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

## MAJOR PERMIT AMENDMENT APPLICATION

## VOLUME 4 OF 6




Prepared for

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

May 2022

Prepared by

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WCG Project No. 0023-404-11-104

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# TARRANT COUNTY, TEXAS
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## MAJOR PERMIT AMENDMENT APPLICATION
## VOLUME 4 OF 6

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**PART III – SITE DEVELOPMENT PLAN**

Appendix IIIF – Surface Water Drainage Plan



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

## MAJOR PERMIT AMENDMENT APPLICATION

## PART III – SITE DEVELOPMENT PLAN
## APPENDIX IIIF
## SURFACE WATER DRAINAGE PLAN

Prepared for

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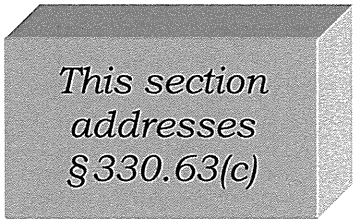
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# 1 INTRODUCTION




This Surface Water Drainage Plan is prepared as part of a permit amendment application for the City of Arlington Landfill consistent with Title 30 Texas Administrative Code (TAC) Chapter 330. This plan addresses surface water drainage design and erosion control. Permit level plans and details are presented for the proposed drainage system in this appendix. This appendix also includes a demonstration consistent with Title 30 TAC §330.305(a) that the proposed landfill development will not adversely alter permitted drainage patterns. Parts I/II, Section 11.1 includes information pertaining to the sites compliance with floodplain location restrictions via the submittal of a Conditional Letter of Map Revisions (CLOMR) to FEMA, revising the effective floodplain limits and elevations. Figures 4.6 and 4.7 illustrate the floodplain information after the proposed projected has been constructed.

This appendix includes the design of the final cover erosion layer and drainage structures (i.e., chutes and swales), perimeter drainage channels, detention ponds, as well as hydrologic and hydraulic calculations. Consistent with Title 30 TAC §330.63(c) and §330.305(b) and (c), these facilities are designed to convey run-off produced from the 25-year storm event. In addition, an Erosion Control Plan for all phases of landfill development is included in Appendix IIIF-F. All drainage facilities will be constructed and maintained in accordance with this plan.

This appendix also includes (Section 4) a demonstration that shows that the proposed landfill development will not adversely alter the existing permitted drainage patterns. As noted in Section 4, the proposed condition represents the proposed configuration of the site after the landfill has been completely developed. Consistent with Title 30 TAC §330.63(c)(1)(C), §330.63(c)(1)(D)(iii), and §330.305(a), the proposed completion condition is compared to the existing permitted condition to demonstrate that the continued development of the City of Arlington Landfill will not adversely alter the existing permitted drainage patterns.

To provide a complete and relevant comparison between the permitted and post-project conditions, the existing permitted landfill layout was evaluated using the latest precipitation data, different hydrograph methodology, and updated offsite drainage area information. These updates are discussed further in Section 4.

# 2 STORMWATER MANAGEMENT

## 2.1 Drainage System Layout

Stormwater runoff collected in swales located on the top dome and sideslopes of the landfill will be conveyed to drainage letdown structures (chutes) down the slopes to the perimeter channels. The perimeter channels collect runoff from drainage letdowns and convey the runoff to stormwater detention ponds. The perimeter channels will be constructed incrementally as the site develops. The perimeter drainage system will be constructed in the general sequence shown on Parts I/II Drawings I/IIA-4 through I/IIA-7. As shown on Drawing IIIF.1 – Drainage Structure Plan, runoff generated from the developed areas will be conveyed into one of two detention ponds to be attenuated before being discharged into the West Fork Trinity River.

In the permitted condition, runoff from the areas north of the permit boundary is routed around the east or west sides of the landfill or is conveyed through the permit boundary in Hurricane Creek. As a part of the proposed landfill development, Hurricane Creek is proposed to be diverted to the west around the north side of the landfill. This runoff will be attenuated in the south pond (P2) before discharging at DCP 2 across the permit boundary, consistent with the permitted conditions, ultimately discharging south into the West Fork.

Pond P1 receives runoff from the eastern portion of the developed landfill and ultimately discharges across the permit boundary at the currently-permitted discharge location (DCP5) in an existing box culvert under F.M. 157. Discharge from P1 merges with sheet flow and channelized runoff offsite areas between the landfill and F.M. 157 before flowing east off of the permit boundary at location DCP5 (see Figures 4.4 and 4.5). Across 157, runoff flows to the south approximately 1 mile to the West Fork.

The runoff from offsite drainage areas discharging onto the permit boundary (see Figures 4.5 and 4.6) is collected by the relocated alignment of Hurricane Creek, located on the north and west sides of the facility. The south pond, P2, detains and ultimately discharges this water and also serves as an overbank floodplain storage area for the West Fork.

The remaining offsite areas (04, 05, and 06) discharge east off the proposed permit boundary area at location DCP5, consistent with the permitted drainage analysis. Discharge points DCP1, DCP2, and DCP3 convey sheet flow off of the permit boundary at the same locations as in the post-project conditions. In the permitted conditions, the south pond discharges through DCP1 into the West Fork. Under the proposed condition, only overland flow between the south pond and the permit boundary discharges at DCP1.

The facility has been designed to prevent discharge of pollutants into waters of the State or waters of the United States, as defined by the Texas Water Code and the Federal Clean Water Act, respectively. The City of Arlington Landfill has a current Texas Pollution Discharge Elimination System (TPDES) multi-sector general permit (MSGP) for industrial activity as stipulated under Section 402 of the Clean Water Act and under Chapter 26 of the Texas Water Code, the TPDES program. A copy of the multi-sector permit is included in Parts I/II, Appendix I/IIG. Any stormwater that has become contaminated by contact with the working face or with leachate will be handled in accordance with Appendix IIIC – Leachate and Contaminated Water Management Plan. The facility maintains a current Stormwater Pollution Prevention Plan prepared consistent with the provisions of TPDES MSGP TXR050000.

## 2.2 Erosion and Sedimentation Control Plan

The City of Arlington Landfill will use various interim and permanent erosion and sedimentation controls during all phases of site development to provide effective erosion stability for the external sideslopes and top dome surfaces. The interim controls will be used around active areas and external embankment sideslopes and top dome surfaces. These controls will include temporary letdown structures, soil berms, and seeding of intermediate cover areas to minimize the erosion potential. These interim controls will be used during all phases of landfill development to provide effective erosion stability for the external sideslopes and top dome surfaces until final cover is installed. Refer to Appendix IIIF-F – Erosion Control Plan for All Phases of Landfill Operation for more information.

Permanent controls include swales and chutes that will be constructed upon completion of the final cover installation. As part of the final cover construction, an erosion layer capable of sustaining vegetation will be constructed. Areas that receive final cover will be vegetated in accordance with Appendix IIIJ – Closure Plan upon completion of final cover placement. Final cover vegetation will protect the erosion layer soil against erosive runoff velocities. A soil loss and sheet flow velocity demonstration for the erosion layer is included in Appendix IIIF-D. The erosion layer will include a vegetation layer that provides for 60 percent ground coverage, to keep soil loss below the required design values. If there are areas that

do not maintain at least 60 percent vegetative coverage, vegetation in these areas will be reestablished to maintain at least 60 percent vegetative cover.

Erosion will be controlled by vegetation in drainage structures with flow velocities less than or equal to 5 feet per second (fps). For drainage structures with flow velocities greater than 5 fps, rock riprap, gabions, or other surface reinforcing materials as designed will be used for surface reinforcement.

During site development, non-structured and structural best management practices (BMPs) will be employed to control erosion and sedimentation ponds will be installed to prevent sediment discharge from the site. BMPs may include the use of temporary rock riprap, silt fences, straw bales, check dams, interceptor swales and berms, temporary and permanent seeding and sodding, surface roughening, matting and mulching, sediment traps, and surface wetting for dust control (refer to Appendix IIIF-F for more information).

Runoff volume (25-year, 24-hour storm event) from the active fill area (i.e., working face of the landfill operation) will be contained by the containment berm (refer to Part III, Appendix IIIC – Leachate and Contaminated Water Management Plan for details) to prevent potential discharge of contaminated runoff from the site.

## 2.3 Stormwater System Maintenance Plan

In accordance with Title 30 TAC §330.305(e)(1), the constructed stormwater systems such as channels, drainage swales, and chutes will be repaired and restored in the event of wash-out or failure from extreme storm events. Stormwater BMPs installed during all phases of landfill development will also be replaced or repaired in the event of failure. Excessive sediment will be removed, as needed, so that the drainage structures, such as the perimeter channels and detention ponds, function as designed. Site inspections by landfill personnel will be performed weekly or within 24 hours after any significant rainfall event of 0.5 inches or more, or as soon as the areas are accessible. Documentation of the inspection will be included in the Site Operating Record.

The following items will be evaluated during the inspections as further discussed in Appendix IIIF-F and Part IV – SOP:

- Erosion of daily and intermediate cover areas, final cover areas, perimeter ditches, chutes, swales, detention ponds, berms, and other drainage features.
- Settlement of intermediate cover areas, final cover areas, perimeter ditches, chutes, swales, and other drainage features.
- Silt and sediment build-up in perimeter ditches, chutes, swales, and detention ponds. Removed silt and sediment used as daily cover or to replenish intermediate cover soils.

- Obstructions in drainage features.
- Presence of erosion or sediment discharge at offsite stormwater discharge locations.
- Presence of sediment discharges along the site boundary in areas which have been disturbed by site activities.

Maintenance activities will be performed to correct damaged or deficient items noted during the site inspections. These activities will be performed once repairs can safely be performed. The time frame for correction of damaged or deficient items will vary based on weather, ground conditions, and other site-specific conditions.

Maintenance activities will consist of the following, as needed:

- Vegetation reestablishment.
- Placement, grading, and stabilization of additional soils in eroded areas or in areas which have settled.
- Replacement or repair of riprap or other surface lining materials.
- Placement of additional riprap in eroded areas.
- Removal of obstructions from drainage features.
- Removal of silt and sediment build-up from drainage features.
- Repairs to erosion and sedimentation controls.
- Installation of additional erosion and sedimentation controls.

# 3 DRAINAGE SYSTEM DESIGN

## 3.1 Methodology

Drainage calculations for the final cover system erosion control structures and perimeter drainage system are based on the peak flow rates resulting from the 25-year frequency rainfall event for the area. The United States Army Corps of Engineers (USACE) HEC-HMS computer program was used to compute peak flow rates produced from the design storm. The hydraulic methods employed in this study are consistent with those presented in the TCEQ *Guidelines for Preparing a Surface Water Drainage Report for Municipal Solid Waste Facility (RG-417, May 2018)* and TxDOT *Bridge Division Hydraulic Manual*, July 2019.

Water surface profiles were determined for the perimeter channels using the Channel Analysis Program (HYDROCALC HYDRAULICS Version 2.0.1 for Windows, Dodson & Associates, 1996-2010) that is based on Manning's formula for uniform flow. The perimeter channels are designed to collect and route runoff from the 25-year frequency storm event to the detention ponds.

## 3.2 Hydrologic Analysis

### 3.2.1 Description of Computer Program

HEC-HMS was developed by the USACE Hydrologic Engineering Center to simulate the surface runoff response of a watershed. The HEC-HMS model represents a watershed as a network of hydrologic and hydraulic components. The modeling process results in the computation of stream-flow hydrographs at desired locations in the watershed. The hydrologic analysis for the post-development condition is presented in Appendix IIIF-A. The hydrologic analysis for the permitted landfill completion condition is included in Appendix IIIF-E.

### 3.2.2 Watershed Subareas and Schematization

The landfill areas that contribute flow to each detention pond were delineated into subareas to derive peak flow rates for the design of the perimeter channel and final cover drainage letdowns. Hydrographs are developed for each subarea and appropriately combined and routed through the swales and perimeter channels.

The subareas are shown on Drawing IIIF.2 – Post-Development Drainage Area Plan as well as in Appendix IIIF-E for the permitted completion condition.

Offsite areas (areas outside the permit boundary) incorporated into the hydrologic analyses as appropriate have been delineated using topography obtained from the United States Geological Survey 7.5-Minute Quadrangle for Euless, TX. The offsite drainage area delineation is shown on Figure 4.3 for the post-development discharge analysis. The offsite areas are also included in the hydrologic analysis for the permitted landfill completion condition, as shown in Appendix IIIF-E.

### 3.2.3 Time Step

The time step, or the program computation interval, is the time interval at which the flow rates for the hydrographs are generated by the program. Time step used for a design storm event hydrograph generation is 5 minutes.

### 3.2.4 Hypothetical Precipitation

The hypothetical storm data used in the hydrologic analyses was obtained from the National Oceanic and Atmospheric Administration's (NOAA) Atlas 14 point precipitation frequency estimates for the project area. For the design storm event analysis, a return period (frequency) of 25 years and a duration of 24 hours is used. The precipitation is assumed to be evenly distributed over the entire area modeled for each time interval.

### 3.2.5 Precipitation Losses

Precipitation losses (the precipitation that does not contribute to the runoff) are calculated using the Soil Conservation Service (SCS) Curve Number (CN) method. CN is a function of soil cover, land use, and antecedent moisture conditions. A CN of 86 was selected to represent the final cover sideslopes, and a CN of 84 was selected for final cover top dome surfaces. A CN of 99 was used for the detention pond areas. Further discussion on selection of CN values is provided in Appendices IIIF-A and IIIF-E for post-development and updated permitted landfill completion conditions, respectively.

### 3.2.6 Hydrograph Information

Two different types of hydrograph generation methods have been used in the drainage analyses: distributed runoff methods and the Snyder unit hydrograph method using the Espey "10-Minute" method for parameter estimation. Muskingum-Cunge and pond storage discharge methods were used for hydrograph routings. Example hydrograph development information for both distributed runoff and Snyder unit hydrograph methods is provided in Appendix IIIF-A.

Distributed Runoff Methods

The distributed runoff method (e.g., kinematic wave method) is applicable to small-water catchments with uniformly sloped overland flow plains that drain into channels. Landfill final cover areas consist of relatively short (typically 120 feet on 4H:IV sideslopes) overland flow lengths that drain into landfill final cover swales. Distributed runoff estimation methods are applicable to landfill final cover areas because of the following:

- These methods were developed for uniform slopes that drain to collection channels. For a landfill final cover area, this translates to an overland flow segment of final cover that drains to a swale.
- These methods were developed for a network of relatively small drainage areas. Typically, to design the various perimeter channels, landfill drainage areas need to be subdivided to determine a peak flow at several points.
- These methods are also inherently conservative because it is based on watershed dimensions as opposed to other methods that use empirical information. Also, this method is conservative because flow attenuation is not accounted for.
- This method is also more conservative than the rational method because watershed lag time is computed as a function of real flow time without any limitations such as using a minimum time of concentration (i.e., 10 minutes), which is common practice for the rational method.

The kinematic wave method has been used for estimating peak runoff rates from the landfill final cover areas. A hydrograph from each drainage area with channelized flow (e.g., landfill final cover areas to swales) was developed using the kinematic wave method to simulate both overland and channelized flow. This method utilizes a simplified form of the energy equation and is based on the characteristics of the drainage area, swale, or channel. This method uses physical (measurable) characteristics (e.g., flow lengths, slopes, surface roughness coefficients, channel cross sections) of a watershed to estimate peak discharges.

Snyder Unit Hydrograph Method

The Snyder unit hydrograph method has been used mainly for non-landfill drainage areas (e.g., offsite drainage areas). The method is applicable to drainage areas with a wide range of characteristics. Several different methods have been developed to estimate Snyder unit hydrograph parameters (watershed lag and peaking coefficient). Espey "10-Minute" method was used in this project to estimate Snyder unit hydrograph parameters. The Espey "10-Minute" method was developed using flow records from 41 different watersheds in Texas and other states. The main advantage of the Espey "10-Minute" method is that it is one of the most widely used and accepted methods for determining hydrograph input values for small-size drainage areas.

Hydrograph Routing

The Muskingum-Cunge Method was used for routing of the flood wave through the drainage channels. This method is capable of accounting for hydrograph attenuation based on physical channel properties such as length, bottom slope, channel shape, and channel roughness.

Hydrographs at pond outlets were generated by routing the combined incoming flow hydrographs through the ponds. Pond routings were performed by using storage/elevation relationships for each pond by defining pond surface area versus depth. Additionally, discharge structure (low level outlet and spillway) characteristics of each pond are used for pond routing.

## 3.3 Hydraulic Analysis

### 3.3.1 Swale and Channel Analysis

Drainage structure details are illustrated on Drawings IIIF.8 through IIIF.12. The swales and channels are designed to convey the peak flow rate generated by the design storm event. These swales and channels will also reduce maintenance at the site after closure by minimizing erosion.

Hydraulic analyses of the swales and channels are conducted using Manning's uniform flow formula. The uniform flow assumption is applicable to long prismatic channels of uniform slope, as proposed at the site.

The general form of Manning's equation is

$$V = \frac{1.49\, R^{0.667}\, S^{0.5}}{n}$$

in which

$V$ = *Velocity of flow, fps (feet per second)*
$n$ = *Manning's "n" (unitless)*
$R = \frac{A}{P}$ = *Hydraulic radius, ft (feet)*
$S$ = *Friction slope for nonuniform flow or channel slope for uniform flow, ft/ft*
$A$ = *Area of water perpendicular to direction of flow, sf (square feet)*
$P$ = *Wetted perimeter, ft.*

Using the relationship

$$Q = VA$$

Manning's equation can be written as

$$Q = \frac{1.49\, A\, R^{0.667} S^{0.5}}{n}$$

The uniform flow assumption equates the channel slope to the friction slope; therefore, the slope of the channel can be used for "S" in Manning's formula for computation of uniform flow.

Typical values for Manning's "*n*" are presented in the 2019 TXDOT Bridge Division *Hydraulic Manual* ("Suggested Manning's Roughness Coefficients" Table, Chapter 6, Section 1). A value of 0.030 is used for "*n*" for swales, a value of 0.040 is used for gabion-lined chutes, and a value of 0.030 is used for perimeter channels. These values represent typical roughness coefficients to the proposed drainage structures, after vegetation has become established.

### 3.3.2 Drainage Letdown Structure (or Chute) Analysis

A typical chute detail is illustrated on Drawing IIIF.10. The final cover drainage letdown structures are designed to convey the flow rate generated by the design storm event. Hydraulic analysis of the letdown structures is conducted under the principles of tumbling flow. Tumbling flow is a function of channel slope, discharge, spacing and sizing of energy dissipating elements. The tumbling flow regime consists of a series of hydraulic jumps and overfalls that maintain critical velocity down the chute. The spacing and sizing of the energy dissipators controls the velocity and flow of the water in the chutes, thereby reducing erosive conditions at slope transitions with the perimeter road low water crossings and chute/perimeter channel confluences.

Appendix IIIF-C presents calculations for the energy dissipators.

# 4 DRAINAGE PATTERNS

Consistent with Title 30 TAC §330.63(c)(1)(C), §330.63(c)(1)(D)(iii), and §330.305(a), this section provides a demonstration showing that the proposed landfill development will not adversely alter the existing permitted landfill completion condition drainage patterns. The appendices containing the two drainage conditions analyzed are listed below.

- Appendix IIIF-A (Post-Development Condition Hydrologic Calculations) – This appendix contains analysis and supporting calculations for the proposed configuration of the site after development of the expanded landfill is complete.
- Appendix IIIF-E (Updated Permitted Condition Hydrologic Calculations) – This appendix contains excerpts from the 2014 expansion permit document and the 2019 permit modification that establish the currently-permitted drainage patterns and peak flow rates for the permit boundary area. Section 4.3.1 includes a discussion of analyses performed to facilitate a comparison between the existing permitted and post-development conditions.

The following three sections discuss: (1) regional drainage associated with the site; (2) site drainage patterns; (3) effect of the proposed development on peak flows, volumes, and velocities discharged from the site.

## 4.1 Regional Drainage Information

As shown on Figure 4.1, the 774-acre City of Arlington Landfill permit boundary is located north of the West Fork Trinity River and west of F.M. 157, located within the Trinity River Drainage Basin, shown on Figure 4.2. As shown on Figure 4.2, the permit boundary is located near the confluence of the Clear Fork and the West Fork of the Trinity River. The site mostly drains south to the West Fork via overland flow or Hurricane Creek; however, the northeast portion of the site drains east to an existing culvert under F.M. 157. The West Fork flows 6 miles east to the main branch of the Trinity River. The total drainage area of the West Fork Watershed upstream of the site is approximately 159,000 acres or 250 square miles. The landfill permit boundary encompasses approximately 0.05 percent of the watershed upstream of the permit boundary.

Figures 4.4 and 4.5 show the watershed associated with flows entering and leaving the permit boundary in the existing permitted, updated permitted, and post-development conditions. The majority of the area within the permit boundary discharges south into the West Fork. The northeast portion of the permit boundary drains east under F.M. 157 and ultimately into the West Fork approximately 1 mile south of the permit boundary.

## 4.2 Site Drainage Patterns

The existing permitted, updated permitted, and post-development site drainage patterns are detailed on Figures 4.4 and 4.5. As shown on Figure 4.5, the post-development drainage patterns are consistent with the currently permitted and updated permitted drainage patterns. The drainage patterns that include the individual outfalls at the permit boundary and individual runon locations (locations where upstream offsite areas flow onto the permit boundary) for both the updated permitted and proposed conditions are the same. Run-on locations have been added to the updated permitted condition to include areas east of the permit boundary from which runon enters the permit boundary (DCP05 and 06).

As shown on Figure 4.4, the total drainage area of the permit boundary is unchanged by the proposed expansion. However, the addition of DCP05 and 06 and the change in hydrologic methodology led to the development of the updated permitted condition. Supplementing the existing permitted condition analysis with an updated hydrologic model allows for a direct comparison to be made between the permitted and post-project conditions. As shown in the onsite drainage area information on Figures 4-4 and 4-5, the updated permitted and proposed onsite drainage delineations are consistent.

Locations DCP1, DCP2, DCP3, and DCP4 discharge across the permit boundary and, either by overland flow paths (DCP1, 3, and 4) or Hurricane Creek (DCP2), into the West Fork in both permitted and post-development conditions. The remaining drainage basin (Area 5, shown on Figure 4.5) enters the permit boundary at locations DCP05 and discharges at DCP5.

The total drainage area to the five outfall locations is consistent between the updated permitted and post-project conditions (4,607 acres). In the existing permit drainage analysis, DCP05 and DCP06 are not accounted for in the runon calculations. The permit boundary and offsite drainage areas are all equally represented in each condition.

## 4.3 Effect of Site Development on Drainage from the Site

The purpose of this section is to evaluate the peak flow rates, runoff volumes, and peak flow velocities of the updated permitted and post-development hydrologic

conditions. A summary of peak flow rates, runoff volumes, and peak flow velocities entering and exiting the permit boundary is provided in Table 4.1 and Figure 4.5 – Site Drainage Patterns, Runon/Runoff. Section 4.3.1 discusses the updated permitted landfill completion condition drainage analysis and how its input and methodology compares to the post-development condition.

Sections 4.3.2 through 4.3.5 discuss the impact of the proposed landfill conditions on peak flow rates, runoff volumes, and peak flow velocities entering and exiting the permit boundary.

## 4.3.1 Comparison of Updated Permitted and Post-Development Analyses

### 4.3.1.1 Overview of Updated Permitted Condition

As shown in Figures 4.4 and 4.5, the drainage analysis included in TCEQ Permit No. 358B (for the purpose of this appendix, this case will be designated the "existing permitted condition") was developed in 2014 by Golder & Associates and modified by WCG in 2019 (TCEQ approval August 19, 2019). These documents utilized different hydrologic methodologies, precipitation data, and offsite areas than what is used in the post-development condition. In order to develop a direct comparison between the existing permitted and post-development conditions, a separate HEC-HMS analysis was developed for the existing permitted condition. This analysis is included in Appendix IIIF-E. As noted in Section 1.2, to comply with Title 30 TAC §330.63(c)(1)(C), the proposed landfill completion condition is compared to the existing permitted condition of the landfill to demonstrate that the continued development of the landfill will not adversely alter the existing permitted drainage patterns. This comparison is only meaningful if both the post-development and existing permitted conditions are based on consistent drainage information, including the same permit boundary.

Additionally, runoff volume and velocity calculations for all discharge locations were not included in the existing permitted drainage calculations at all discharge locations. These calculations were prepared as a part of this application and are included in Appendix IIIF-E.

## 4.3.2 Peak Flow Rates

As shown on Figure 4.5 and in Table 4-1, the peak flow rates entering the permit boundary from DCPO1, DCPO2, DCPO3, DCPO4, DCPO5, and DCP06 are identical for the updated permitted and post-development conditions. Stormwater that enters the site from an off-site area and stormwater that is generated from within the permit boundary discharges at five separate locations along the permit boundary (DCP1, DCP2, DCP3, DCP4, and DCP5 as shown on Figure 4.5). At these discharge points, the peak flow rates from the 25-year frequency storm event that are discharged from the site for the post-development condition are all less than the permitted conditions. This reduction in the peak flow rates is due to the additional

detention provided by the larger west pond (P2) and different chute/swale configurations on the final cover.

### 4.3.3 Volumes

As shown in Table 4-1, the volumes entering the permit boundary are consistent for the permitted and post-development landfill conditions (the volume generated within the permit boundary increases for the site by 3 ac-ft or 0.2%). The increase in the runoff volume for the entire site is a result of the larger detention pond area (approximate 5 acres), for which a CN of 100 is used. This volume increase is insignificant, because the reduced peak flow rate results in a better regulated release of the increased storm volume. Runoff volume calculations are provided in Appendices IIIF-A and IIIF-E.

### 4.3.4 Velocities

A summary of the 25-year frequency storm peak flow velocities that enter and exit the site are shown on Table 4-1. As shown, the velocities at each discharge point are equal or lower for the post-development condition compared to the permitted conditions. This is due to the lower flow rates, given that the cross-sectional area at each drainage outfall remains unchanged. Velocity calculations are provided in Appendices IIIF-A and IIIF-E for the post-development and permitted conditions, respectively.

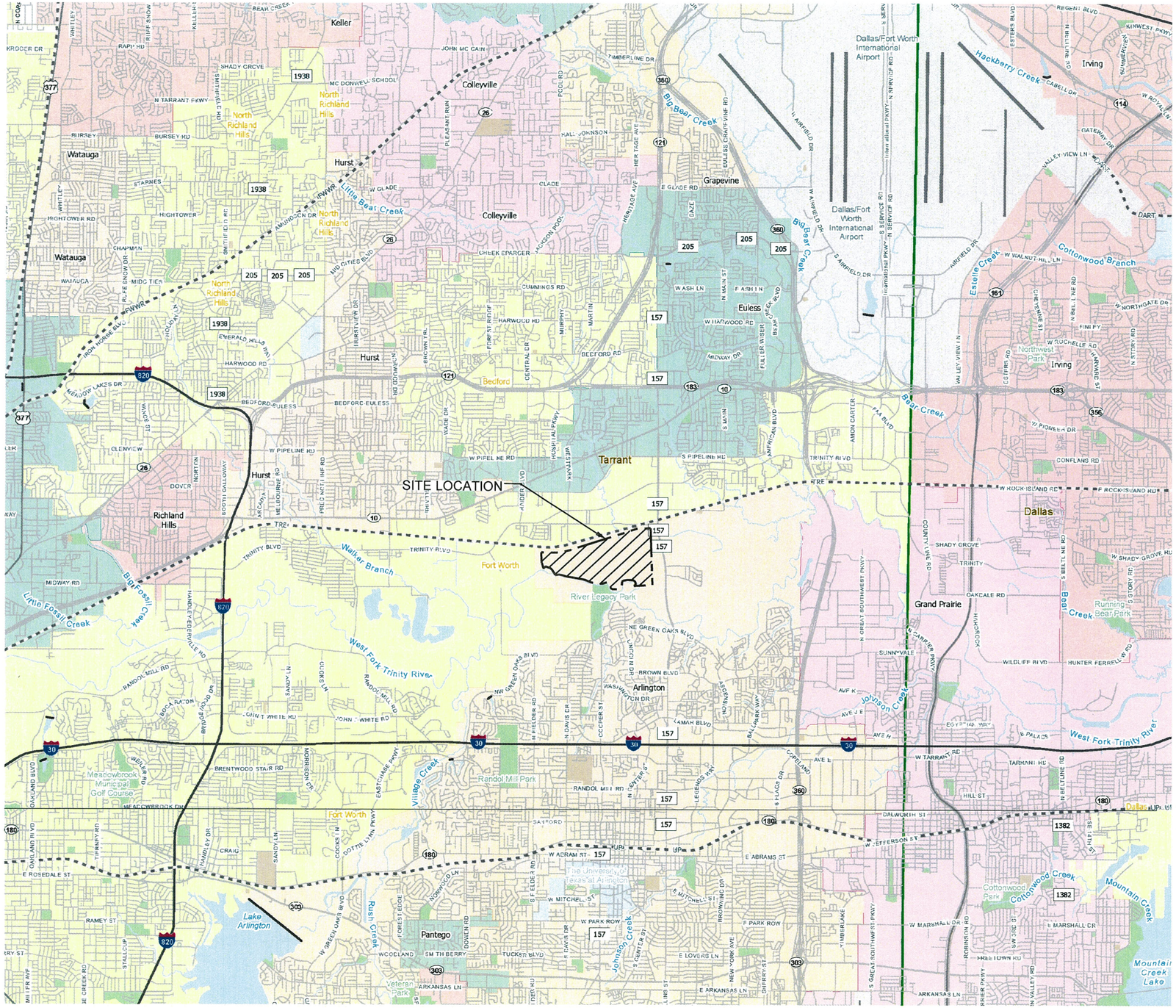
## 4.4 Summary

From the hydrologic evaluations of the updated permitted and proposed conditions, the existing drainage conditions at the permit boundary will not be adversely altered by the proposed development. Given that: (1) drainage patterns are not adversely altered, (2) total design stormwater peak discharge rate at the permit boundary is less than the permitted total stormwater peak discharge rate (and the post-development peak flows entering the site are equal to the permitted peak flows entering the site), (3) total volume of stormwater entering and leaving the permit boundary is not significantly altered, (4) there is no increase in velocity at the permit boundary, and (5) the stormwater discharge outfall locations are consistent with the permitted configuration, it is concluded that the proposed landfill development will not adversely alter permitted drainage patterns consistent with Title 30 TAC 330.63(c)(1)(C), §330.63(c)(1)(D)(iii), and §330.305(a).

## Table 4-1
## Flow Rates, Drainage Areas, Hydrograph Time to Peak Values, Runoff Volumes, and Velocities for the 25-Year Design Storm Event

| Stormwater Discharge Point[1] | Existing Permitted Condition[5] | | | | | Updated Permitted Condition[5] | | | | | Post-Development Condition | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flow Rate (cfs) | Drainage Area (acres) | Time to Peak (hrs) | Runoff Volume (ac-ft) | Velocity at Permit Boundary[2] (fps) | Flow Rate (cfs) | Drainage Area (acres) | Time to Peak (hrs) | Runoff Volume (ac-ft) | Velocity at Permit Boundary[2] (fps) | Flow Rate (cfs) | Drainage Area (acres) | Time to Peak (hrs) | Runoff Volume (ac-ft) | Velocity at Permit Boundary[2] (fps) |
| DCPO1[3] | -- | 82 | -- | -- | -- | 261 | 82 | 13.42 | 36 | 7.40 | 261 | 82 | 13.42 | 36 | 7.40 |
| DCPO2[3] | -- | 160 | -- | -- | -- | 476 | 160 | 13.50 | 71 | 9.82 | 476 | 160 | 13.50 | 71 | 9.82 |
| DCPO3 | 6,356 | 3,520 | -- | 1,486 | -- | 6,011 | 3,520 | 13.83 | 1,487 | 12.53 | 6,011 | 3,520 | 13.83 | 1,487 | 12.53 |
| DCPO4 | 156 | 41 | -- | 12 | 3.10 | 146 | 41 | 13.33 | 18 | 6.05 | 146 | 41 | 13.33 | 18 | 6.05 |
| DCP05[4] | -- | -- | -- | -- | -- | 24 | 4 | 13.17 | 2 | 1.65 | 24 | 4 | 13.17 | 2 | 1.65 |
| DCP06[4] | -- | -- | -- | -- | -- | 140 | 26 | 13.17 | 12 | 1.88 | 140 | 26 | 13.17 | 12 | 1.88 |
| DCP1 | 67 | 312 | -- | 139 | 2.94 | 256 | 312 | 15.00 | 253 | 12.80 | 197 | 65 | 13.50 | 29 | 11.99 |
| DCP2 | 5,625 | 287 | -- | 1,585 | -- | 6,413 | 287 | 13.92 | 1,610 | 10.97 | 4,122 | 516 | 14.83 | 1,833 | 9.54 |
| DCP3 | 65 | 21 | -- | 4 | 1.71 | 91 | 21 | 13.25 | 10 | 2.03 | 58 | 21 | 13.58 | 10 | 1.72 |
| DCP4 | 195 | 74 | -- | 30 | 0.72 | 404 | 32 | 13.08 | 31 | 4.62 | 355 | 88 | 13.17 | 33 | 4.44 |
| DCP5 | 143 | 79 | -- | 44 | 7.21 | 229 | 79 | 13.58 | 72 | 9.03 | 228 | 84 | 13.58 | 74 | 9.02 |

1 Stormwater discharge points are shown on Figure 4.5. The volume shown is the total volume of runoff for the hydrograph duration.
2 Runoff volume and velocity calculations are provided in Appendix IIIF-A and IIIF-E.
3 Discharge points DCP01 and DCP02 consist of four separate run-on locations in the current permitted conditions.
4 Discharge points DCP05 and DCP06 were not included in the current permitted conditions.
5 Refer to Section 4.3.1.1 for a discussion on the existing permitted condition and updated permitted condition.




0 1 2
SCALE IN MILES

LEGEND

Texas Department of Transportation

- Unincorporated Community
- County Seat
- Border Crossing
- Cemetery
- Cemetery (Inside City)
- Deep Draft Port
- Shallow Draft Port
- Railroad
- Dam
- River or Stream
- TXDOT District
- Lakes
- Education
- Military
- Airport Runway
- Airport
- Prison
- Parks and Other Public Land

LANDFILL PROPERTY

NOTES:

1. REPRODUCED FROM 2018 TEXAS DEPARTMENT OF TRANSPORTATION COUNTY MAPS. COUNTIES INCLUDE TARRANT COUNTY AND DALLAS COUNTY.

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105073
PROFESSIONAL ENGINEER
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05.19.22

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DESIGN BY: RJS
REVIEWED BY: CRM

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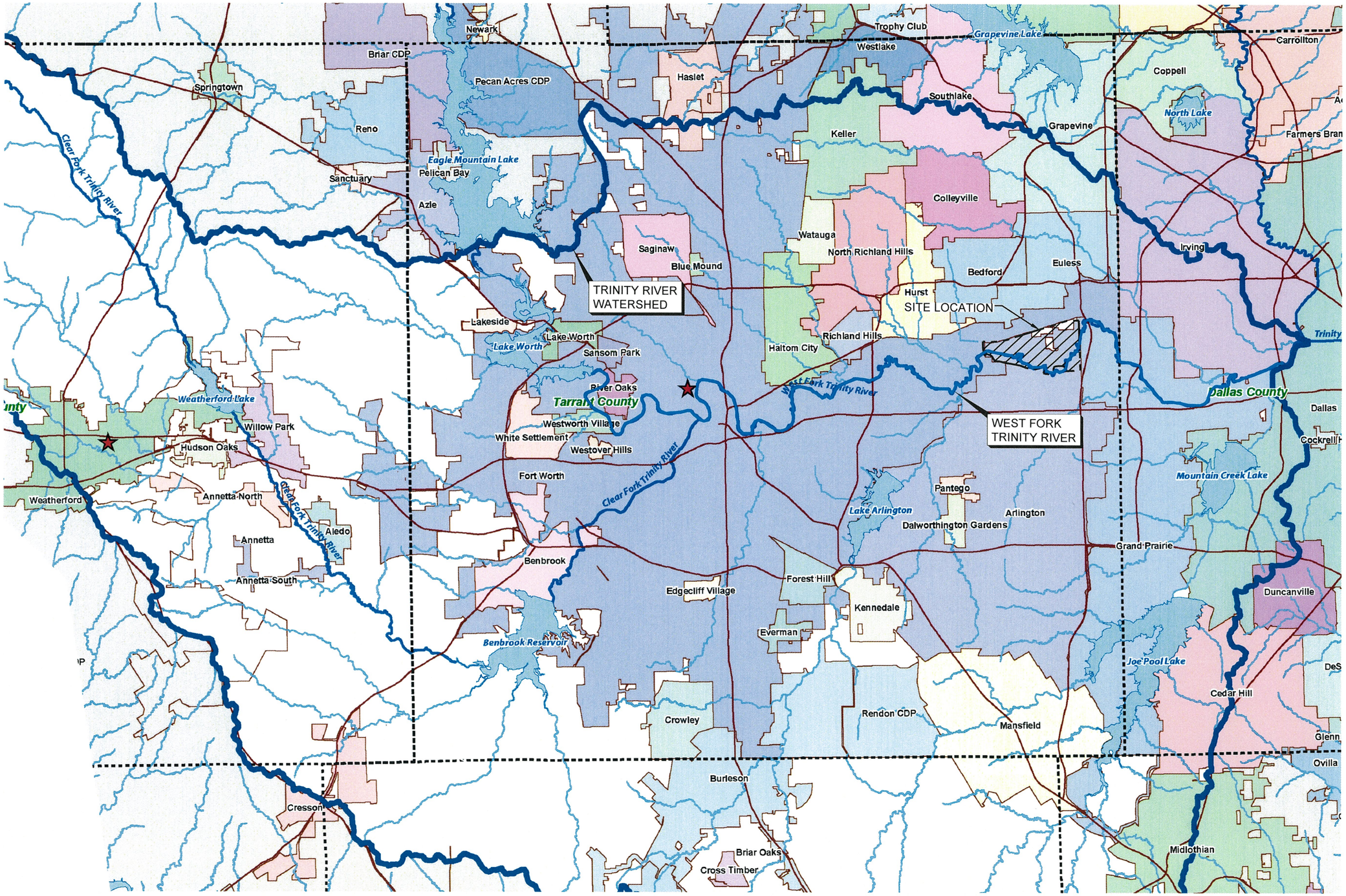
# SITE LOCATION MAP

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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FIGURE 4.1

O:\0023\404\EXPANSION 2021\PART II\IIF\4.1 - SITE LOCATION.dwg, jwilson, 1:2




0 1 2
SCALE IN MILES

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NOTES:

1. WEST FORK TRINITY RIVER WATERSHED MAP REPRODUCED FROM FEMA's NATIONAL FLOOD INSURANCE PROGRAM DISCOVERY MAP PROGRAM, 2013.

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# WEST FORK TRINITY RIVER DRAINAGE BASIN

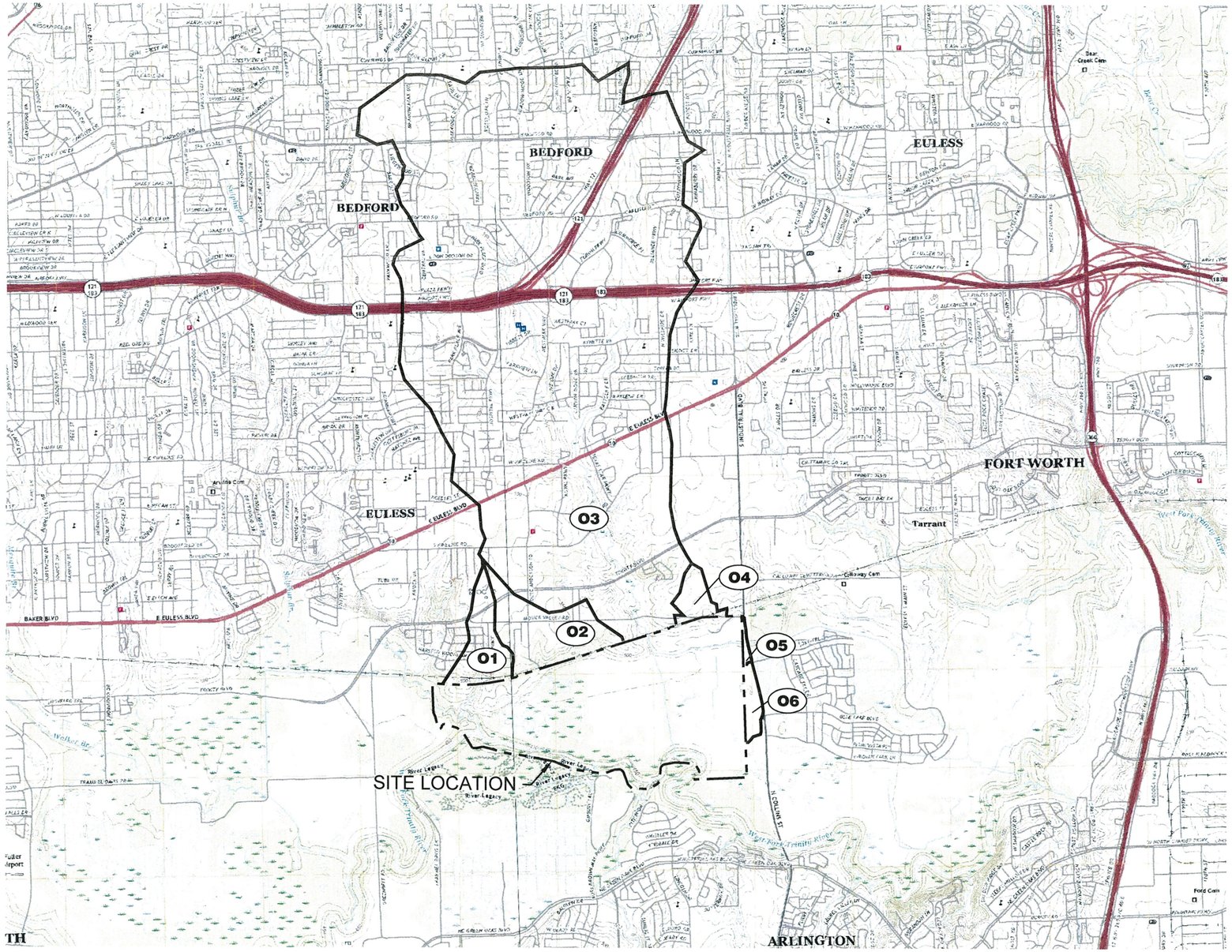
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FIGURE 4.2

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O:\0023\404\EXPANSION 2021\PART II\MIFV4.2 - OFFSITE DRAINAGE.dwg, jwilson, 1:2




| DRAINAGE AREA NO. | AREA (ACRES) |
|---|---|
| 01 | 81.63 |
| 02 | 160.32 |
| 03 (SEE NOTE 2) | 3520.00 |
| 04 | 41.33 |
| 05 | 4.04 |
| 06 | 25.70 |
| TOTAL | 3833.01 |

N

0 2000 4000

SCALE IN FEET

NOTES:

1. REPRODUCED FROM 7.5 MINUTE, HURST, TEXAS QUADRANGLE USGS MAP DATED 2019 AND 7.5 MINUTE, EULESS, TEXAS QUADRANGLE USGS MAP DATED 2019.
2. THE DRAINAGE ARE FOR BASIN 03 (5.5 SQUARE MILES OR 3,520 ACRES) WAS REPRODUCED FROM THE EFFECTIVE FEMA FLOOD INSURANCE STUDY NUMBER 48439CV001B, DATED MARCH 21, 2019.

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LEGEND

PERMIT BOUNDARY

DRAINAGE AREA BOUNDARY

01 DRAINAGE AREA DESIGNATION

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# MAJOR PERMIT AMENDMENT
# OFFSITE DRAINAGE AREA MAP

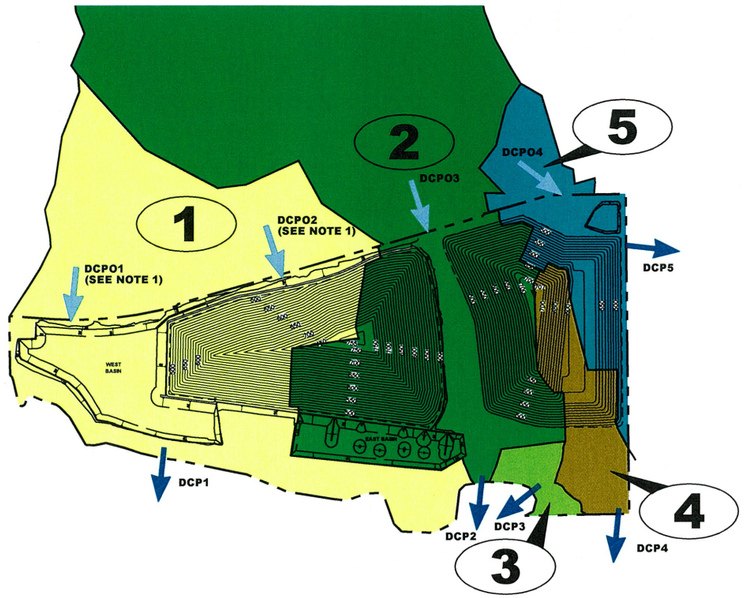
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FIGURE 4.3

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EXISTING PERMITTED DRAINAGE PATTERNS [2]

ONSITE AREAS

1 = 312 ACRES

2 = 287 ACRES

3 = 21 ACRES

4 = 74 ACRES

5 = 79 ACRES

TOTAL = 774 ACRES

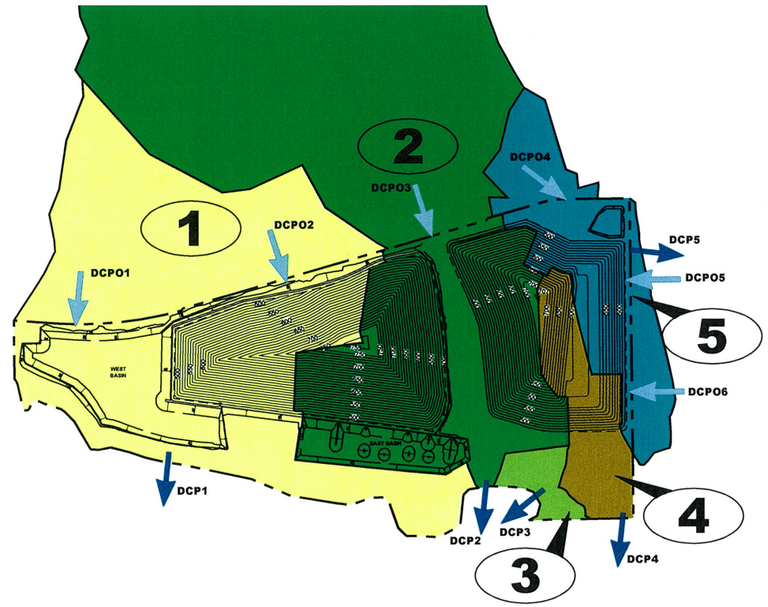
OFF-SITE AREAS

01 = 82 ACRES

02 = 160 ACRES

03 = 3520 ACRES

04 = 41 ACRES




UPDATED PERMITTED DRAINAGE PATTERNS [2]

ONSITE AREAS

1 = 312 ACRES

2 = 287 ACRES

3 = 21 ACRES

4 = 74 ACRES

5 = 79 ACRES

TOTAL = 774 ACRES

OFF-SITE AREAS

01 = 82 ACRES

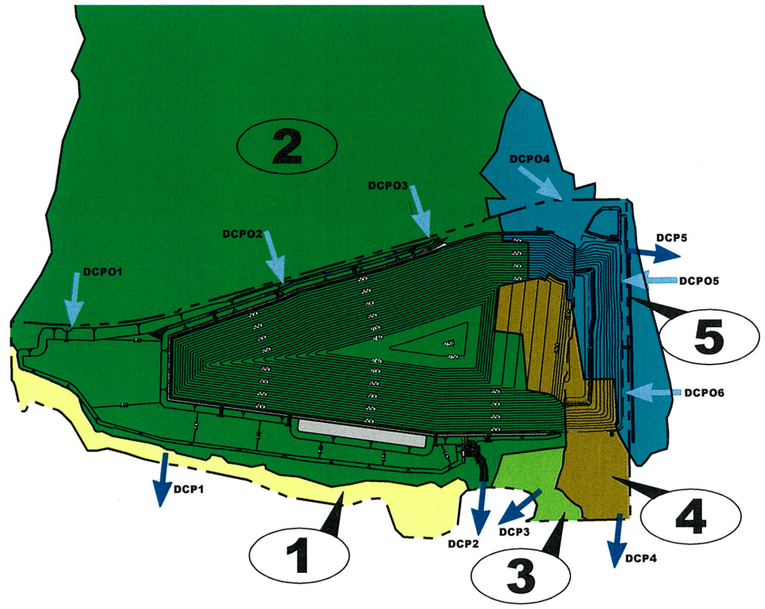
02 = 160 ACRES

03 = 3520 ACRES

04 = 41 ACRES

05 = 4 ACRES

06 = 26 ACRES




POST PROJECT DRAINAGE PATTERNS

ONSITE AREAS

1 = 65 ACRES

2 = 516 ACRES

3 = 21 ACRES

4 = 88 ACRES

5 = 84 ACRES

TOTAL = 774 ACRES

OFF-SITE AREAS

01 = 82 ACRES

02 = 160 ACRES

03 = 3520 ACRES

04 = 41 ACRES

05 = 4 ACRES

06 = 26 ACRES

LEGEND

PERMIT BOUNDARY

100 ELEVATION OF FINAL COVER SYSTEM

DRAINAGE AREA BOUNDARY

CC DRAINAGE AREA DESIGNATION

UPLAND DRAINAGE ENTERING THE SITE

STORMWATER DISCHARGE POINT

NOTES:

1. DCPO1 AND DCPO2 CONSIST OF FOUR SEPARATE RUN-ON LOCATIONS IN THE CURRENTLY-PERMITTED CONDITIONS.
2. REFER TO SECTION 4.3.1.1 FOR A DISCUSSION ON THE EXISTING PERMITTED CONDITION AND UPDATED PERMITTED CONDITION.

