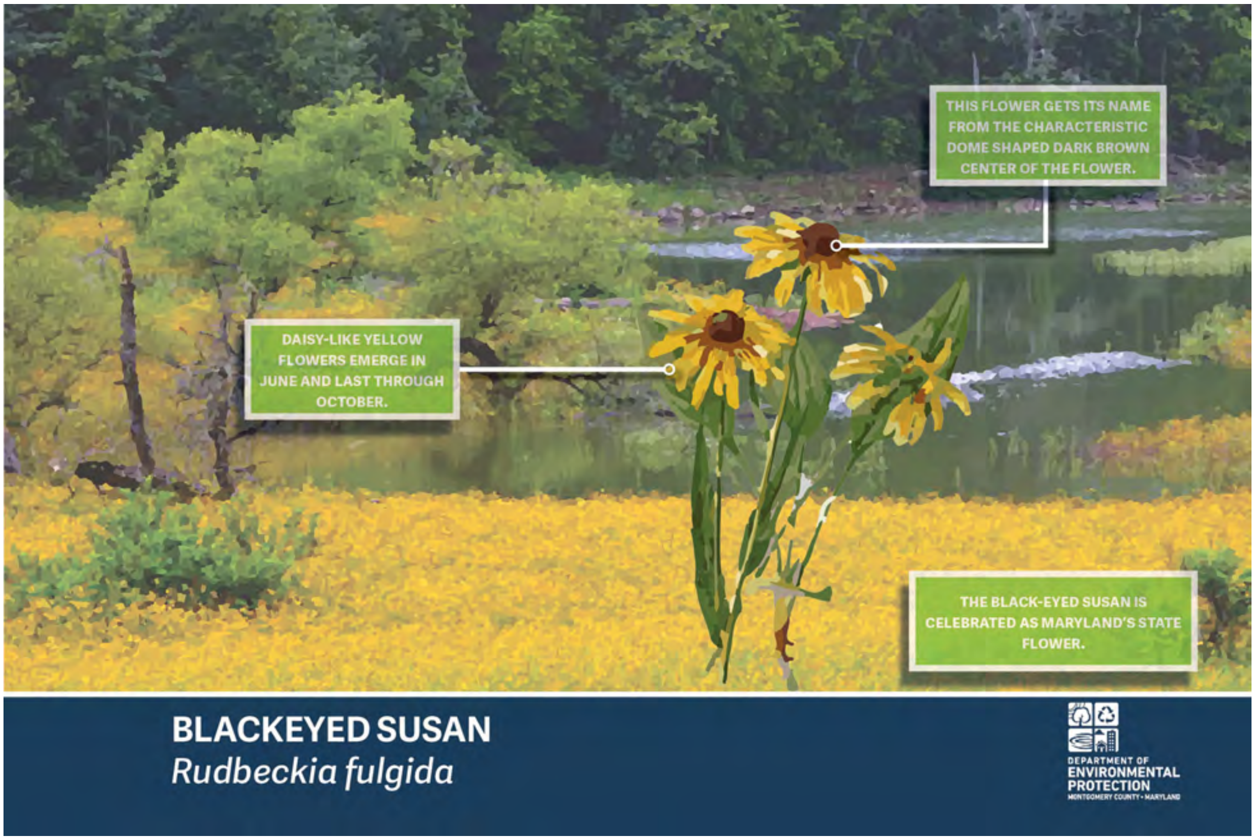
Educational Post #4 – Little Bluestem



Educational Post #5 – Red-shouldered Hawk

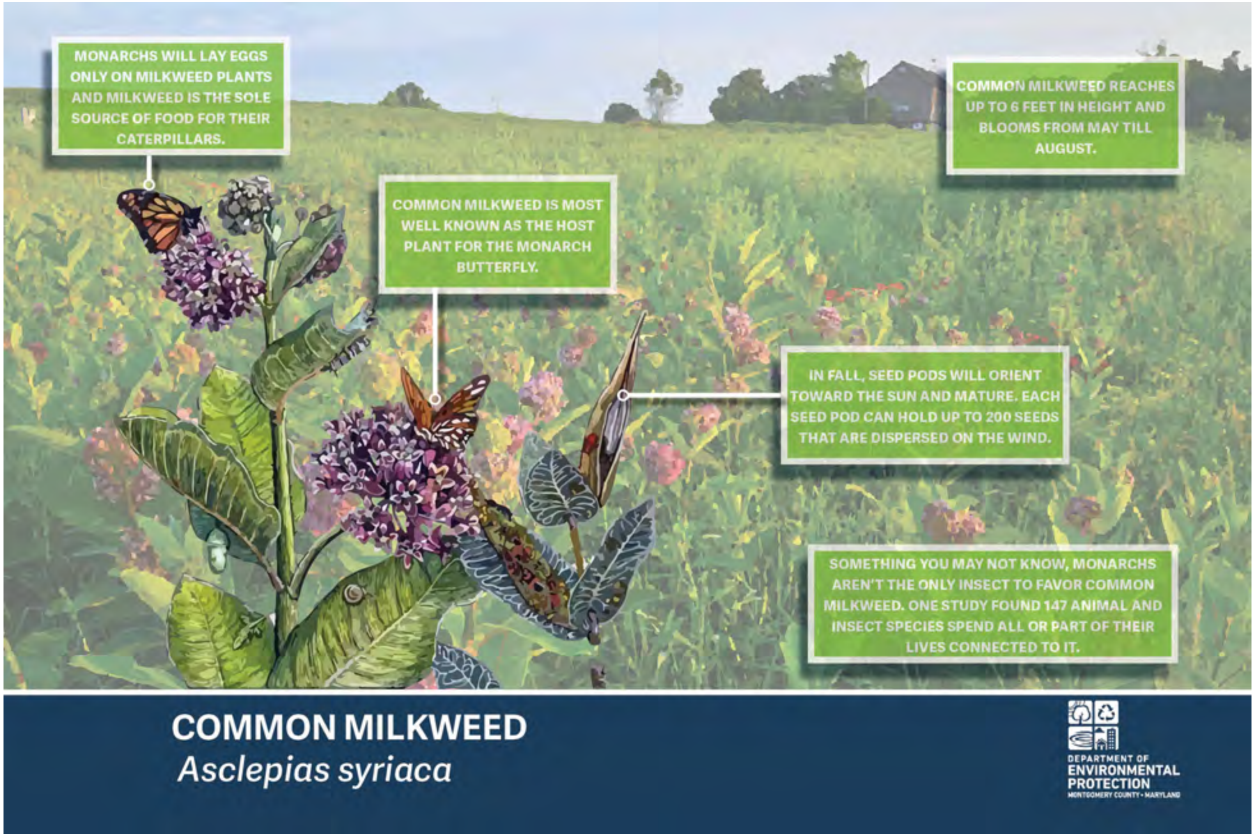


Educational Post #6 – Blackeyed Susan



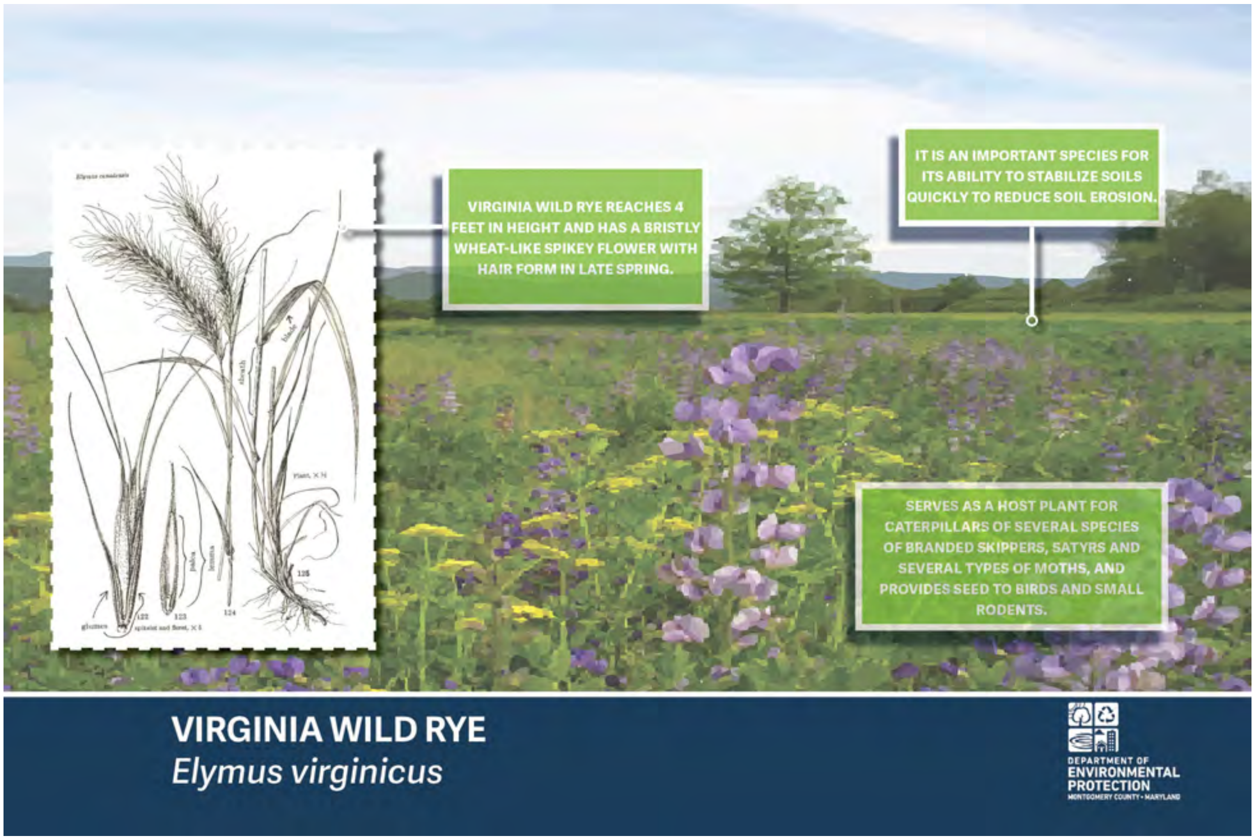
Educational Post #7 – Cedar Waxwing

Educational Post #8 – Common Milkweed