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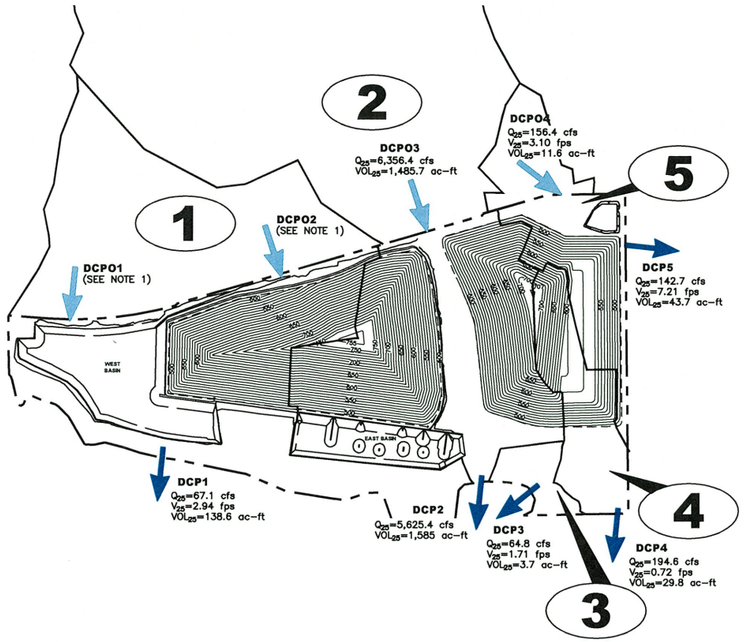
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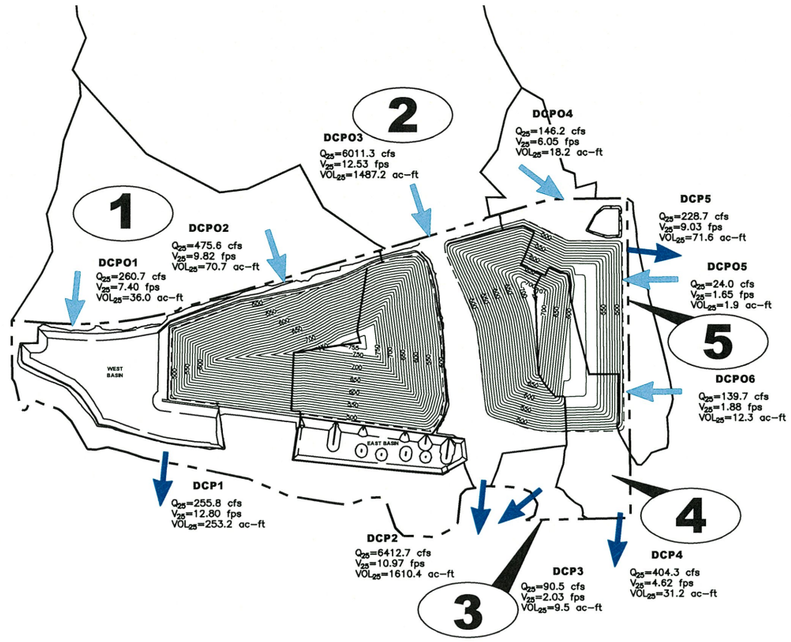
FIGURE 4.4

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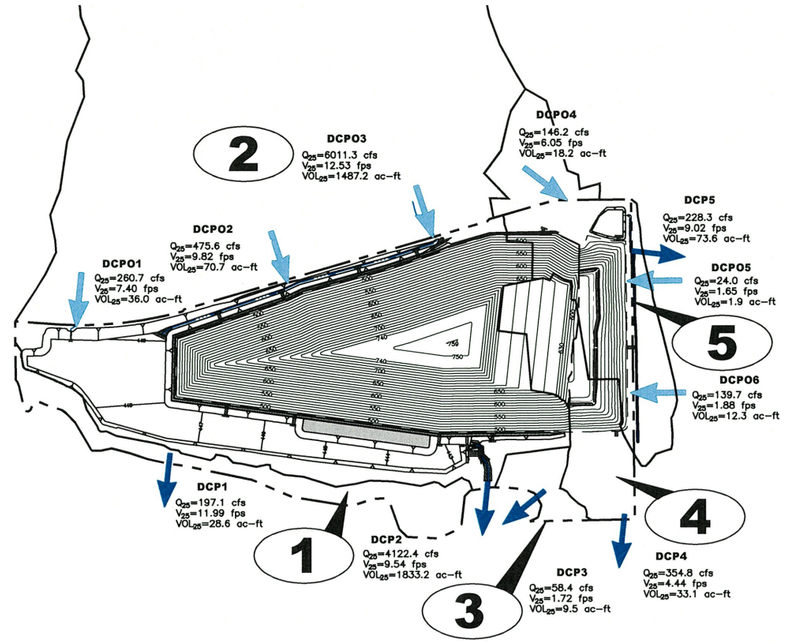
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EXISTING PERMITTED DRAINAGE PATTERNS [2]




UPDATED PERMITTED DRAINAGE PATTERNS [2]




POST PROJECT DRAINAGE PATTERNS

NOTES:

1. DCPO1 AND DCPO2 CONSIST OF FOUR SEPARATE RUN-ON LOCATIONS IN THE CURRENTLY-PERMITTED CONDITIONS.
2. REFER TO SECTION 4.3.1.1 FOR A DISCUSSION ON THE EXISTING PERMITTED CONDITION AND UPDATED PERMITTED CONDITION.

LEGEND

- PERMIT BOUNDARY
- 100 — ELEVATION OF FINAL COVER SYSTEM
- DRAINAGE AREA BOUNDARY
- CC — DRAINAGE AREA DESIGNATION
- UPLAND DRAINAGE ENTERING THE SITE
- STORMWATER DISCHARGE POINT

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# SITE DRAINAGE PATTERNS
# RUN-ON/RUNOFF

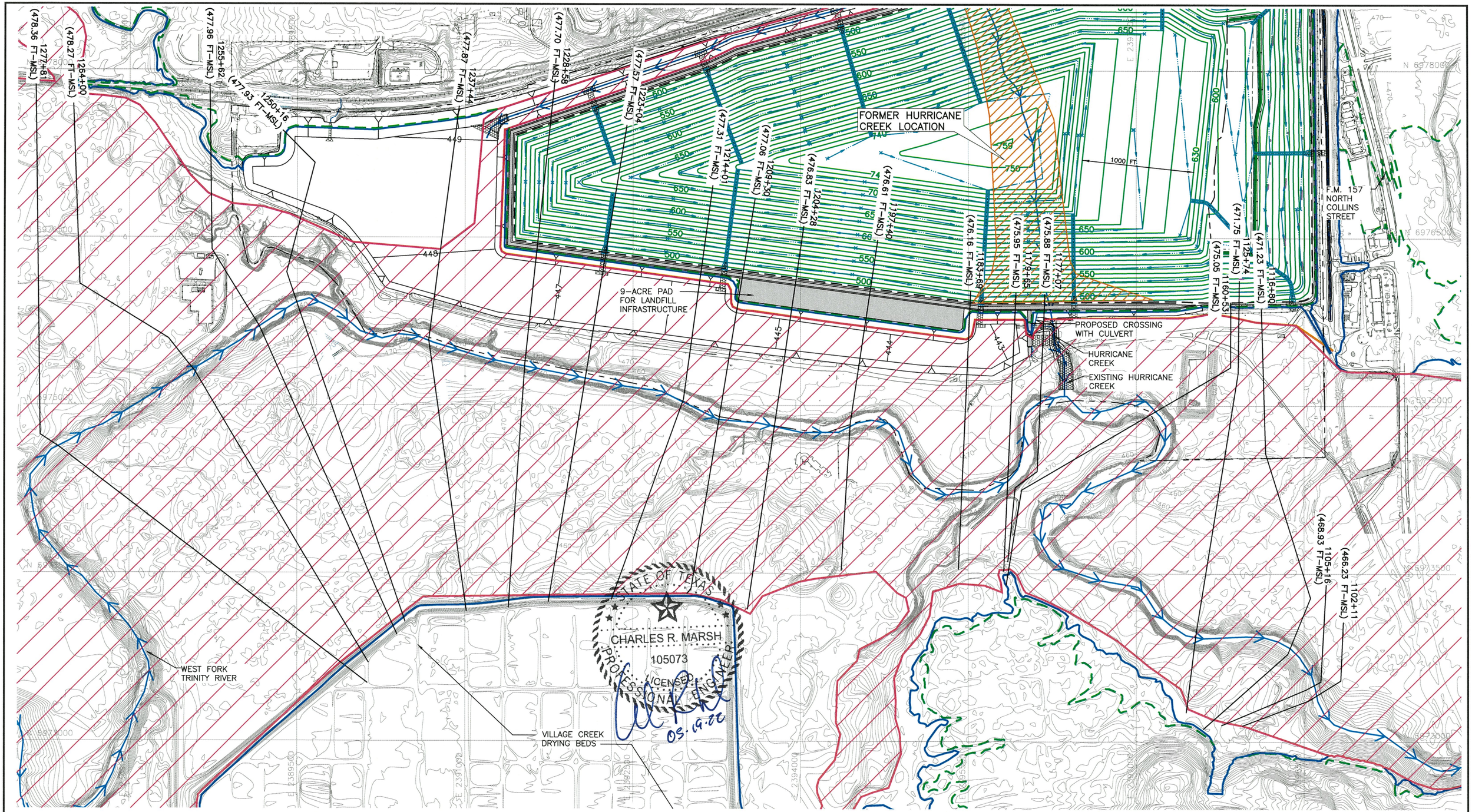
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FIGURE 4.5

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PERMIT BOUNDARY
PERMITTED LIMIT OF WASTE
500 EXISTING CONTOUR
N 6975000 STATEPLANE COORDINATE SYSTEM
HYDRAULIC MODELING FLOWLINE
POST-PROJECT EFFECTIVE 100-YEAR FLOODPLAIN

POST-PROJECT EFFECTIVE 500-YEAR FLOODPLAIN
POST-PROJECT EFFECTIVE FLOODWAY

1250+16
(479.09 FT-MSL)
POST-PROJECT HEC-RAS CROSS SECTION AND 100-YEAR FLOODPLAIN ELEVATION

0 400 800
SCALE IN FEET

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NOTES:

1. EXISTING CONTOURS AND ELEVATIONS WITHIN THE PERMIT BOUNDARY PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY FLOWN 04-01-2021. ADDITIONAL 2007 OFFSITE TOPOGRAPHY PROVIDED BY DFWMAPS.COM.

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# MAJOR PERMIT AMENDMENT
# POST-PROJECT CONDITION
# ELEVATIONS-WEST FORK TRINITY RIVER

CITY OF ARLINGTON LANDFILL
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FIGURE 4.6

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60+00 (486.12 FT–MSL)
51+20 (483.11 FT–MSL)
50+10 (482.99 FT–MSL)
49+70 (482.63 FT–MSL)
42+30 (481.14 FT–MSL)
41+40 (477.42 FT–MSL)
40+80 (478.83 FT–MSL)
40+11 (478.57 FT–MSL)
39+71 (477.34 FT–MSL)
38+11 (477.95 FT–MSL)
36+11 (477.94 FT–MSL)
34+11 (477.90 FT–MSL)
32+11 (477.86 FT–MSL)
30+11 (477.84 FT–MSL)
28+11 (477.82 FT–MSL)
26+11 (477.81 FT–MSL)
24+11 (477.80 FT–MSL)
22+11 (477.78 FT–MSL)
20+11 (477.77 FT–MSL)
18+11 (477.75 FT–MSL)
16+11 (477.80 FT–MSL)
14+11 (477.83 FT–MSL)
12+11 (477.82 FT–MSL)
10+11 (477.82 FT–MSL)
8+11 (477.82 FT–MSL)
6+11 (477.81 FT–MSL)
4+11 (477.81 FT–MSL)
2+11 (477.81 FT–MSL)
+11 (477.80 FT–MSL)
–189 (477.80 FT–MSL)
–389 (477.80 FT–MSL)
–589 (477.87 FT–MSL)

C.R.I.&P. RAILROAD
PROPOSED RELOCATED HURRICANE CREEK
CONNECTION TO THE WEST FORK
FORMER HURRICANE CREEK LOCATION

0 200 400
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- PERMITTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- HYDRAULIC MODELING FLOWLINE
- POST–PROJECT EFFECTIVE 100–YEAR FLOODPLAIN
- POST–PROJECT EFFECTIVE 500–YEAR FLOODPLAIN
- POST–PROJECT EFFECTIVE FLOODWAY
- 1250+16 (479.09 FT–MSL) POST–PROJECT HEC–RAS CROSS SECTION AND 100–YEAR FLOODPLAIN ELEVATION
- TURF REINFORCEMENT MAT

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS WITHIN THE PERMIT BOUNDARY PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY FLOWN 04–01–2021. ADDITIONAL 2007 OFFSITE TOPOGRAPHY PROVIDED BY DFWMAPS.COM.

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# POST–PROJECT CONDITION FLOODPLAIN ELEVATIONS–HURRICANE CREEK

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TARRANT COUNTY, TEXAS

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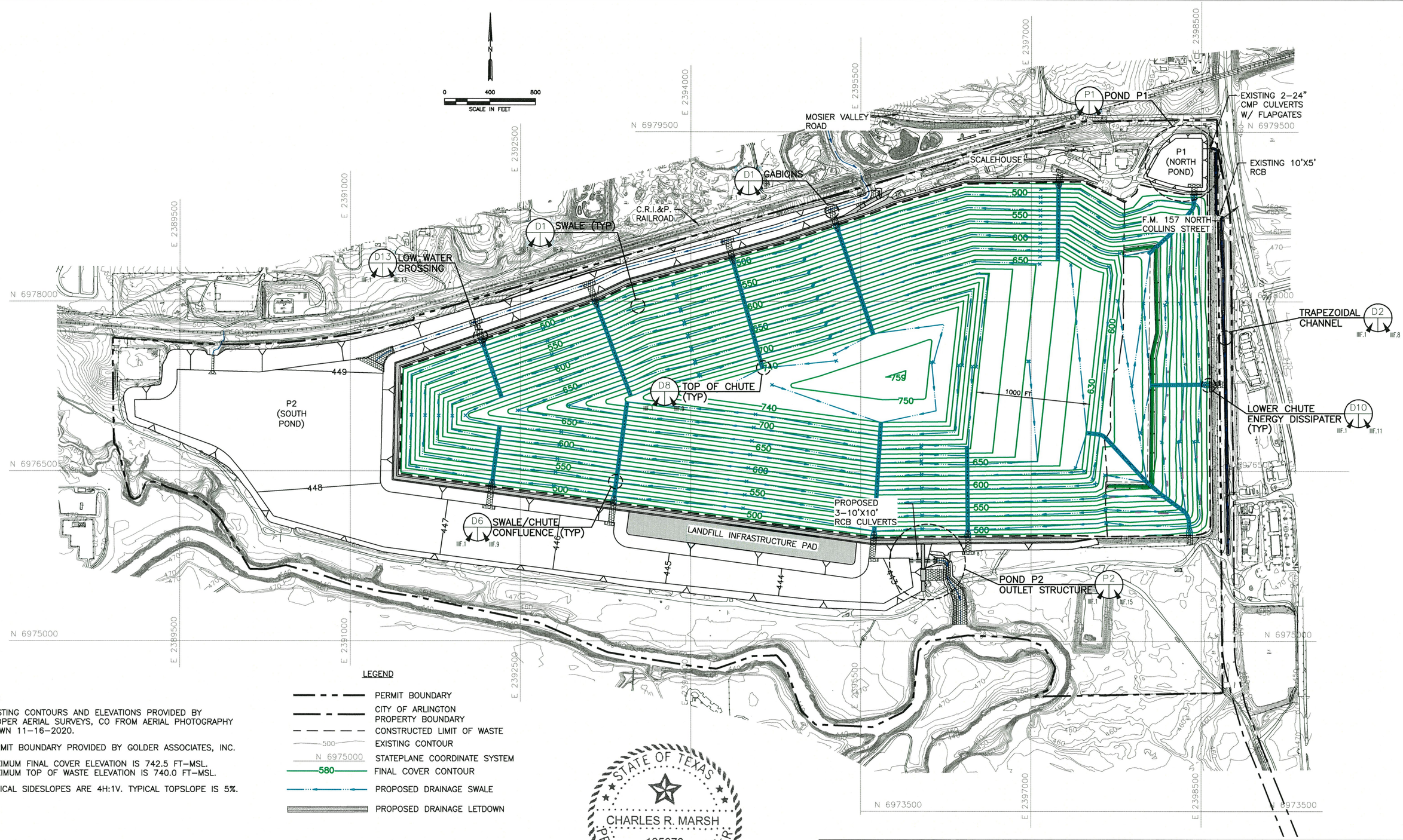
FIGURE 4.7

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# DRAWINGS

**IIIF.1 – Drainage Structure Plan**
**IIIF.2 – Post-Project Drainage**
**IIIF.3 –Offsite Drainage Area Map**
**IIIF.4 – Perimeter Drainage Plan**
**IIIF.5 – Channels 1 and 2 Plan and Profile**
**IIIF.6 – Channels 1 and 2 Sections**
**IIIF.7 – Post-Development Channel Profile**
**IIIF.8 – Drainage Details**
**IIIF.9 – Drainage Details**
**IIIF.10 – Drainage Details**
**IIIF.11 – Drainage Details**
**IIIF.12 – Drainage Details**
**IIIF.13 – Drainage Details**
**IIIF.14 – Pond P1 Plan**
**IIIF.15 – Pond P2 Plan**
**IIIF.16 – Pond P2 Outlet**






LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11–16–2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT–MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT–MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.

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

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TBPE REGISTRATION NO. F–3727

PREPARED FOR
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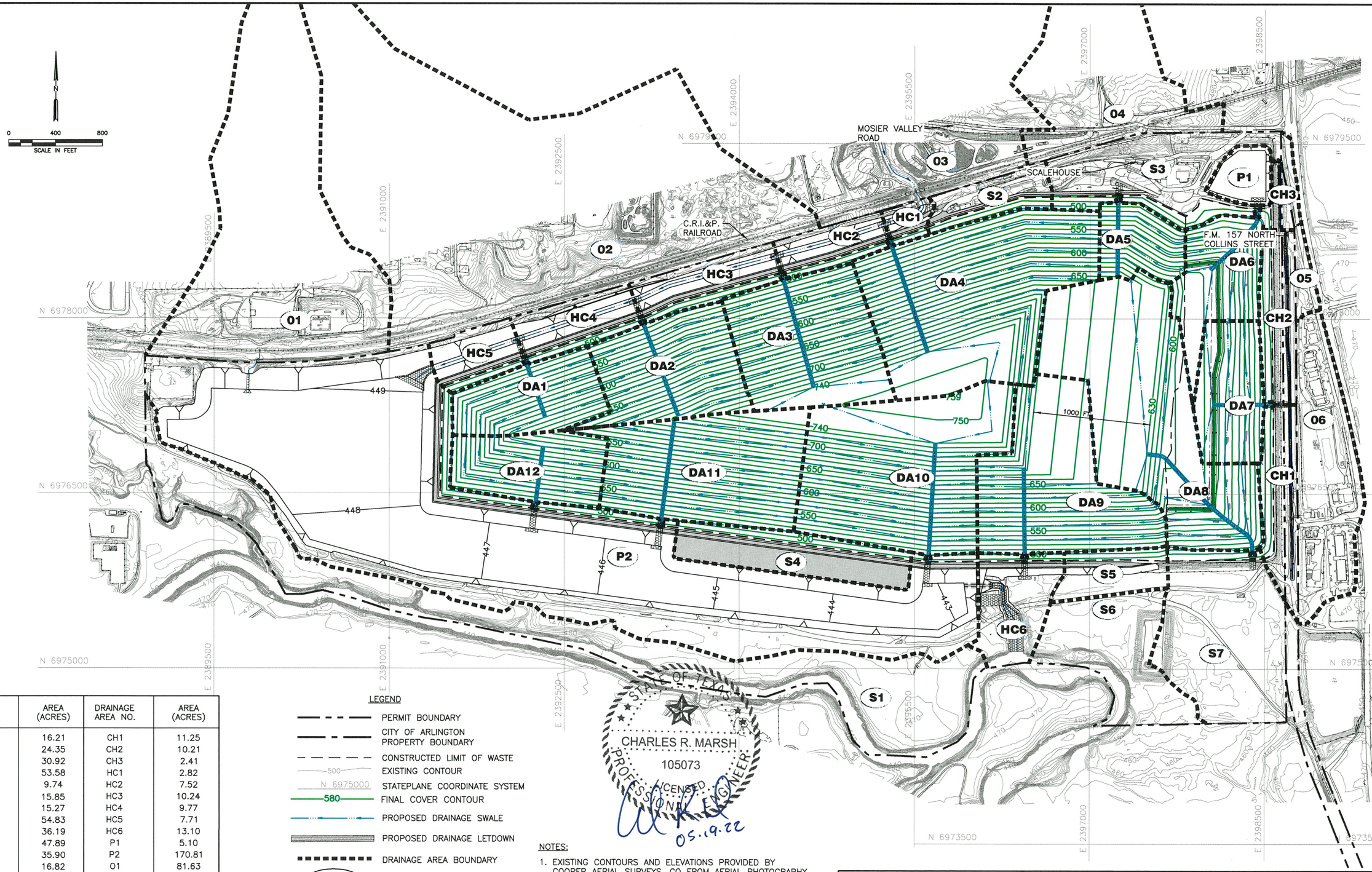
# MAJOR PERMIT AMENDMENT
# DRAINAGE STRUCTURE PLAN

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIIF.1

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| DRAINAGE AREA NO. | AREA (ACRES) | DRAINAGE AREA NO. | AREA (ACRES) |
|---|---|---|---|
| DA1 | 16.21 | CH1 | 11.25 |
| DA2 | 24.35 | CH2 | 10.21 |
| DA3 | 30.92 | CH3 | 2.41 |
| DA4 | 53.58 | HC1 | 2.82 |
| DA5 | 9.74 | HC2 | 7.52 |
| DA6 | 15.85 | HC3 | 10.24 |
| DA7 | 15.27 | HC4 | 9.77 |
| DA8 | 54.83 | HC5 | 7.71 |
| DA9 | 36.19 | HC6 | 13.10 |
| DA10 | 47.89 | P1 | 5.10 |
| DA11 | 35.90 | P2 | 170.81 |
| DA12 | 16.82 | 01 | 81.63 |
| S1 | 64.93 | 02 | 160.32 |
| S2 | 7.92 | 03 | 3520.00 |
| S3 | 23.39 | 04 | 41.33 |
| S4 | 16.05 | 05 | 4.04 |
| S5 | 8.15 | 06 | 25.70 |
| S6 | 21.47 | | |
| S7 | 32.83 | | |

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN
- DRAINAGE AREA BOUNDARY
- DA4 DRAINAGE AREA DESIGNATION

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05.19.22

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.
5. REFRE TO APPENDIX IIIF-A FOR DRAINAGE AREA DELINEATION INFORMATION AND POST PROJECT HYDROLOGIC CALCULATIONS.

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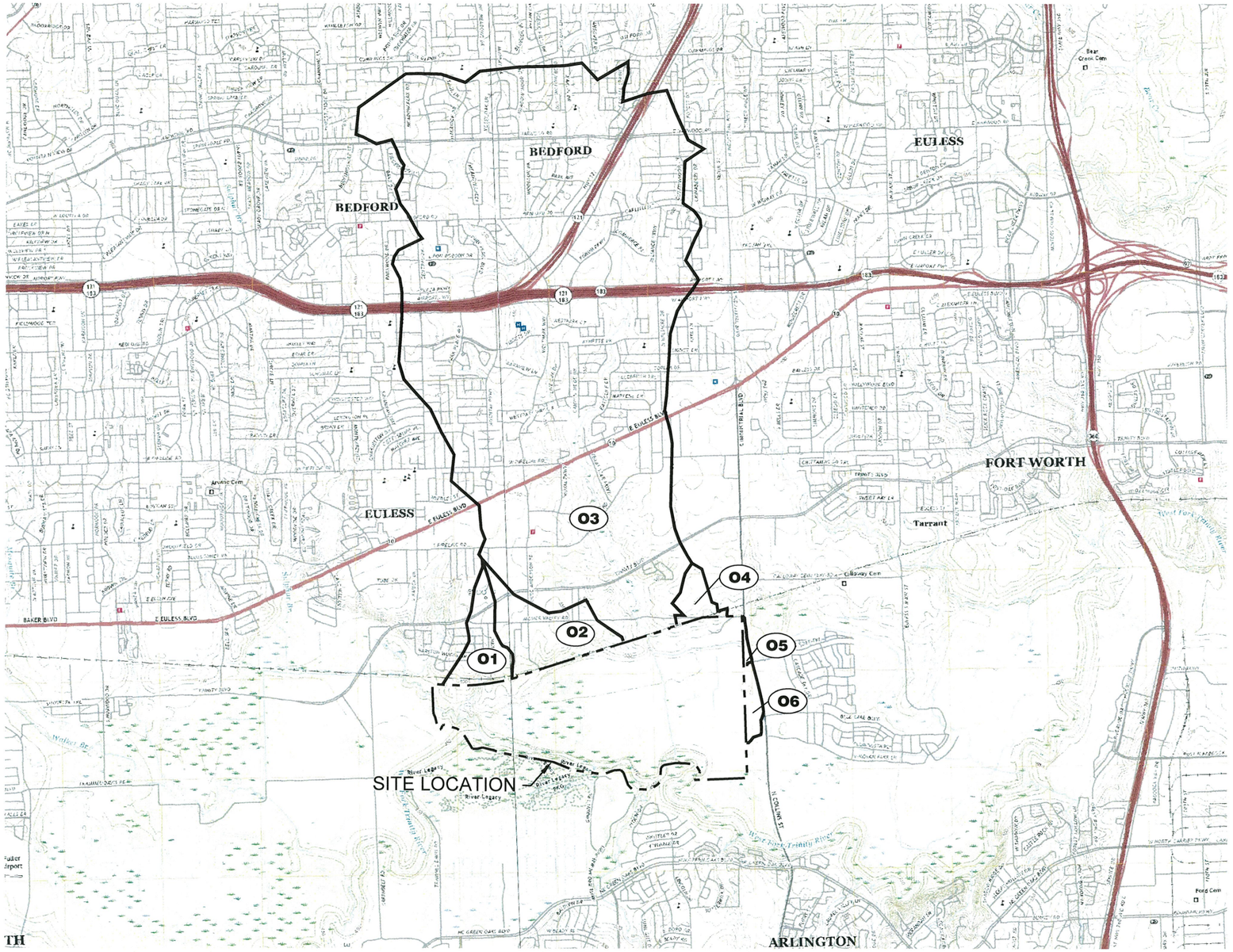
# MAJOR PERMIT AMENDMENT POST PROJECT DRAINAGE

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TARRANT COUNTY, TEXAS

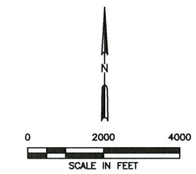
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| DRAINAGE AREA NO. | AREA (ACRES) |
|---|---|
| 01 | 81.63 |
| 02 | 160.32 |
| 03 (SEE NOTE 2) | 3520.00 |
| 04 | 41.33 |
| 05 | 4.04 |
| 06 | 25.70 |
| TOTAL | 3833.01 |




NOTES:

1. REPRODUCED FROM 7.5 MINUTE, HURST, TEXAS QUADRANGLE USGS MAP DATED 2019 AND 7.5 MINUTE, EULESS, TEXAS QUADRANGLE USGS MAP DATED 2019.
2. THE DRAINAGE ARE FOR BASIN 03 (5.5 SQUARE MILES OR 3,520 ACRES) WAS REPRODUCED FROM THE EFFECTIVE FEMA FLOOD INSURANCE STUDY NUMBER 48439CV001B, DATED MARCH 21, 2019.




LEGEND

PERMIT BOUNDARY

DRAINAGE AREA BOUNDARY

01 DRAINAGE AREA DESIGNATION

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REVIEWED BY: RJS

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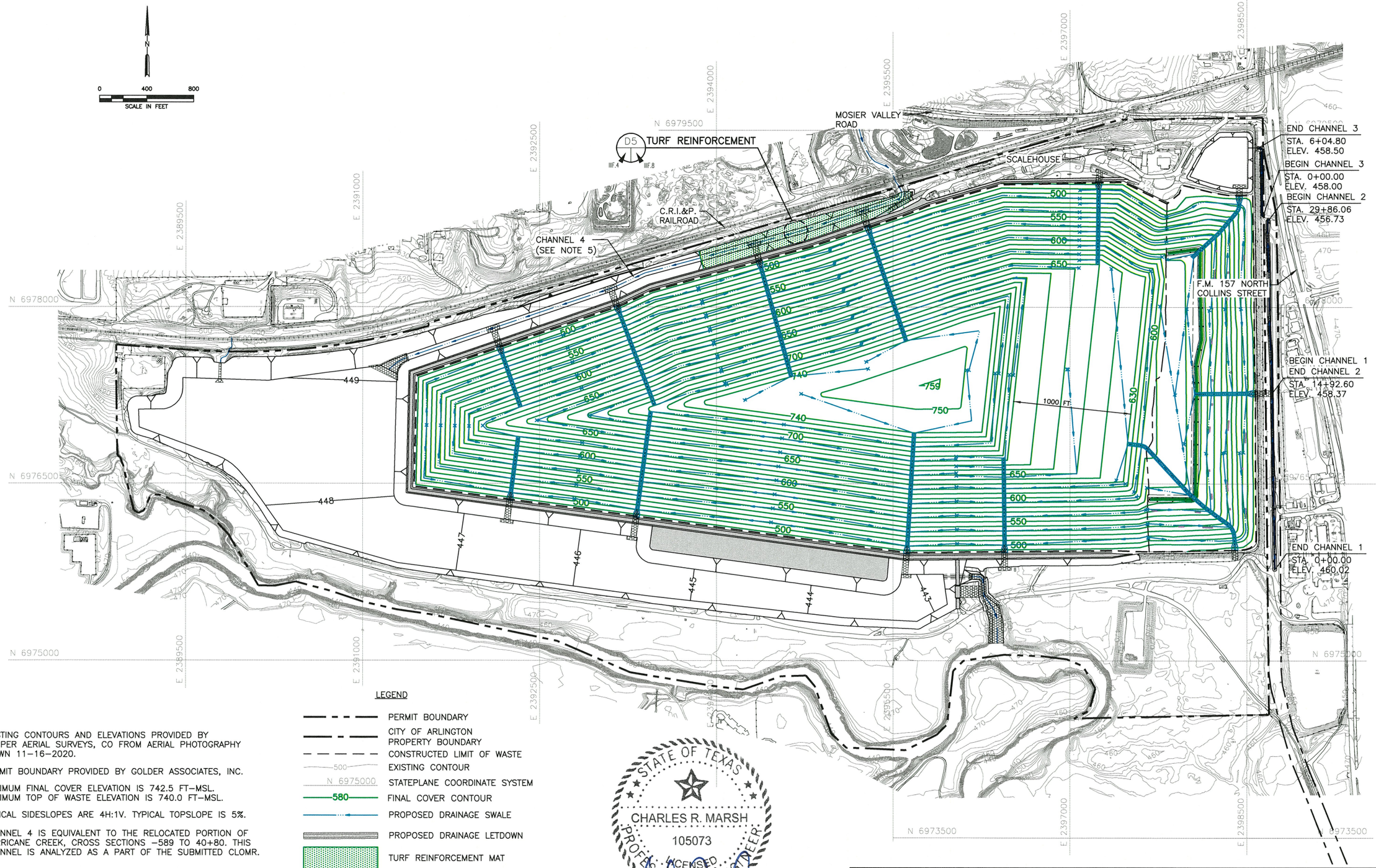
# MAJOR PERMIT AMENDMENT OFFSITE DRAINAGE AREA MAP

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIIF.3

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NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.
5. CHANNEL 4 IS EQUIVALENT TO THE RELOCATED PORTION OF HURRICANE CREEK, CROSS SECTIONS -589 TO 40+80. THIS CHANNEL IS ANALYZED AS A PART OF THE SUBMITTED CLOMR.

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN
- TURF REINFORCEMENT MAT

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# MAJOR PERMIT AMENDMENT
# PERIMETER DRAINAGE PLAN

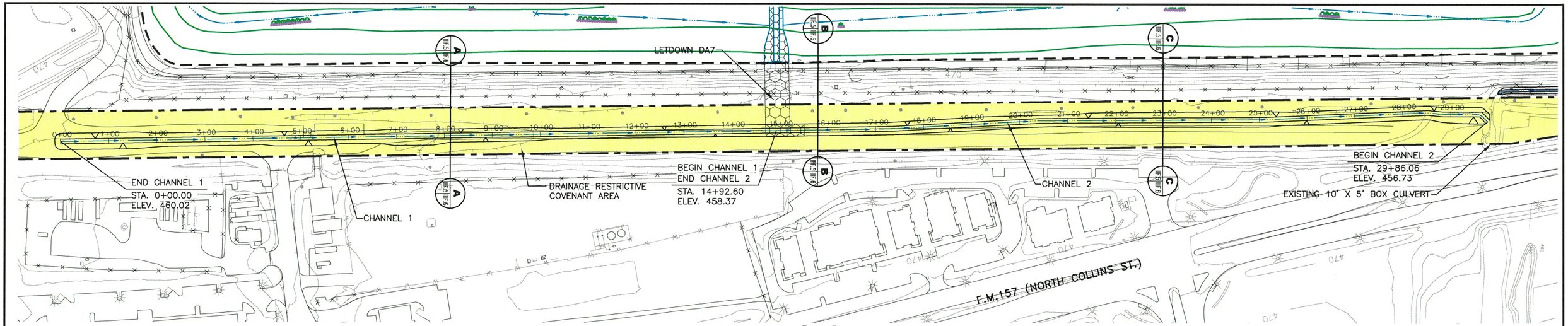
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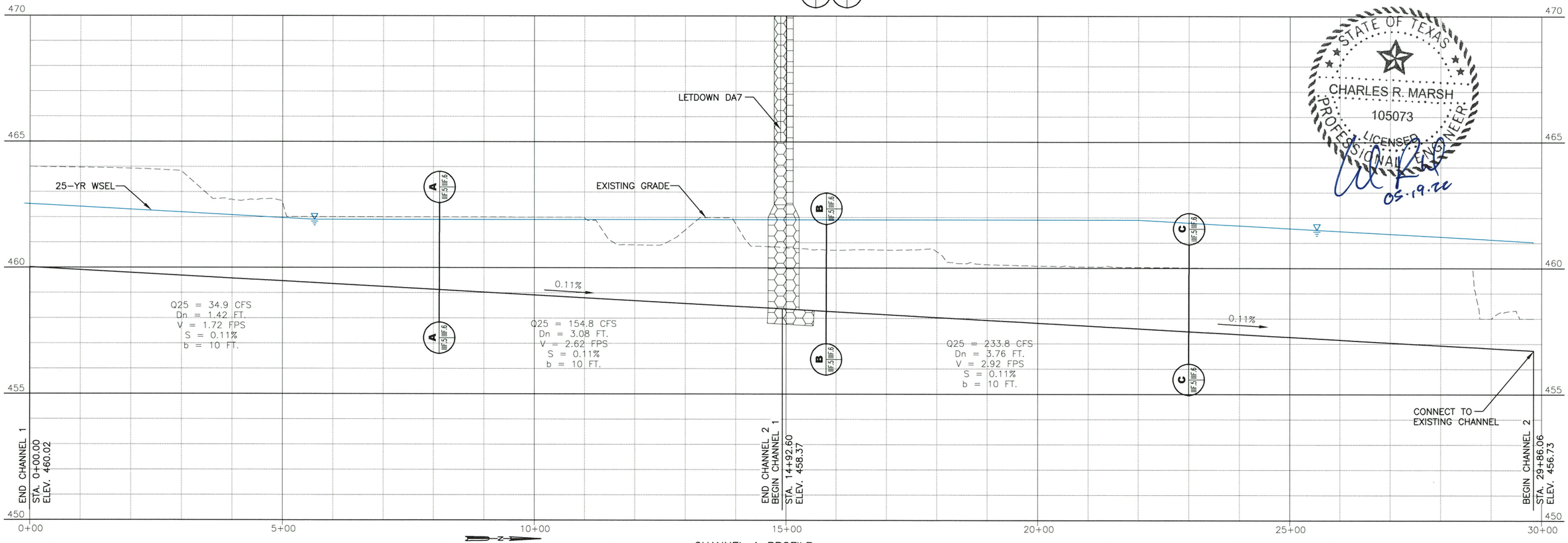
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DRAWING IIIF.4

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0 100 200 — HORIZONTAL SCALE IN FEET
0 2 4 — VERTICAL SCALE IN FEET

CHANNEL 1 PROFILE

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- SUBBASIN BOUNDARY
- PERIMETER ACCESS ROAD/LEVEE
- CHANNEL 1
- DRAINAGE RESTRICTIVE COVENANT AREA

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NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.

2. REFER TO APPENDIX IIIF-B FOR HYDRAULIC CALCULATIONS. HYDRAULIC CALCULATIONS WITHIN CHANNEL 1 WERE COMPLETED USING DODSON HYDROCALC HYDRAULICS FOR WINDOWS, VERSION 2.0.1, 1996-2010.

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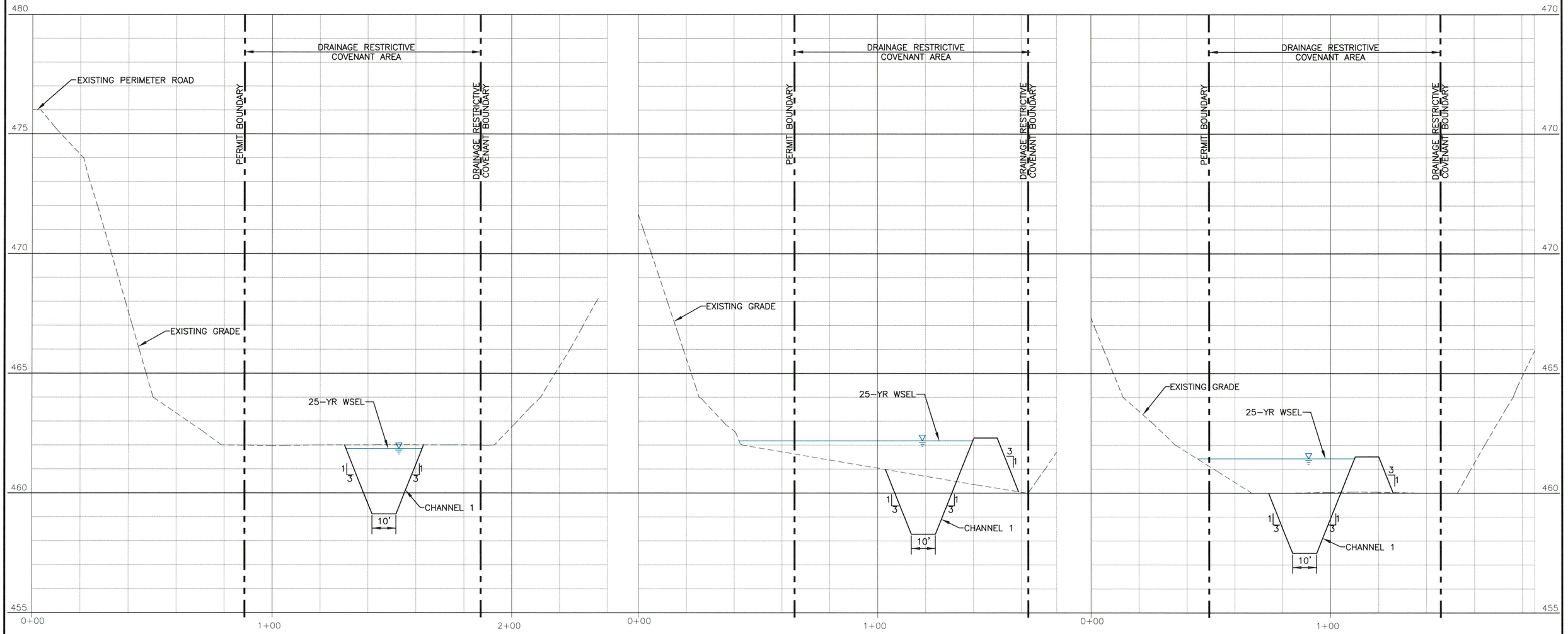
# MAJOR PERMIT AMENDMENT CHANNELS 1 AND 2 PLAN AND PROFILE

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FIGURE IIIF.5

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SECTION A (A, IIIF.5 | IIIF.6)

0 20 40 HORIZONTAL SCALE IN FEET

0 2 4 VERTICAL SCALE IN FEET

SECTION B (B, IIIF.5 | IIIF.6)

0 20 40 HORIZONTAL SCALE IN FEET

0 2 4 VERTICAL SCALE IN FEET

SECTION C (C, IIIF.5 | IIIF.6)

0 20 40 HORIZONTAL SCALE IN FEET

0 2 4 VERTICAL SCALE IN FEET

LEGEND

PERMIT BOUNDARY

CITY OF ARLINGTON PROPERTY BOUNDARY

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NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.

2. REFER TO FIGURE 2-6 FOR HYDRAULIC CALCULATIONS. HYDRAULIC CALCULATIONS WITHIN CHANNEL 1 WERE COMPLETED USING DODSON HYDROCALC HYDRAULICS FOR WINDOWS, VERSION 2.0.1, 1996-2010.

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# MAJOR PERMIT AMENDMENT CHANNELS 1 AND 2 SECTIONS

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TARRANT COUNTY, TEXAS

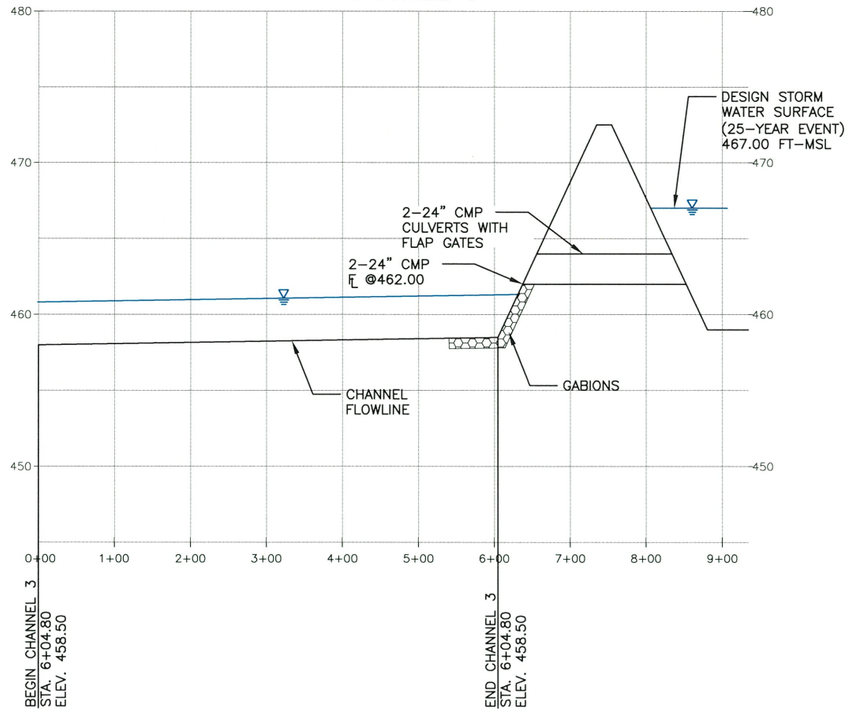
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FIGURE IIIF.6

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# CHANNEL 3




CHANNEL 3 (CH3 IIIF.4 | IIIF.8)

0 100 200
HORIZONTAL SCALE IN FEET

0 5 10
VERTICAL SCALE IN FEET

| 25-YEAR CHANNEL "3" INFORMATION | | | | | | |
|---|---|---|---|---|---|---|
| CHANNEL STATION | | BOTTOM WIDTH (FT) | PEAK INFLOW (CFS) | SLOPE (%) | FLOW DEPTH (FT.) | VELOCITY (FT/S) |
| FROM | TO | | | | | |
| 0+00 | 6+04.80 | 10 | 81.9 | 0.08 | 2.42 | 1.96 |

NOTE: NORMAL DEPTH CALCULATION DOES NOT ACCOUNT FOR BACK WATER FROM THE 10'X5' R.C.B. UNDER FM 157 WHICH WILL INCREASE FLOW DEPTH (SEE PROFILE) AND DECREASE VELOCITY.