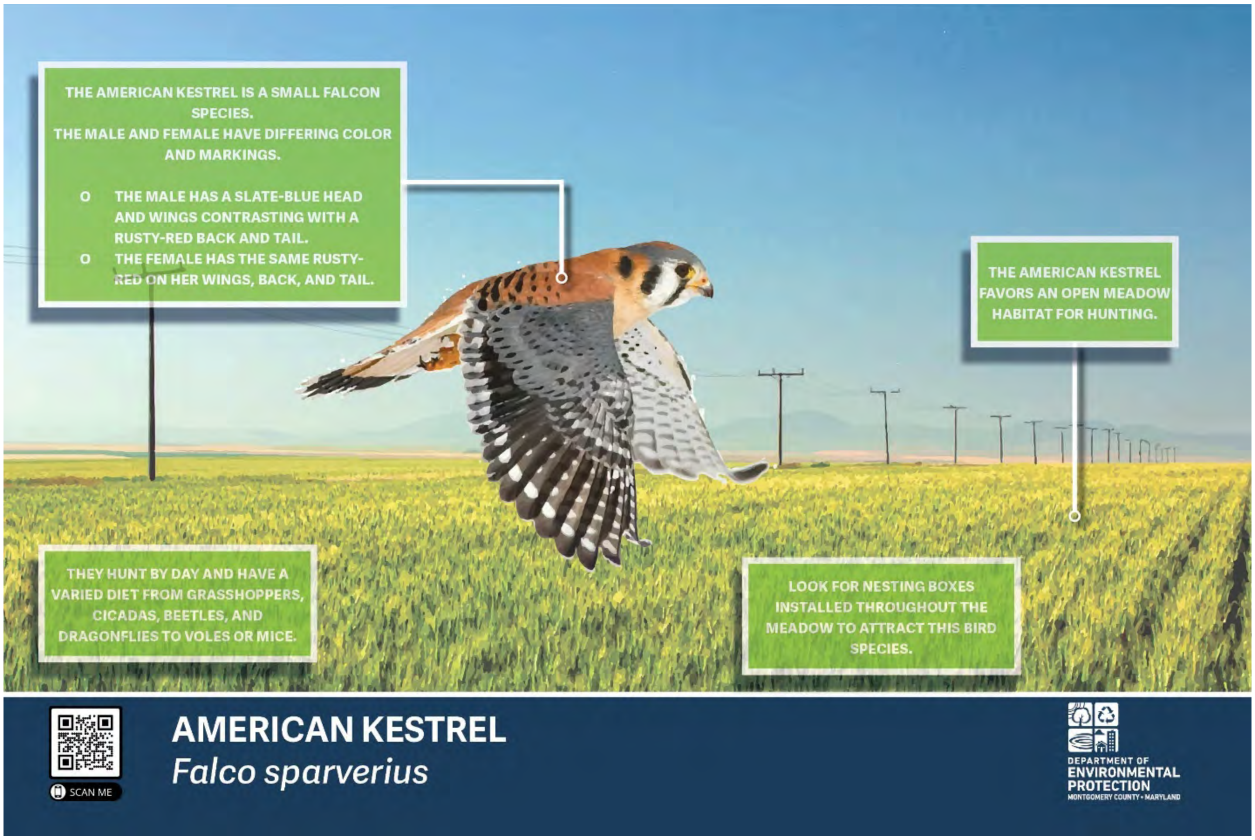


Educational Post #9 – Field Sparrow

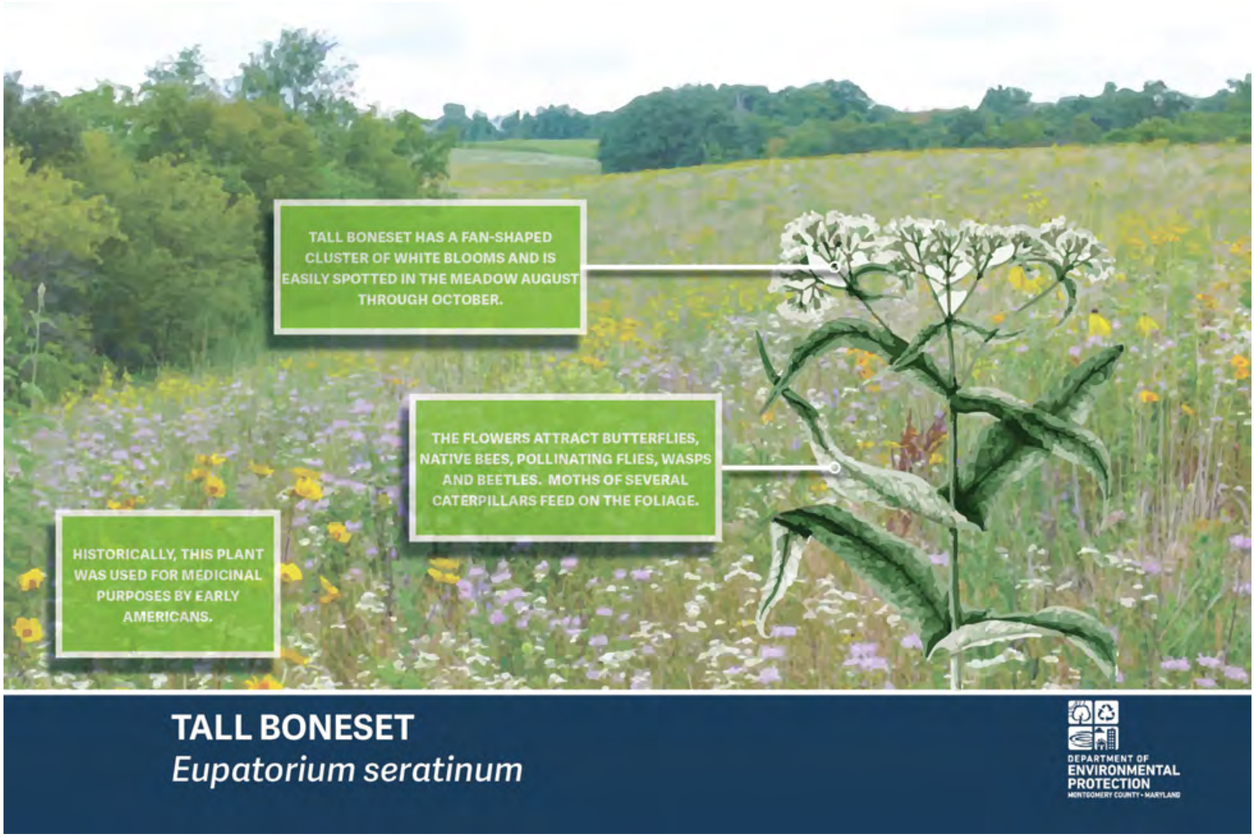
Educational Post #10 – Virginia Wild Rye