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MAJOR PERMIT AMENDMENT
POST DEVELOPMENT
CHANNEL PROFILE

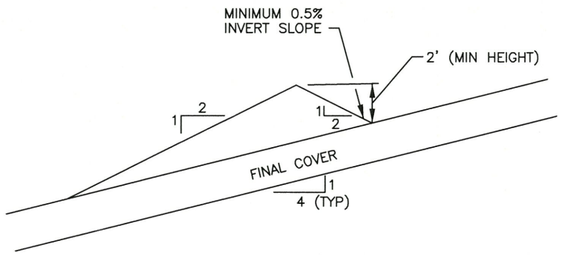
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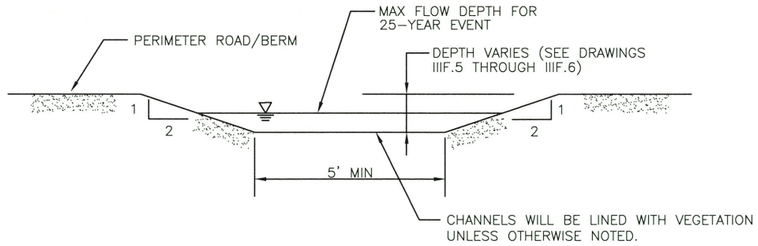
FIGURE IIIF.7

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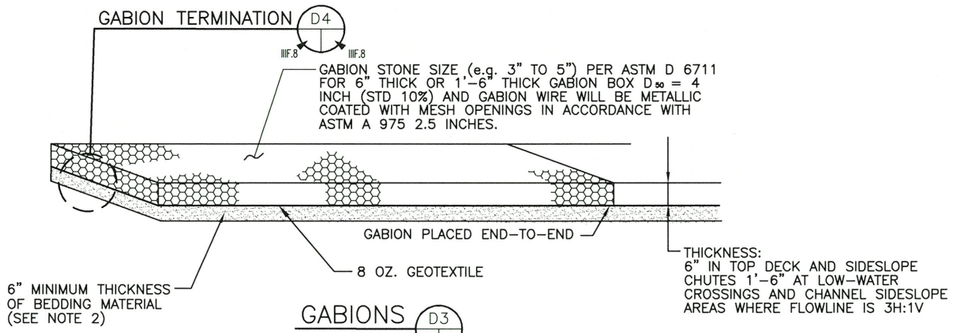
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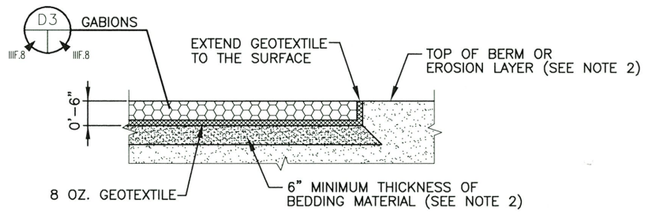

SWALE (TYP) D1
IIIF.1 IIIF.8
0 4 8
SCALE IN FEET

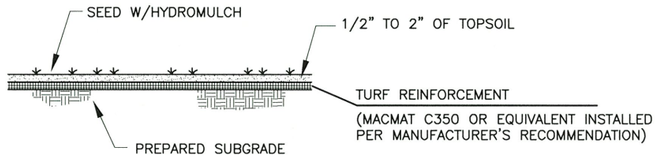



TRAPEZOIDAL CHANNEL (TYP) D2
IIIF.1 IIIF.8
0 2 4
SCALE IN FEET



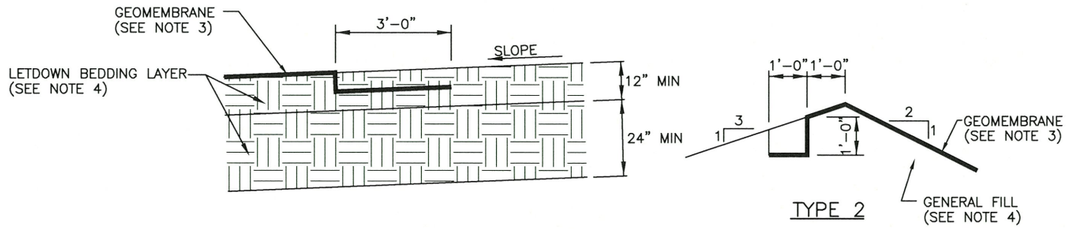

GABIONS D3
IIIF.1 IIIF.8
0 2 4
SCALE IN FEET



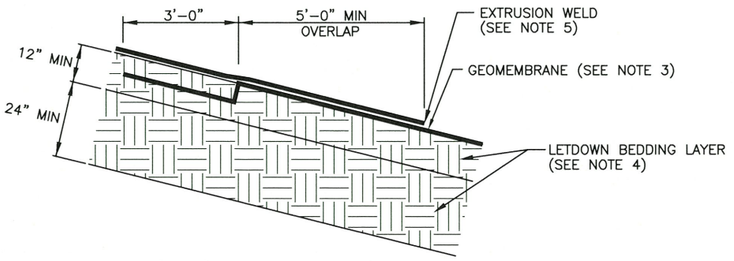

GABION TERMINATION D4
IIIF.8 IIIF.8
0 2 4
SCALE IN FEET

TURF REINFORCEMENT D5
NOT TO SCALE
(SEE NOTE 2)
IIIF.4 IIIF.8




TYPE 1

TYPE 2




TYPE 3

ANCHOR TRENCH D10
IIIF.10 IIIF.8
0 2 4
SCALE IN FEET

NOTES:

1. REFER TO DRAWING IIIF.1–DRAINAGE STRUCTURE PLAN FOR LOCATION OF DETAILS.
2. BEDDING MATERIAL WILL CONSIST OF CLAYEY SOILS COMPACTED TO PROVIDE FIRM BASE THAT WILL BE OVERLAIN BY 8 oz/sy GEOTEXTILE PRIOR TO PLACEMENT OF GABIONS.
3. 60 MIL HDPE GEOMEMBRANE TEXTURED BOTH SIDES SHALL BE USED FOR GEOMEMBRANE LETDOWN LINING.
4. SOIL PLACED UNDER GEOMEMBRANE LETDOWN AND CONCRETE DISSIPATER SHALL NOT CONTAIN TOPSOIL THAT WILL BE USED FOR VEGETATION LAYER.
5. EXTRUSION WELD UPSTREAM PANEL OVER DOWNSTREAM PANEL USING 1'–0" LONG EXTRUSION WELD WITH A SPACING OF 1'–0" BETWEEN EACH WELD.

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MAJOR PERMIT AMENDMENT
DRAINAGE DETAILS

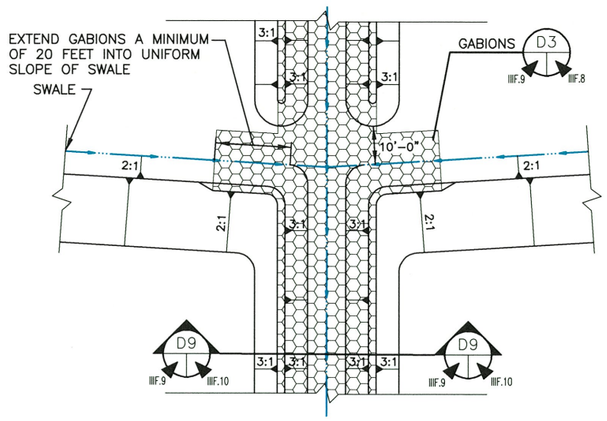
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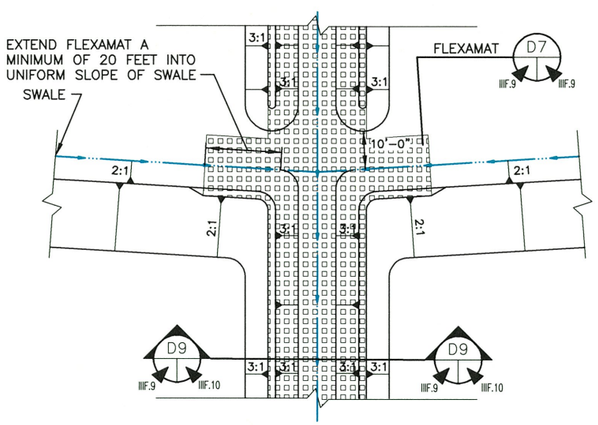
FIGURE IIIF.8

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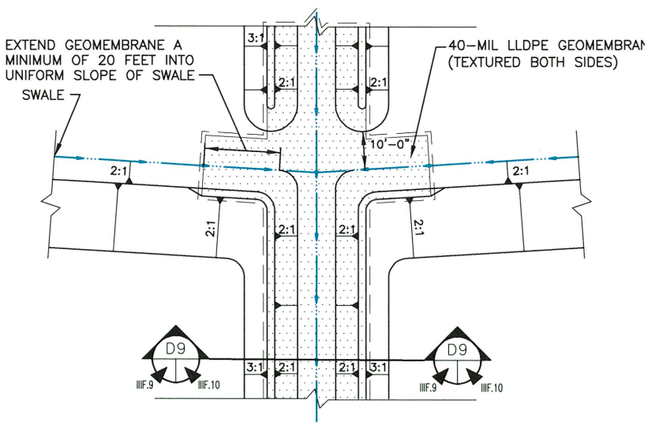
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GABION/GROUTED RIPRAP OPTION




FLEXAMAT OPTION




GEOMEMBRANE LINER OPTION

SWALE/CHUTE CONFLUENCE (TYP) D6 IIIF.1 IIIF.9

0 20 40

SCALE IN FEET



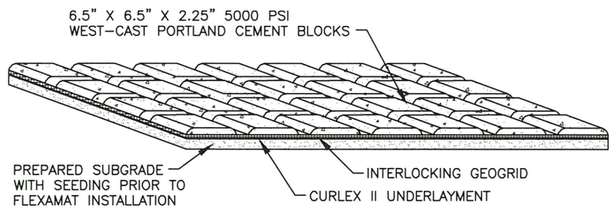

GABION/GROUTED RIPRAP OPTION




FLEXAMAT OPTION




GEOMEMBRANE LINER OPTION




FLEXAMAT D7 IIIF.9 IIIF.9

0 2 4

SCALE IN FEET

TOP OF CHUTE (TYP) D8 IIIF.1 IIIF.9

0 20 40

SCALE IN FEET

NOTES:

1. REFER TO DRAWING IIIF.1 STORMWATER MANAGEMENT PLAN FOR LOCATION OF DETAILS.
2. SEE APPENDIX IIIF-C FOR BOTTOM WIDTHS OF EACH INDIVIDUAL CHUTE.

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# MAJOR PERMIT AMENDMENT DRAINAGE DETAILS

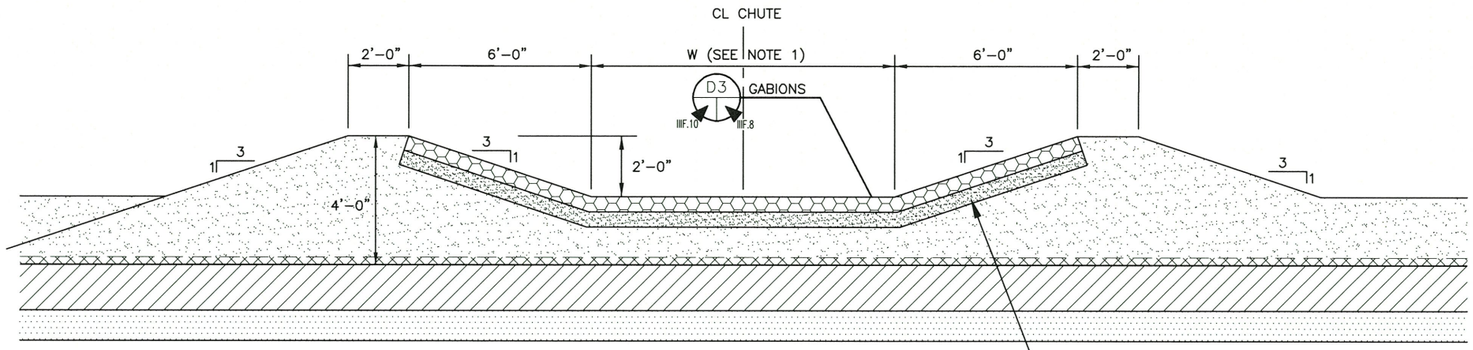
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FIGURE IIIF.9

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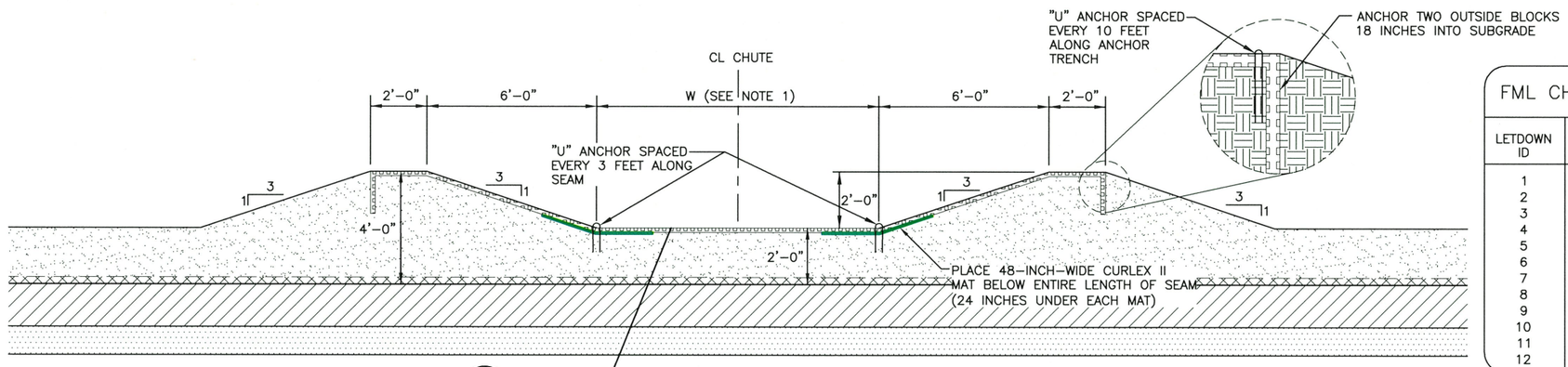
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GABION/GROUTED RIRAP OPTION

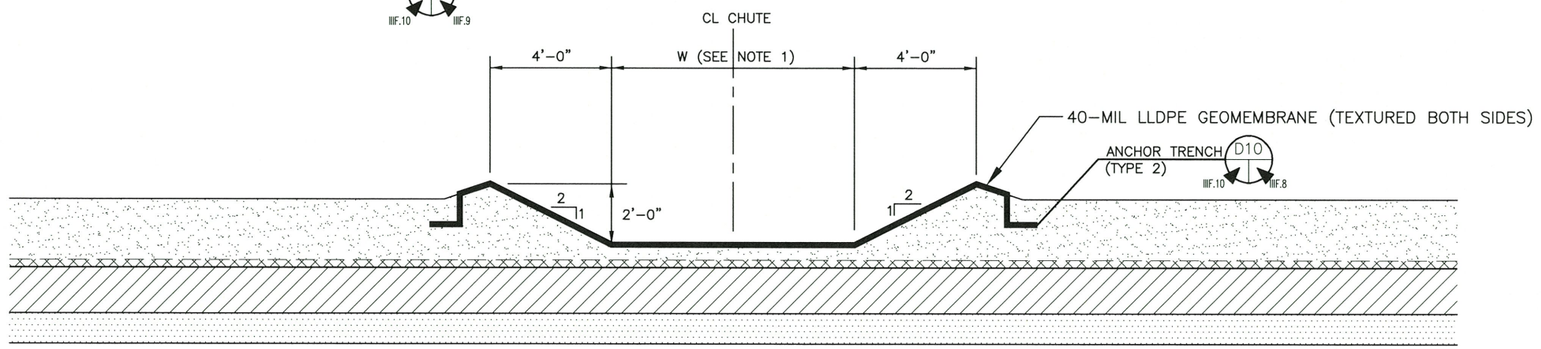
6" MINIMUM THICKNESS OF BEDDING MATERIAL

| GABION/GROUTED RIPRAP/FLEXAMAT CHUTE BOTTOM WIDTH SUMMARY | | |
|---|---|---|
| LETDOWN ID | CHUTE WIDTH ABOVE ENERGY DISSIPATER (FT) | CHUTE WIDTH AT ENERGY DISSIPATER (FT) |
| 1 | 12 | 14 |
| 2 | 12 | 22 |
| 3 | 12 | 30 |
| 4 | 12 | 50 |
| 5 | 12 | 12 |
| 6 | 12 | 16 |
| 7 | 12 | 16 |
| 8 | 12 | 32 |
| 9 | 12 | 32 |
| 10 | 12 | 42 |
| 11 | 12 | 32 |
| 12 | 12 | 16 |

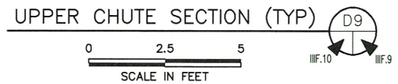



FLEXAMAT RIPRAP OPTION

| FML CHUTE BOTTOM WIDTH SUMMARY | | |
|---|---|---|
| LETDOWN ID | CHUTE WIDTH ABOVE ENERGY DISSIPATER (FT) | CHUTE WIDTH AT ENERGY DISSIPATER (FT) |
| 1 | 8 | 14 |
| 2 | 8 | 22 |
| 3 | 8 | 28 |
| 4 | 8 | 52 |
| 5 | 8 | 8 |
| 6 | 8 | 16 |
| 7 | 8 | 16 |
| 8 | 8 | 32 |
| 9 | 8 | 32 |
| 10 | 8 | 44 |
| 11 | 8 | 32 |
| 12 | 8 | 16 |




GEOMEMBRANE OPTION




## GROUTED RIPRAP SPECIFICATION

RIPRAP: STONE USED FOR RIPRAP SHALL BE HARD, DURABLE, ANGULAR IN SHAPE; RESISTANT TO WEATHERING AND TO WATER ACTION; FREE FROM OVERBURDEN, SPOIL, SHALE AND ORGANIC MATERIAL; AND SHALL MEET THE GRADATION REQUIREMENTS SPECIFIED. STONE RIPRAP SHALL BE PLACED ON THE PREPARED SUBGRADE/FILTER FABRIC IN A MANNER WHICH WILL PRODUCE A REASONABLY WELL–GRADED MASS OF STONE WITH THE MINIMUM PARTICLE PERCENTAGE OF VOIDS. THE ENTIRE MASS OF STONE SHALL BE PLACED SO AS TO BE IN CONFORMANCE WITH THE LINES, GRADES, AND THICKNESS SHOWN ON THE PLANS. THE LARGER STONES SHALL BE WELL DISTRIBUTED AND PLACED SO THAT THERE WILL BE NO LARGE ACCUMULATIONS OF EITHER THE LARGER OR SMALLER SIZES OF STONE. IT IS THE INTENT OF THESE SPECIFICATIONS TO PRODUCE A FAIRLY COMPACT RIPRAP PROTECTION IN WHICH ALL SIZES OF MATERIAL ARE PLACED IN THEIR PROPER PROPORTIONS. HAND PLACING OR REARRANGING OF INDIVIDUAL STONES BY MECHANICAL EQUIPMENT MAY BE REQUIRED TO THE EXTENT NECESSARY TO SECURE THE RESULTS SPECIFIED.

24–INCH THICK RIPRAP GRADATION: ($D_{15}$ = 9–INCH, $D_{50}$ = 15–INCH, $D_{MAX}$ = 24–INCH).

GROUT: GROUT SHALL CONSIST OF 3,500 PSI CONCRETE USING A MAXIMUM AGGREGATE SIZE OF 3/4 INCH. THE FINISHED GROUT SHOULD LEAVE FACE STONES EXPOSED APPROXIMATELY 6 INCHES. THE SURFACE OF THE GROUT SHOULD EXPOSE A MATRIX OF COARSE AGGREGATE. THE ROCK SHOULD BE WET IMMEDIATELY PRIOR TO COMMENCING THE GROUTING OPERATION.

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NOTES:

1. SEE APPENDIX IIIF–C FOR CHUTE HYDRAULIC CALCULATIONS.

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DATE: 03/2022
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CAD: IIIF.10 DRAINAGE DETAILS.DWG

DRAWN BY: JDW
DESIGN BY: CRM
REVIEWED BY: RJS

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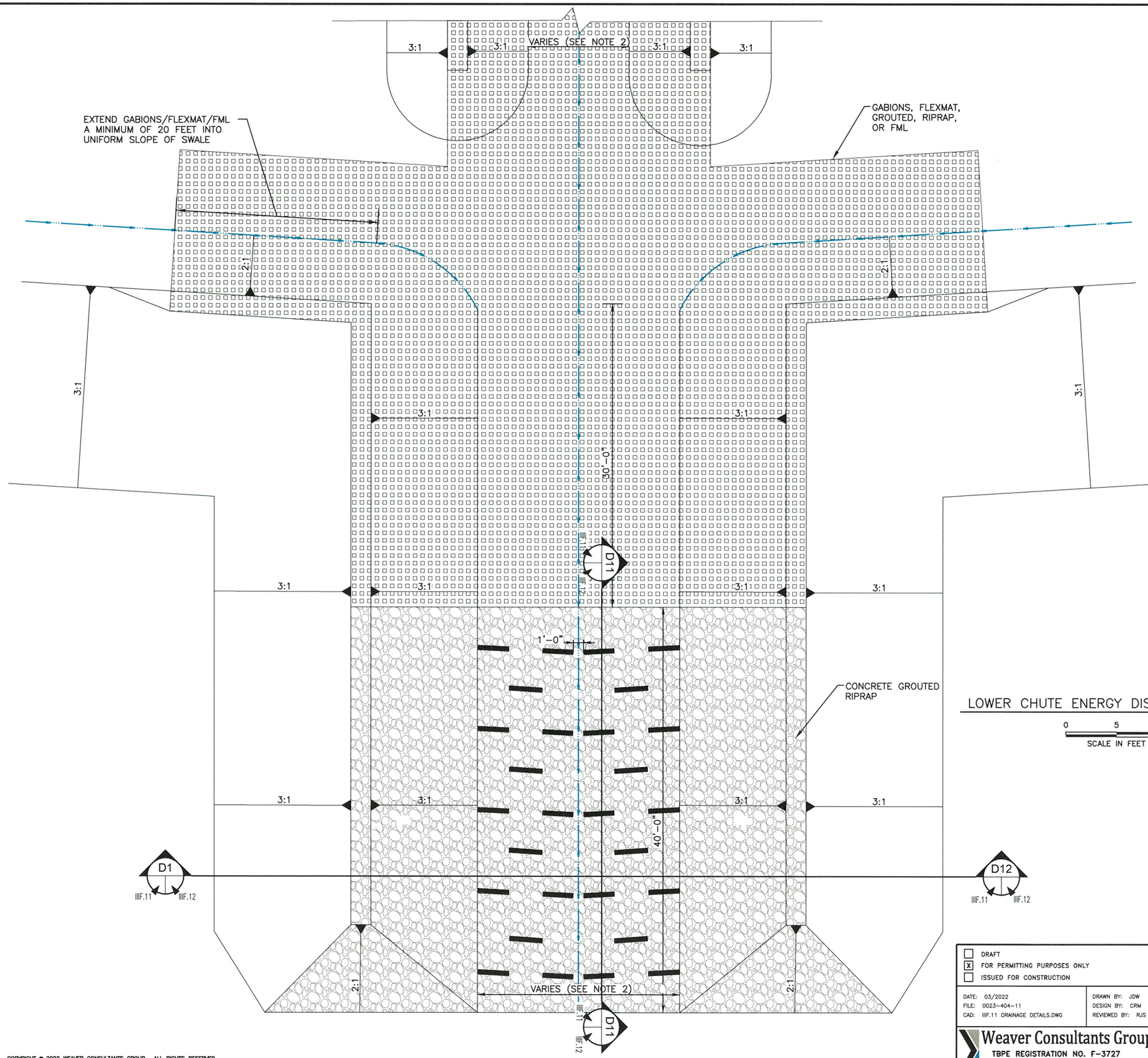
# MAJOR PERMIT AMENDMENT DRAINAGE DETAILS

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FIGURE IIIF.10

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## GABION/GROUTED RIPRAP/FLEXAMAT ENERGY DISSIPATER SUMMARY

| LETDOWN ID | BOTTOM WIDTH (FT) | DISSIPATER ELEMENT HEIGHT (IN) | LENGTH OF DISSIPATER (FT) |
|---|---|---|---|
| 1 | 14 | 12 | 40 |
| 2 | 22 | 12 | 40 |
| 3 | 30 | 12 | 40 |
| 4 | 50 | 12 | 40 |
| 5 | 12 | 12 | 40 |
| 6 | 16 | 12 | 40 |
| 7 | 16 | 12 | 40 |
| 8 | 32 | 12 | 40 |
| 9 | 32 | 12 | 40 |
| 10 | 42 | 12 | 40 |
| 11 | 32 | 12 | 40 |
| 12 | 16 | 12 | 40 |

## FML ENERGY DISSIPATER SUMMARY

| LETDOWN ID | BOTTOM WIDTH (FT) | DISSIPATER ELEMENT HEIGHT (IN) | LENGTH OF DISSIPATER (FT) |
|---|---|---|---|
| 1 | 14 | 12 | 40 |
| 2 | 22 | 12 | 40 |
| 3 | 28 | 12 | 40 |
| 4 | 52 | 12 | 40 |
| 5 | 8 | 12 | 40 |
| 6 | 16 | 12 | 40 |
| 7 | 16 | 12 | 40 |
| 8 | 32 | 12 | 40 |
| 9 | 32 | 12 | 40 |
| 10 | 42 | 12 | 40 |
| 11 | 32 | 12 | 40 |
| 12 | 16 | 12 | 40 |

LOWER CHUTE ENERGY DISSIPATER (TYP) D10 IIIF.1 IIIF.11

0 5 10
SCALE IN FEET

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05·19·22

NOTES:

1. REFER TO DRAWING IIIF.1 STORMWATER MANAGEMENT PLAN FOR LOCATION OF DETAILS.
2. SEE APPENDIX IIIF–C FOR CHUTE HYDRAULIC CALCULATIONS.

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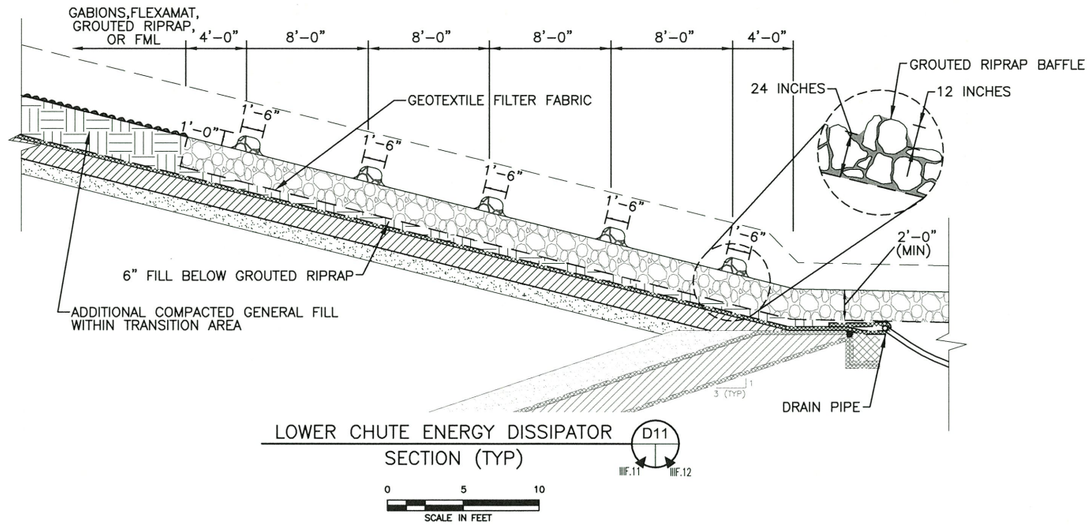
# MAJOR PERMIT AMENDMENT DRAINAGE DETAILS

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FIGURE IIIF.11

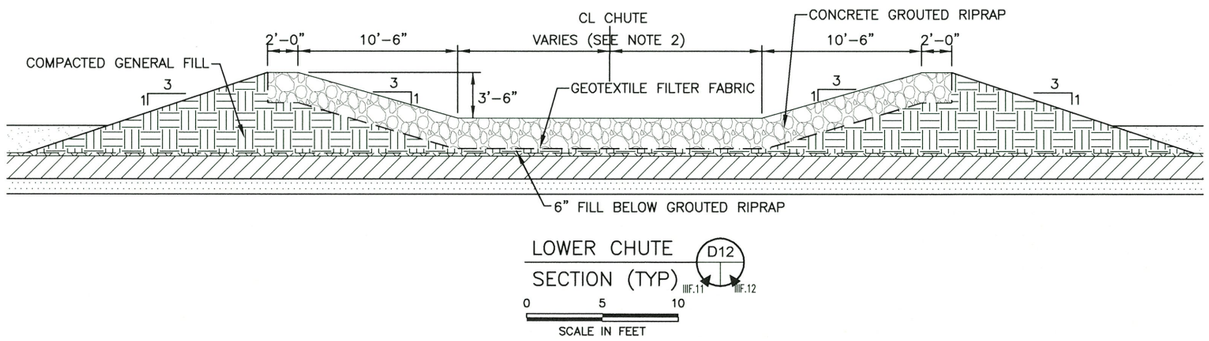
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LOWER CHUTE ENERGY DISSIPATOR SECTION (TYP) — D11 — IIIF.11 IIIF.12

0 5 10

SCALE IN FEET




LOWER CHUTE SECTION (TYP) — D12 — IIIF.11 IIIF.12

0 5 10

SCALE IN FEET

STATE OF TEXAS
CHARLES R. MARSH
105073
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05.19.22

NOTES:

1. REFER TO DRAWING IIIF.1 STORMWATER MANAGEMENT PLAN FOR LOCATION OF DETAILS.
2. SEE APPENDIX IIIF–C FOR CHUTE HYDRAULIC CALCULATIONS.

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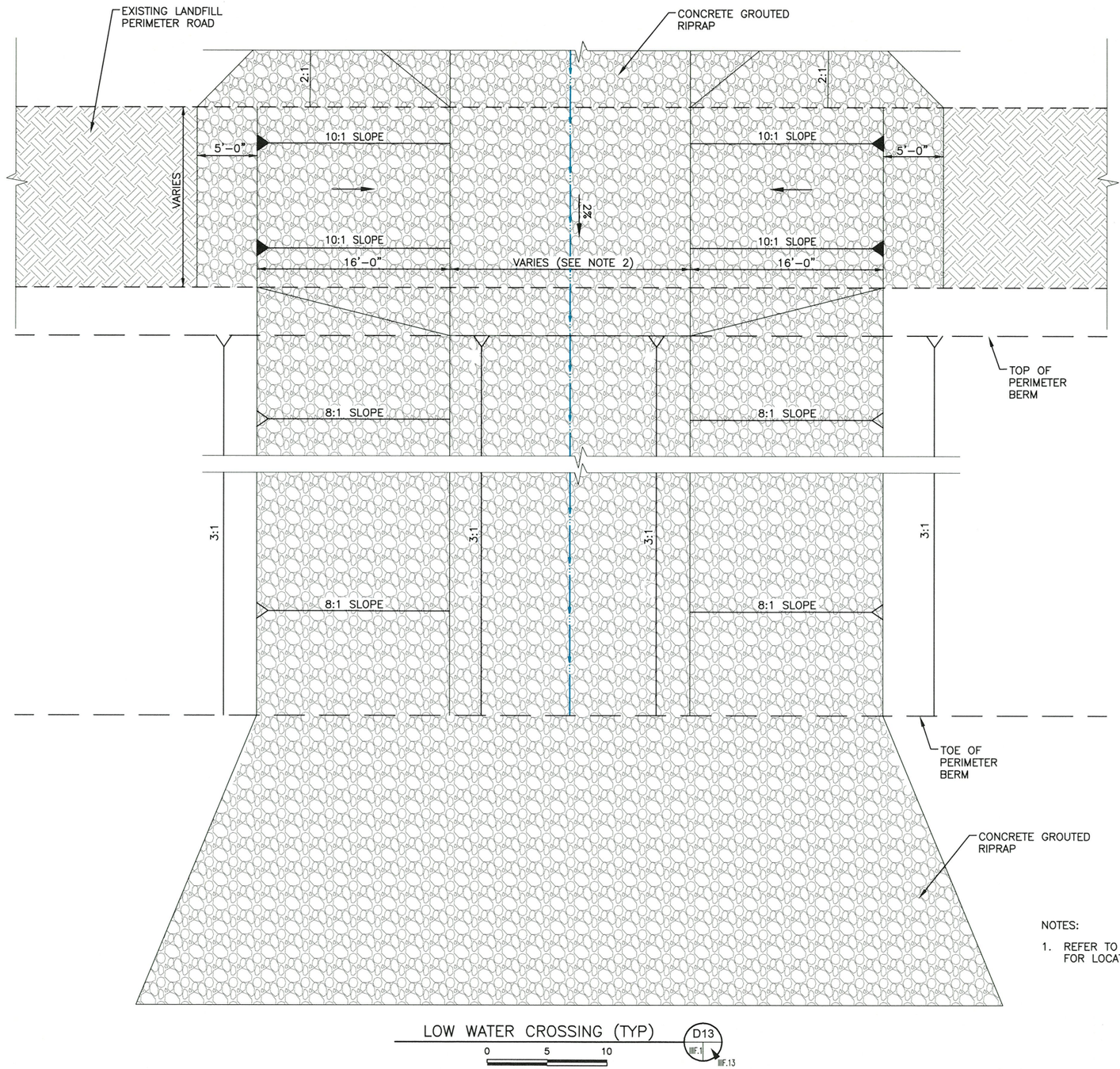
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FIGURE IIIF.12

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LOW WATER CROSSING (TYP) D13 IIIF.1 IIIF.13

0 5 10

SCALE IN FEET

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105073
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PROFESSIONAL ENGINEER
05.19.22

NOTES:

1. REFER TO DRAWING IIIF.1 STORMWATER MANAGEMENT PLAN FOR LOCATION OF DETAILS.

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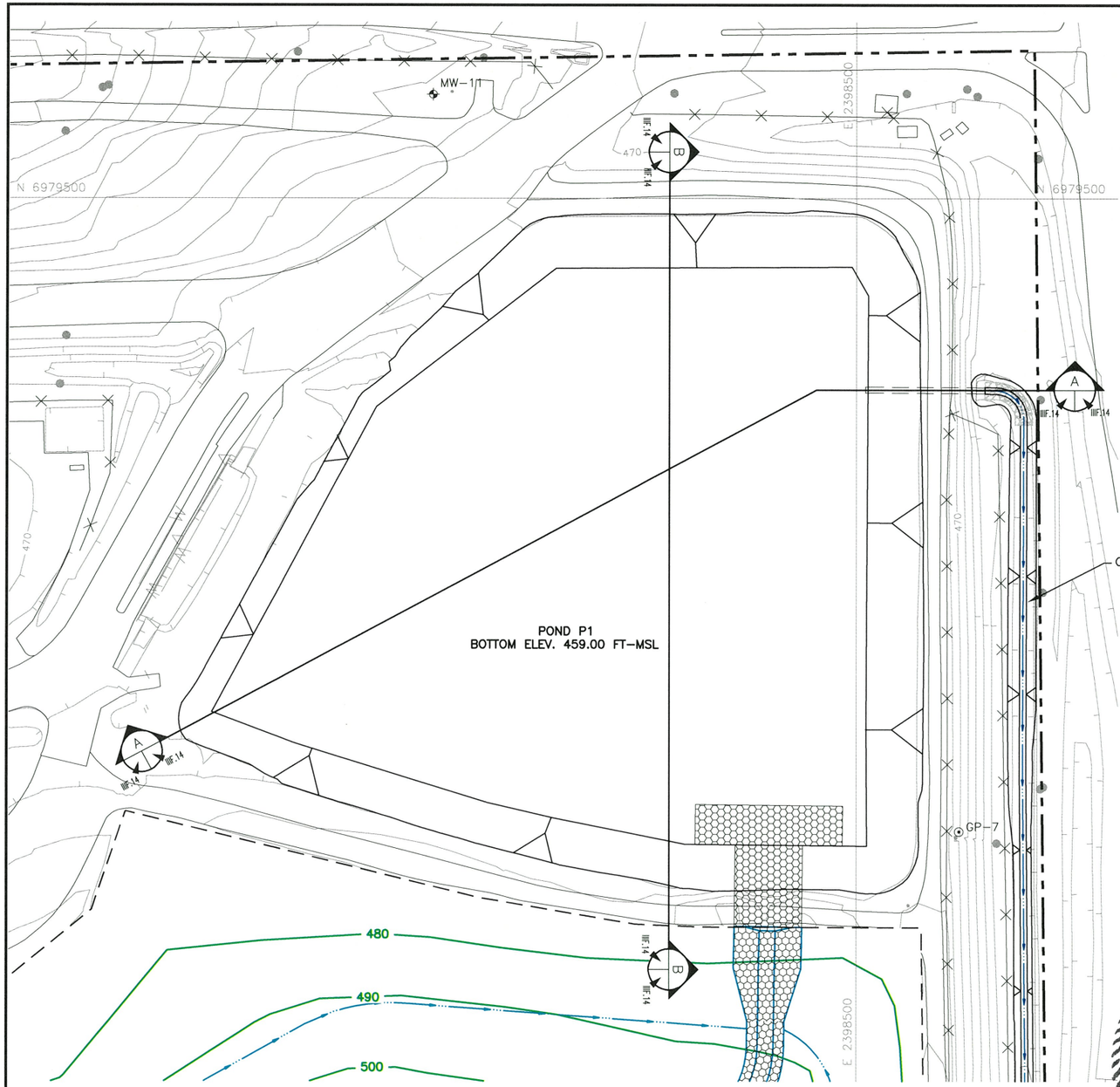
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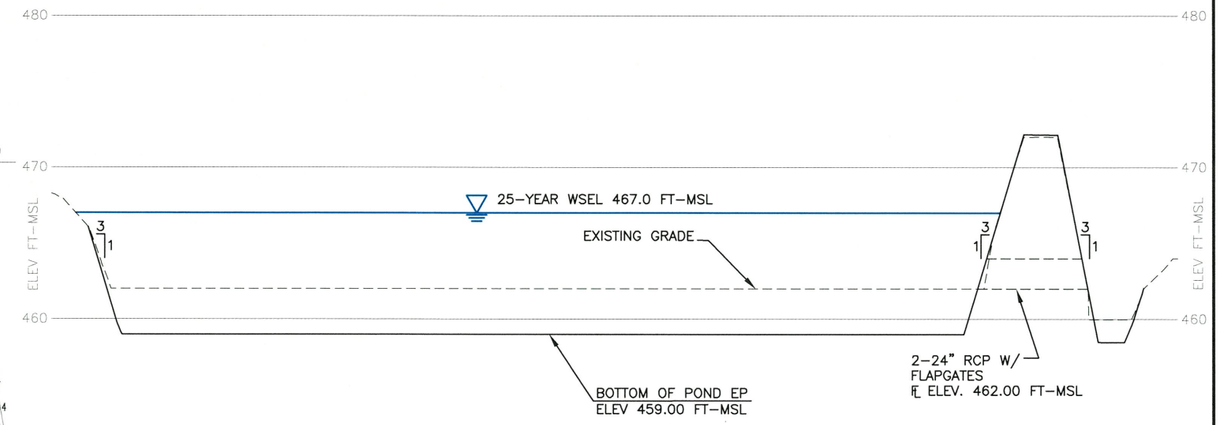
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FIGURE IIIF.13

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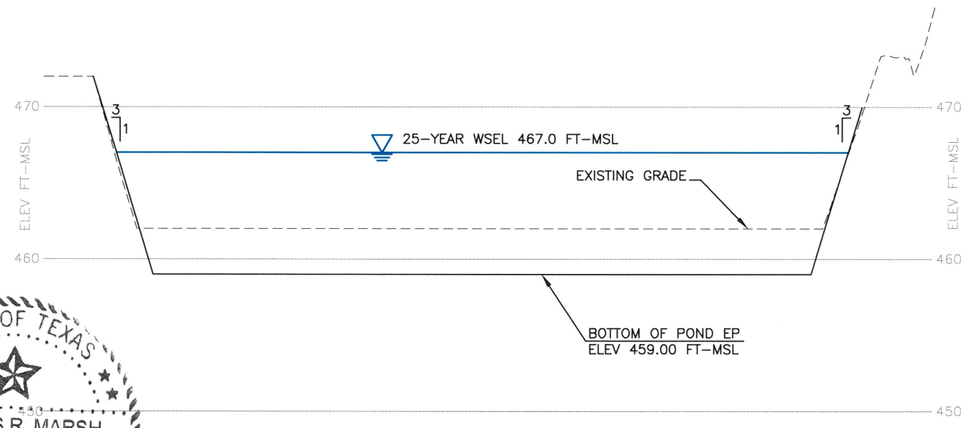
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DETENTION POND P1 SECTION A

0 50 100 IIIF.14 IIIF.14
HORIZONTAL SCALE IN FEET
0 5 10
VERTICAL SCALE IN FEET




DETENTION POND P1 SECTION B

0 50 100 IIIF.14 IIIF.14
HORIZONTAL SCALE IN FEET
0 5 10
VERTICAL SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- MW-3 EXISTING GROUNDWATER MONITOR WELL
- GP-11 EXISTING LANDFILL GAS DETECTION PROBE
- GABIONS

N

0 50 100
SCALE IN FEET

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.

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105073
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PROFESSIONAL ENGINEER
05.19.22

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DESIGN BY: CRM
REVIEWED BY: RJS

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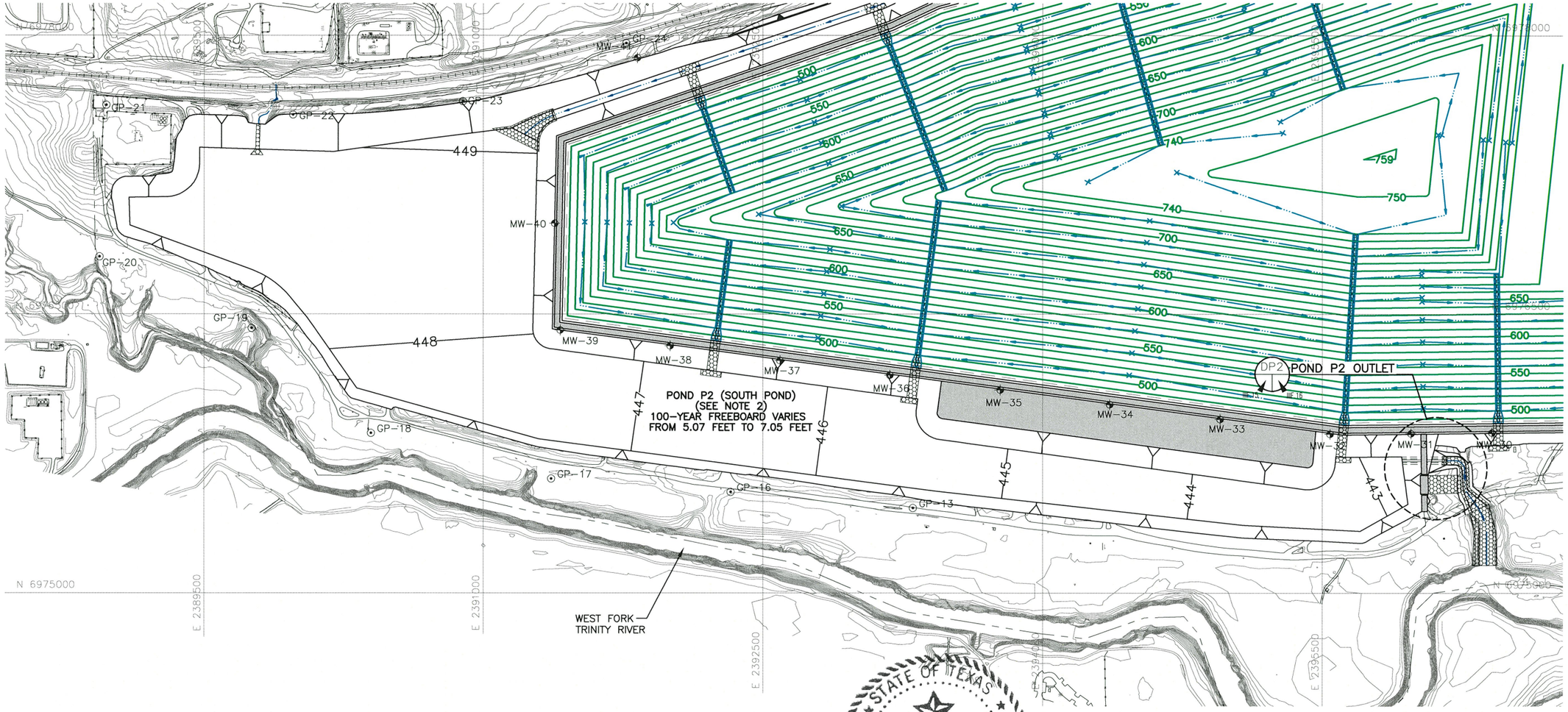
# MAJOR PERMIT AMENDMENT
# POND P1 PLAN

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LEGEND

- PERMIT BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- MW-3 EXISTING GROUNDWATER MONITOR WELL
- GP-11 EXISTING LANDFILL GAS DETECTION PROBE

0 300 600
SCALE IN FEET

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. HYDRAULIC CONDITIONS WITHIN POND P2 ARE MODELED IN THE PROPOSED CLOMR AS PART OF THE WEST FORK TRINITY RIVER (SECTIONS 1250+16 TO 1179+65). HEC-RAS OUTPUT DATA IS INCLUDED IN APPENDIX IIIF-B.