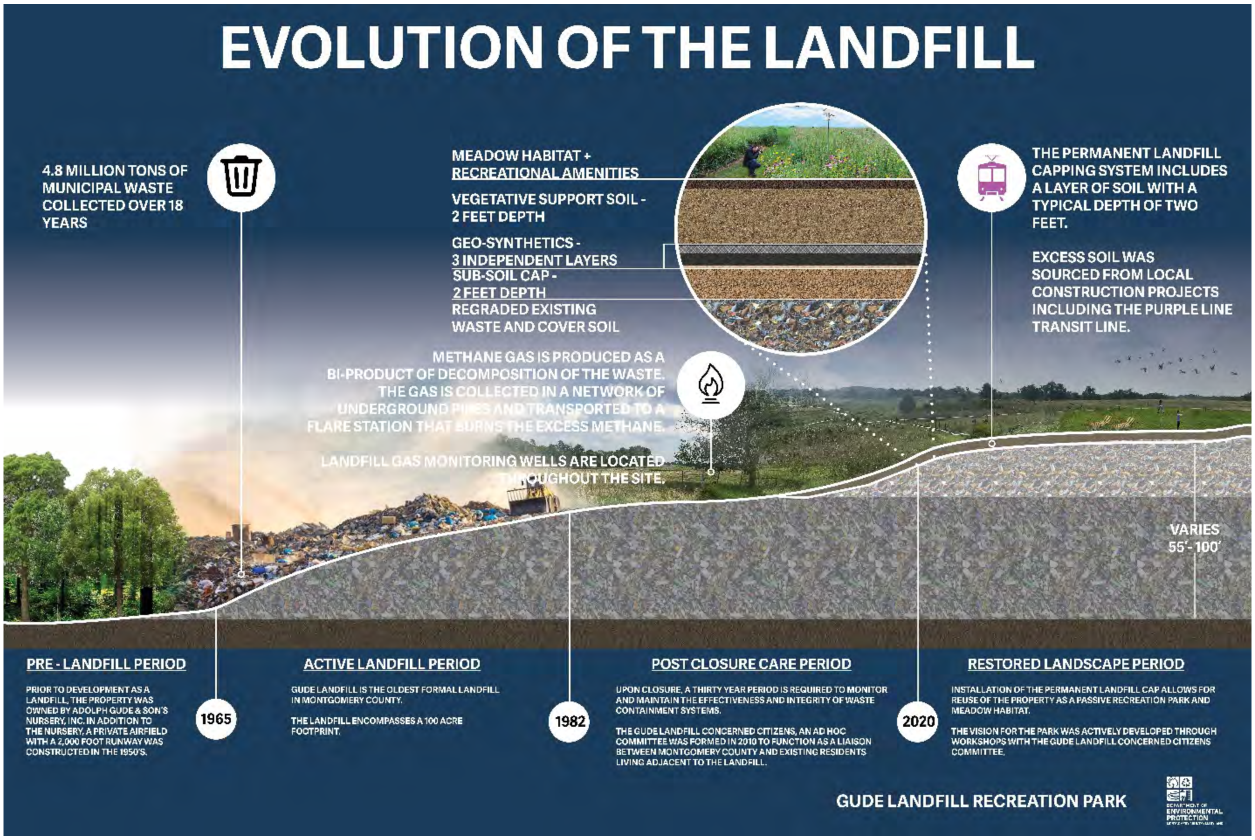
Educational Post #11 – American Kestrel



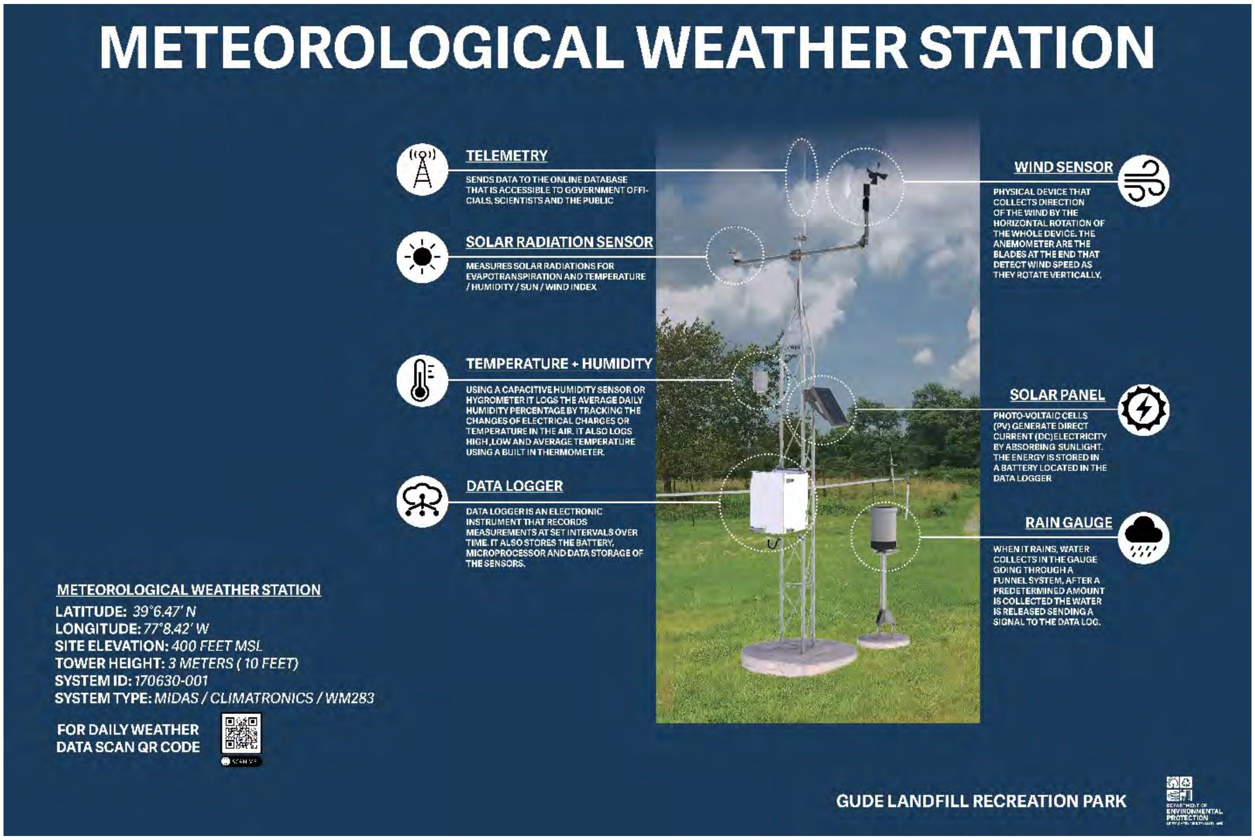
Educational Post #12 – Tall Boneset



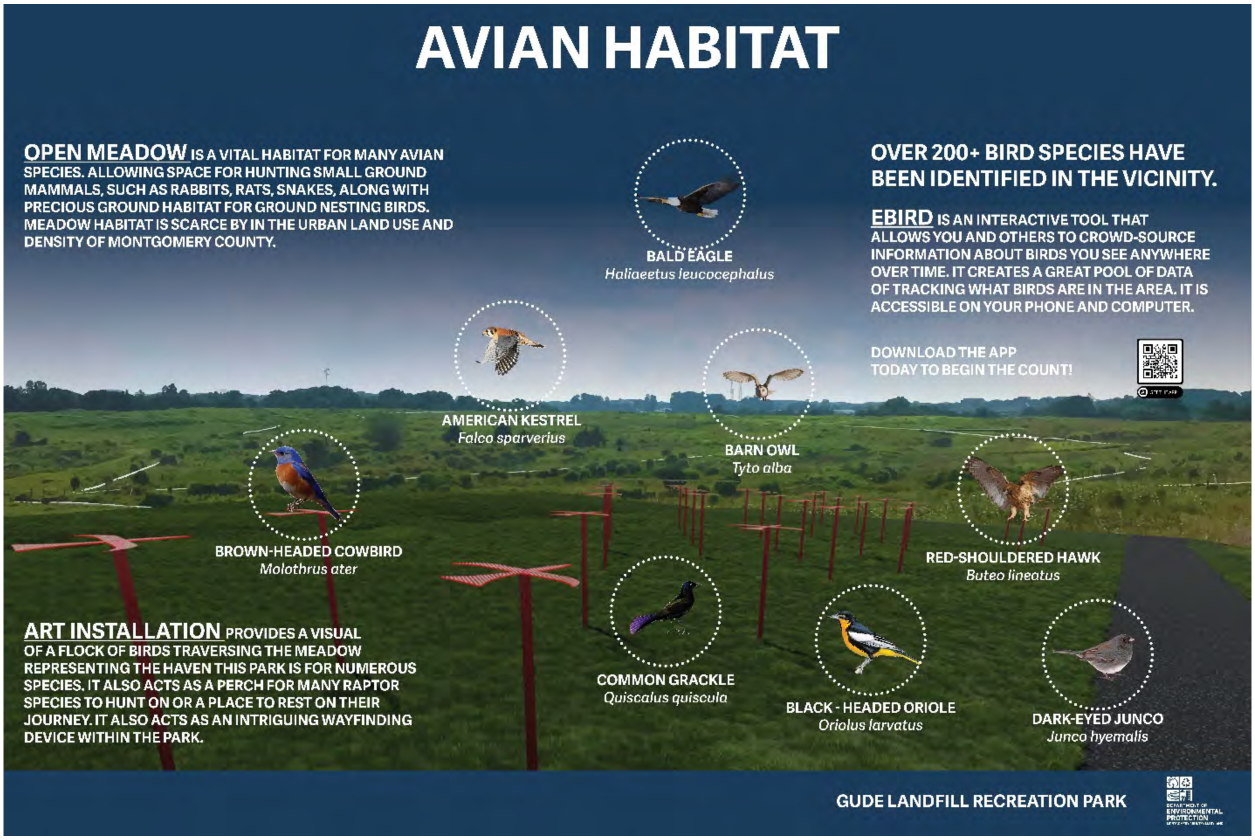
Educational Sign (Large) /Waystation #1 - Evolution of the Landfill