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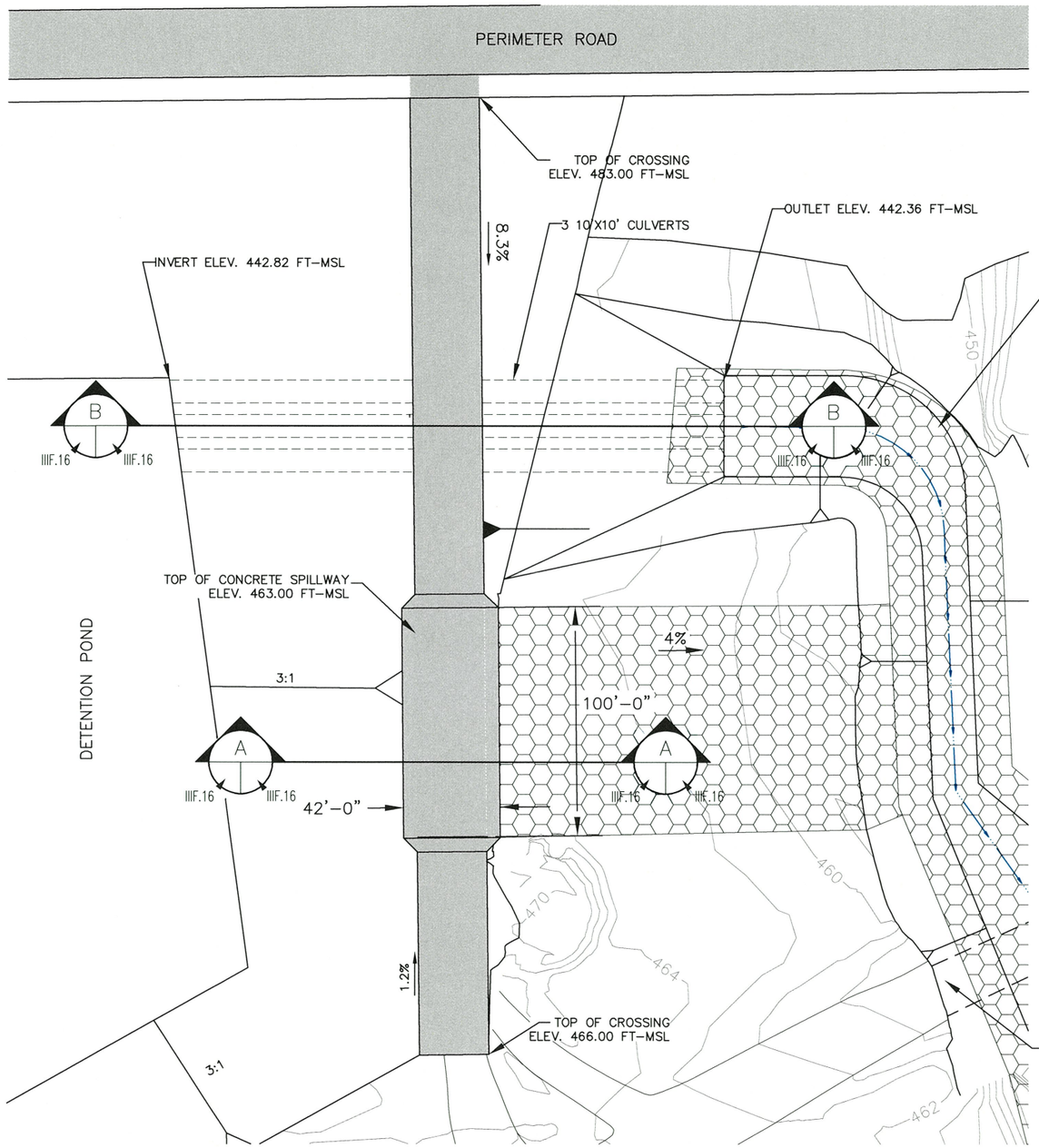
# MAJOR PERMIT AMENDMENT
# POND P2 PLAN

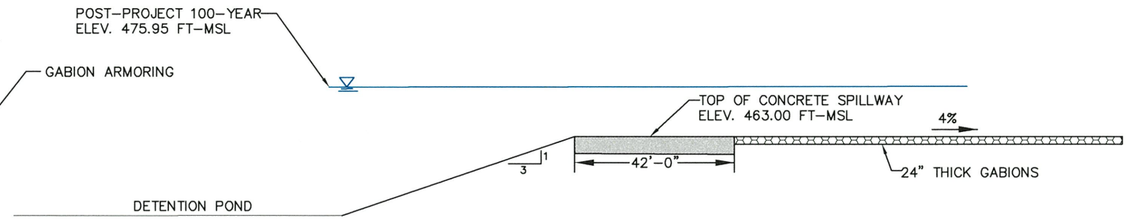
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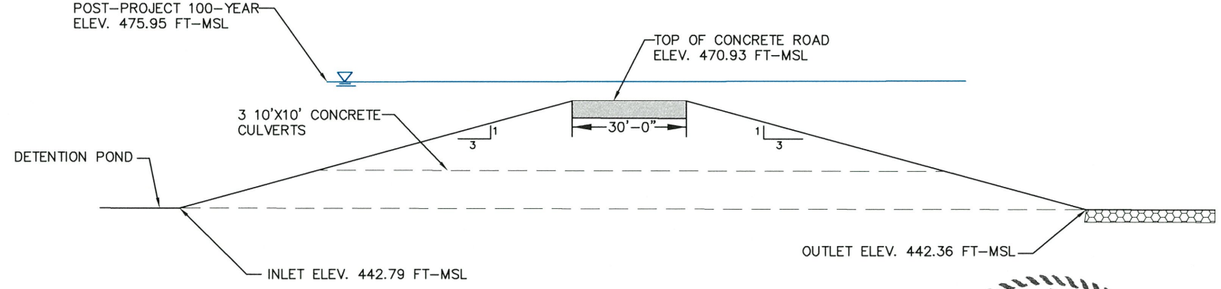




A LONGITUDINAL SECTION

IIIF.16 IIIF.16

0 20 40

HORIZONTAL SCALE IN FEET




B LONGITUDINAL SECTION

IIIF.16 IIIF.16

0 20 40

HORIZONTAL SCALE IN FEET

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# MAJOR PERMIT AMENDMENT
# POND P2 OUTLET

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# APPENDIX IIIF-A

# POST-DEVELOPMENT CONDITION HYDROLOGIC CALCULATIONS

Includes pages IIIF-A-1 through IIIF-A-103



# CONTENTS


| | |
|---|---|
| Hypothetical Storm Data | IIIF-A-1 |
| Precipitation Loss Data | IIIF-A-3 |
| Hydrograph Development Information | IIIF-A-12 |
| Post-development HEC-HMS Analysis Drainage Areas | IIIF-A-24 |
| HEC-HMS Output – Post-development 25-Year, 24-Hour Storm Event | IIIF-A-27 |
| Volume Calculations | IIIF-A-93 |
| Velocity Calculations | IIIF-A-98 |




# HYPOTHETICAL STORM DATA

**Hypothetical Storm Data**

Precipitation data taken from NOAA Atlas 14 rainfall data.

| Time | 5 min | 15 min | 60 min | 2 hr | 3 hr | 6 hr | 12 hr | 24 hr |
|---|---|---|---|---|---|---|---|---|
| 25-Year Event | 0.82 | 1.63 | 2.94 | 3.75 | 4.26 | 5.18 | 6.13 | 7.16 |

NOAA Atlas 14 - Precipitation-Frequency Atlas of the United States, Volume 11, Version 2.0: Texas (*U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, 2018*) was used to identify precipitation values for storm durations ranging from 5 minutes to 24 hours.

# PRECIPITATION LOSS DATA

**Required:** Determine the SCS curve numbers for both on-site and off-site drainage areas for use in the HEC-HMS analysis.

**References:**

1. Dodson's and Associates, Inc., *ProHec-1 Plus Program Documentation*, 1995.
2. United States Department of Agriculture, National Resource Conservation Service, Web Soil Survey for Tarrant County, Texas ( http://websoilsurvey.nrcs.usda.gov ).

**Note:** Web Soil Survey data for permit boundary area shown on SCS map (page IIIF-A-5).

**Solution:**

Based on the soil survey information found in Ref. 2, hydrologic group A and B soils predominate the areas within the permit boundary (see pages IIIF-A-5 through IIIF-A-8). For a conservative estimate of runoff and to account for the use of clays and/or geosynthetics, drainage areas within the landfill area, group D soils were used for Curve Number selection.

All non-landfill on-site drainage areas and most off-site drainage areas (O1, O2, O3, and O4) were considered pasture land in fair conditions. A curve number was selected using the table on page IIIF-A-11.

| Use: | 84 |
|---|---|

Off-site drainage areas O5 and O6 were modeled assuming most of the area within the drainage area is paved or otherwise impervious. A composite curve number was selected assuming an unpaved CN = 84 and a paved CN = 99.

The final cover system was assumed to be in place and the erosion layer will control precipitation loss. A curve number that is corrected for the surface slope of the erosion layer may be computed first using the chart on page IIIF-A-10 to select an un-adjusted curve number. Calculate the adjusted curve number using equation 34 from Ref. 3 (see page IIIF-A-11).

$$CN_{II} = 100 - ( 100 - CN_{II\,o} ) * ( L^{*\,2} / S^{*} ) \wedge (CN_{II\,o}^{-0.81})$$

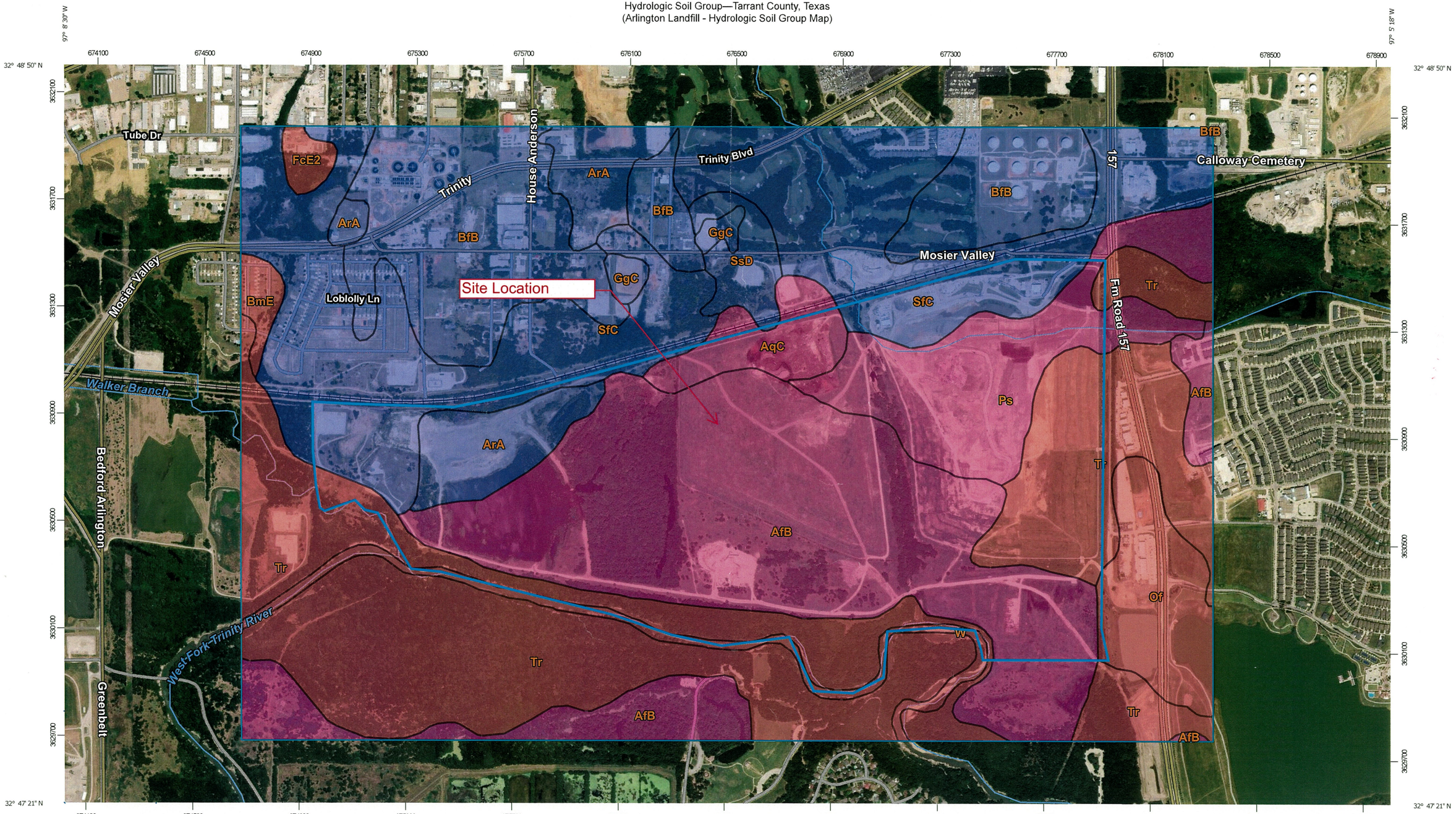
| | | |
|---|---|---|
| Use: | $CN_{II\,o} = 84$ , $L^{*} = (300/500)$ , $S^{*} = (.05/.04)$ | for top dome surfaces |
| Use: | $CN_{II\,o} = 84$ , $L^{*} = (120/500)$ , $S^{*} = (.25/.04)$ | for side slopes |

| | | |
|---|---|---|
| Calculate: | CN = 85 | for top dome surfaces |
| Calculate: | CN = 86 | for side slopes |

The pond areas are assumed to collect all precipitation for their areas:

| Use: | CN = 100 |
|---|---|

Hydrologic Soil Group—Tarrant County, Texas
(Arlington Landfill - Hydrologic Soil Group Map)




97° 8' 30" W — 97° 5' 18" W

32° 48' 50" N — 32° 47' 21" N

674100 674500 674900 675300 675700 676100 676500 676900 677300 677700 678100 678500 678900

3632100 3631700 3631300 3630900 3630500 3630100 3629700

Map Scale: 1:13,400 if printed on B landscape (17" x 11") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N 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 1:20,000.

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: Tarrant County, Texas
Survey Area Data: Version 19, Sep 10, 2021

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

Date(s) aerial images were photographed: Jan 18, 2020—Nov 15, 2020

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 |
|---|---|---|---|---|
| AfB | Arents, frequently flooded | A | 477.5 | 23.0% |
| AqC | Aquilla loamy fine sand, 1 to 5 percent slopes | A | 41.0 | 2.0% |
| ArA | Arents, loamy | B | 82.1 | 4.0% |
| BfB | Bastsil fine sandy loam, 0 to 3 percent slopes | B | 240.6 | 11.6% |
| BmE | Birome-Aubrey-Rayex complex, 5 to 15 percent slopes | D | 10.7 | 0.5% |
| FcE2 | Ferris clay, 5 to 12 percent slopes, eroded | D | 9.3 | 0.4% |
| GgC | Gasil sandy clay loam, graded, 1 to 5 percent slopes | B | 10.3 | 0.5% |
| Of | Ovan clay, frequently flooded | D | 70.3 | 3.4% |
| Ps | Pulexas fine sandy loam, frequently flooded | A | 133.8 | 6.5% |
| SfC | Silawa fine sandy loam, 3 to 8 percent slopes | B | 420.0 | 20.3% |
| SsD | Silstid loamy fine sand, 1 to 5 percent slopes | B | 25.7 | 1.2% |
| Tr | Trinity clay, 0 to 1 percent slopes, frequently flooded | D | 521.4 | 25.2% |
| W | Water | D | 30.3 | 1.5% |
| **Totals for Area of Interest** | | | **2,073.1** | **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

where

$CN_{II_o}$ = AMC-II curve number for mild slope (unadjusted for slope)

$C_0$ = regression constant for a given level of vegetation

$C_1$ = regression constant for a given level of vegetation

$C_2$ = regression constant for a given level of vegetation

$IR$ = infiltration correlation parameter for given soil type

The relationship between $CN_{II}$, the vegetative cover and default soil texture is shown graphically in Figure 8. Table 7 gives values of $C_0$, $C_1$ and $C_2$ for the five types of vegetative cover built into the HELP program.

### 4.2.3 Adjustment of Curve Number for Surface Slope

A regression equation was developed to adjust the AMC-II curve number for surface slope conditions. The regression was developed based on kinematic wave theory where

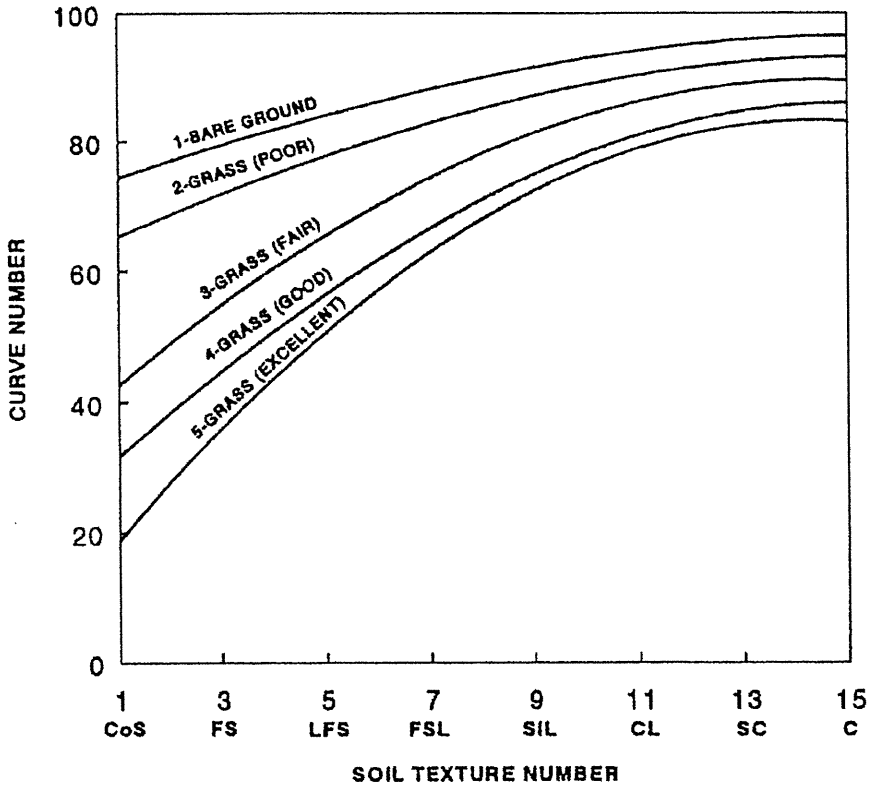



Figure 8. Relation between SCS Curve Number and Default Soil Texture Number for Various Levels of Vegetation

loam, and clayey loam as specified by saturated hydraulic conductivity, capillary drive, porosity, and maximum relative saturation, Two levels of vegetation were described--a good stand of grass (bluegrass sod) and a poor stand of grass (clipped range). Slopes of 0.04,0.10,0.20,0.35, and 0.50 ft/ft and slope lengths of 50, 100, 250, and 500 ft were used. Rainfalls of 1.1 inches, l-hour duration and 2nd quartile Huff distribution and of 3.8 inches, 6-hour duration and balanced distribution were modeled.

The resulting regression equation used for adjusting the AMC-II curve number computed for default soils and vegetation placed at mild slopes, $CN_{II_o}$, is:

$$CN_{II} = 100 - (100 - CN_{II_o}) \cdot \left(\frac{L^{*2}}{S^*}\right)^{CN_{II_o}^{-0.81}} \qquad (34)$$

where

$L^*$ = standardized dimensionless length, (L/500 ft)

$S^*$ = standardized dimensionless slope, (S/0.04)

This same equation is used to adjust user-specified AMC-II curve numbers for surface slope conditions by substituting the user value for $CN_{II_o}$ in Equation 34.

### 4.2.4 Adjustment of Curve Number for Frozen Soil

When the HELP program predicts frozen conditions to exist, the value of $CN_{II}$ is increased, resulting in a higher calculated runoff. Knisel et al. (1985) found that this type of curve number adjustment in the CREAMS model resulted in improved predictions of annual runoff for several test watersheds. If the $CN_{II}$ for unfrozen soil is less than or equal to 80, the $CN_{II}$ for frozen soil conditions is set at 95. When the unfrozen soil $CN_{II}$ is greater than 80, the $CN_{II}$ is reset to be 98 on days when the program has determined the soil to be frozen. This adjustment results in an increase in $CN_I$ and consequently a decrease in $S_{mx}$ and $S'$ (Equations 19, 26, and 30).

From Equations 19 and 21, it is apparent that as $S'$ approaches zero, $Q$ approaches $P$. In other words, as $S'$ decreases, the calculated runoff becomes closer to being equal to the net rainfall which is most often, when frozen soil conditions exist, predominantly snowmelt. This will result in a decrease in infiltration under frozen soil conditions, which has been observed in numerous studies.

### 4.2.5 Summary of Daily Runoff Computation

The HELP model determines daily runoff by the following procedure:

**Table 2-2a** Runoff curve numbers for urban areas [1]

| Cover description | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|
| Cover type and hydrologic condition | Average percent impervious area [2] | A | B | C | D |
| *Fully developed urban areas (vegetation established)* | | | | | |
| Open space (lawns, parks, golf courses, cemeteries, etc.) [3]: | | | | | |
| Poor condition (grass cover < 50%) | | 68 | 79 | 86 | 89 |
| Fair condition (grass cover 50% to 75%) | | 49 | 69 | 79 | 84 |
| Good condition (grass cover > 75%) | | 39 | 61 | 74 | 80 |
| Impervious areas: | | | | | |
| Paved parking lots, roofs, driveways, etc. (excluding right-of-way) | | 98 | 98 | 98 | 98 |
| Streets and roads: | | | | | |
| Paved; curbs and storm sewers (excluding right-of-way) | | 98 | 98 | 98 | 98 |
| Paved; open ditches (including right-of-way) | | 83 | 89 | 92 | 93 |
| Gravel (including right-of-way) | | 76 | 85 | 89 | 91 |
| Dirt (including right-of-way) | | 72 | 82 | 87 | 89 |
| Western desert urban areas: | | | | | |
| Natural desert landscaping (pervious areas only) [4] | | 63 | 77 | 85 | 88 |
| Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders) | | 96 | 96 | 96 | 96 |
| Urban districts: | | | | | |
| Commercial and business | 85 | 89 | 92 | 94 | 95 |
| Industrial | 72 | 81 | 88 | 91 | 93 |
| Residential districts by average lot size: | | | | | |
| 1/8 acre or less (town houses) | 65 | 77 | 85 | 90 | 92 |
| 1/4 acre | 38 | 61 | 75 | 83 | 87 |
| 1/3 acre | 30 | 57 | 72 | 81 | 86 |
| 1/2 acre | 25 | 54 | 70 | 80 | 85 |
| 1 acre | 20 | 51 | 68 | 79 | 84 |
| 2 acres | 12 | 46 | 65 | 77 | 82 |
| *Developing urban areas* | | | | | |
| Newly graded areas (pervious areas only, no vegetation) [5] | | 77 | 86 | 91 | 94 |
| Idle lands (CN's are determined using cover types similar to those in table 2-2c). | | | | | |

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

# HYDROGRAPH DEVELOPMENT INFORMATION

# HYDROGRAPH DEVELOPMENT INFORMATION

## Landfill Areas

Direct runoff methods, (i.e., kinematic wave) have been used for the majority of the landfill final cover areas. The kinematic wave method has been used to model the 5 percent topslope areas and 25 percent side slope areas before the flow is intercepted by the drainage swales. The kinematic wave method is a physically based method using slope, surface roughness, catchment lengths and areas. This method does not consider attenuation for flood wave; as a consequence, this method provides for a conservative analysis. The following typical parameters for the kinematic wave method have been developed for landfill areas.

Kinematic wave parameters for overland flow:

Slope: Varies from 0.05 to 0.25 ft/ft landfill slopes

N: 0.30 Manning's friction coefficient (based on using a value between dense grass (N = 0.24) and Bermuda grass (N = 0.41) listed in Soil Conservation Services TR-55)

L: Represents a typical distance between swales for overland flow for each drainage area. For example, as shown on Sheet IIIF-A-23, the swale spacing on 4H:1V sideslopes is 120 feet.

Percentage of drainage area represented by this element is 100 percent.

Kinematic Wave routing for channels:

- Channel length (ft): The length of the channel section.
- Channel slope (ft/ft): Varies from 0.0010 to 0.0574 (0.005 for swales).
- Channel roughness coefficient: 0.03 for grass lined channels and swales.
- Channel type: A trapezoidal channel was used with varying width and 2:1 side slopes ("V" ditch with varying side slopes for swales).

## Non-Landfill Final Cover Areas

Hydrographs for the majority of non-landfill final cover areas within and near the permit boundary (e.g., pond areas) were developed using the Snyder unit

hydrograph method. Espey "10-Minute" method has been used to estimate Snyder parameters. Snyder parameter estimations are provided on pages IIIF-A-19 through IIIF-A-23.

As discussed in Section 2 of Appendix IIIF, hydrographs for the areas outside of the permit boundary (O1 through O6) and larger areas inside the permit boundary (S1 through S7) were developed using the Snyder unit hydrograph method. The percent imperviousness ranges from 2 percent to 50 percent, for the majority of the non-landfill on-site and off-site areas, which represents the majority of the watershed as undeveloped. Pond areas are assumed to be 99 percent impervious, and areas with significant channel surface or paved surfaces were assigned higher percentages of impervious area, as shown on IIIF-A-19.

## Drainage Areas

The drainage areas used for this analysis are shown on Sheet IIIF-A-26. The routing scheme for the post-development condition is shown in the HEC-HMS output file presented on pages IIIF-A-27 through IIIF-A-93.

# DISTRIBUTED RUNOFF METHOD
# KINEMATIC WAVE EXAMPLE

Drainage area "DA4" is used in this example (refer to Sheet IIIF-A-17 for location of drainage area).

**Watershed Specific Parameters:**

| | | | |
|---|---|---|---|
| A = | 53.58 | acres | Watershed Area (acres) |
| A = | 0.0837 | sq-miles | Watershed Area (sq-miles) |
| CN= | 86 | | SCS Curve Number (see sheet IIIF-A-4 for more information) |

**Kinematic Wave parameter for overland flow:**

| | | | |
|---|---|---|---|
| L= | 120 | ft | Typical overland flow (ft) |
| S= | 0.25 | ft/ft | Landfill slope (ft/ft) |
| N= | 0.30 | | Manning's Coefficient |

Percentage of the drainage area represented by this element is 100 percent

**Kinematic Wave routing data for the swale:**

| | | | |
|---|---|---|---|
| L= | 11946 | ft | Typical swale length (ft) |
| S= | 0.005 | ft/ft | Swale bottom slope (ft/ft) |
| N= | 0.03 | | Manning's Coefficient |
| Channel= | TRAP | | Swale Type* |

* A trapezoidal channel with no bottom width was used to simulate a triangular channel.

0 400 800
SCALE IN FEET

MOSIER VALLEY ROAD
SCALEHOUSE
C.R.I.&P. RAILROAD
F.M. 157 NORTH COLLINS STREET
DA4
1000 FT.

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN
- DRAINAGE AREA BOUNDARY
- DA4 DRAINAGE AREA DESIGNATION

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05.19.22

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

DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-A-17-KINEMATIC.DWG

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

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
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# MAJOR PERMIT AMENDMENT KINEMATIC WAVE PARAMETERS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

DRAWING IIIF-A-17

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# ESPEY 10-MINUTE METHOD PARAMETERS

Snyder's Hydrograph Coefficients (Espey's 10 Minute Method)

Proposed Expansion Conditions

| Area No. | Area (acres) | Max. Flow Length (L) (ft) | S (ft/ft) | I (%) | Manning "n" | $\Phi$[1] | $T_r$[2] (min) | $T_{lag}$[3] (min) | $T_{lag}$ (hr) | Area[4] (sq mi) | $q_p$[5] (cfs/sq mi) | $C_p$[6] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O1 | 81.63 | 3,997 | 0.0200 | 15 | 0.04 | 0.82 | 25.0 | 22.5 | 0.37 | 0.1275 | 1097.0 | 0.64 |
| O2 | 160.32 | 5,556 | 0.0180 | 15 | 0.04 | 0.82 | 27.7 | 25.2 | 0.42 | 0.2505 | 957.1 | 0.63 |
| O3* | 3520.00 | 15,979 | 0.0043 | 16 | 0.04 | 0.82 | 49.8 | 47.3 | 0.79 | 5.5000 | 450.4 | 0.56 |
| O4 | 41.33 | 1,878 | 0.0266 | 10 | 0.04 | 0.84 | 21.8 | 19.3 | 0.32 | 0.0646 | 1301.3 | 0.66 |
| O5 | 4.04 | 212 | 0.0330 | 25 | 0.03 | 0.75 | 8.9 | 6.4 | 0.11 | 0.0063 | 3731.5 | 0.62 |
| O6 | 25.70 | 639 | 0.0099 | 50 | 0.03 | 0.68 | 11.7 | 9.2 | 0.15 | 0.0402 | 2579.1 | 0.62 |
| S1 | 64.93 | 1,714 | 0.0362 | 2 | 0.04 | 0.87 | 28.0 | 25.5 | 0.42 | 0.1015 | 981.2 | 0.65 |
| S2 | 7.92 | 1,043 | 0.0288 | 25 | 0.03 | 0.75 | 13.3 | 10.8 | 0.18 | 0.0124 | 2367.7 | 0.66 |
| S3 | 23.39 | 1,557 | 0.0218 | 25 | 0.03 | 0.75 | 15.6 | 13.1 | 0.22 | 0.0365 | 1908.5 | 0.65 |
| S4 | 16.05 | 365 | 0.0740 | 90 | 0.02 | 0.6 | 4.6 | 2.1 | 0.04 | 0.0251 | 7144.0 | 0.39 |
| S5 | 8.15 | 1,213 | 0.0396 | 10 | 0.04 | 0.84 | 17.9 | 15.4 | 0.26 | 0.0127 | 1719.6 | 0.69 |
| S6 | 21.47 | 754 | 0.0019 | 10 | 0.04 | 0.84 | 34.3 | 31.8 | 0.53 | 0.0335 | 823.4 | 0.68 |
| S7 | 32.83 | 1,462 | 0.0096 | 10 | 0.04 | 0.84 | 26.6 | 24.1 | 0.40 | 0.0513 | 1062.9 | 0.67 |

* O3 area was determiend from a FEMA Flood Insurance Study (FIS). I(%) and $\Phi$ were adjusted to match flow rates provided in the FIS.

[1] Conveyance efficiency coefficient from Dodson & Associates Inc., *ProHec-1 Program Documentation*, 1995, pages 6-19 and 6-20.
[2] $T_r = 3.1(L^{0.23})(S^{-0.25})(I^{-0.18})(\Phi^{1.57})$
[3] $T_{lag} = T_r - \Delta t/2$
[4] From area summary sheet
[5] $q_p = 31600(A^{-0.04})(T_r^{-1.07})$
[6] $C_p = 49.375(A^{-0.04})(T_r^{-1.07})(T_{lag})$

$T_r$ = surface runoff to unit hydrograph peak (min)
L = distance along main channel from study point to watershed boundary (ft)
S = main channel slope (ft/ft)
I = impervious cover within the watershed (%)
$T_{lag}$ = watershed lag time (min)
$\Delta t$= computation interval (minutes)
$q_p$ = unit hydrograph peak discharge (cfs/sq mi)
$C_p$ = Snyder's peaking coefficient

Snyder Unit Hydrograph uses lag time ($T_{lag}$) and peaking coefficient accounting for flood wave and watershed storage conditions.

Drainage area "S6" in the post-project condition is used in this example.

Estimated Watershed specific parameters

| | | | |
|---|---|---|---|
| A = | 21.47 | acres | watershed area |
| L = | 754 | feet | maximun flow length with this watershed |
| S = | 0.0019 | feet/feet | watershed slope |
| I = | 10 | percent (%) | watershed imperviousness |
| n = | 0.04 | | Manning's coefficient |

Calculate Tr: time beginning of surface runoff to the unit hydrograph peak in minutes

$T_r = 3.1(L^{0.23})(S^{-0.25})(I^{-0.18})(\Phi^{1.57})$

Estimate : conveyance efficiency coefficient

$\Phi$ = for 2 percent impervious cover and n = 0.06

$\Phi = 0.84$

$T_r = 3.1(783^{0.23})(0.0204^{-0.25})(10^{-0.18})(0.84^{1.57})$

$T_r = 34.3$ min

Calculate $T_{lag}$: watershed lag time

$T_{lag} = Tr - (\Delta t/2)$ $\Delta t$ is calculation interval, and 5 minutes is used

$T_{lag} = 31.8$ minutes in the HEC - 1 modeling in this project

$T_{lag} = 0.53$ hours

$A = A/640$

$A = 0.0335$ square miles

Calculate $q_p$: peak discharge of unit hydrograph per unit area (cfs/sq. mi).

$q_p = 31600(A^{-0.04})(T_r^{-1.07})$

$q_p = 31600(0.0038^{-0.04})(19.1^{-1.07})$

$q_p = 823.4$ cfs/sq. mi

Calculate Peaking coefficient $C_p$:

$C_p = 49.375(A^{-0.04})(T_r^{-1.07})(T_{lag})$

$C_p = 49.375(0.0038^{-0.04})(19.1^{-1.07})(0.28)$

$C_p = 0.68$

compute the value of Snyder's peaking coefficient $C_p$ for use in HEC-1 analyses. First, the watershed lag time $T_L$ is determined by subtracting one-half of the computation interval from the time to rise ($T_L = T_r - \Delta t/2$). Then, $C_p$ may be computed by substituting the known values of $T_L$ and $q_p$ into Snyder's equation for peak unit hydrograph flow rate and solving for $C_p$.

$$C_p = \frac{q_p \times T_L}{640} \qquad 6.30$$

## Espey "10-Minute" Method for Estimating Snyder Parameters

In another study, Espey [1977] derived the following equation for computing the time from the beginning of surface runoff to the unit hydrograph peak:

$$T_r = 3.10\, L^{0.23} S^{-0.25} I^{-0.18} \Phi^{1.57} \qquad 6.31$$

in which:

$T_r$ = time from beginning of surface runoff to unit hydrograph peak (minutes)

$L$ = total distance along main channel from study point to watershed boundary (feet)

$S$ = main channel slope between the reference point and a point 0.2L downstream from the upstream watershed boundary (feet per foot)

$I$ = impervious cover within the watershed (percent)

$\Phi$ = description of conveyance efficiency of the watershed drainage system.

The conveyance efficiency coefficient $\Phi$ is determined using the relationships illustrated on Figure 6.12.

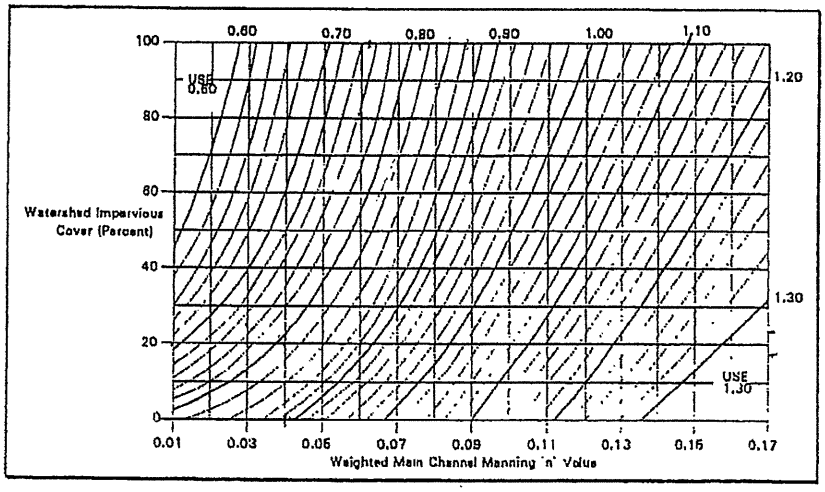



FIGURE 6.12 Determination of Conveyance Efficiency Coefficient $\Phi$

This equation was derived from records for 41 watersheds in Texas, Tennessee, Mississippi, Pennsylvania, North Carolina, Colorado, Kentucky, and Indiana. The range in the watershed characteristics used to develop the equations for urban areas were:

Area : From 0.0128 square miles to 15.00 square miles

$L$ : From 555 feet to 35,600 feet


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$S$ : From 0.0005 ft. per ft. to 0.0295 ft. per ft.

$I$: From 2% to 100%

$\Phi$ : From 0.60 to 1.30

Again, note that the time to rise $T_r$ is not the same as the watershed lag time $T_p$. The difference between the two is that $T_r$ is defined as the time from the beginning of effective rainfall to the peak of the unit hydrograph, while $T_L$ is the time from the centroid of the effective rainfall to the peak of the unit hydrograph. For the purposes of HEC-1 analyses, however, $T_L$ may be determined simply by subtracting one-half the computation time interval from the computed value of $T_r$ ($T_R$ - $\Delta t/2$).

The relationship developed by Espey to compute the peak flow rate of the unit hydrograph is as follows:

6.32 $$Q_u = 31600 \ A^{0.96} T_r^{-1.07}$$

in which:

$Q_u$ = unit hydrograph peak discharge (cfs)

$A$ = drainage area (square miles)

$T_r$ = time of rise from beginning of surface runoff to unit hydrograph peak (minutes)

### *Riverside County Method for Estimating Snyder Parameters*

Three watershed lag equations have been derived for use in rural areas of Riverside County, California by the Riverside County Flood Control and Water Conservation District [Anonymous, 1963]. These equations differ slightly from those developed at the Tulsa District of the U.S. Army Corps of Engineers in that lag is defined as the time from the beginning of rainfall to the point on the unit hydrograph corresponding to one-half of the total runoff volume.

Each equation is applicable to a different topographic region:

6.33 $$T_L = 1.20\left(\frac{L \times L_{ca}}{\sqrt{S}}\right)^{0.38}$$ (Mountain Areas)

6.34 $$T_L = 0.72\left(\frac{L \times L_{ca}}{\sqrt{S}}\right)^{0.38}$$ (Foothill Areas)

6.35 $$T_L = 0.38\left(\frac{L \times L_{ca}}{\sqrt{S}}\right)^{0.38}$$ (Valley Areas)

in which:

$T_L$ = watershed lag in hours

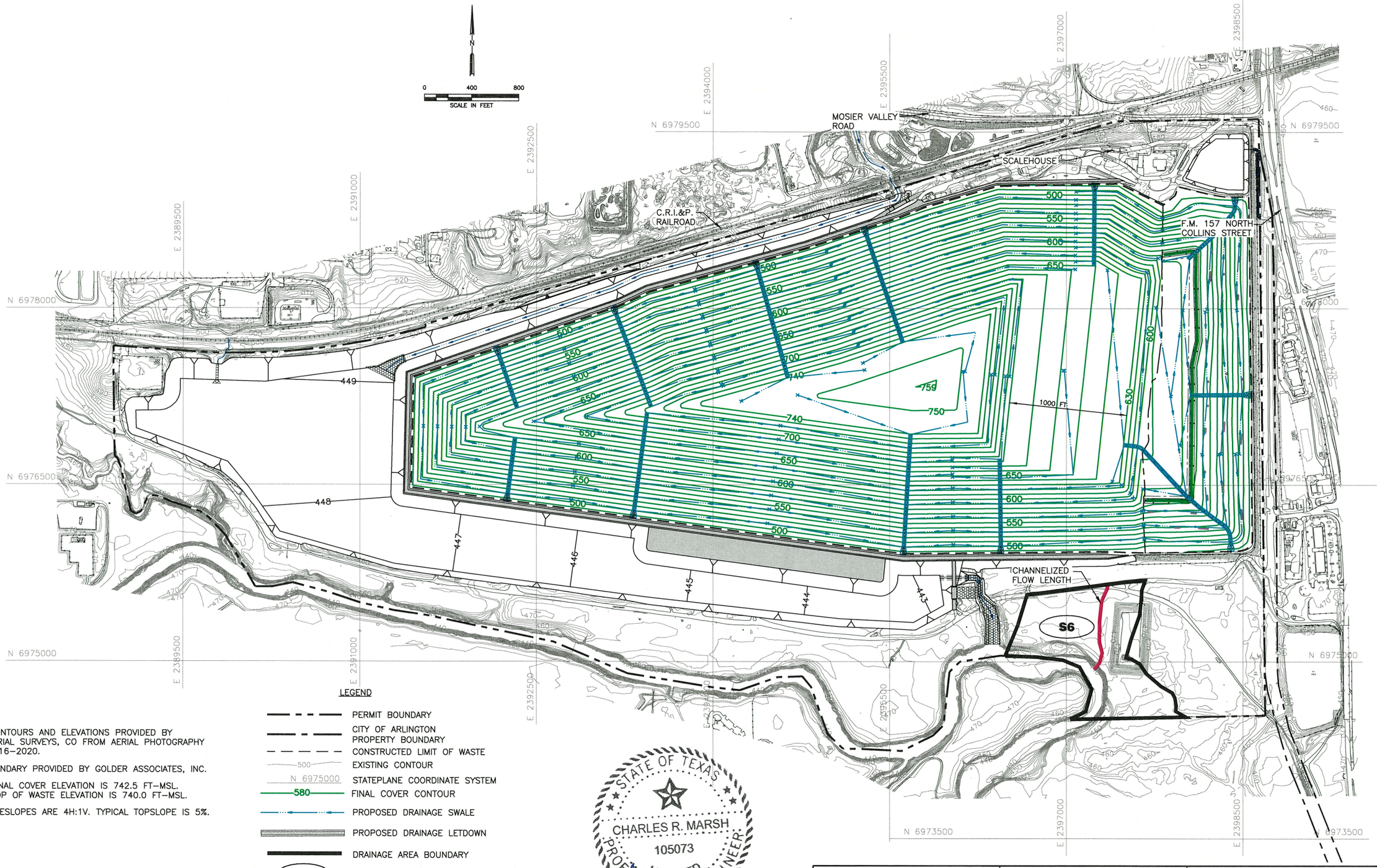
$L$ = watershed length in miles

$L_{ca}$ = length to centroid in miles

$S$ = watershed slope in feet per mile.

The sizes of the watersheds studied in developing these equations ranged from 2.3 square miles to 645 square miles.


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NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN
- DRAINAGE AREA BOUNDARY
- S6 DRAINAGE AREA DESIGNATION

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05.19.22

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- ☒ FOR PERMITTING PURPOSES ONLY
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DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-A-23-ESPEY.DWG
DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: RJS

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

REVISIONS

| NO. | DATE | DESCRIPTION |
|---|---|---|
| | | |
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# MAJOR PERMIT AMENDMENT EPSEY "10-MINUTE" METHOD PARAMETERS

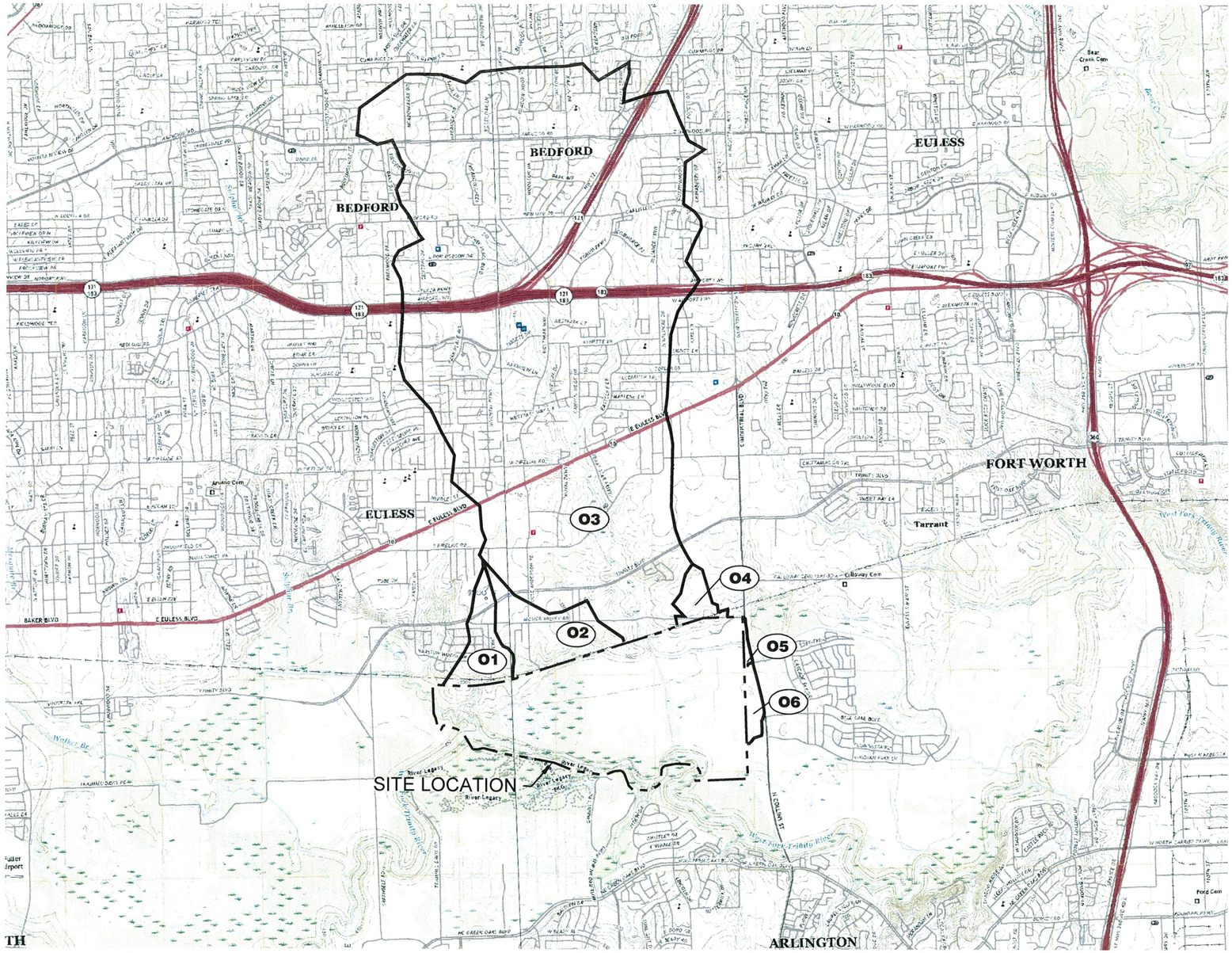
CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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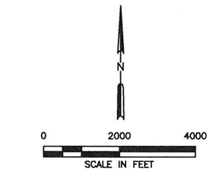
DRAWING IIIF-A-23

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# POST-DEVELOPMENT HEC-HMS ANALYSIS
# DRAINAGE AREAS




| DRAINAGE AREA NO. | AREA (ACRES) |
|---|---|
| 01 | 81.63 |
| 02 | 160.32 |
| 03 (SEE NOTE 2) | 3520.00 |
| 04 | 41.33 |
| 05 | 4.04 |
| 06 | 25.70 |
| TOTAL | 3833.01 |




NOTES:

1. REPRODUCED FROM 7.5 MINUTE, HURST, TEXAS QUADRANGLE USGS MAP DATED 2019 AND 7.5 MINUTE, EULESS, TEXAS QUADRANGLE USGS MAP DATED 2019.
2. THE DRAINAGE ARE FOR BASIN 03 (5.5 SQUARE MILES OR 3,520 ACRES) WAS REPRODUCED FROM THE EFFECTIVE FEMA FLOOD INSURANCE STUDY NUMBER 48439CV001B, DATED MARCH 21, 2019.




LEGEND

PERMIT BOUNDARY

DRAINAGE AREA BOUNDARY

01 DRAINAGE AREA DESIGNATION

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DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-A-25 OFFSITE DRAINAGE.DWG

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

Weaver Consultants Group
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| NO. | DATE | DESCRIPTION |
|---|---|---|
| | | |
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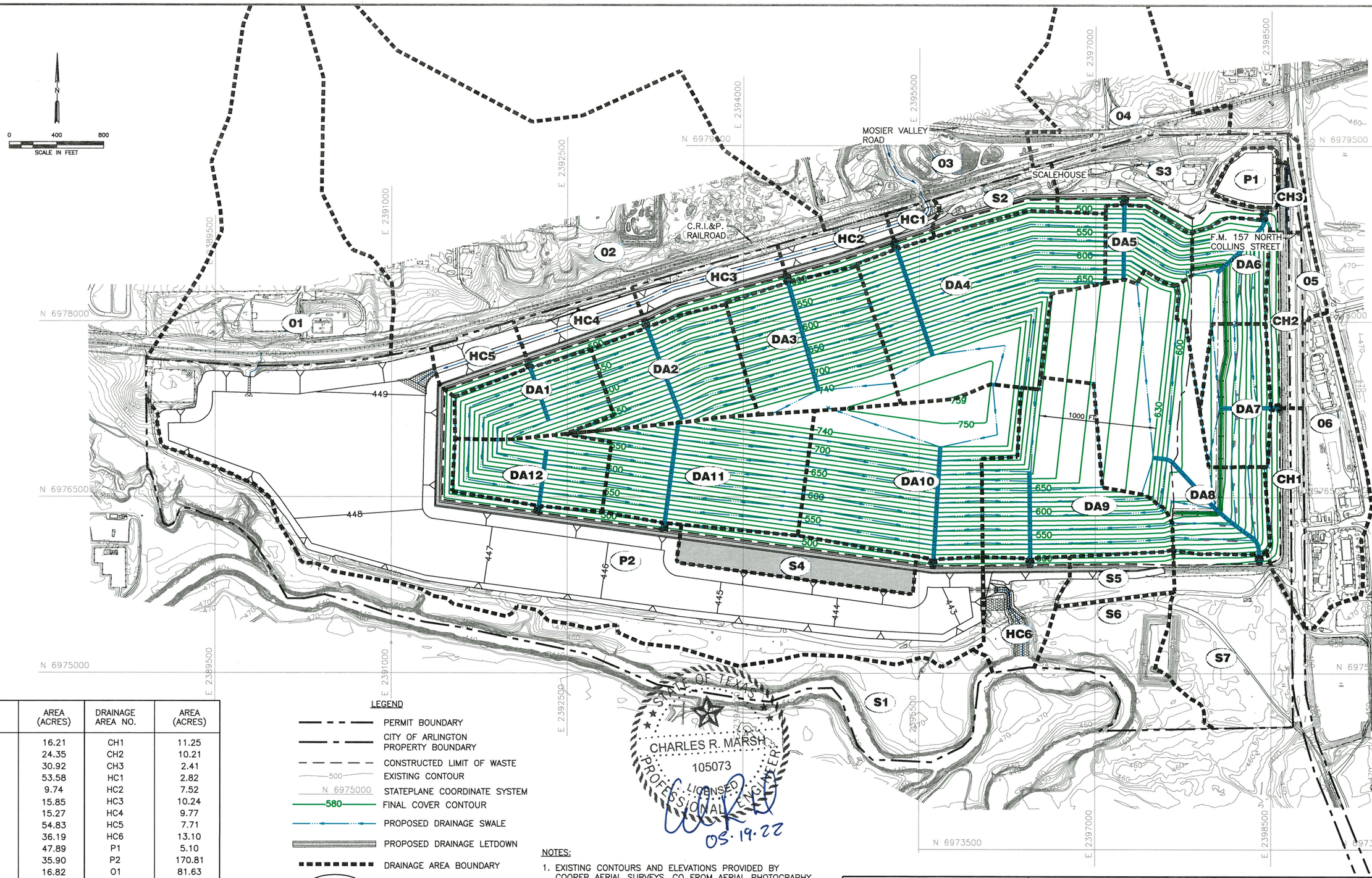
# MAJOR PERMIT AMENDMENT
# OFFSITE DRAINAGE AREA MAP

CITY OF ARLINGTON LANDFILL
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O:\0023\404\EXPANSION 2021\PART III\IIIF\IIIF-A\IIIF-A-25-OFFSITE DRAINAGE.dwg, jwilson, 1:2




| DRAINAGE AREA NO. | AREA (ACRES) | DRAINAGE AREA NO. | AREA (ACRES) |
|---|---|---|---|
| DA1 | 16.21 | CH1 | 11.25 |
| DA2 | 24.35 | CH2 | 10.21 |
| DA3 | 30.92 | CH3 | 2.41 |
| DA4 | 53.58 | HC1 | 2.82 |
| DA5 | 9.74 | HC2 | 7.52 |
| DA6 | 15.85 | HC3 | 10.24 |
| DA7 | 15.27 | HC4 | 9.77 |
| DA8 | 54.83 | HC5 | 7.71 |
| DA9 | 36.19 | HC6 | 13.10 |
| DA10 | 47.89 | P1 | 5.10 |
| DA11 | 35.90 | P2 | 170.81 |
| DA12 | 16.82 | 01 | 81.63 |
| S1 | 64.93 | 02 | 160.32 |
| S2 | 7.92 | 03 | 3520.00 |
| S3 | 23.39 | 04 | 41.33 |
| S4 | 16.05 | 05 | 4.04 |
| S5 | 8.15 | 06 | 25.70 |
| S6 | 21.47 | | |
| S7 | 32.83 | | |

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN
- DRAINAGE AREA BOUNDARY
- DA4 DRAINAGE AREA DESIGNATION

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED PROFESSIONAL ENGINEER
05.19.22

NOTES:

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DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-A-26-POST PROJECT.DWG

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

Weaver Consultants Group
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|---|---|---|
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# MAJOR PERMIT AMENDMENT
# POST PROJECT DRAINAGE AREAS

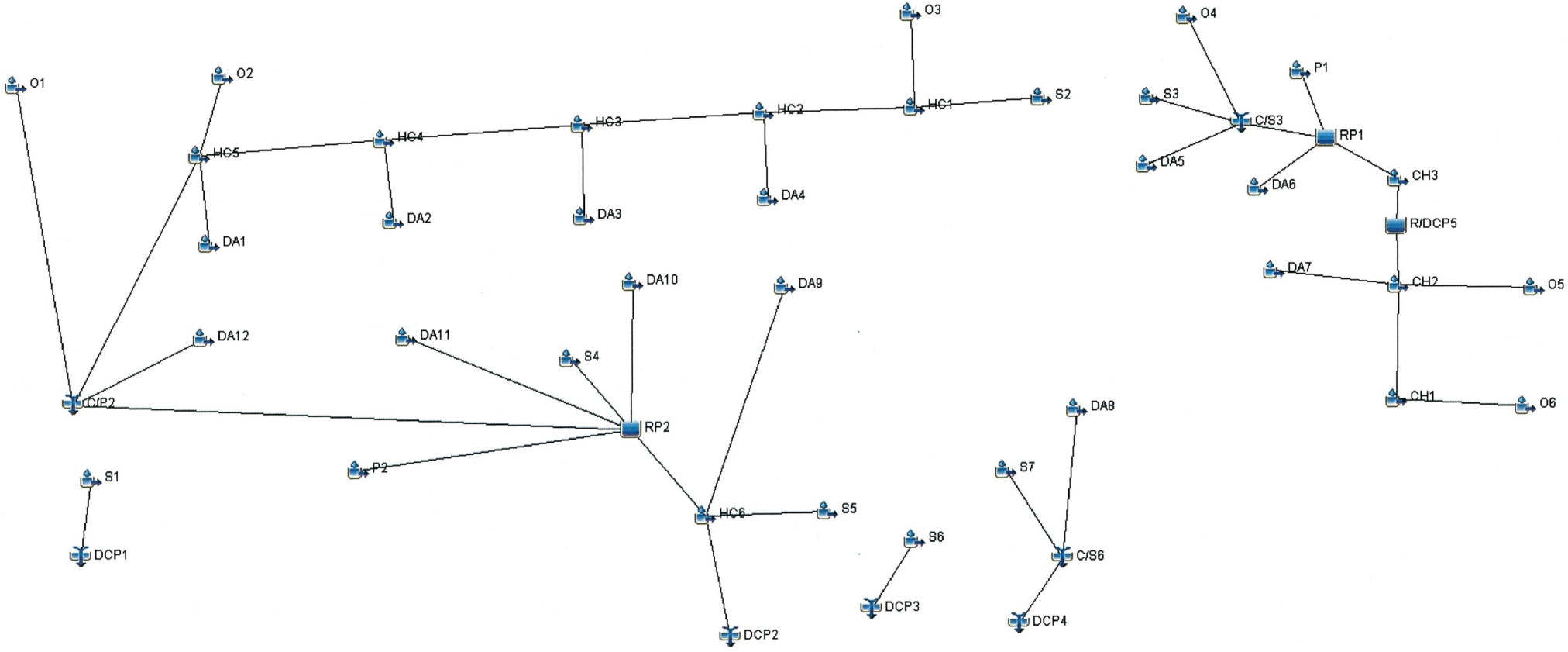
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# HEC-HMS OUTPUT – POST-DEVELOPMENT
# 25-YEAR, 24-HOUR STORM EVENT


O1
O2
O3
HC5
HC4
HC3
HC2
HC1
S2
DA1
DA2
DA3
DA4
C/P2
DA12
DA11
S4
DA10
DA9
RP2
P2
S1
DCP1
HC6
S5
S6
DCP3
DCP2
S7
DA8
C/S6
DCP4
O4
P1
S3
C/S3
RP1
DA5
DA6
CH3
R/DCP5
DA7
CH2
O5
CH1
O6

**Project:** Arlington_LF___Proposed_Con
**Simulation Run:** Post-Project - 25-Year
**Simulation Start:** 29 December 2020, 01:00
**Simulation End:** 31 December 2020, 13:00

**HMS Version:** 4.8
**Executed:** 20 January 2022, 20:20

## Global Parameter Summary - Subbasin

Area ($ft^2$)

| Element Name | Area ($ft^2$) |
|---|---|
| S1 | 0.1 |
| O3 | 5.5 |
| S2 | 0.01 |
| Hc1 | 0 |
| Da4 | 0.08 |
| Hc2 | 0.01 |
| Da3 | 0.05 |
| Hc3 | 0.02 |
| Da2 | 0.04 |
| Hc4 | 0.02 |
| O2 | 0.25 |
| Da1 | 0.03 |
| Hc5 | 0.01 |
| O1 | 0.13 |
| Da12 | 0.03 |
| P2 | 0.27 |
| Da10 | 0.07 |
| Da11 | 0.06 |
| S4 | 0.03 |
| Da9 | 0.06 |
| S5 | 0.01 |
| Hc6 | 0.02 |
| Da8 | 0.07 |
| S7 | 0.05 |
| O4 | 0.06 |
| S3 | 0.04 |
| Da5 | 0.02 |

| | |
|---|---|
| Da6 | 0.02 |
| P1 | 0.01 |
| Ch3 | 0 |
| O6 | 0.04 |
| Ch1 | 0.02 |
| Da7 | 0.02 |
| O5 | 0.01 |
| Ch2 | 0.02 |
| S6 | 0.03 |

**Downstream**

| Element Name | Downstream |
|---|---|
| S1 | Dcp1 |
| O3 | Hc1 |
| S2 | Hc1 |
| Hc1 | Hc2 |
| Da4 | Hc2 |
| Hc2 | Hc3 |
| Da3 | Hc3 |
| Hc3 | Hc4 |
| Da2 | Hc4 |
| Hc4 | Hc5 |
| O2 | Hc5 |
| Da1 | Hc5 |
| Hc5 | C/p2 |
| O1 | C/p2 |
| Da12 | C/p2 |
| P2 | Rp2 |
| Da10 | Rp2 |
| Da11 | Rp2 |
| S4 | Rp2 |
| Da9 | Hc6 |
| S5 | Hc6 |
| Hc6 | Dcp2 |
| Da8 | C/s6 |
| S7 | C/s6 |
| O4 | C/s3 |
| S3 | C/s3 |
| Da5 | C/s3 |
| Da6 | Rp1 |
| P1 | Rp1 |
| Ch3 | R/dcp5 |
| O6 | Ch1 |
| Ch1 | Ch2 |
| Da7 | Ch2 |
| O5 | Ch2 |
| Ch2 | R/dcp5 |
| S6 | Dcp3 |

**Loss Rate: Scs**

| Element Name | Percent Impervious Area | Curve Number |
|---|---|---|
| S1 | 0 | 84 |
| O3 | 10 | 80 |
| S2 | 0 | 84 |
| O2 | 0 | 84 |
| O1 | 0 | 84 |
| P2 | 0 | 99 |
| S4 | 0 | 98 |
| S5 | 0 | 84 |
| S7 | 0 | 84 |
| O4 | 0 | 84 |
| S3 | 0 | 84 |
| P1 | 0 | 99 |
| O6 | 0 | 88 |
| O5 | 0 | 86 |
| S6 | 0 | 84 |

**Transform: Snyder**

| Element Name | Snyder Method | Snyder Tp | Snyder Cp |
|---|---|---|---|
| S1 | Standard | 0.42 | 0.65 |
| O3 | Standard | 0.79 | 0.56 |
| S2 | Standard | 0.18 | 0.66 |
| O2 | Standard | 0.42 | 0.63 |
| O1 | Standard | 0.37 | 0.64 |
| S4 | Standard | 0.1 | 0.39 |
| S5 | Standard | 0.26 | 0.69 |
| S7 | Standard | 0.4 | 0.67 |
| O4 | Standard | 0.32 | 0.66 |
| S3 | Standard | 0.22 | 0.65 |
| O6 | Standard | 0.15 | 0.62 |
| O5 | Standard | 0.11 | 0.62 |
| S6 | Standard | 0.53 | 0.68 |

**Transform: Kinematic Wave**

| Element Name | Transform |
|---|---|
| Hc1 | Kinematic Wave |
| Da4 | Kinematic Wave |
| Hc2 | Kinematic Wave |
| Da3 | Kinematic Wave |
| Hc3 | Kinematic Wave |
| Da2 | Kinematic Wave |
| Hc4 | Kinematic Wave |
| Da1 | Kinematic Wave |
| Hc5 | Kinematic Wave |
| Da12 | Kinematic Wave |
| Da10 | Kinematic Wave |
| Da11 | Kinematic Wave |
| Da9 | Kinematic Wave |
| Hc6 | Kinematic Wave |
| Da8 | Kinematic Wave |
| Da5 | Kinematic Wave |
| Da6 | Kinematic Wave |
| Ch3 | Kinematic Wave |
| Ch1 | Kinematic Wave |
| Da7 | Kinematic Wave |
| Ch2 | Kinematic Wave |

**Transform: Scs**

| Element Name | Lag | Unitgraph Type |
|---|---|---|
| P2 | 0.1 | Standard |
| P1 | 0.1 | Standard |

# Global Results Summary

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (IN) |
|---|---|---|---|---|
| S1 | 0.1 | 197.05 | 29Dec2020, 13:30 | 5.29 |
| O3 | 5.5 | 6011.26 | 29Dec2020, 13:50 | 5.07 |
| S2 | 0.01 | 38.01 | 29Dec2020, 13:15 | 5.29 |
| Hc1 | 5.52 | 6011.16 | 29Dec2020, 13:50 | 5.08 |
| Da4 | 0.08 | 458.78 | 29Dec2020, 13:05 | 4.83 |
| Hc2 | 5.61 | 6046.47 | 29Dec2020, 13:50 | 5.07 |
| Da3 | 0.05 | 260.76 | 29Dec2020, 13:05 | 4.8 |
| Hc3 | 5.68 | 6067.15 | 29Dec2020, 13:55 | 5.07 |
| Da2 | 0.04 | 202.83 | 29Dec2020, 13:05 | 4.58 |
| Hc4 | 5.73 | 6101.06 | 29Dec2020, 13:55 | 5.07 |

| | | | | |
|---|---|---|---|---|
| O2 | 0.25 | 475.6 | 29Dec2020, 13:30 | 5.29 |
| Da1 | 0.03 | 130.27 | 29Dec2020, 13:05 | 4.35 |
| Hc5 | 6.02 | 6387.62 | 29Dec2020, 13:55 | 5.08 |
| O1 | 0.13 | 260.66 | 29Dec2020, 13:25 | 5.29 |
| Da12 | 0.03 | 151.4 | 29Dec2020, 13:05 | 5.11 |
| C/p2 | 6.17 | 6531.97 | 29Dec2020, 13:55 | 5.08 |
| P2 | 0.27 | 1484.5 | 29Dec2020, 13:05 | 7.04 |
| Da10 | 0.07 | 397.86 | 29Dec2020, 13:05 | 4.59 |
| Da11 | 0.06 | 296.87 | 29Dec2020, 13:05 | 4.52 |
| S4 | 0.03 | 74.9 | 29Dec2020, 13:10 | 6.92 |
| Rp2 | 6.59 | 4105.01 | 29Dec2020, 14:50 | 4.93 |
| Da9 | 0.06 | 294.96 | 29Dec2020, 13:05 | 4.39 |
| S5 | 0.01 | 33.42 | 29Dec2020, 13:20 | 5.29 |
| Hc6 | 6.68 | 4122.37 | 29Dec2020, 14:50 | 4.93 |
| Dcp2 | 6.68 | 4122.37 | 29Dec2020, 14:50 | 4.93 |
| Da8 | 0.07 | 237.65 | 29Dec2020, 13:10 | 4.07 |
| S7 | 0.05 | 103.33 | 29Dec2020, 13:25 | 5.29 |
| C/s6 | 0.12 | 297.35 | 29Dec2020, 13:10 | 4.58 |
| O4 | 0.06 | 146.21 | 29Dec2020, 13:20 | 5.29 |
| S3 | 0.04 | 99.57 | 29Dec2020, 13:15 | 5.29 |
| Da5 | 0.02 | 46.68 | 29Dec2020, 13:10 | 5.52 |
| C/s3 | 0.12 | 275.91 | 29Dec2020, 13:20 | 5.32 |
| Da6 | 0.02 | 137.83 | 29Dec2020, 13:05 | 4.82 |
| P1 | 0.01 | 44.5 | 29Dec2020, 13:05 | 7.04 |
| Rp1 | 0.15 | 80.58 | 29Dec2020, 14:05 | 5.15 |
| Ch3 | 0.15 | 81.9 | 29Dec2020, 14:05 | 5.15 |
| O6 | 0.04 | 139.7 | 29Dec2020, 13:10 | 5.75 |
| Ch1 | 0.06 | 154.76 | 29Dec2020, 13:15 | 5.57 |
| Da7 | 0.02 | 131.13 | 29Dec2020, 13:05 | 4.93 |
| O5 | 0.01 | 23.99 | 29Dec2020, 13:10 | 5.52 |
| Ch2 | 0.1 | 233.83 | 29Dec2020, 13:15 | 5.35 |
| R/dcp5 | 0.26 | 228.33 | 29Dec2020, 13:35 | 4.67 |
| Dcp4 | 0.12 | 297.35 | 29Dec2020, 13:10 | 4.58 |
| Dcp1 | 0.1 | 197.05 | 29Dec2020, 13:30 | 5.29 |
| S6 | 0.03 | 58.4 | 29Dec2020, 13:35 | 5.29 |
| Dcp3 | 0.03 | 58.4 | 29Dec2020, 13:35 | 5.29 |

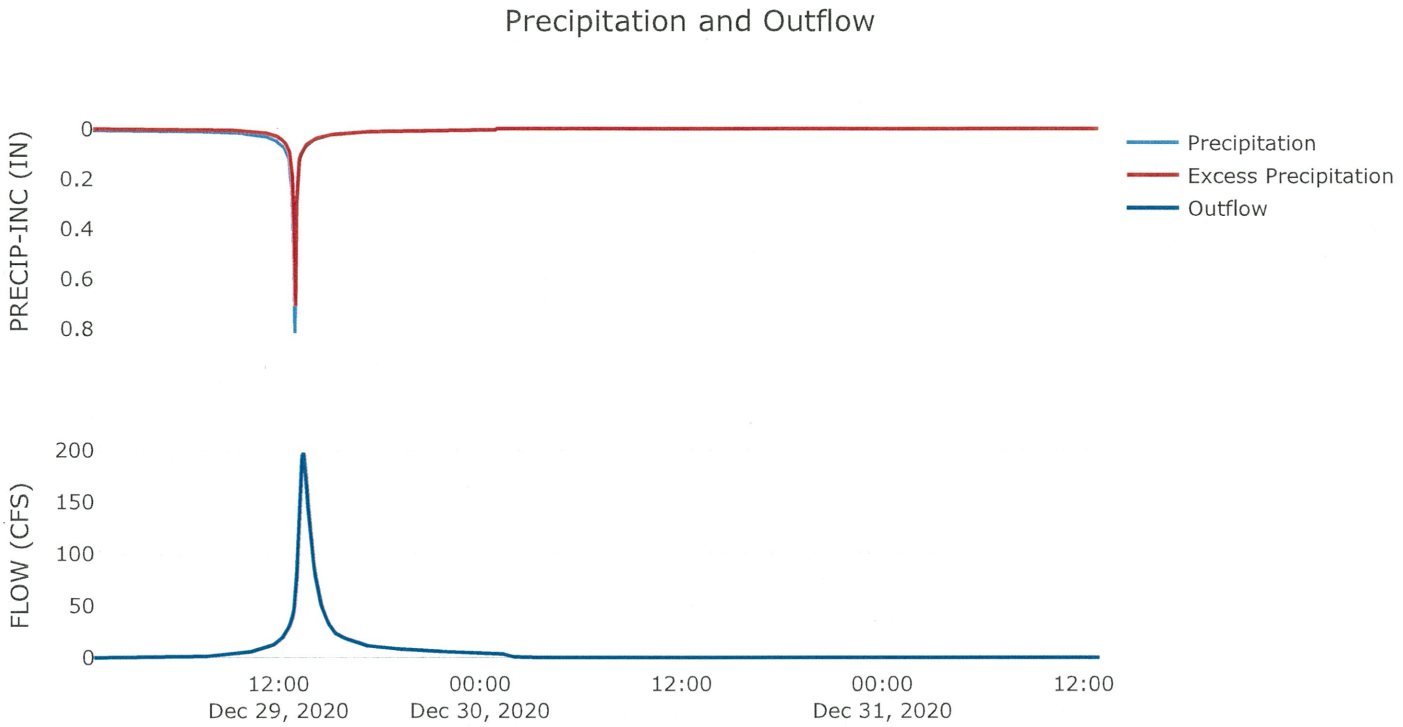
# Subbasin: S1

**Area ($ft^2$)** : 0.1
**Downstream** : Dcp1

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.42 |
| Snyder Cp | 0.65 |

| Results: S1 | |
|---|---|
| Peak Discharge (CFS) | 197.05 |
| Time of Peak Discharge | 29Dec2020, 13:30 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 38.76 |
| Loss Volume (AC - FT) | 10.11 |
| Excess Volume (AC - FT) | 28.65 |
| Direct Runoff Volume (AC - FT) | 28.65 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
200
150
100
50
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: O3

**Area ($ft^2$) :** 5.5
**Downstream :** HC1

**Loss Rate: Scs**

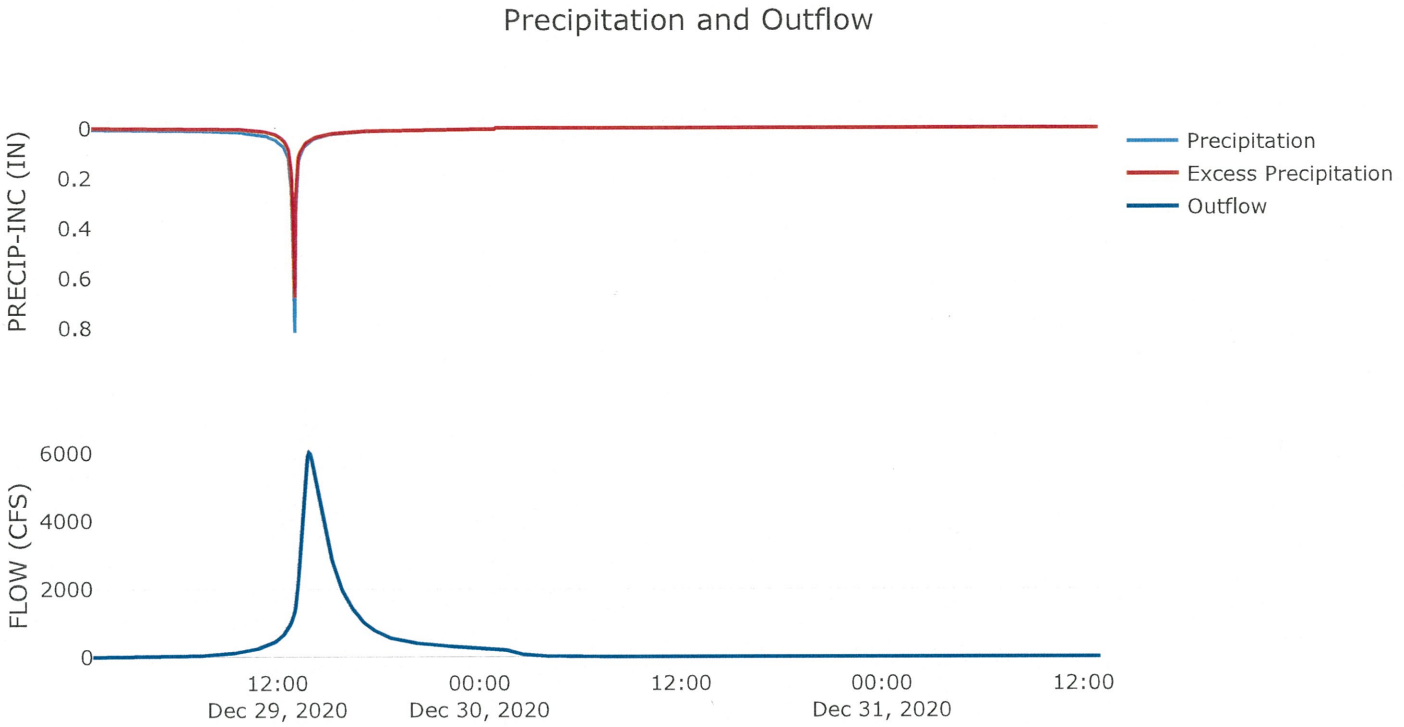
| | |
|---|---|
| Percent Impervious Area | 10 |
| Curve Number | 80 |

**Transform: Snyder**

| | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.79 |
| Snyder Cp | 0.56 |

**Results: O3**

| | |
|---|---|
| Peak Discharge (CFS) | 6011.26 |
| Time of Peak Discharge | 29Dec2020, 13:50 |
| Volume (IN) | 5.07 |
| Precipitation Volume (AC - FT) | 2100.27 |
| Loss Volume (AC - FT) | 611.87 |
| Excess Volume (AC - FT) | 1488.4 |
| Direct Runoff Volume (AC - FT) | 1488.4 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
6000
4000
2000
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

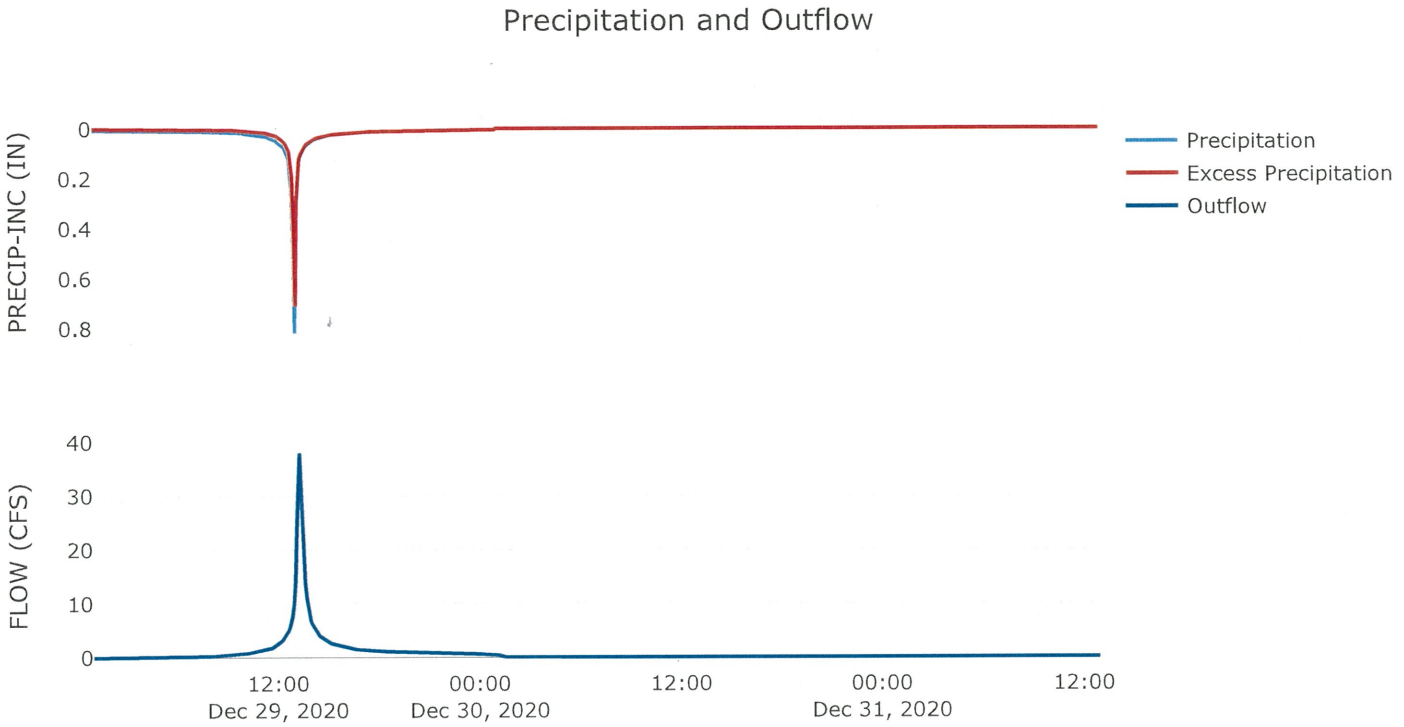
# Subbasin: S2

**Area ($ft^2$)** : 0.01
**Downstream** : Hc1

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.18 |
| Snyder Cp | 0.66 |

| Results: S2 | |
|---|---|
| Peak Discharge (CFS) | 38.01 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 4.74 |
| Loss Volume (AC - FT) | 1.24 |
| Excess Volume (AC - FT) | 3.5 |
| Direct Runoff Volume (AC - FT) | 3.5 |
| Baseflow Volume (AC - FT) | 0 |

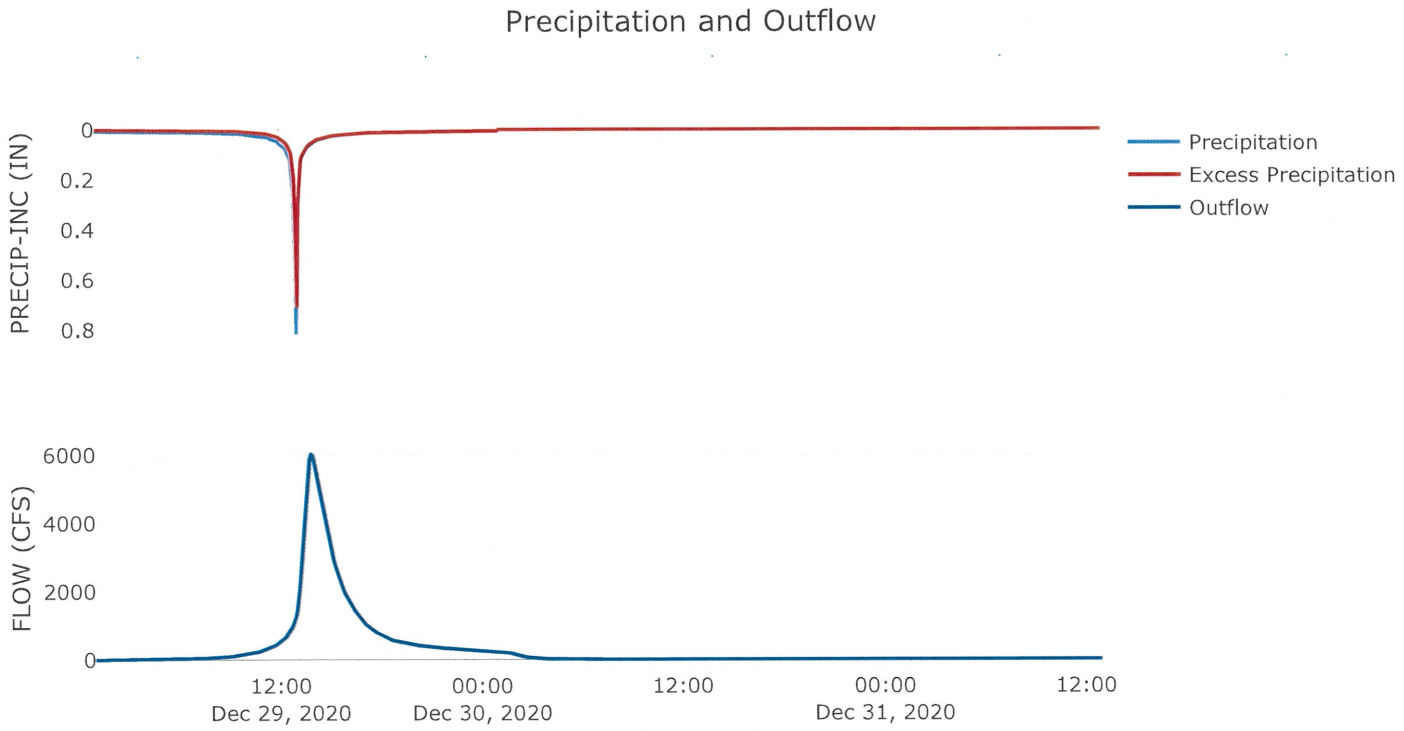

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
40
30
20
10
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: HC1

**Area (ft²)** : 0
**Downstream** : Hc2
**Transform** : Kinematic Wave

**Results: HC1**

| | |
|---|---|
| Peak Discharge (CFS) | 6011.16 |
| Time of Peak Discharge | 29Dec2020, 13:50 |
| Volume (IN) | 5.08 |
| Precipitation Volume (AC - FT) | 2106.68 |
| Loss Volume (AC - FT) | 549.59 |
| Excess Volume (AC - FT) | 1557.09 |
| Direct Runoff Volume (AC - FT) | 1493.24 |
| Baseflow Volume (AC - FT) | 0 |

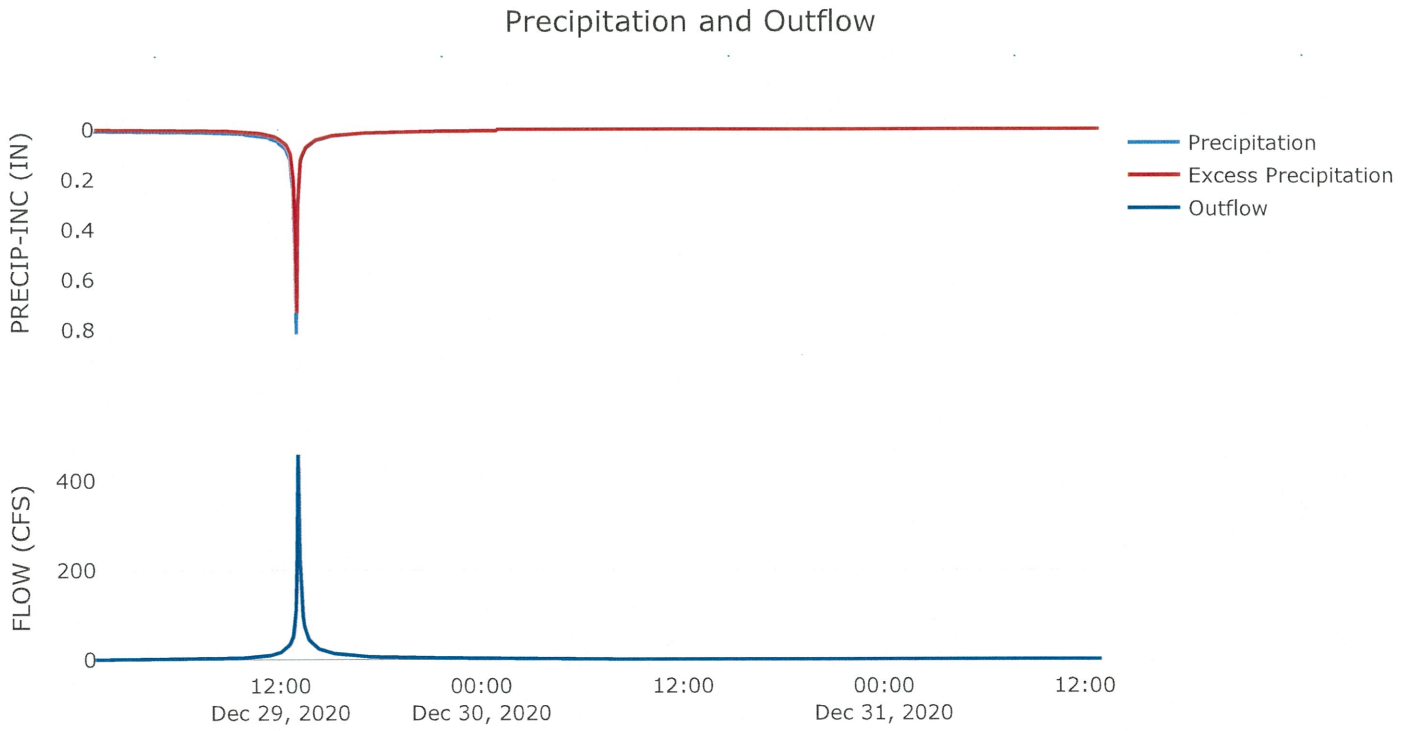


# Subbasin: DA4

**Area (ft²)** : 0.08
**Downstream** : Hc2
**Transform** : Kinematic Wave

**Results: DA4**

| | |
|---|---|
| Peak Discharge (CFS) | 458.78 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.83 |
| Precipitation Volume (AC - FT) | 31.96 |
| Loss Volume (AC - FT) | 7.32 |
| Excess Volume (AC - FT) | 24.64 |
| Direct Runoff Volume (AC - FT) | 21.54 |
| Baseflow Volume (AC - FT) | 0 |

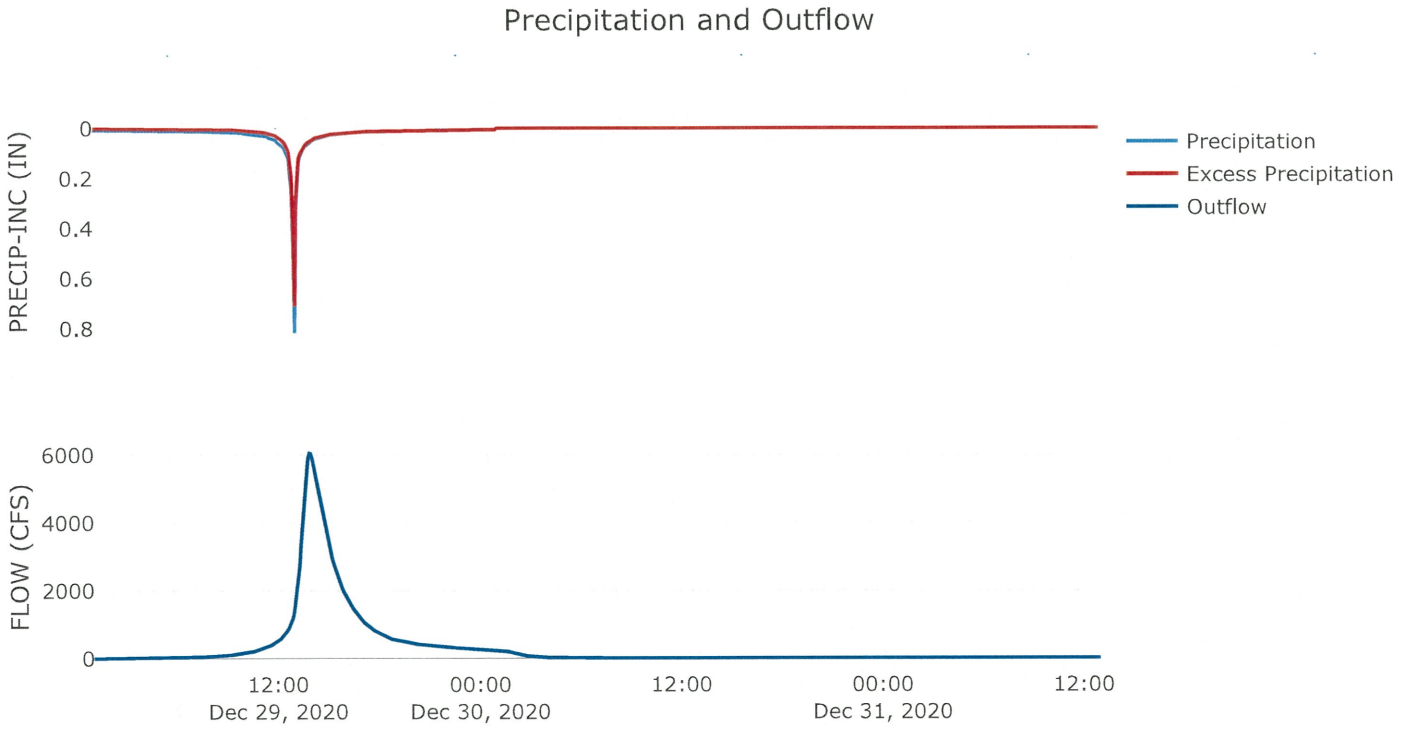


# Subbasin: HC2

**Area (ft²)** : 0.01
**Downstream** : Hc3
**Transform** : Kinematic Wave

**Results: HC2**

| | |
|---|---|
| Peak Discharge (CFS) | 6046.47 |
| Time of Peak Discharge | 29Dec2020, 13:50 |
| Volume (IN) | 5.07 |
| Precipitation Volume (AC - FT) | 2143.15 |
| Loss Volume (AC - FT) | 559.11 |
| Excess Volume (AC - FT) | 1584.04 |
| Direct Runoff Volume (AC - FT) | 1518.13 |
| Baseflow Volume (AC - FT) | 0 |

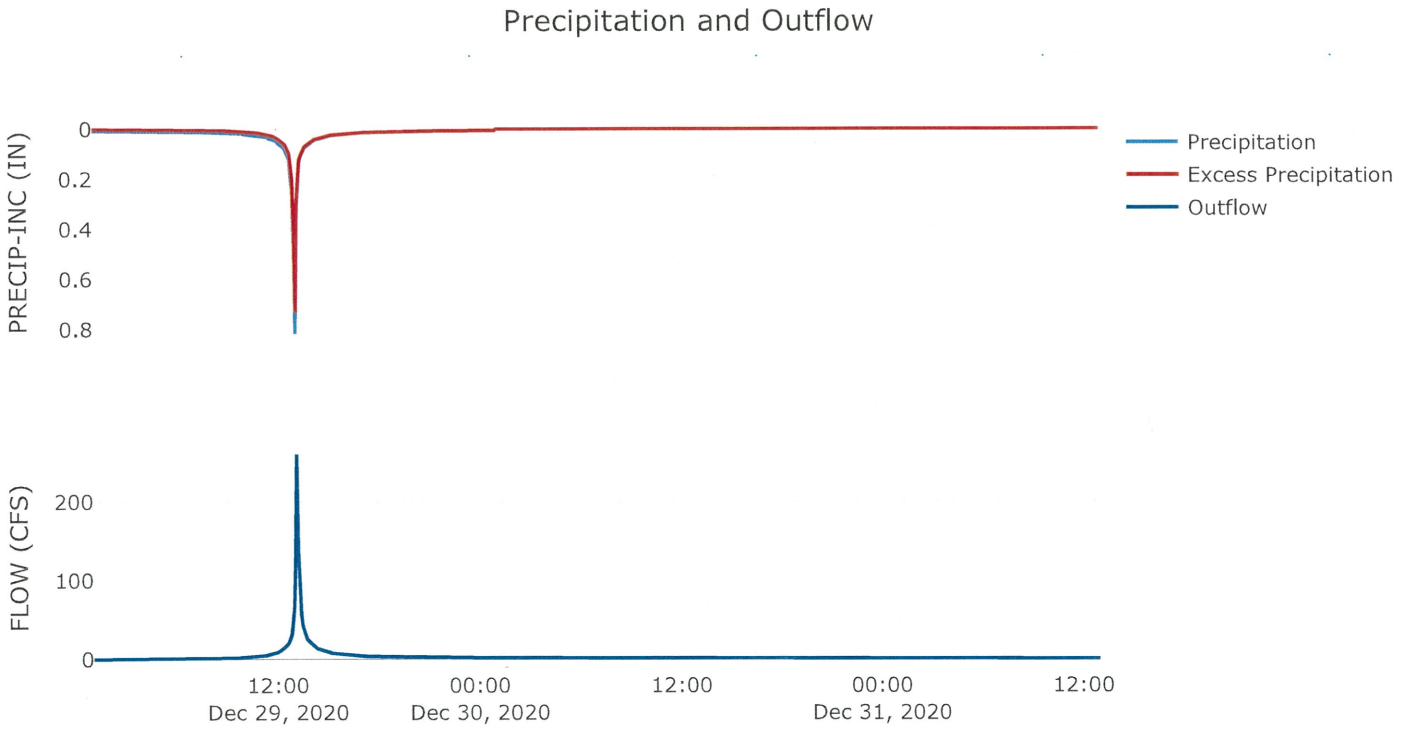


# Subbasin: DA3

**Area (ft²)** : 0.05
**Downstream** : Hc3
**Transform** : Kinematic Wave

**Results: DA3**

| | |
|---|---|
| Peak Discharge (CFS) | 260.76 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.8 |
| Precipitation Volume (AC - FT) | 18.44 |
| Loss Volume (AC - FT) | 4.23 |
| Excess Volume (AC - FT) | 14.22 |
| Direct Runoff Volume (AC - FT) | 12.36 |
| Baseflow Volume (AC - FT) | 0 |

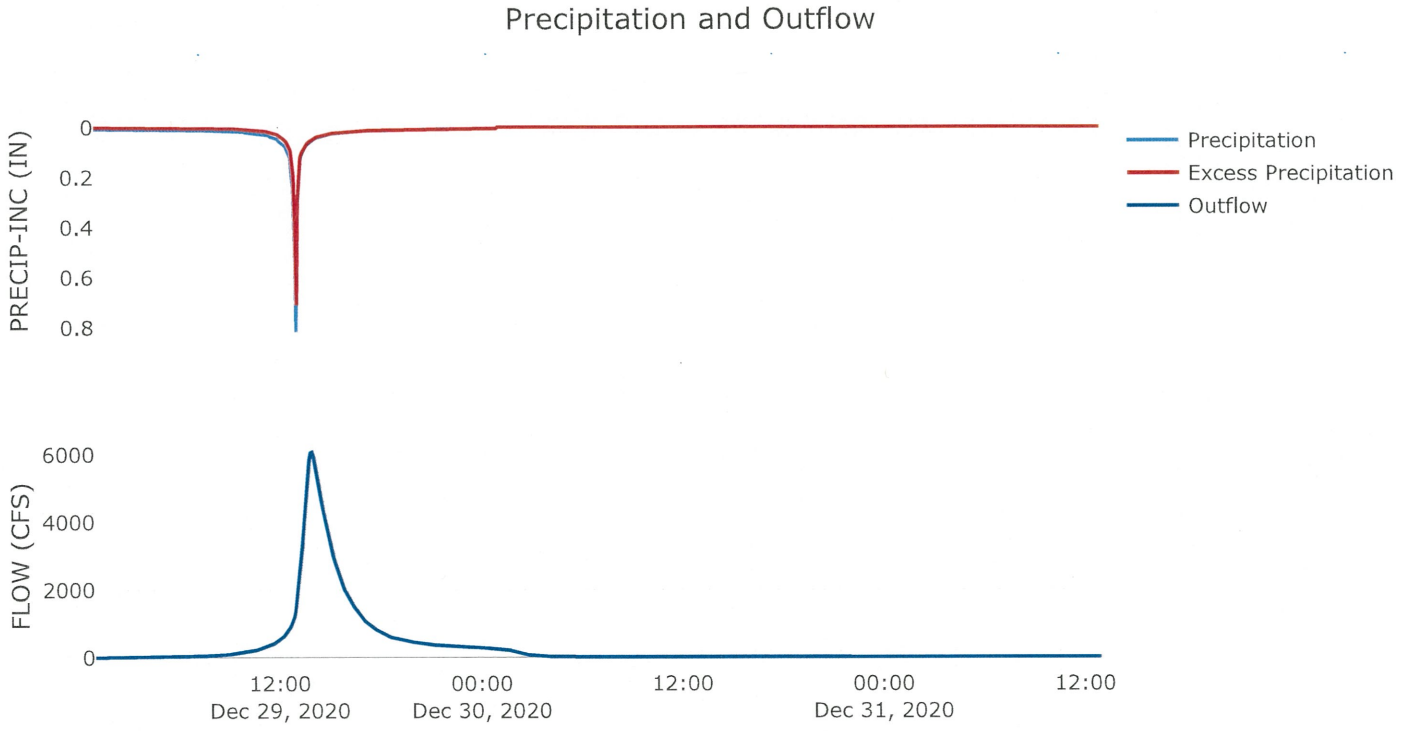


# Subbasin: HC3

**Area (ft²)** : 0.02
**Downstream** : Hc4
**Transform** : Kinematic Wave

**Results: HC3**

| | |
|---|---|
| Peak Discharge (CFS) | 6067.15 |
| Time of Peak Discharge | 29Dec2020, 13:55 |
| Volume (IN) | 5.07 |
| Precipitation Volume (AC - FT) | 2167.7 |
| Loss Volume (AC - FT) | 565.51 |
| Excess Volume (AC - FT) | 1602.19 |
| Direct Runoff Volume (AC - FT) | 1535.16 |
| Baseflow Volume (AC - FT) | 0 |