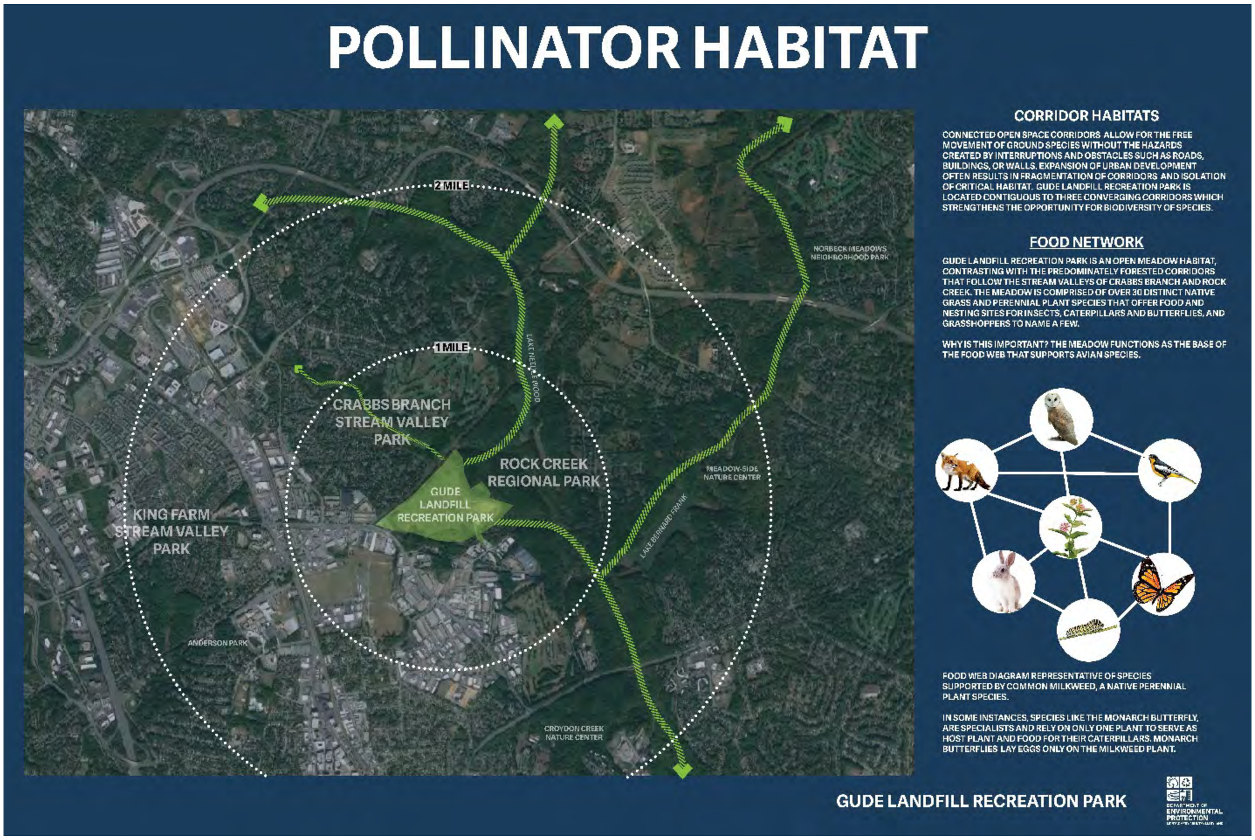
Educational Sign (Large) /Waystation #2 – Meteorological Weather Station