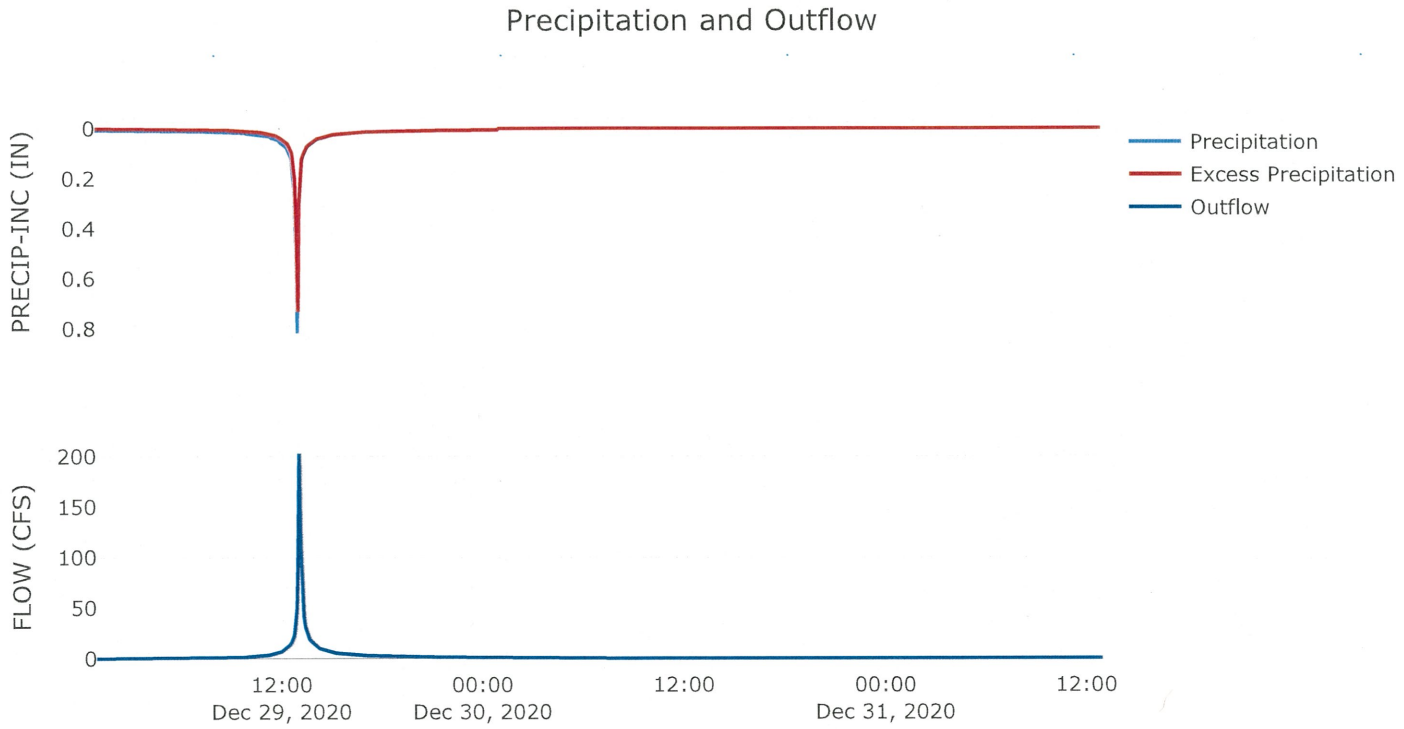


# Subbasin: DA2

**Area (ft²)** : 0.04
**Downstream** : Hc4
**Transform** : Kinematic Wave

**Results: DA2**

| | |
|---|---|
| Peak Discharge (CFS) | 202.83 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.58 |
| Precipitation Volume (AC - FT) | 14.51 |
| Loss Volume (AC - FT) | 3.32 |
| Excess Volume (AC - FT) | 11.19 |
| Direct Runoff Volume (AC - FT) | 9.28 |
| Baseflow Volume (AC - FT) | 0 |

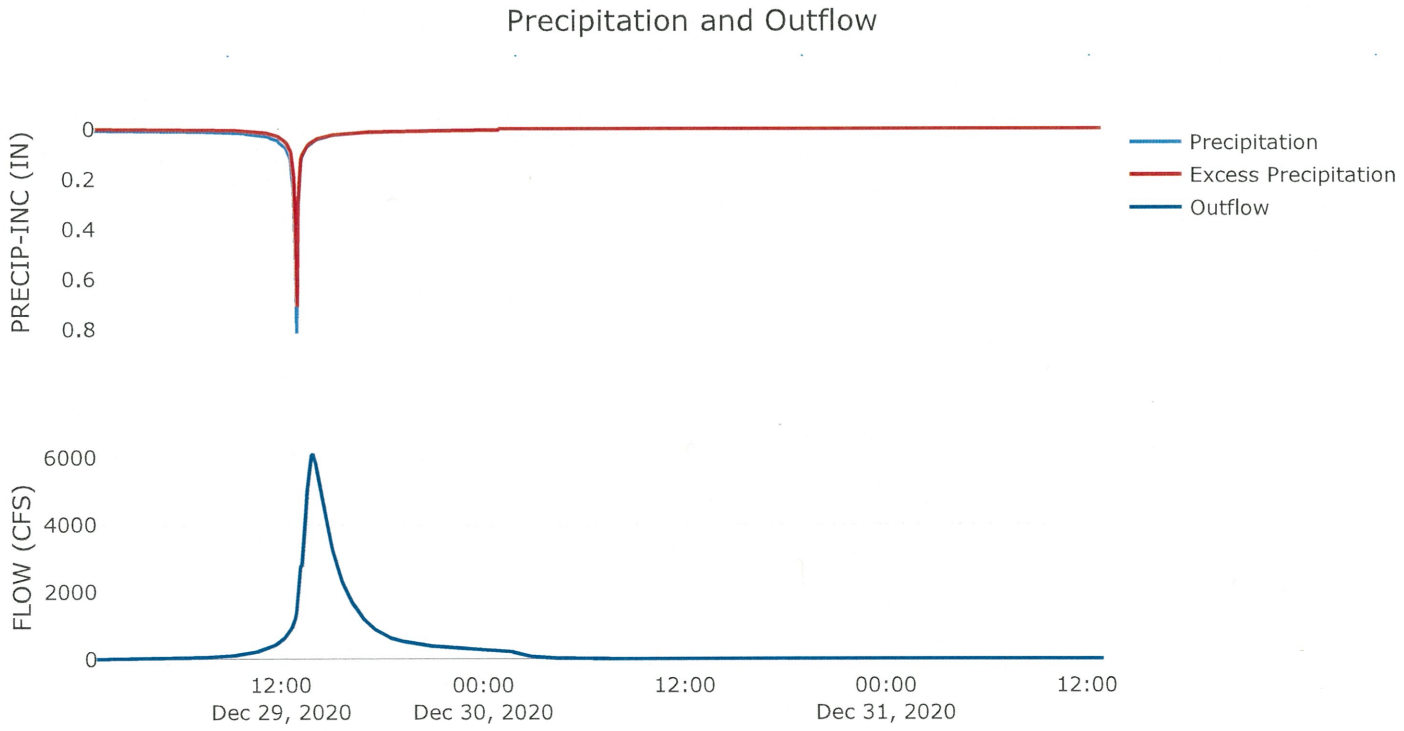


# Subbasin: HC4

**Area (ft²)** : 0.02
**Downstream** : Hc5
**Transform** : Kinematic Wave

**Results: HC4**

| | |
|---|---|
| Peak Discharge (CFS) | 6101.06 |
| Time of Peak Discharge | 29Dec2020, 13:55 |
| Volume (IN) | 5.07 |
| Precipitation Volume (AC - FT) | 2188.06 |
| Loss Volume (AC - FT) | 570.82 |
| Excess Volume (AC - FT) | 1617.23 |
| Direct Runoff Volume (AC - FT) | 1548.78 |
| Baseflow Volume (AC - FT) | 0 |



# Subbasin: O2

**Area ($ft^2$)** : 0.25
**Downstream** : Hc5

**Loss Rate: Scs**

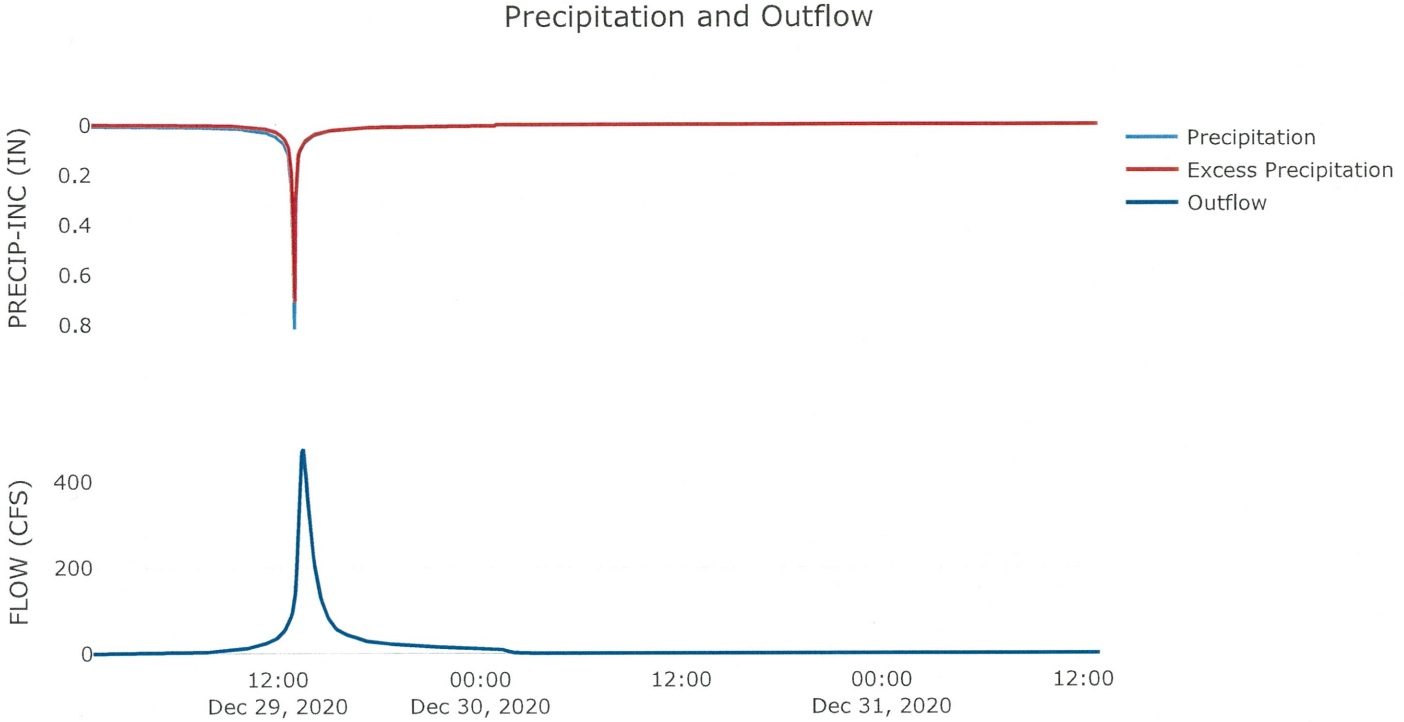
| | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

**Transform: Snyder**

| | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.42 |
| Snyder Cp | 0.63 |

**Results: O2**

| | |
|---|---|
| Peak Discharge (CFS) | 475.6 |
| Time of Peak Discharge | 29Dec2020, 13:30 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 95.66 |
| Loss Volume (AC - FT) | 24.96 |
| Excess Volume (AC - FT) | 70.7 |
| Direct Runoff Volume (AC - FT) | 70.7 |
| Baseflow Volume (AC - FT) | 0 |

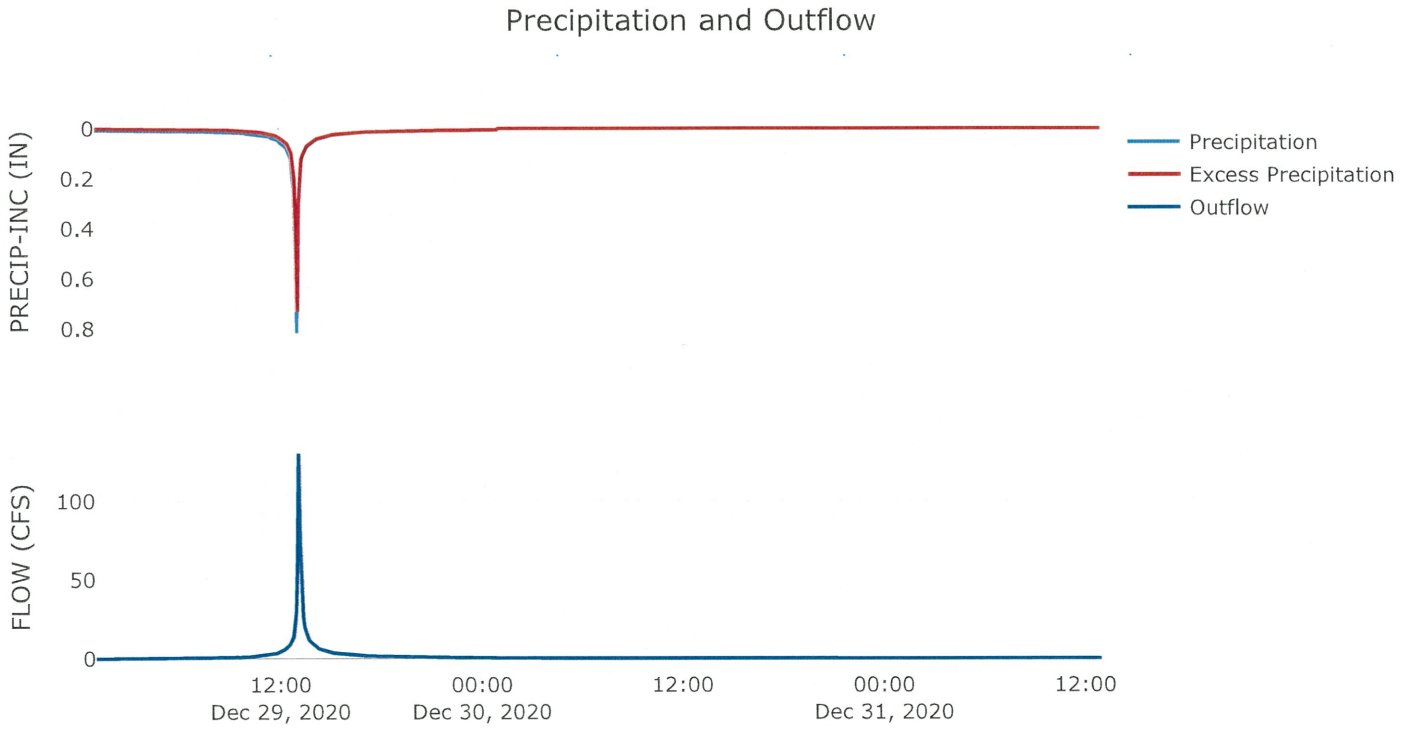

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
400
200
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA1

**Area (ft²)** : 0.03
**Downstream** : Hc5
**Transform** : Kinematic Wave

**Results: DA1**

| | |
|---|---|
| Peak Discharge (CFS) | 130.27 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.35 |
| Precipitation Volume (AC - FT) | 9.66 |
| Loss Volume (AC - FT) | 2.21 |
| Excess Volume (AC - FT) | 7.45 |
| Direct Runoff Volume (AC - FT) | 5.87 |
| Baseflow Volume (AC - FT) | 0 |

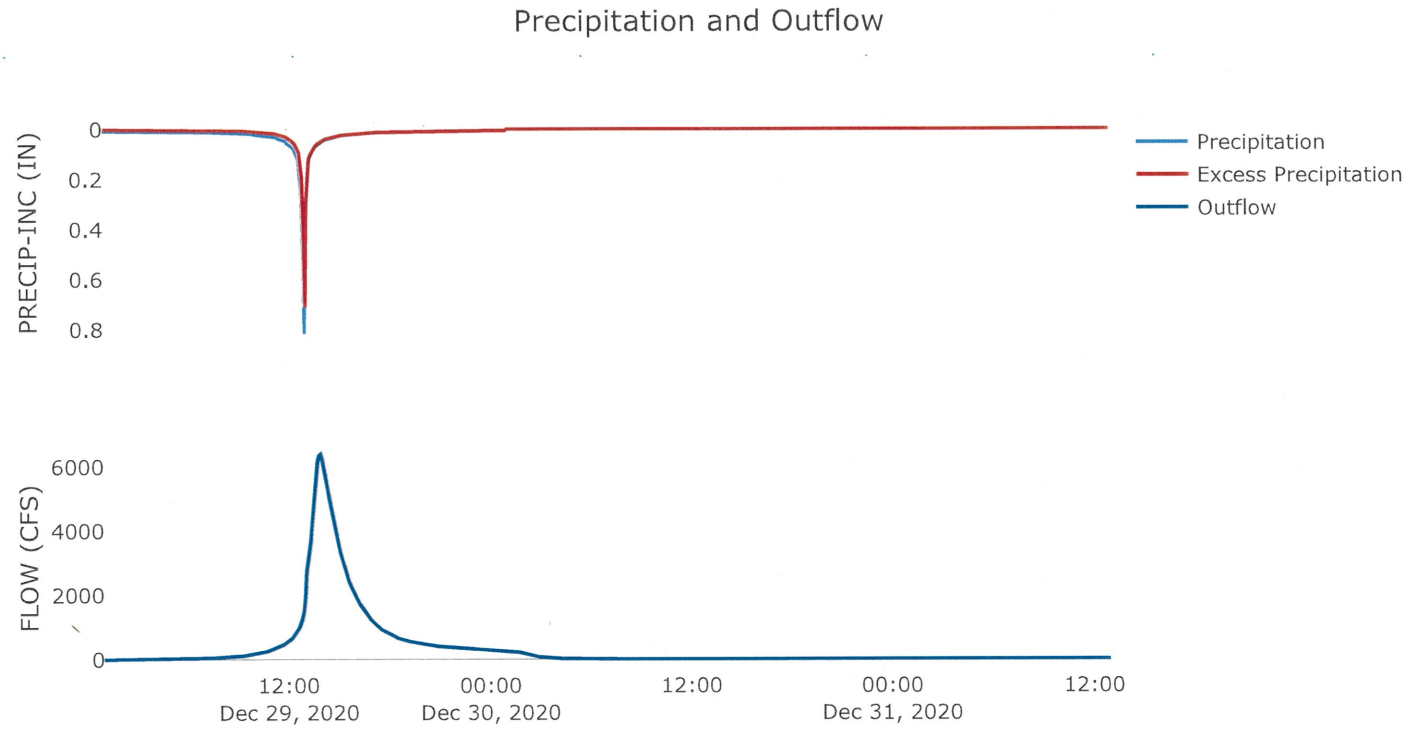


# Subbasin: HC5

**Area (ft²)** : 0.01
**Downstream** : C/p2
**Transform** : Kinematic Wave

**Results: HC5**

| | |
|---|---|
| Peak Discharge (CFS) | 6387.62 |
| Time of Peak Discharge | 29Dec2020, 13:55 |
| Volume (IN) | 5.08 |
| Precipitation Volume (AC - FT) | 2298 |
| Loss Volume (AC - FT) | 599.5 |
| Excess Volume (AC - FT) | 1698.49 |
| Direct Runoff Volume (AC - FT) | 1628.86 |
| Baseflow Volume (AC - FT) | 0 |



# Subbasin: O1

**Area (ft²)** : 0.13
**Downstream** : C/p2

**Loss Rate: Scs**

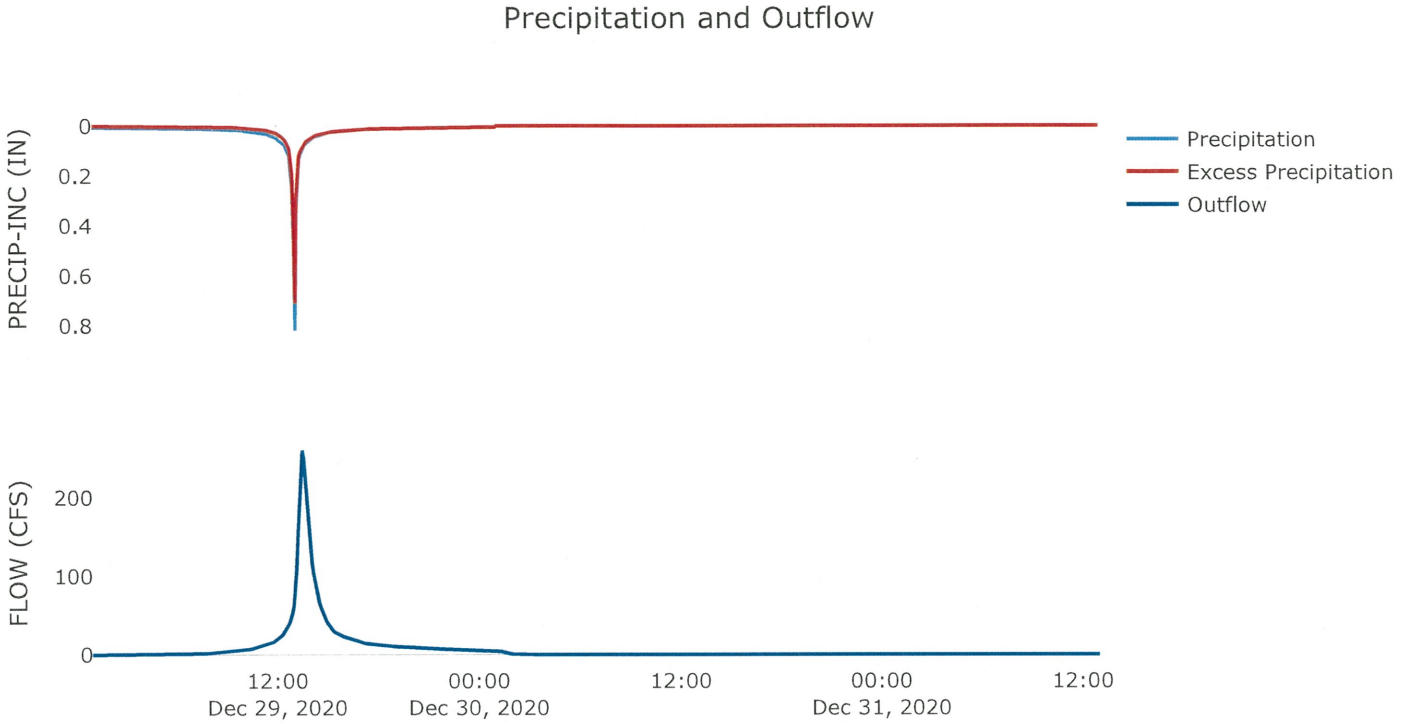
| | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

**Transform: Snyder**

| | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.37 |
| Snyder Cp | 0.64 |

**Results: O1**

| | |
|---|---|
| Peak Discharge (CFS) | 260.66 |
| Time of Peak Discharge | 29Dec2020, 13:25 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 48.69 |
| Loss Volume (AC - FT) | 12.7 |
| Excess Volume (AC - FT) | 35.99 |
| Direct Runoff Volume (AC - FT) | 35.99 |
| Baseflow Volume (AC - FT) | 0 |

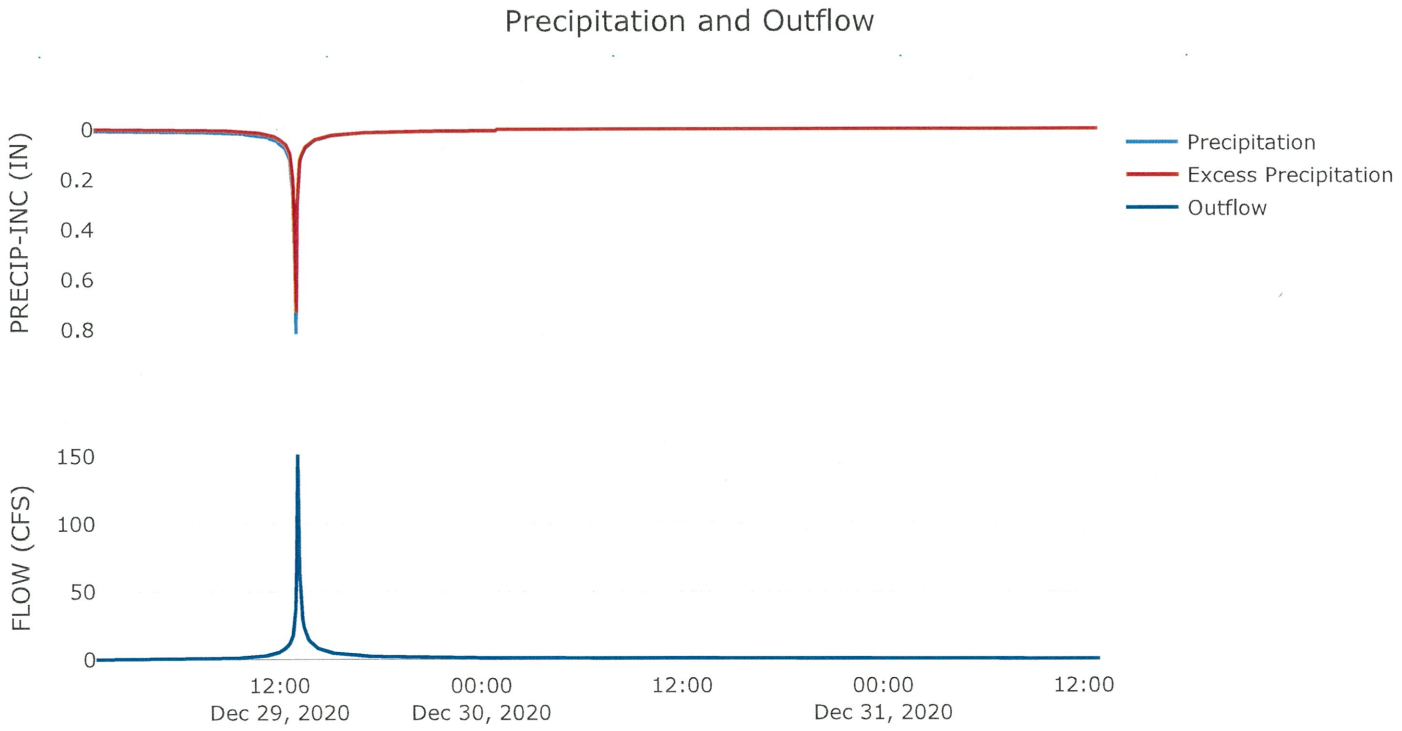

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
200
100
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA12

**Area (ft²)** : 0.03
**Downstream** : C/p2
**Transform** : Kinematic Wave

**Results: DA12**

| | |
|---|---|
| Peak Discharge (CFS) | 151.4 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 5.11 |
| Precipitation Volume (AC - FT) | 10.04 |
| Loss Volume (AC - FT) | 2.3 |
| Excess Volume (AC - FT) | 7.74 |
| Direct Runoff Volume (AC - FT) | 7.16 |
| Baseflow Volume (AC - FT) | 0 |

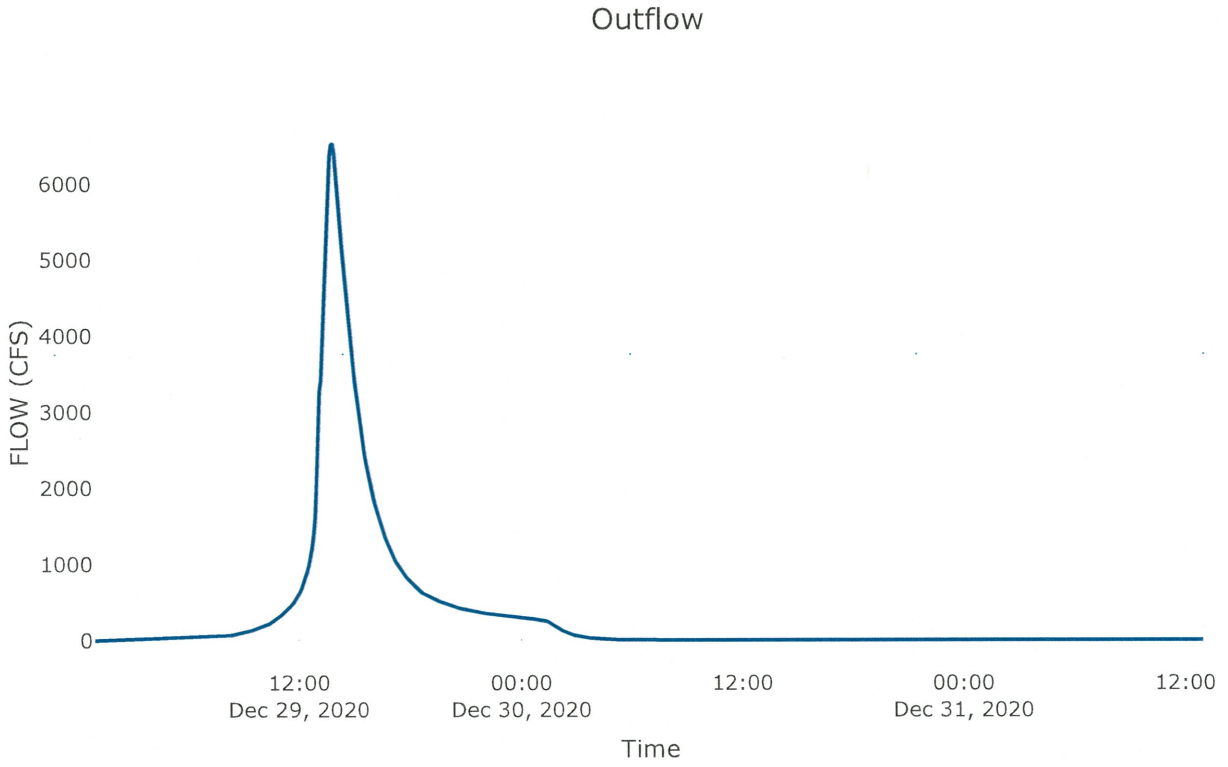


# Junction: C/P2

**Downstream** : Rp2

**Results: C/P2**

| | |
|---|---|
| Peak Discharge (CFS) | 6531.97 |
| Time of Peak Discharge | 29Dec2020, 13:55 |
| Volume (IN) | 5.08 |



# Subbasin: P2

**Area (ft²)** : 0.27
**Downstream** : Rp2

**Loss Rate: Scs**

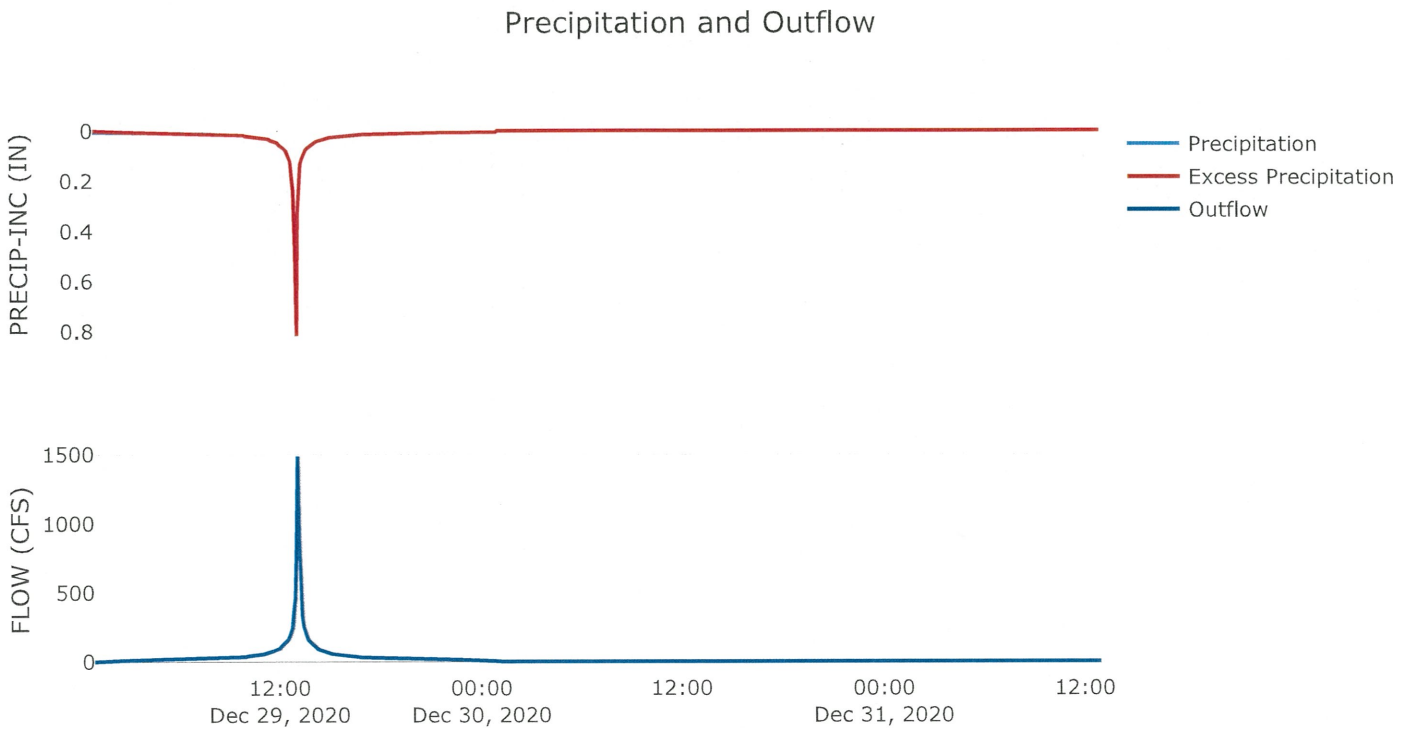
| | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 99 |

**Transform: Scs**

| | |
|---|---|
| Lag | 0.1 |
| Unitgraph Type | Standard |

**Results: P2**

| | |
|---|---|
| Peak Discharge (CFS) | 1484.5 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 7.04 |
| Precipitation Volume (AC - FT) | 101.92 |
| Loss Volume (AC - FT) | 1.71 |
| Excess Volume (AC - FT) | 100.21 |
| Direct Runoff Volume (AC - FT) | 100.21 |
| Baseflow Volume (AC - FT) | 0 |

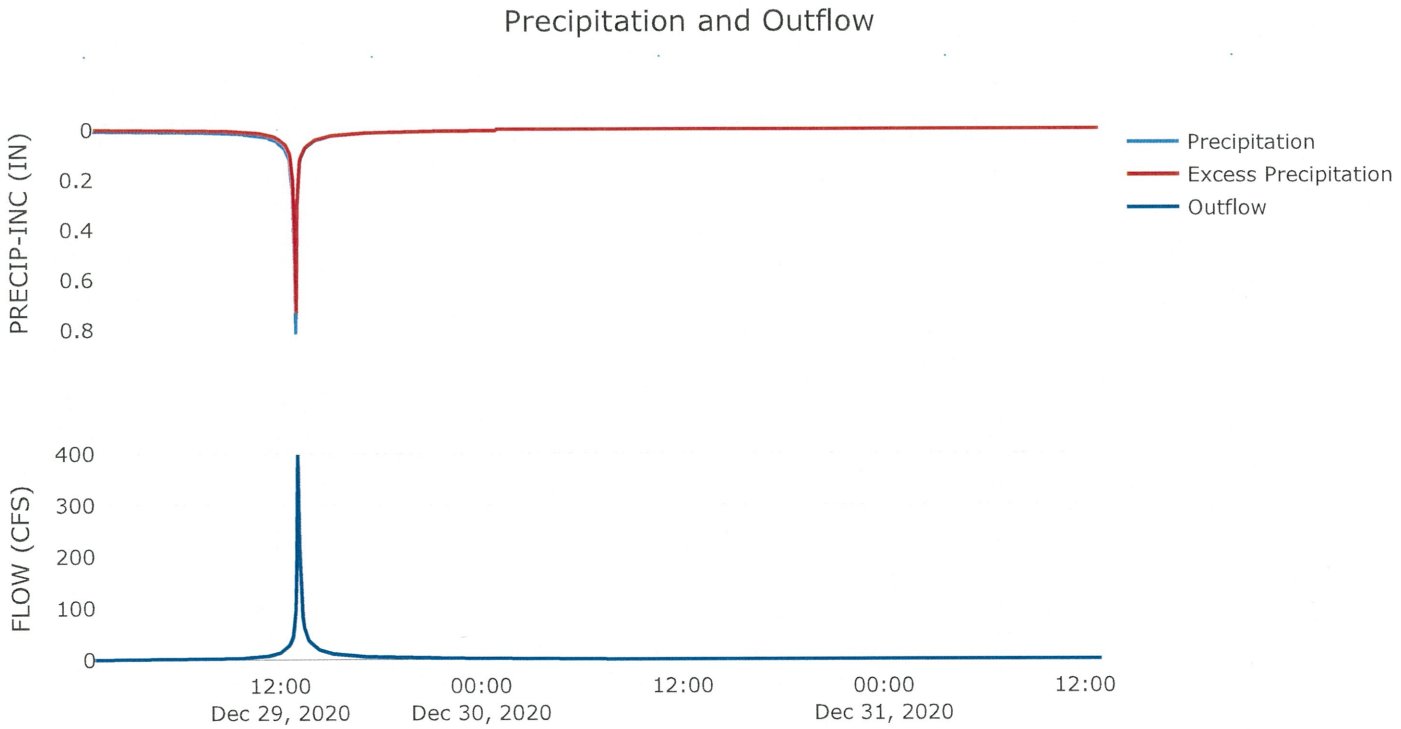


# Subbasin: DA10

**Area (ft²)** : 0.07
**Downstream** : Rp2
**Transform** : Kinematic Wave

**Results: DA10**

| | |
|---|---|
| Peak Discharge (CFS) | 397.86 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.59 |
| Precipitation Volume (AC - FT) | 28.56 |
| Loss Volume (AC - FT) | 6.54 |
| Excess Volume (AC - FT) | 22.02 |
| Direct Runoff Volume (AC - FT) | 18.33 |
| Baseflow Volume (AC - FT) | 0 |

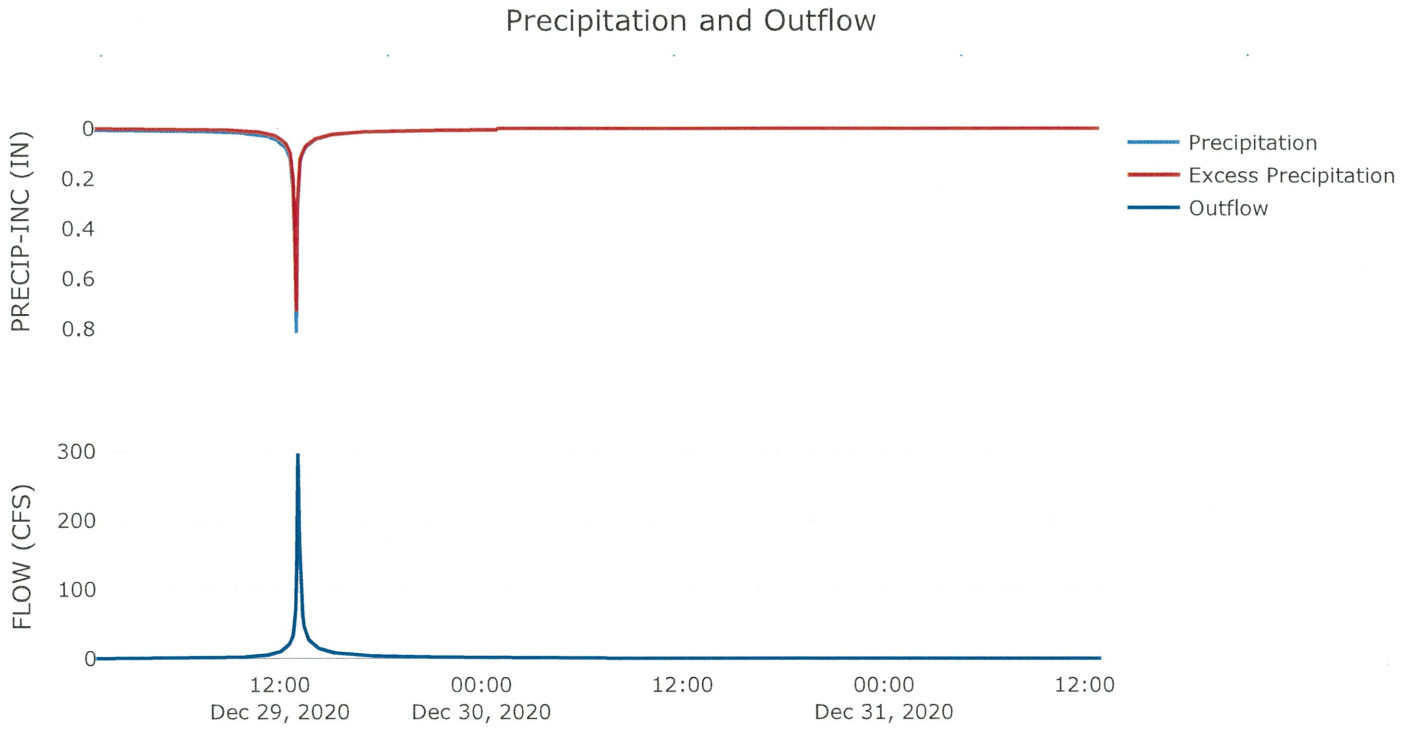


# Subbasin: DA11

**Area (ft²)** : 0.06
**Downstream** : Rp2
**Transform** : Kinematic Wave

**Results: DA11**

| | |
|---|---|
| Peak Discharge (CFS) | 296.87 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.52 |
| Precipitation Volume (AC - FT) | 21.42 |
| Loss Volume (AC - FT) | 4.91 |
| Excess Volume (AC - FT) | 16.51 |
| Direct Runoff Volume (AC - FT) | 13.52 |
| Baseflow Volume (AC - FT) | 0 |



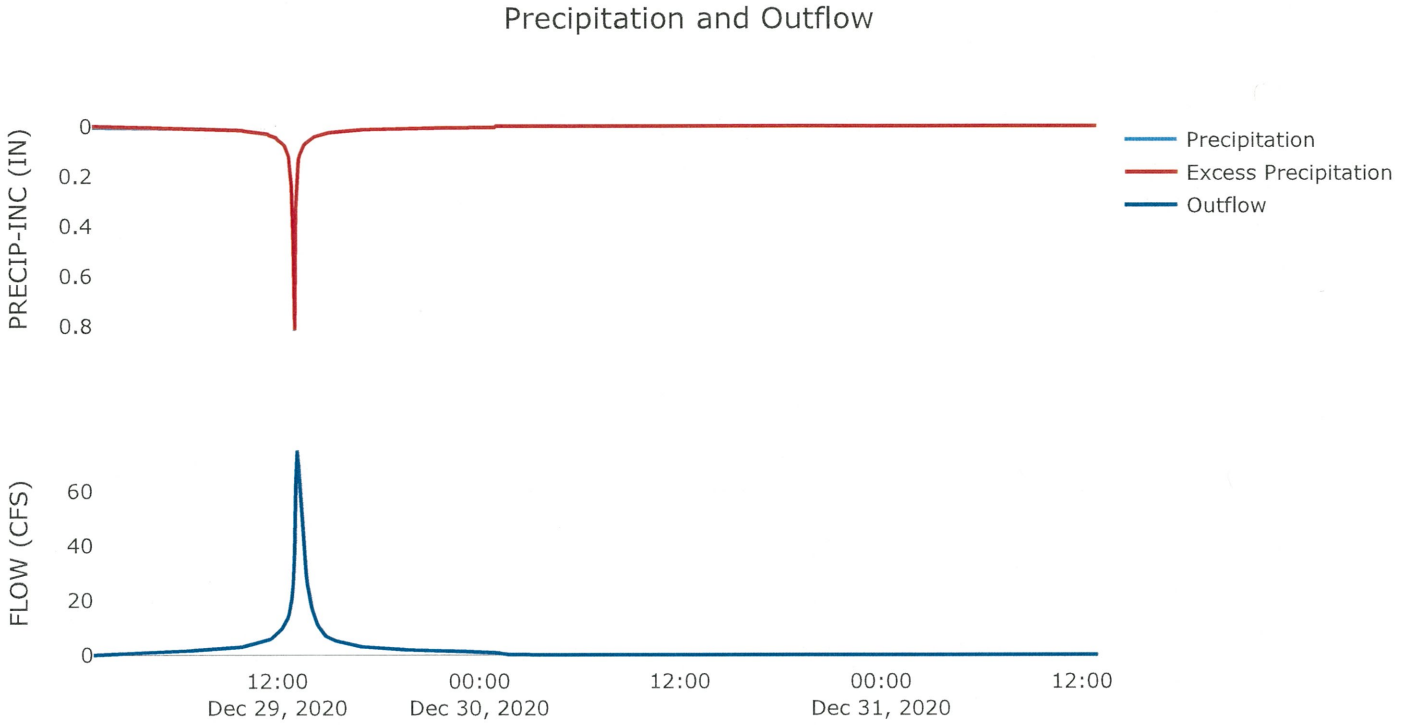
# Subbasin: S4

**Area (ft²)** : 0.03
**Downstream** : Rp2

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 98 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.1 |
| Snyder Cp | 0.39 |

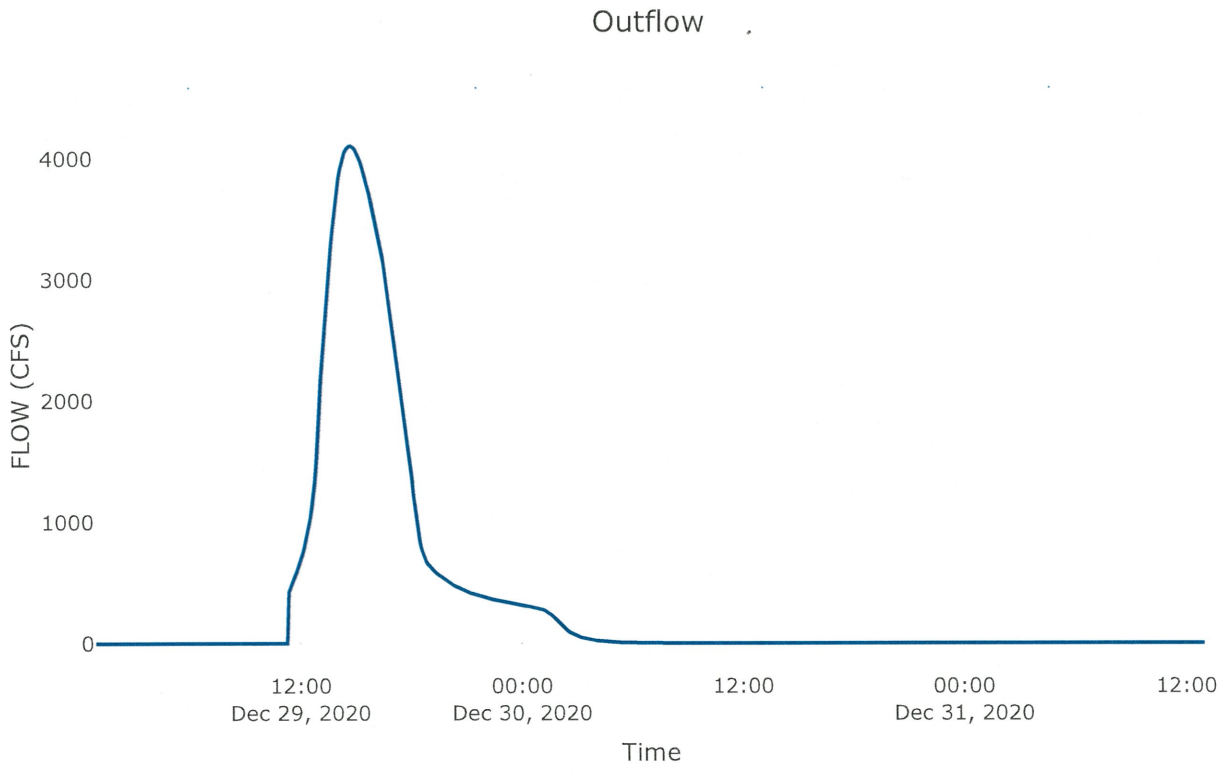
| Results: S4 | |
|---|---|
| Peak Discharge (CFS) | 74.9 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 6.92 |
| Precipitation Volume (AC - FT) | 9.58 |
| Loss Volume (AC - FT) | 0.32 |
| Excess Volume (AC - FT) | 9.26 |
| Direct Runoff Volume (AC - FT) | 9.26 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
60
40
20
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Reservoir: RP2

**Downstream** : Hc6

| Results: RP2 | |
|---|---|
| Peak Discharge (CFS) | 4105.01 |
| Time of Peak Discharge | 29Dec2020, 14:50 |
| Volume (IN) | 4.93 |
| Peak Inflow (CFS) | 6730.29 |
| Time of Peak Inflow | 29Dec2020, 13:55 |
| Inflow Volume (AC - FT) | 1813.34 |
| Maximum Storage (AC - FT) | 423.8 |
| Peak Elevation (FT) | 451.91 |
| Discharge Volume (AC - FT) | 1733.94 |

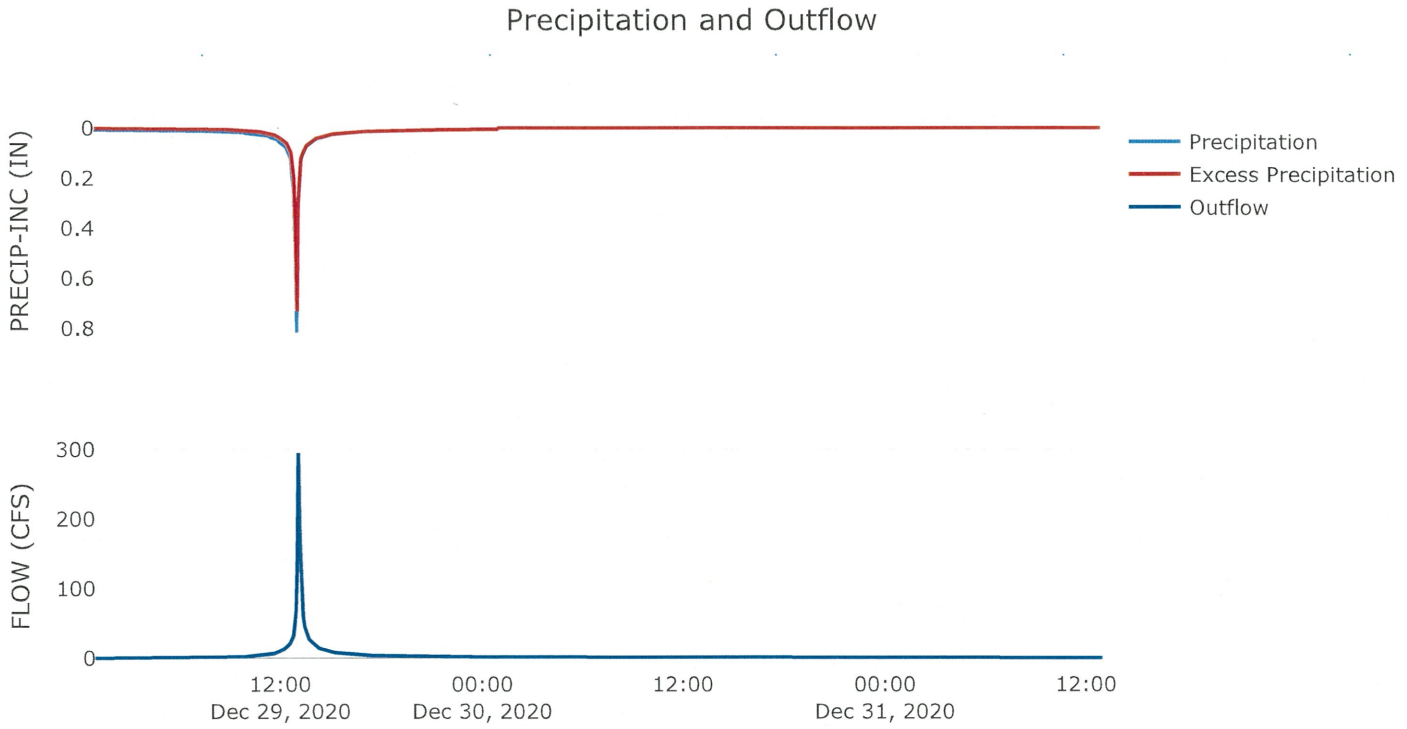


# Subbasin: DA9

**Area (ft²)** : 0.06
**Downstream** : Hc6
**Transform** : Kinematic Wave

**Results: DA9**

| | |
|---|---|
| Peak Discharge (CFS) | 294.96 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.39 |
| Precipitation Volume (AC - FT) | 21.58 |
| Loss Volume (AC - FT) | 4.94 |
| Excess Volume (AC - FT) | 16.63 |
| Direct Runoff Volume (AC - FT) | 13.23 |
| Baseflow Volume (AC - FT) | 0 |



# Subbasin: S5

**Area ($ft^2$)** : 0.01
**Downstream** : Hc6

**Loss Rate: Scs**

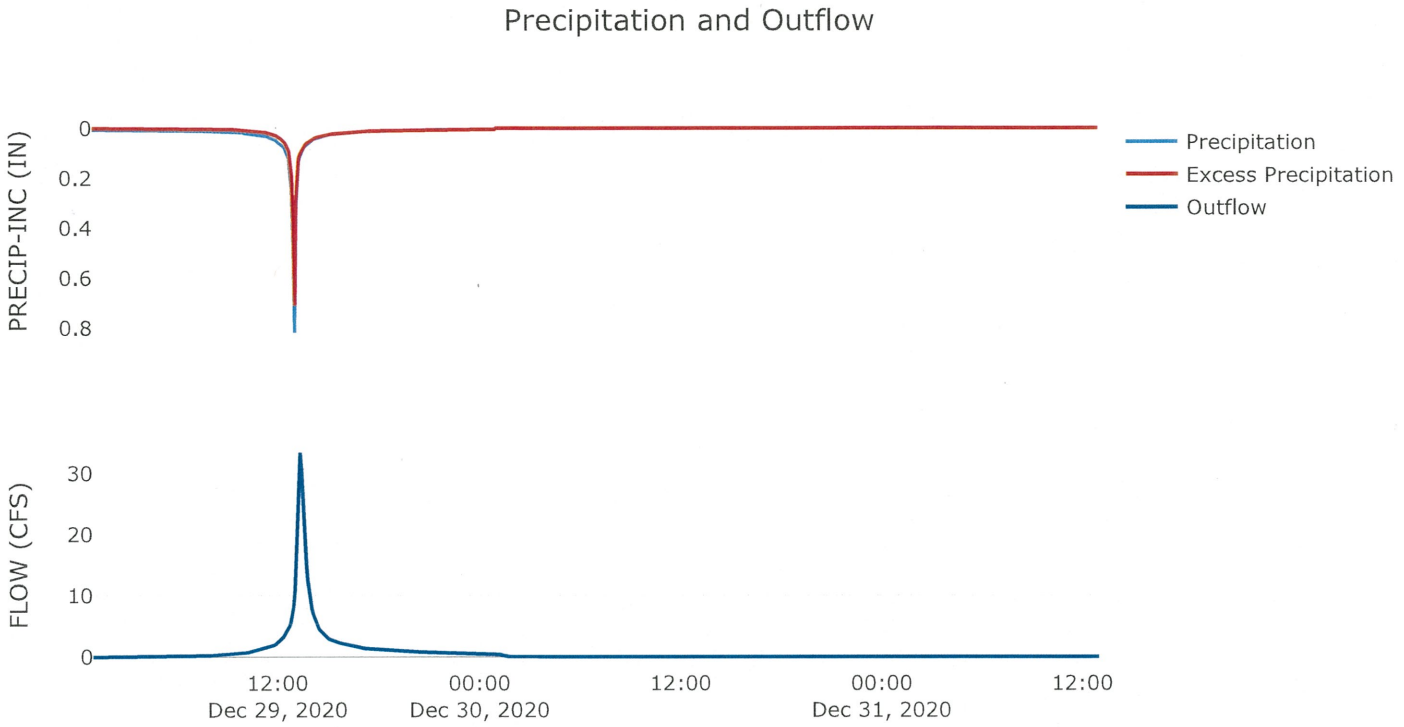
| | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

**Transform: Snyder**

| | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.26 |
| Snyder Cp | 0.69 |

**Results: S5**

| | |
|---|---|
| Peak Discharge (CFS) | 33.42 |
| Time of Peak Discharge | 29Dec2020, 13:20 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 4.85 |
| Loss Volume (AC - FT) | 1.27 |
| Excess Volume (AC - FT) | 3.58 |
| Direct Runoff Volume (AC - FT) | 3.58 |
| Baseflow Volume (AC - FT) | 0 |

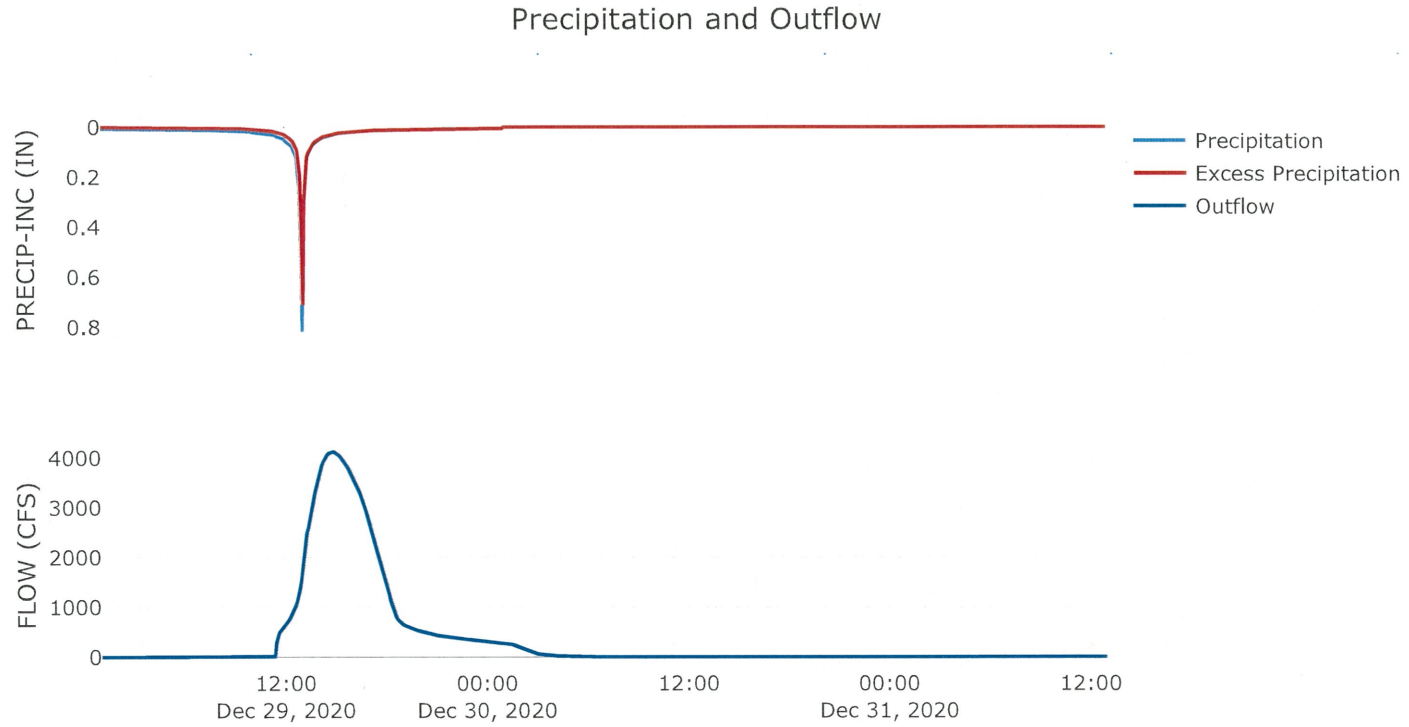

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
30
20
10
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: HC6

**Area (ft²)** : 0.02
**Downstream** : Dcp2
**Transform** : Kinematic Wave

**Results: HC6**

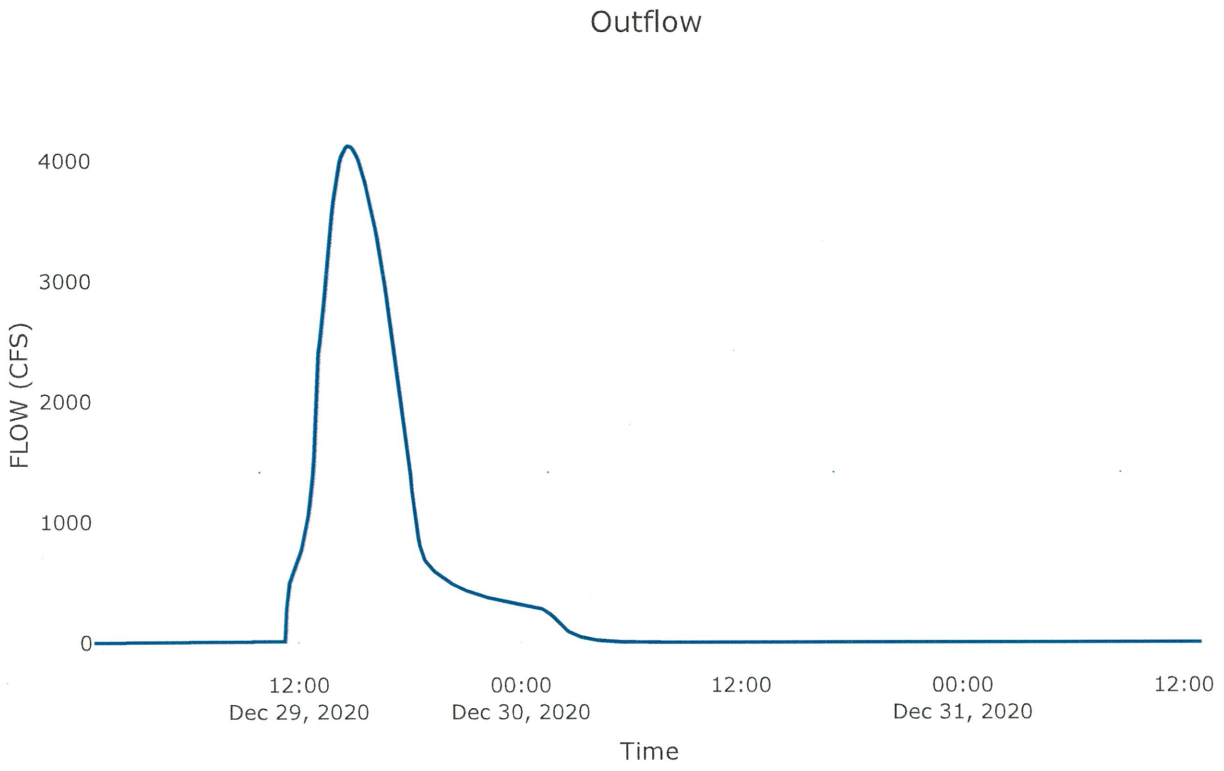
| | |
|---|---|
| Peak Discharge (CFS) | 4122.37 |
| Time of Peak Discharge | 29Dec2020, 14:50 |
| Volume (IN) | 4.93 |
| Precipitation Volume (AC - FT) | 2552.47 |
| Loss Volume (AC - FT) | 665.89 |
| Excess Volume (AC - FT) | 1886.58 |
| Direct Runoff Volume (AC - FT) | 1756.63 |
| Baseflow Volume (AC - FT) | 0 |



# Junction: DCP2

**Results: DCP2**

| | |
|---|---|
| Peak Discharge (CFS) | 4122.37 |
| Time of Peak Discharge | 29Dec2020, 14:50 |
| Volume (IN) | 4.93 |

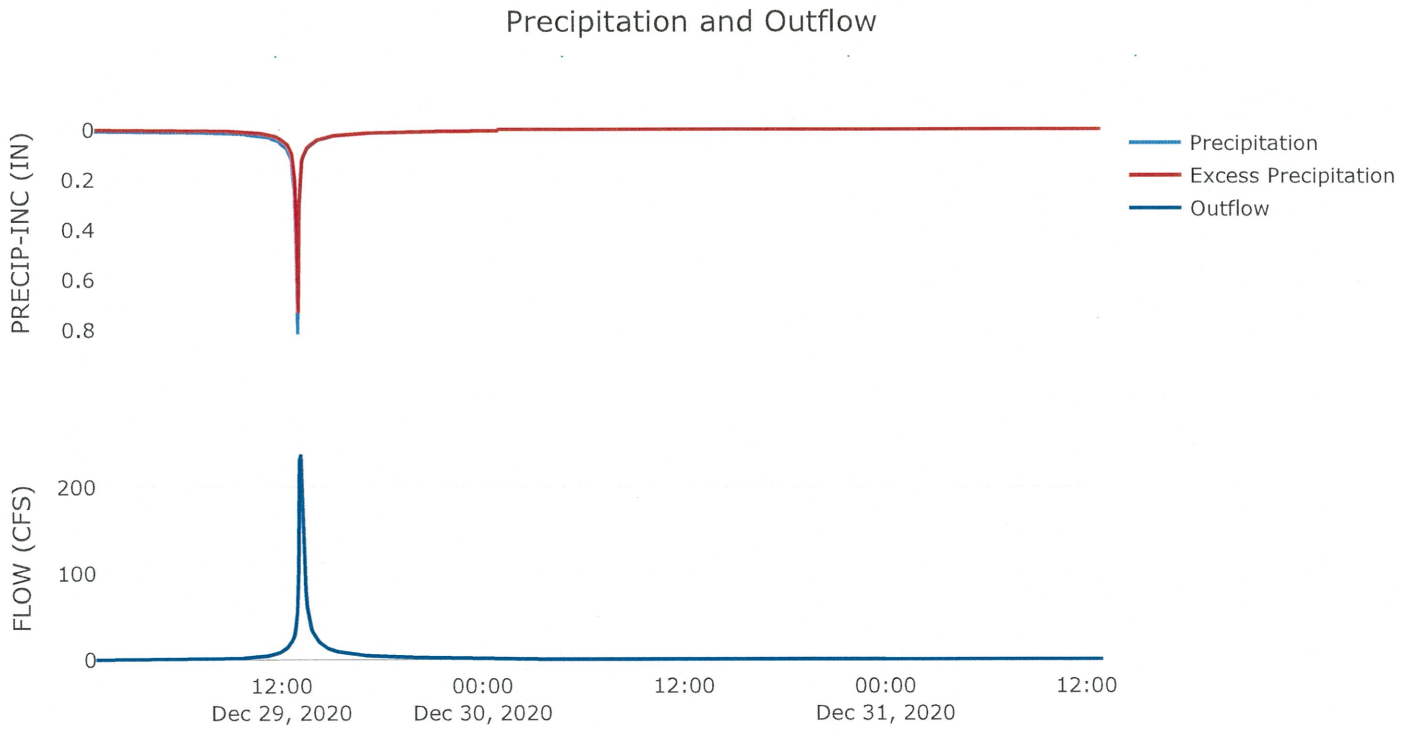


# Subbasin: DA8

**Area (ft²)** : 0.07
**Downstream** : C/s6
**Transform** : Kinematic Wave

**Results: DA8**

| | |
|---|---|
| Peak Discharge (CFS) | 237.65 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 4.07 |
| Precipitation Volume (AC - FT) | 26.92 |
| Loss Volume (AC - FT) | 6.17 |
| Excess Volume (AC - FT) | 20.75 |
| Direct Runoff Volume (AC - FT) | 15.3 |
| Baseflow Volume (AC - FT) | 0 |



# Subbasin: S7

**Area ($ft^2$)** : 0.05
**Downstream** : C/s6

**Loss Rate: Scs**

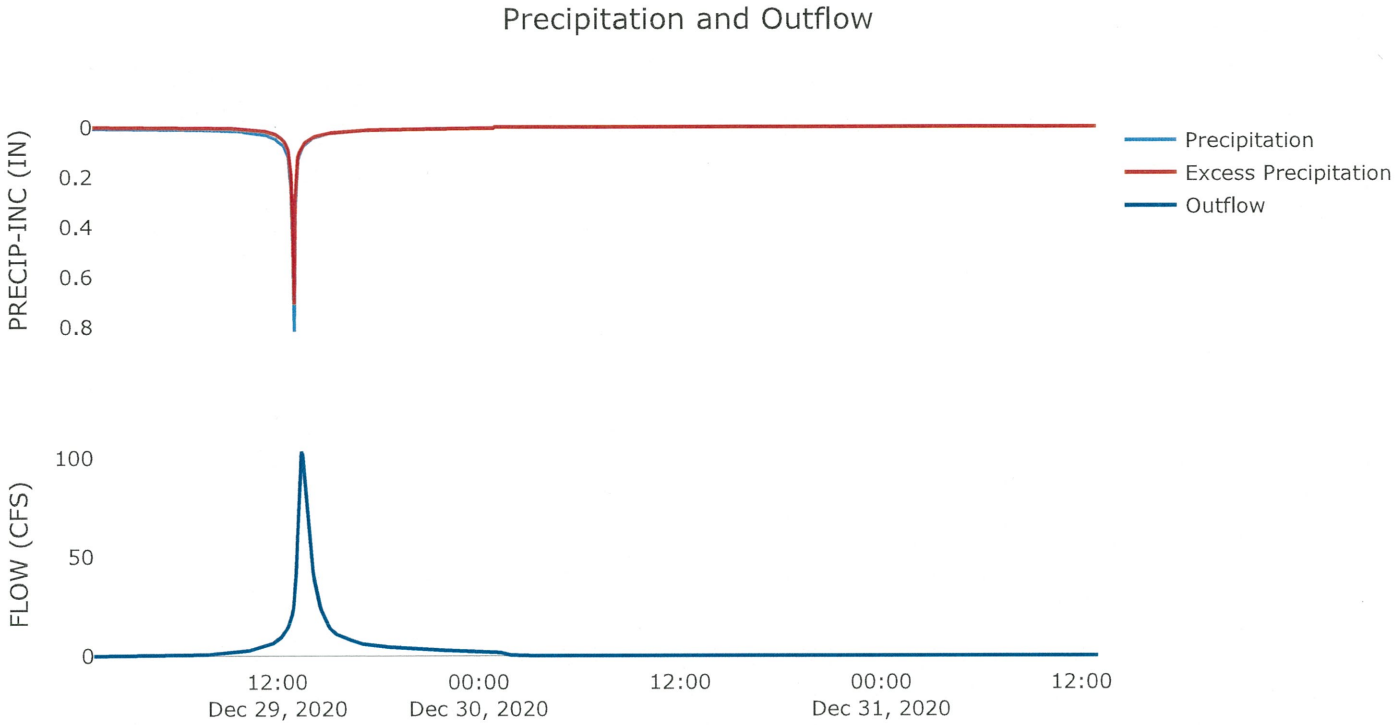
| | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

**Transform: Snyder**

| | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.4 |
| Snyder Cp | 0.67 |

**Results: S7**

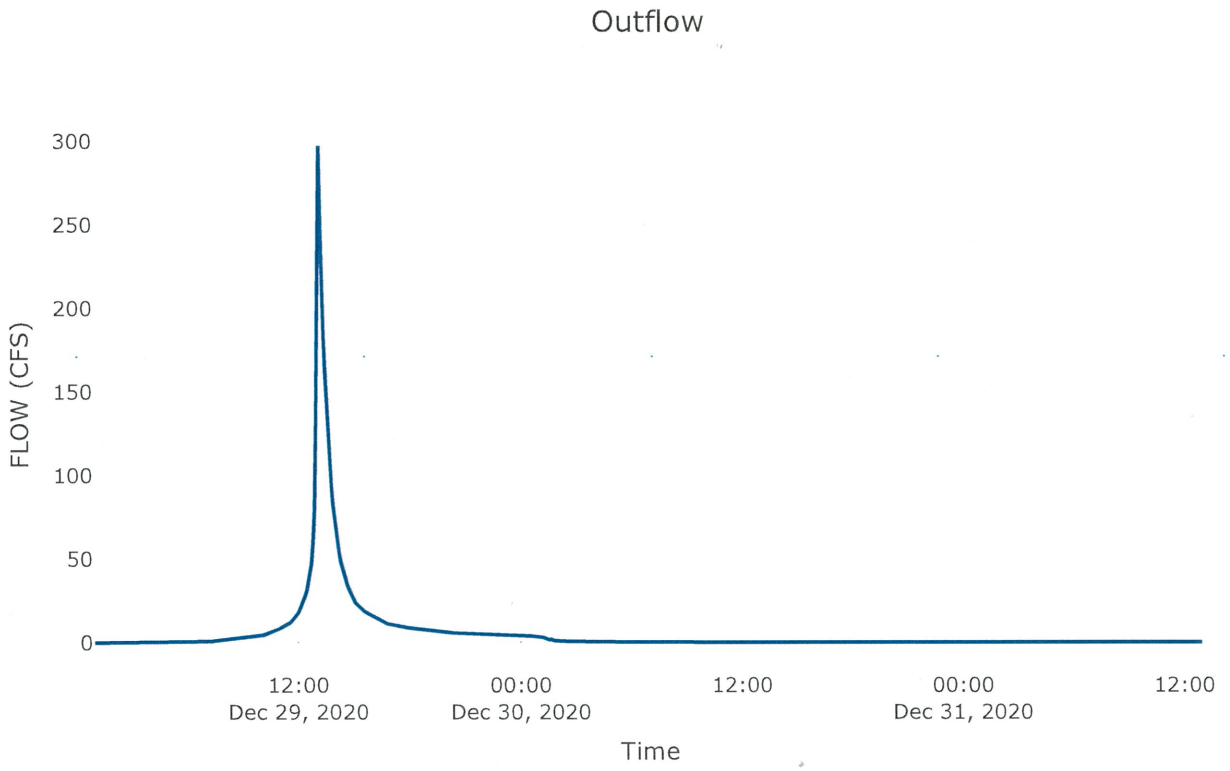
| | |
|---|---|
| Peak Discharge (CFS) | 103.33 |
| Time of Peak Discharge | 29Dec2020, 13:25 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 19.59 |
| Loss Volume (AC - FT) | 5.11 |
| Excess Volume (AC - FT) | 14.48 |
| Direct Runoff Volume (AC - FT) | 14.48 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
100
50
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Junction: C/S6

**Downstream** : Dcp4

| Results: C/S6 | |
|---|---|
| Peak Discharge (CFS) | 297.35 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 4.58 |



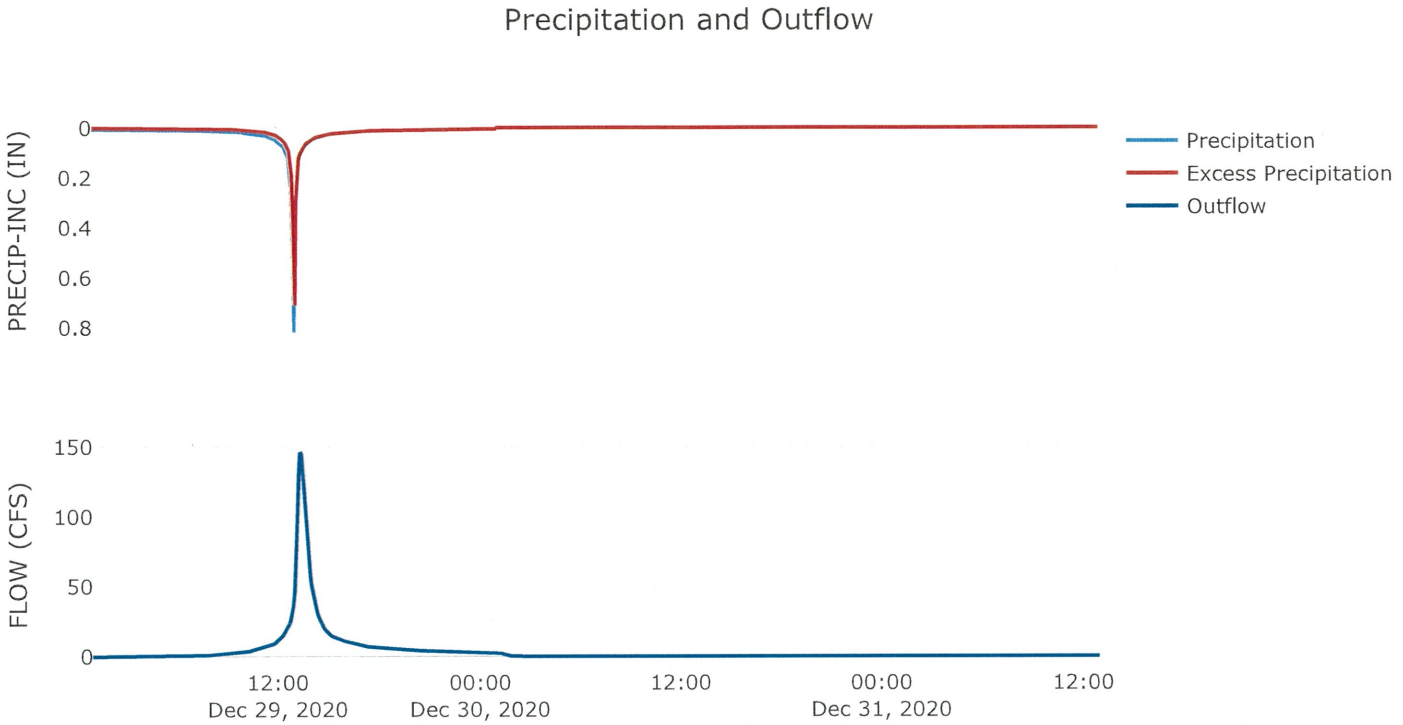
# Subbasin: O4

**Area ($ft^2$)** : 0.06
**Downstream** : C/s3

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.32 |
| Snyder Cp | 0.66 |

| Results: O4 | |
|---|---|
| Peak Discharge (CFS) | 146.21 |
| Time of Peak Discharge | 29Dec2020, 13:20 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 24.67 |
| Loss Volume (AC - FT) | 6.44 |
| Excess Volume (AC - FT) | 18.23 |
| Direct Runoff Volume (AC - FT) | 18.23 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
150
100
50
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: S3

**Area ($ft^2$)** : 0.04
**Downstream** : C/s3

**Loss Rate: Scs**

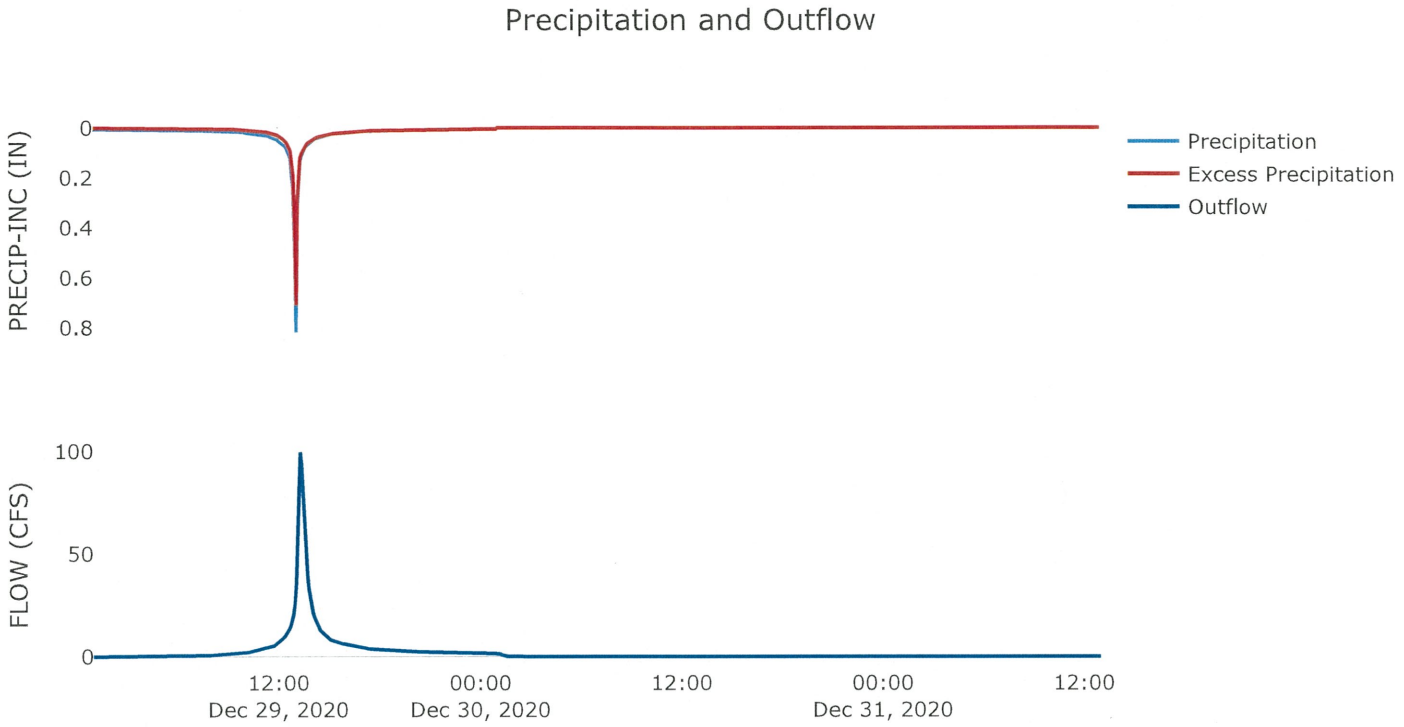
| | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

**Transform: Snyder**

| | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.22 |
| Snyder Cp | 0.65 |

**Results: S3**

| | |
|---|---|
| Peak Discharge (CFS) | 99.57 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 13.94 |
| Loss Volume (AC - FT) | 3.64 |
| Excess Volume (AC - FT) | 10.3 |
| Direct Runoff Volume (AC - FT) | 10.3 |
| Baseflow Volume (AC - FT) | 0 |

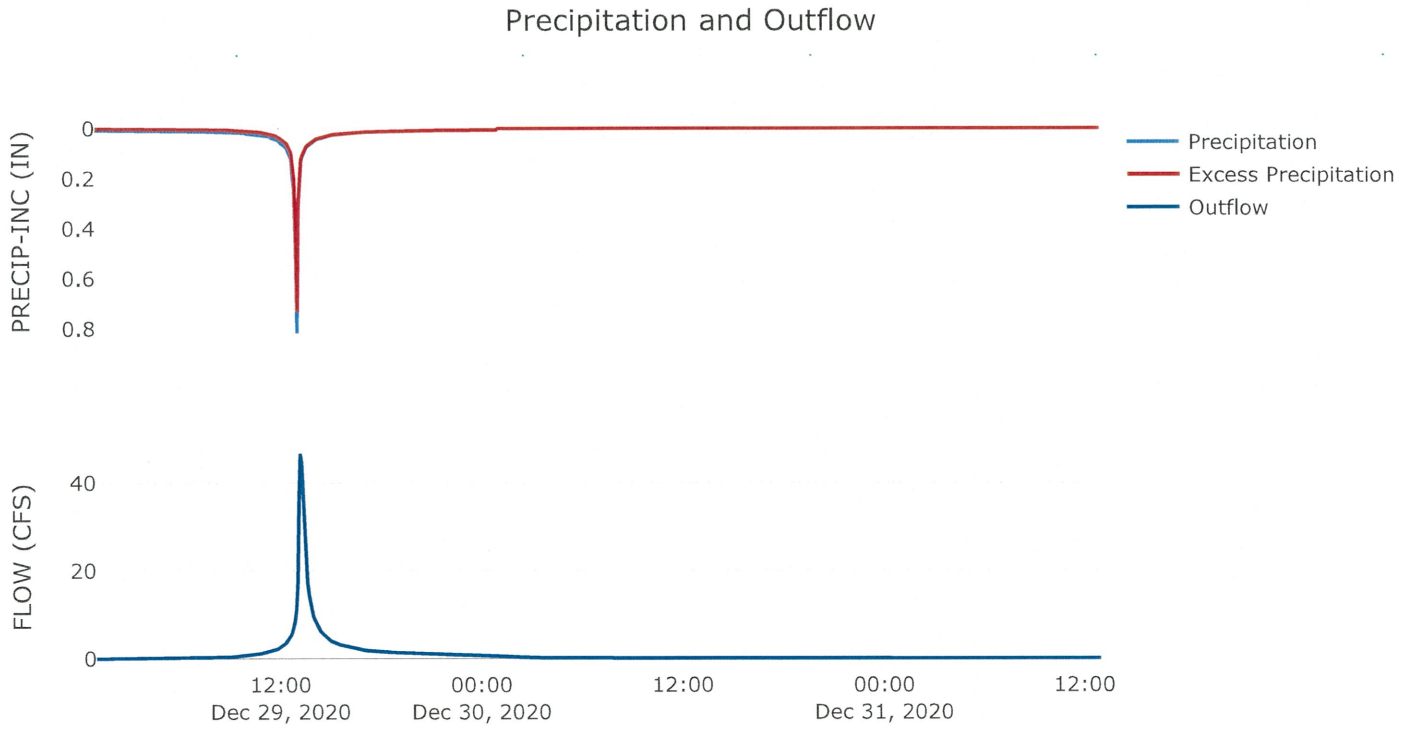

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
100
50
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA5

**Area (ft²)** : 0.02
**Downstream** : C/s3
**Transform** : Kinematic Wave

**Results: DA5**

| | |
|---|---|
| Peak Discharge (CFS) | 46.68 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 5.52 |
| Precipitation Volume (AC - FT) | 5.8 |
| Loss Volume (AC - FT) | 1.33 |
| Excess Volume (AC - FT) | 4.47 |
| Direct Runoff Volume (AC - FT) | 4.48 |
| Baseflow Volume (AC - FT) | 0 |

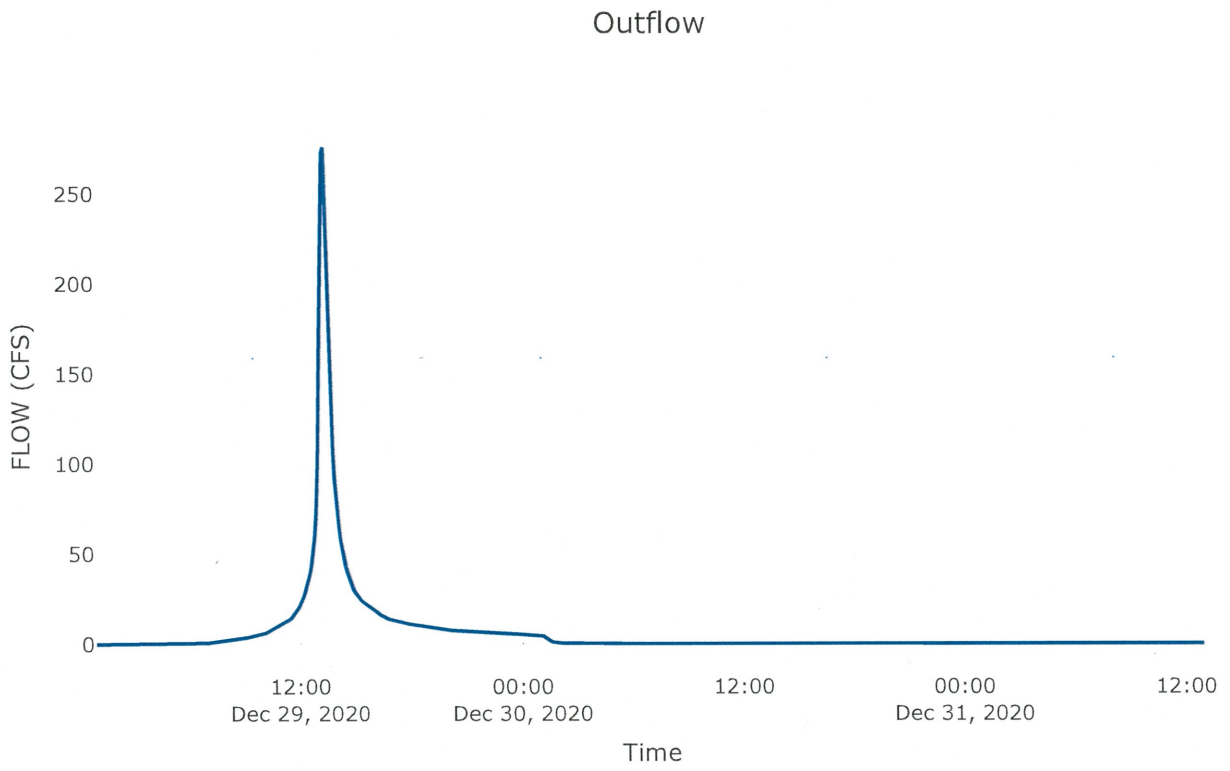


# Junction: C/S3

**Downstream** : Rp1

**Results: C/S3**

| | |
|---|---|
| Peak Discharge (CFS) | 275.91 |
| Time of Peak Discharge | 29Dec2020, 13:20 |
| Volume (IN) | 5.32 |

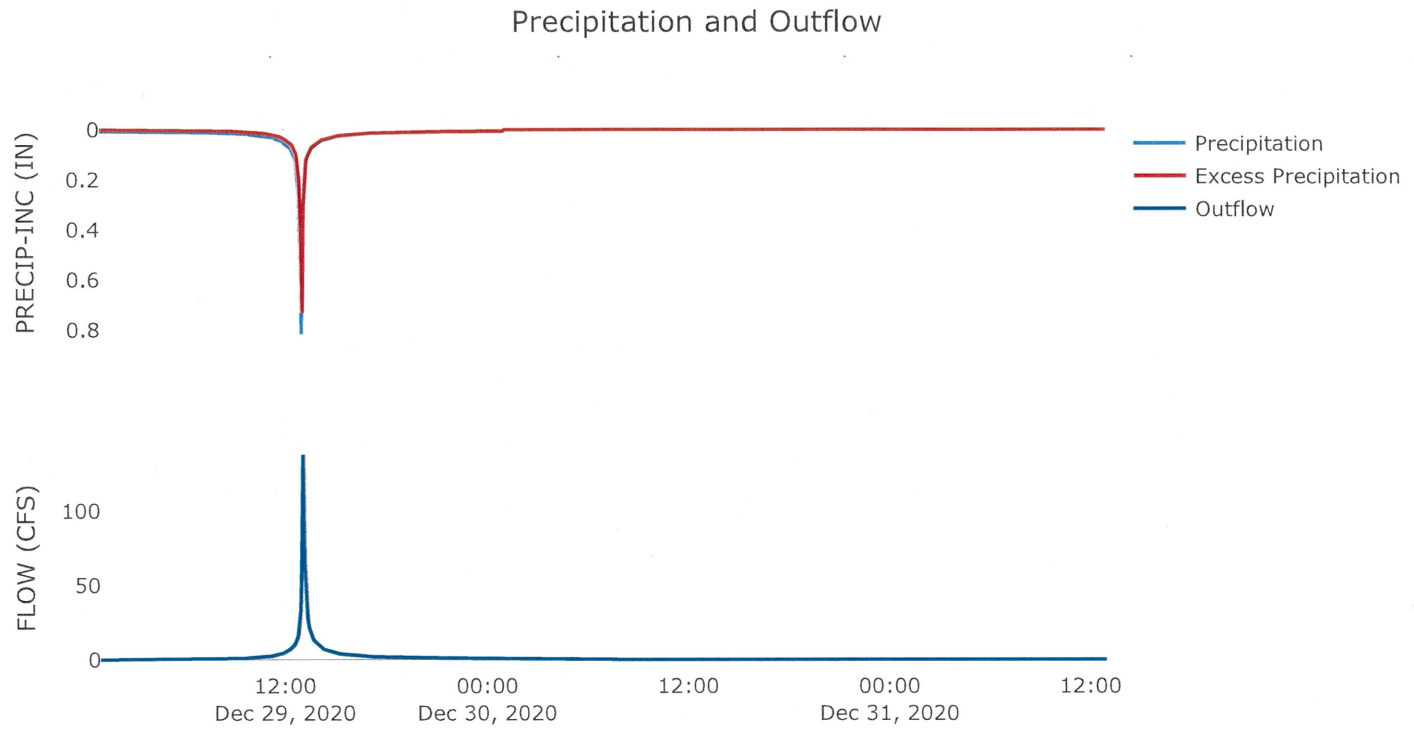


# Subbasin: DA6

**Area (ft²)** : 0.02
**Downstream** : Rp1
**Transform** : Kinematic Wave

**Results: DA6**

| | |
|---|---|
| Peak Discharge (CFS) | 137.83 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.82 |
| Precipitation Volume (AC - FT) | 9.47 |
| Loss Volume (AC - FT) | 2.17 |
| Excess Volume (AC - FT) | 7.3 |
| Direct Runoff Volume (AC - FT) | 6.37 |
| Baseflow Volume (AC - FT) | 0 |