Educational Sign (Large) /Waystation #3 – Avian Habitat



Educational Sign (Large) /Waystation #4 – Pollinator Habitat



ATTACHMENT C – MEADOW MIX SPECIES LIST

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Meadow Mix #1 – Custom Upland Deer Tolerant Meadow Mix

% of Mix	Latin Name	Common Name	Cultivar/ Ecotype
1.3	*Asclepias tuberosa*	Butterfly Milkweed	Any
1.3	*Aster oblongifolius*	Aromatic Aster	PA
1.3	*Aster prenanthoides*	Zig Zag Aster	PA
0.3	*Baptisia tinctoria*	Wild Indigo	PA
4.0	*Chamaecrista fasciculata*	Partridge Pea	PA
4.0	*Coreopsis lanceolata*	Lance Leaf Coreopsis	Any
8.6	*Echinacea purpurea*	Purple Coneflower	Any
20.0	*Elymus virginicus*	Virginia Wildrye	PA
0.3	*Eragrostis spectabilis*	Purple Lovegrass	PA
0.7	*Eupatorium coelestinum*	Mistflower	VA
0.2	*Geum canadense*	White Avens	PA
2.6	*Heliopsis helianthoides*	Ox-Eye Sunflower	PA
0.5	*Liatris spicata*	Spiked Gayfeather	PA or any
1.0	*Liatris squarrosa*	Scaly Blazing Star	VA
0.4	*Monarda fistulosa*	Wild Bergamot	FIG (PA)
0.3	*Monarda punctata*	Dotted Mint	MD or APB
0.3	*Oenothera fruticosa*	Sundrops	PA
19.0	*Panicum anceps*	Beaked Panicgrass	MD
3.0	*Panicum sphaerocarpon*	Roundseeded Panicgrass	PA
0.4	*Penstemon canescens*	Grayhairy Beardtongue	WV
0.7	*Penstemon digitalis*	Tall White Beardtongue	PA
0.4	*Penstemon hirsutus*	Hairy Beardtongue	PA
0.9	*Pycnanthemum tenuifolium*	Narrow Leaved Mountain Mint	PA
0.7	*Rudbeckia fulgida*	Orange Coneflower	VA
4.0	*Rudbeckia hirta*	Black Eyed Susan	PA or any
20.0	*Schizachyrium scoparium*	Little Bluestem	PA or Camper
1.0	*Senna hebecarpa*	Wild Senna	WV
0.6	*Solidago nemoralis*	Gray Goldenrod	PA
0.2	*Solidago odora*	Licorice Scented Goldenrod	PA
1.5	*Tradescantia ohiensis*	Ohio Spiderwort	PA
0.5	*Zizia aurea*	Golden Alexanders	PA
100	*Total*		

By seed count this mix has approximately 357,000 seeds/lb and is 28.1% grasses and 71.9% wildflowers. If an item in this mix is not available, add its percentage to a member of the same genera in the mix or to *Schizachyrium scoparium*. Apply this mix at 10 lbs PLS or 15 bulk lbs/acre along with a cover crop.

For a cover crop use one of the following: Grain Oats, *Avena sativa*, (1 Jan to 30 Apr; 30 lbs/acre), Brown Top Millet, *Brachiaria ramosa*, (1 May to 31 Aug; 10 lbs/acre), or Grain Rye, *Secale cereale*, (1 Sep to 31 Dec; 30 lbs/acre).

Meadow Mix #2 – Three-way Tall Fescue Mix (ERNMX-136 or equivalent)

% of Mix	Latin Name	Common Name	Cultivar/ Ecotype
34.0	*Festuca arundinacea ‘Firecracker SLS’*	Tall Fescue, ‘Firecracker SLS’	Any
33.0	*Festuca arundinacea ‘Ninja III’*	Tall Fescue, ‘Ninja III’	Any
33.0	*Festuca arundinacea ‘Valkyrie LS’*	Tall Fescue, ‘Valkyrie LS’	Any
100	*Total*		

Apply this mix at 43.5 bulk lbs/acre.

Meadow Mix #3 – Custom Upland Deer Tolerant Slope Meadow Mix

% of Mix	Latin Name	Common Name	Cultivar/ Ecotype
0.2	*Asclepias tuberosa*	Butterfly Milkweed	Any
0.2	*Aster oblongifolius*	Aromatic Aster	PA
0.2	*Aster prenanthoides*	Zig Zag Aster	PA
1.6	*Chamaecrista fasciculata*	Partridge Pea	PA
1.3	*Coreopsis lanceolata*	Lance Leaf Coreopsis	Any
2.8	*Echinacea purpurea*	Purple Coneflower	Any
22.2	*Elymus virginicus*	Virginia Wildrye	PA
0.1	*Eragrostis spectabilis*	Purple Lovegrass	PA
0.1	*Eupatorium coelestinum*	Mistflower	VA
0.1	*Geum canadense*	White Avens	PA
0.9	*Heliopsis helianthoides*	Ox-Eye Sunflower	PA
0.1	*Liatris spicata*	Spiked Gayfeather	PA or any
0.1	*Liatris squarrosa*	Scaly Blazing Star	VA
0.2	*Monarda fistulosa*	Wild Bergamot	FIG (PA)
0.2	*Monarda punctata*	Dotted Mint	MD or APB
0.1	*Oenothera fruticosa*	Sundrops	PA
31.1	*Panicum anceps*	Beaked Panicgrass	MD
4.4	*Panicum sphaerocarpon*	Roundseeded Panicgrass	PA
0.1	*Penstemon canescens*	Grayhairy Beardtongue	WV
0.2	*Penstemon digitalis*	Tall White Beardtongue	PA
0.1	*Penstemon hirsutus*	Hairy Beardtongue	PA
0.2	*Pycnanthemum tenuifolium*	Narrow Leaved Mountain Mint	PA
0.1	*Rudbeckia fulgida*	Orange Coneflower	VA
1.3	*Rudbeckia hirta*	Black Eyed Susan	PA or any
31.1	*Schizachyrium scoparium*	Little Bluestem	PA or Camper
0.4	*Senna hebecarpa*	Wild Senna	WV
0.1	*Solidago nemoralis*	Gray Goldenrod	PA
0.1	*Solidago odora*	Licorice Scented Goldenrod	PA
0.3	*Tradescantia ohiensis*	Ohio Spiderwort	PA
0.1	*Zizia aurea*	Golden Alexanders	PA
100	*Total*		

By seed count this mix has approximately 234,000 seeds/lb and is 63.7% grasses and 36.3% wildflowers. If an item in this mix is not available, add its percentage to a member of the same genera in the mix or to *Schizachyrium scoparium*. Apply this mix at 45 bulk lbs/acre along with a cover crop and an erosion control blanket.

For a cover crop use one of the following: Grain Oats, *Avena sativa*, (1 Jan to 30 Apr; 30 lbs/acre), Brown Top Millet, *Brachiaria ramosa*, (1 May to 31 Aug; 10 lbs/acre), or Grain Rye, *Secale cereale*, (1 Sep to 31 Dec; 30 lbs/acre).

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ATTACHMENT D – MEADOW MAINTENANCE SCHEDULE

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Meadow Maintenance & Invasive Species Management Schedule												
				Growing Season (April.15 –Nov. 15)								
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Year One												
Meadow Seed Installation												
Installation												
Watering												
Water weekly for 2 months after install (Assume 8)												
Water every 10 days in drought (Assume 4)												
Mowing/Bush-Hogging												
Mowing (Assume 3)												
Inspection/ Application Foliar Treatment to Control Invasive Species												
Inspection												
Application												
Year Two												
Reseeding												
Reseed, if required												
Watering												
Water every 10 days in drought (Assume 4)												
Mowing/Bush-Hogging												
Annual Spring Mowing												
Mowing Invasive Control (Assume 1)												
Inspection/ Application Foliar Treatment to Control Invasive Species												
Inspection												
Application												
Year Three												
Watering												
Water every 10 days in drought (Assume 4)												
Mowing/Bush-Hogging												
Annual Spring Mowing												
Mowing (Assume 1)												
Inspection/ Application Foliar Treatment to Control Invasive Species												
Inspection												
Application												

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