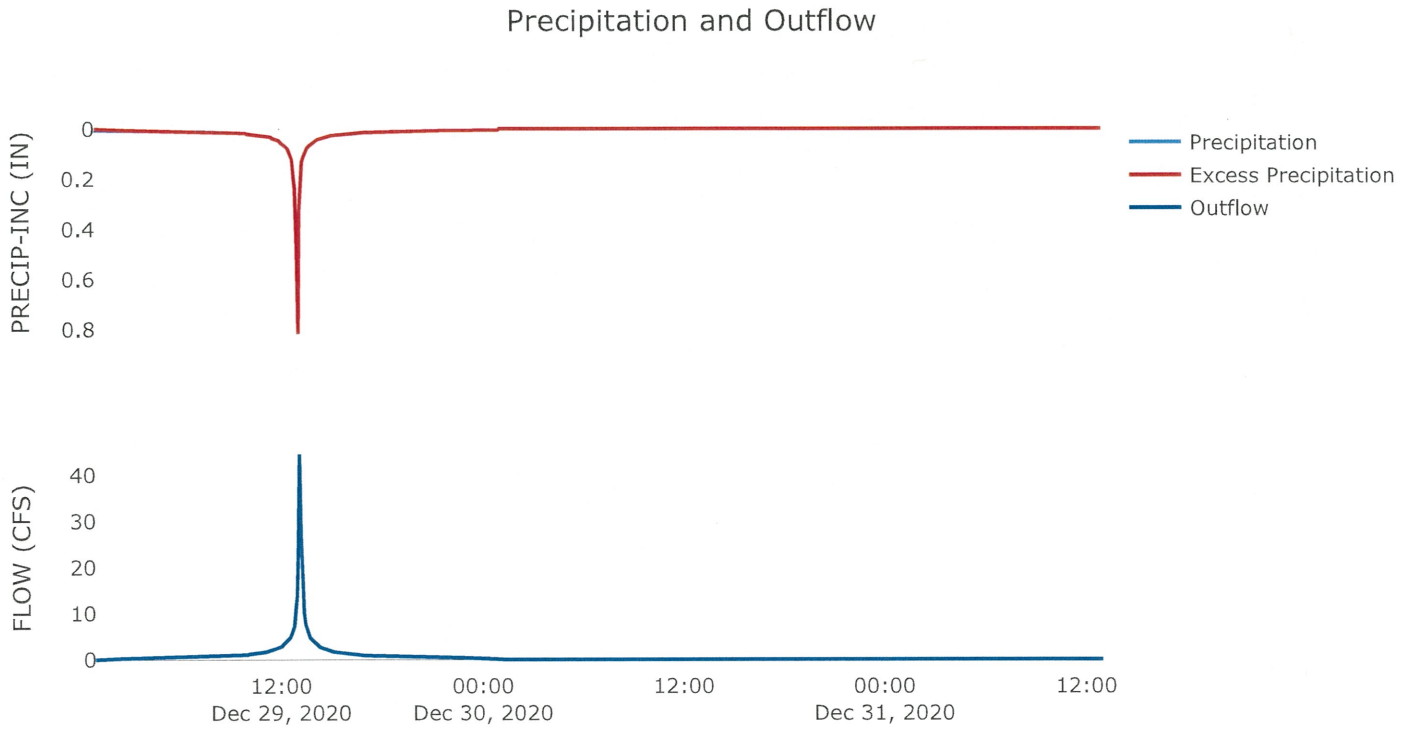
# Subbasin: P1

**Area (ft²)** : 0.01
**Downstream** : Rp1

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 99 |

| Transform: Scs | |
|---|---|
| Lag | 0.1 |
| Unitgraph Type | Standard |

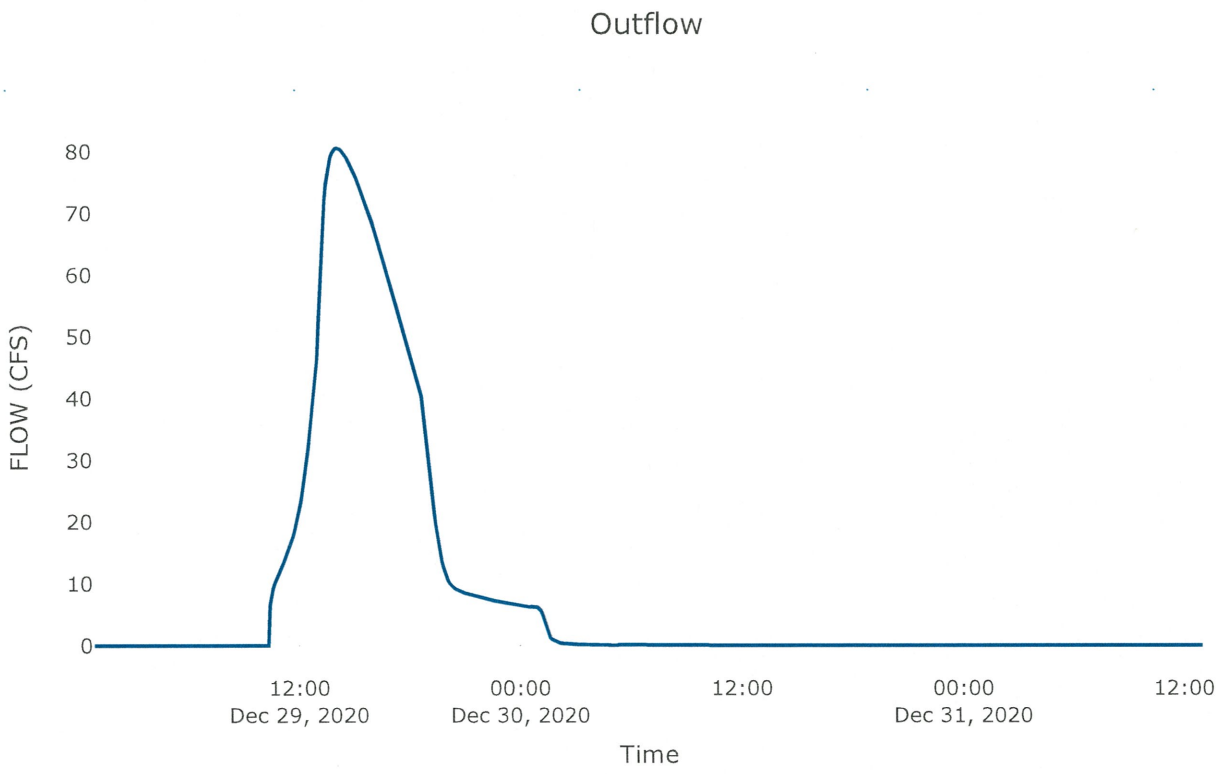
| Results: P1 | |
|---|---|
| Peak Discharge (CFS) | 44.5 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 7.04 |
| Precipitation Volume (AC - FT) | 3.05 |
| Loss Volume (AC - FT) | 0.05 |
| Excess Volume (AC - FT) | 3 |
| Direct Runoff Volume (AC - FT) | 3 |
| Baseflow Volume (AC - FT) | 0 |



# Reservoir: RP1

**Downstream** : Ch3

| Results: RP1 | |
|---|---|
| Peak Discharge (CFS) | 80.58 |
| Time of Peak Discharge | 29Dec2020, 14:05 |
| Volume (IN) | 5.15 |
| Peak Inflow (CFS) | 340.93 |
| Time of Peak Inflow | 29Dec2020, 13:05 |
| Inflow Volume (AC - FT) | 42.38 |
| Maximum Storage (AC - FT) | 17.2 |
| Peak Elevation (FT) | 467 |
| Discharge Volume (AC - FT) | 40.92 |

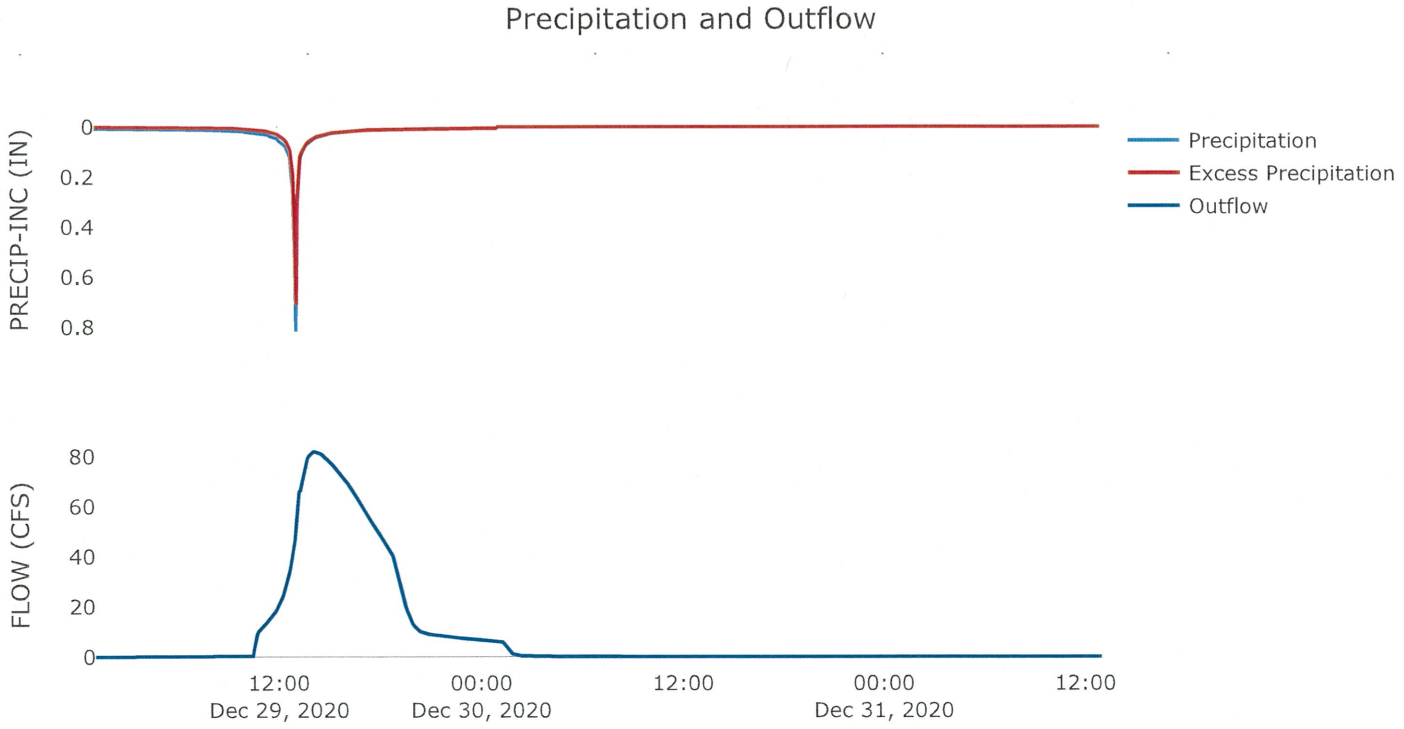


# Subbasin: CH3

**Area (ft²)** : 0
**Downstream** : R/dcp5
**Transform** : Kinematic Wave

**Results: CH3**

| | |
|---|---|
| Peak Discharge (CFS) | 81.9 |
| Time of Peak Discharge | 29Dec2020, 14:05 |
| Volume (IN) | 5.15 |
| Precipitation Volume (AC - FT) | 58.39 |
| Loss Volume (AC - FT) | 15.23 |
| Excess Volume (AC - FT) | 43.16 |
| Direct Runoff Volume (AC - FT) | 41.99 |
| Baseflow Volume (AC - FT) | 0 |



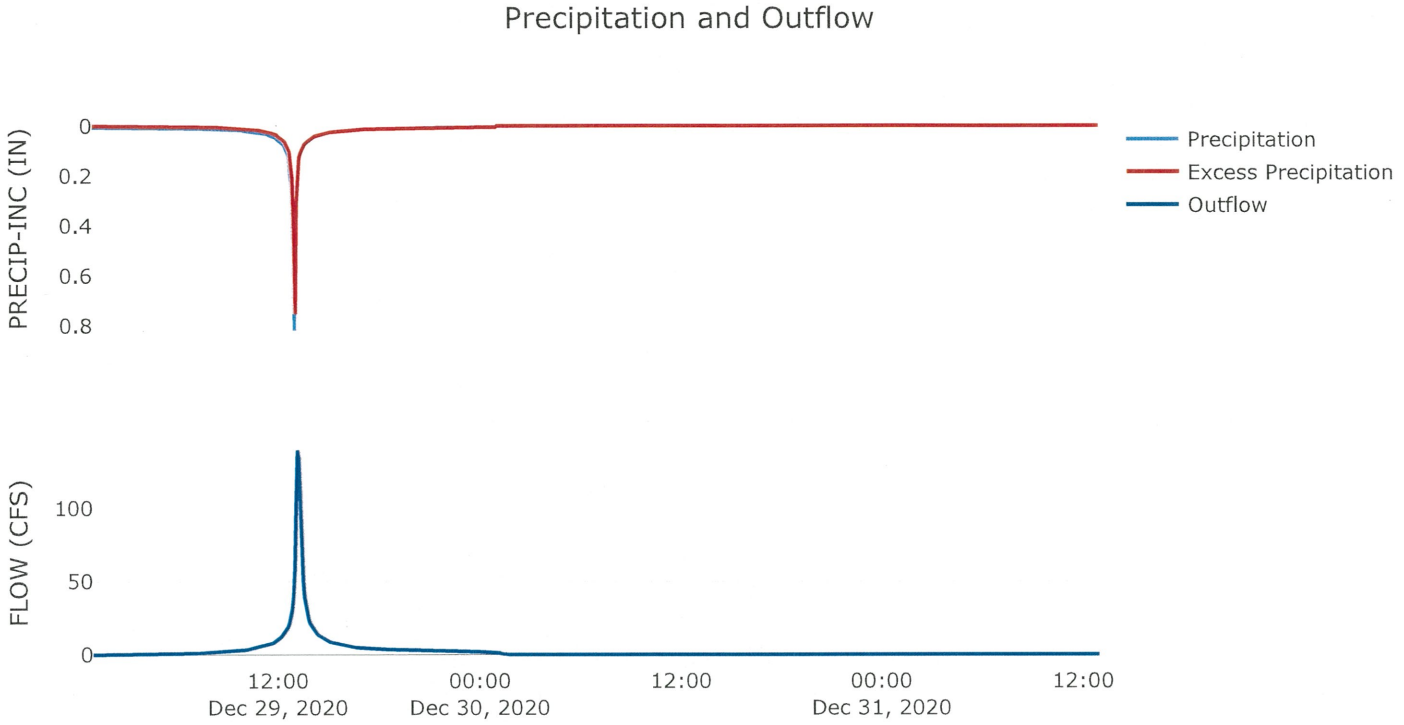
# Subbasin: O6

**Area ($ft^2$)** : 0.04
**Downstream** : Ch1

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 88 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.15 |
| Snyder Cp | 0.62 |

| Results: O6 | |
|---|---|
| Peak Discharge (CFS) | 139.7 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 5.75 |
| Precipitation Volume (AC - FT) | 15.35 |
| Loss Volume (AC - FT) | 3.03 |
| Excess Volume (AC - FT) | 12.33 |
| Direct Runoff Volume (AC - FT) | 12.33 |
| Baseflow Volume (AC - FT) | 0 |

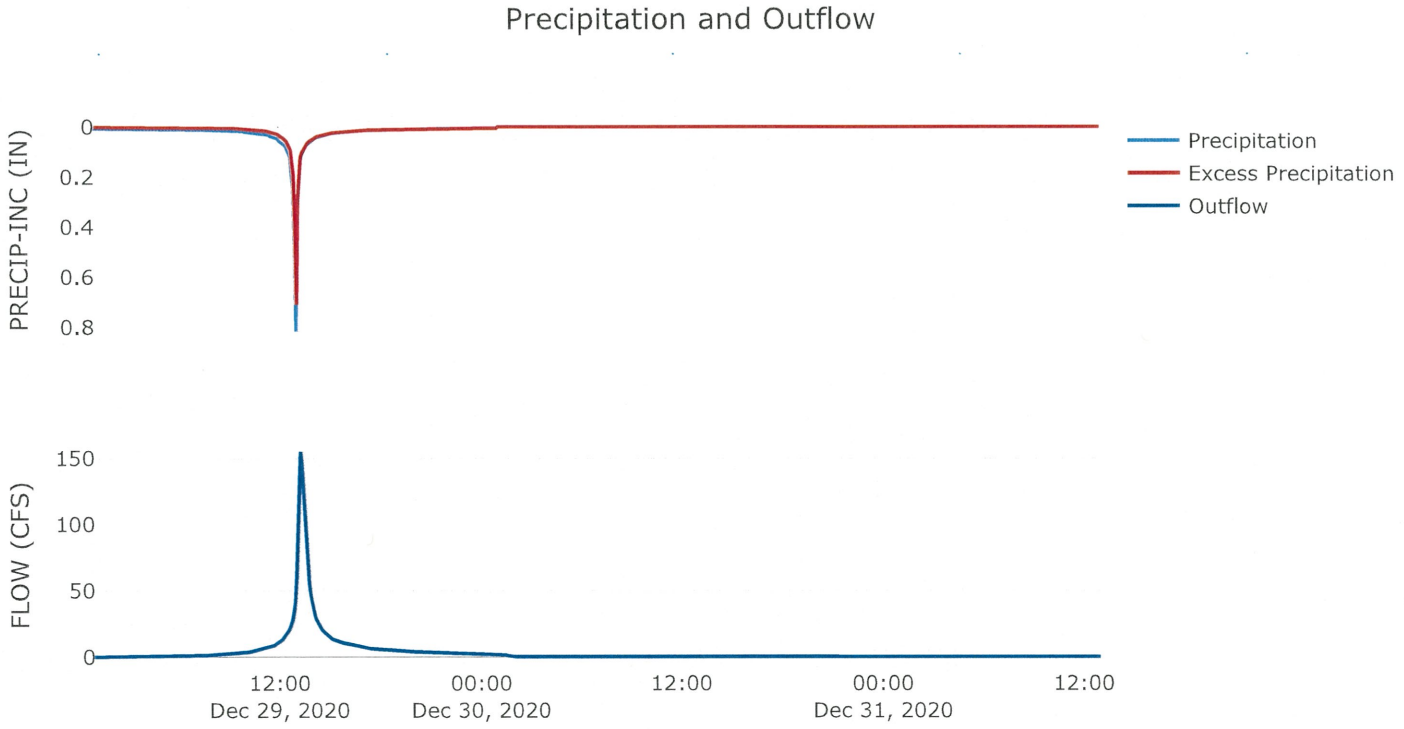

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
100
50
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: CH1

**Area (ft²)** : 0.02
**Downstream** : Ch2
**Transform** : Kinematic Wave

**Results: CH1**

| | |
|---|---|
| Peak Discharge (CFS) | 154.76 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.57 |
| Precipitation Volume (AC - FT) | 22.07 |
| Loss Volume (AC - FT) | 5.76 |
| Excess Volume (AC - FT) | 16.31 |
| Direct Runoff Volume (AC - FT) | 17.16 |
| Baseflow Volume (AC - FT) | 0 |

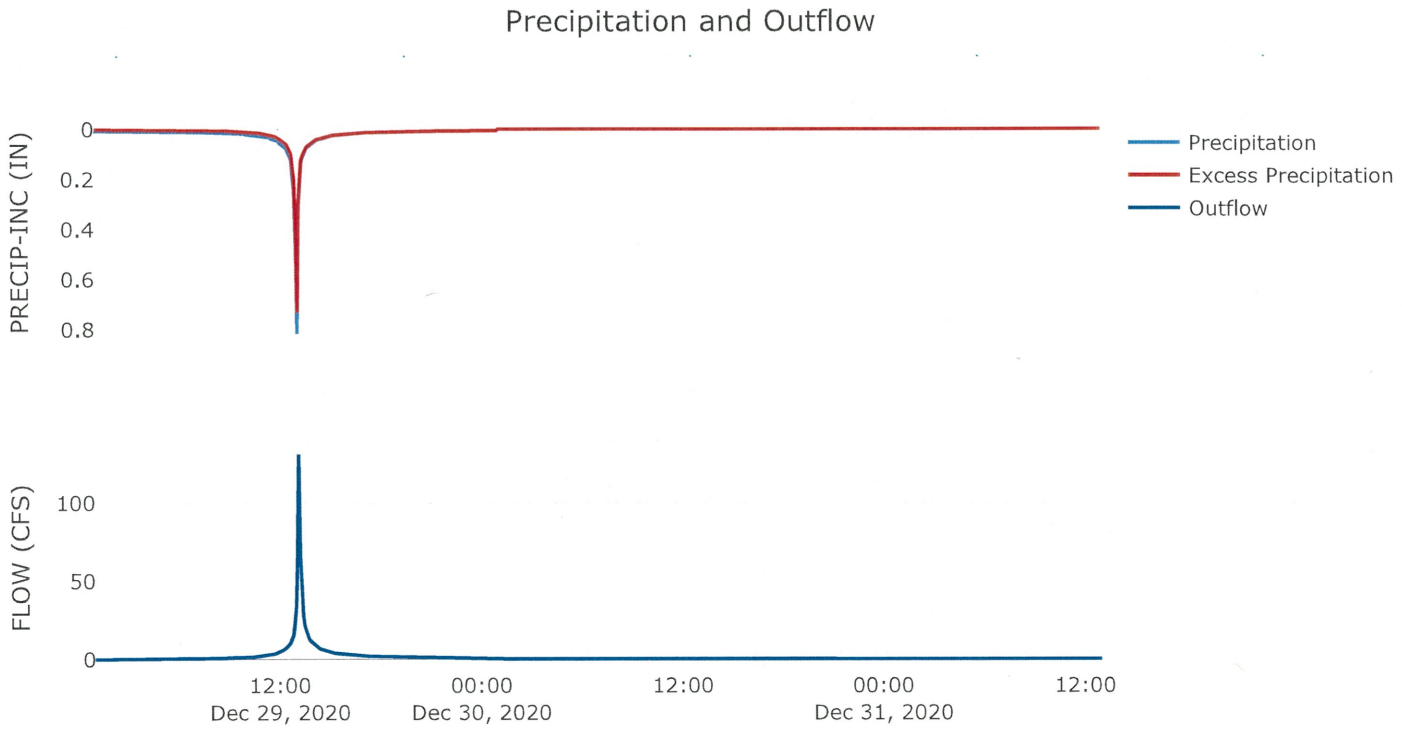


# Subbasin: DA7

**Area (ft²)** : 0.02
**Downstream** : Ch2
**Transform** : Kinematic Wave

**Results: DA7**

| | |
|---|---|
| Peak Discharge (CFS) | 131.13 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.93 |
| Precipitation Volume (AC - FT) | 9.13 |
| Loss Volume (AC - FT) | 2.09 |
| Excess Volume (AC - FT) | 7.04 |
| Direct Runoff Volume (AC - FT) | 6.28 |
| Baseflow Volume (AC - FT) | 0 |



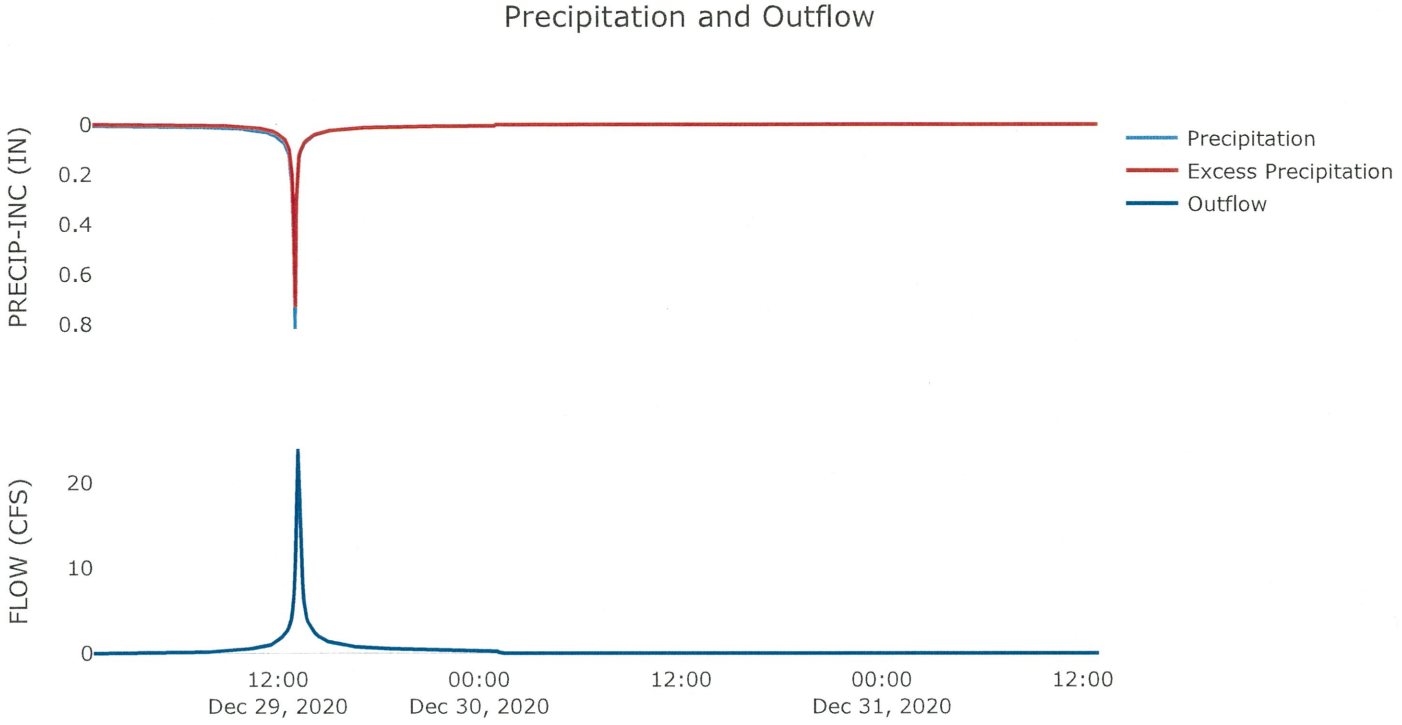
# Subbasin: O5

**Area ($ft^2$)** : 0.01
**Downstream** : Ch2

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 86 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.11 |
| Snyder Cp | 0.62 |

| Results: O5 | |
|---|---|
| Peak Discharge (CFS) | 23.99 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 5.52 |
| Precipitation Volume (AC - FT) | 2.41 |
| Loss Volume (AC - FT) | 0.55 |
| Excess Volume (AC - FT) | 1.85 |
| Direct Runoff Volume (AC - FT) | 1.85 |
| Baseflow Volume (AC - FT) | 0 |

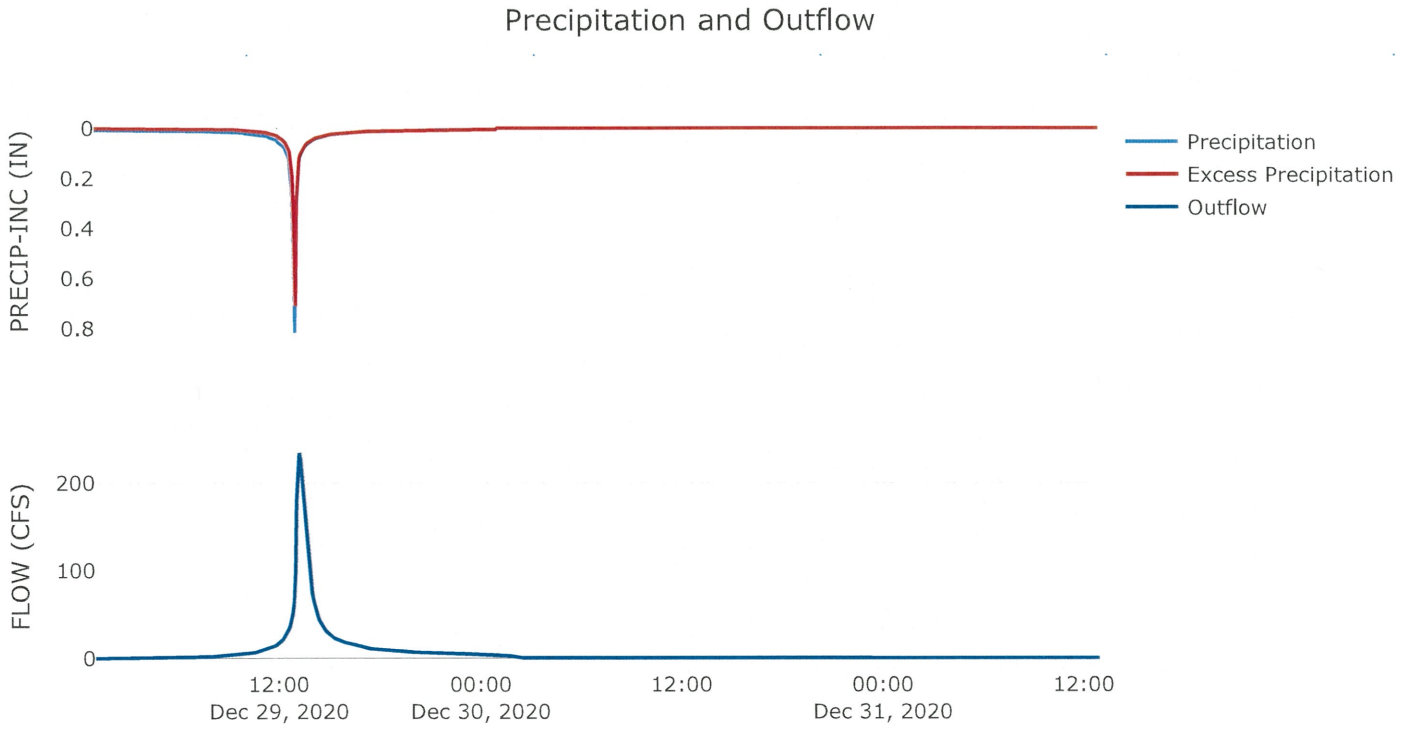

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
20
10
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: CH2

**Area (ft²)** : 0.02
**Downstream** : R/dcp5
**Transform** : Kinematic Wave

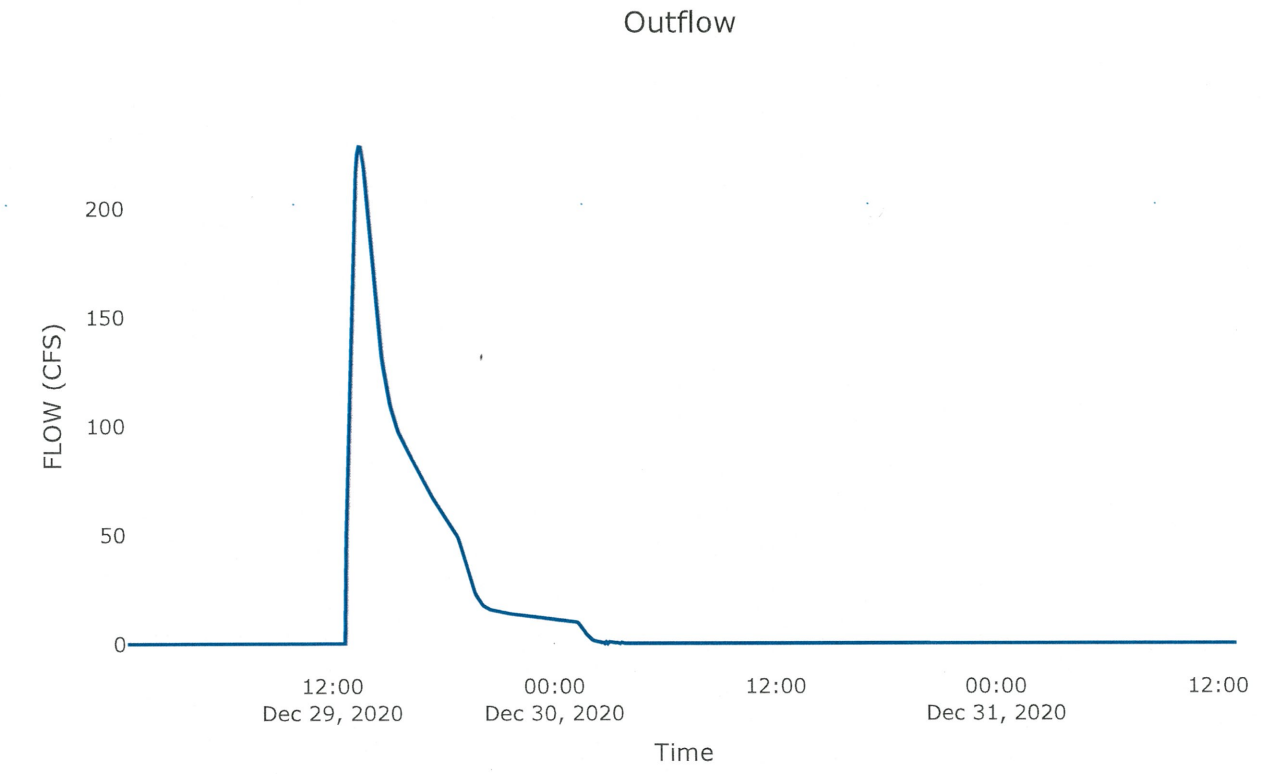
**Results: CH2**

| | |
|---|---|
| Peak Discharge (CFS) | 233.83 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.35 |
| Precipitation Volume (AC - FT) | 39.71 |
| Loss Volume (AC - FT) | 10.36 |
| Excess Volume (AC - FT) | 29.35 |
| Direct Runoff Volume (AC - FT) | 29.68 |
| Baseflow Volume (AC - FT) | 0 |



# Reservoir: R/DCP5

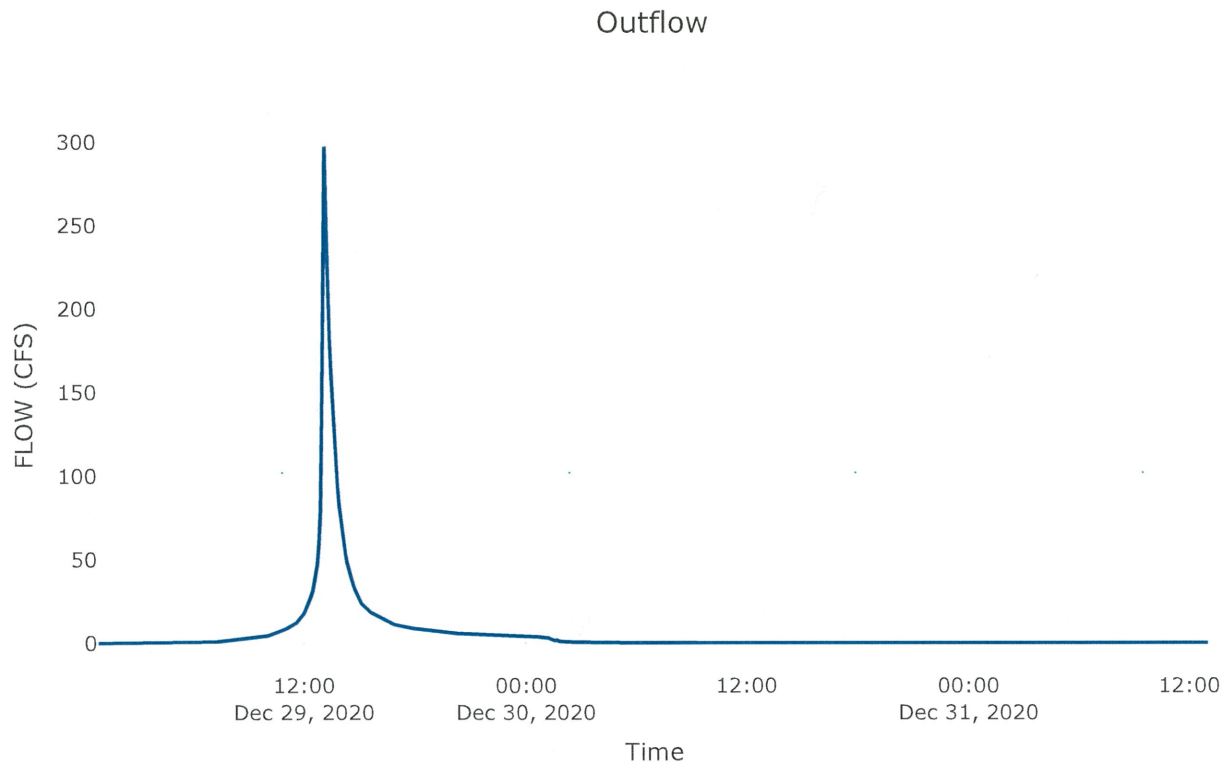
| Results: R/DCP5 | |
|---|---|
| Peak Discharge (CFS) | 228.33 |
| Time of Peak Discharge | 29Dec2020, 13:35 |
| Volume (IN) | 4.67 |
| Peak Inflow (CFS) | 300.26 |
| Time of Peak Inflow | 29Dec2020, 13:15 |
| Inflow Volume (AC - FT) | 71.67 |
| Maximum Storage (AC - FT) | 12.47 |
| Peak Elevation (FT) | 462.51 |
| Discharge Volume (AC - FT) | 64.05 |



# Junction: DCP4

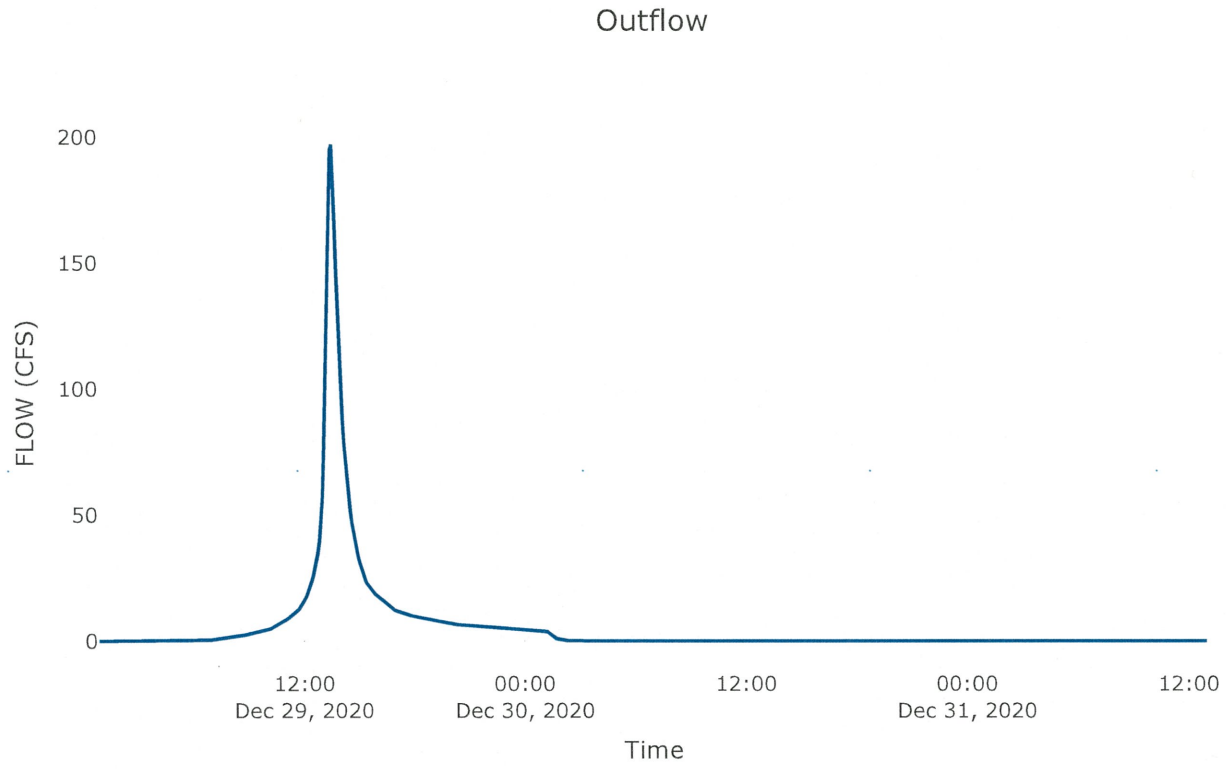
**Results: DCP4**

| | |
|---|---|
| Peak Discharge (CFS) | 297.35 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 4.58 |



# Junction: DCP1

| Results: DCP1 | |
|---|---|
| Peak Discharge (CFS) | 197.05 |
| Time of Peak Discharge | 29Dec2020, 13:30 |
| Volume (IN) | 5.29 |



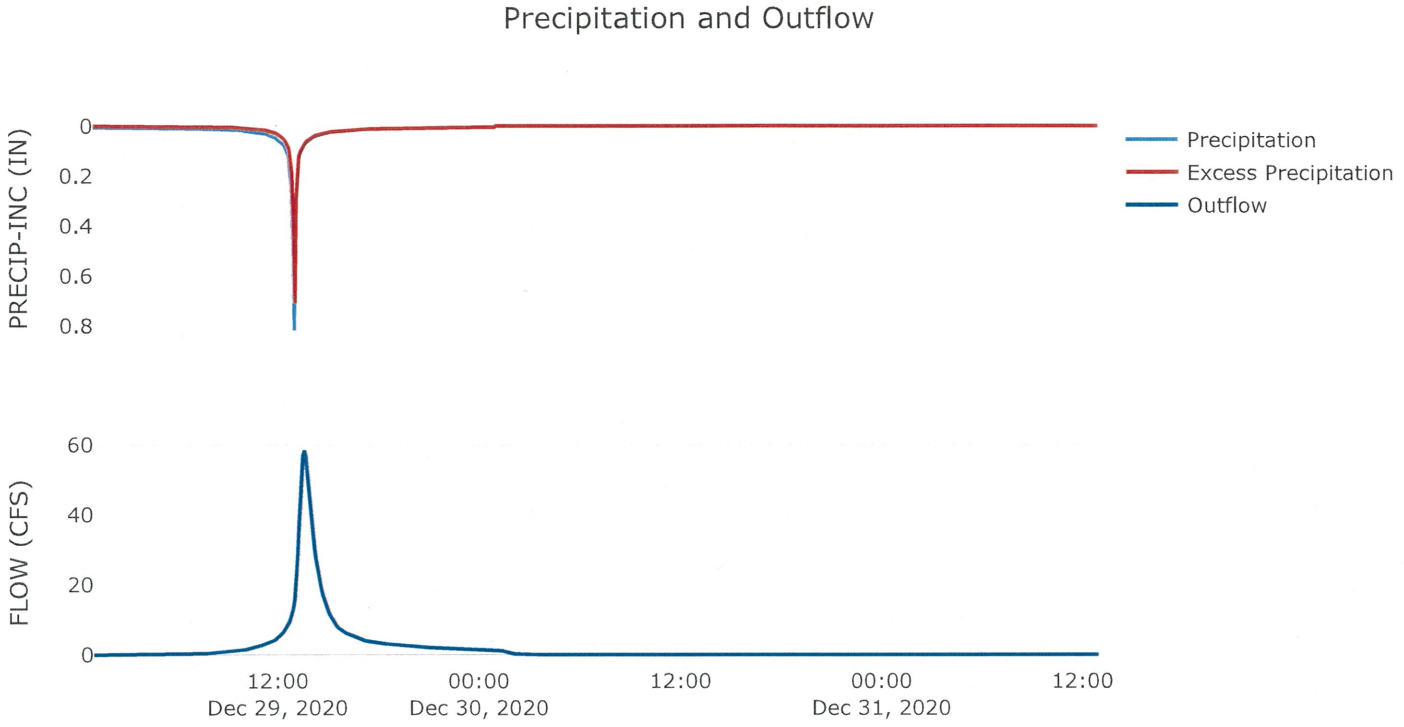
# Subbasin: S6

**Area ($ft^2$)** : 0.03
**Downstream** : Dcp3

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

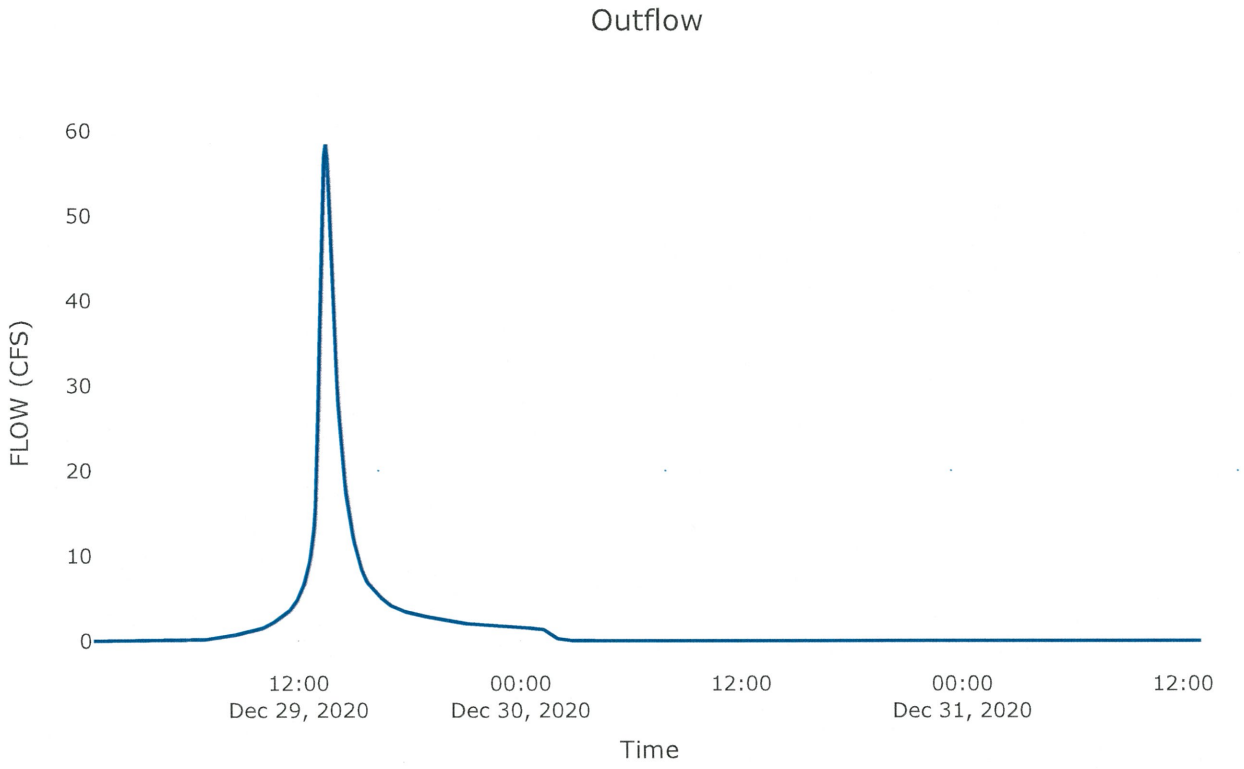
| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.53 |
| Snyder Cp | 0.68 |

| Results: S6 | |
|---|---|
| Peak Discharge (CFS) | 58.4 |
| Time of Peak Discharge | 29Dec2020, 13:35 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 12.79 |
| Loss Volume (AC - FT) | 3.34 |
| Excess Volume (AC - FT) | 9.46 |
| Direct Runoff Volume (AC - FT) | 9.46 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
60
40
20
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Junction: DCP3

| Results: DCP3 | |
|---|---|
| Peak Discharge (CFS) | 58.4 |
| Time of Peak Discharge | 29Dec2020, 13:35 |
| Volume (IN) | 5.29 |



# VOLUME CALCULATIONS

# EXCESS RAINFALL VOLUME CALCULATION

The volume generated by the site and the surrounding properties is calculated for the 25-year storm event. A summary of the design information that is included in this Appendix and related appendices are listed below.

- Drainage areas used in the volume calculations were taken from the drawing located on page IIIF-A-26.
- 25-year excess rainfall information is included on pages III-F-A-28 through III-F-A-93.
- 25-year Post-development condition volume information is summarized on pages IIIF-A-96 through IIIF-A-98.

**Required:** Determine the 25-year 24-hour storm volume generated by the site and offsite areas using the excess rainfall calculated in the HEC-HMS analysis of the proposed expansion site condition

**Method:** Use the excess rainfall data generated by the HEC-HMS analysis (pages IIIF-A-27 through IIIF-A-93) to determine the volume produced by the site for the proposed expansion conditions.

Proposed Expansion Conditions

**1. Volume Discharging At DCP1**

| Area No. | Area (Square Miles) | Area (Acre) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|---|
| **S1** | **0.10** | **64.93** | **5.29** | **28.62** |
| Total Volume Discharging At DCP1 | | | | 28.62 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP1 = | **28.6** | **ac-ft** |

## 2. Volume Discharging At DCP2

| Area No. | Area (Square Miles) | Area (Acre) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|---|
| **HC 1** | **0.02** | **2.82** | **5.08** | **1.19** |
| **HC 2** | **0.09** | **7.52** | **5.07** | **3.18** |
| **HC 3** | **0.07** | **10.24** | **5.07** | **4.33** |
| **HC 4** | **0.05** | **9.77** | **5.07** | **4.13** |
| **HC 5** | **0.29** | **7.71** | **5.08** | **3.26** |
| **HC 6** | **0.66** | **13.10** | **4.93** | **5.38** |
| **O1** | **0.13** | **81.63** | **5.29** | **35.99** |
| **O2** | **0.25** | **160.32** | **5.29** | **70.67** |
| **O3** | **5.50** | **3520.00** | **5.07** | **1,487.20** |
| **DA1** | **0.03** | **16.21** | **4.35** | **5.88** |
| **DA2** | **0.04** | **24.35** | **4.58** | **9.29** |
| **DA3** | **0.05** | **30.92** | **4.80** | **12.37** |
| **DA4** | **0.08** | **53.58** | **4.83** | **21.57** |
| **DA9** | **0.06** | **36.19** | **4.39** | **13.24** |
| **DA10** | **0.07** | **47.87** | **4.59** | **18.31** |
| **DA11** | **0.06** | **35.90** | **4.52** | **13.52** |
| **DA12** | **0.03** | **16.82** | **5.11** | **7.16** |
| **P2** | **0.27** | **170.81** | **7.04** | **100.21** |
| **S2** | **0.01** | **7.92** | **5.29** | **3.49** |
| **S4** | **0.03** | **16.05** | **6.92** | **9.26** |
| **S5** | **0.01** | **8.15** | **5.29** | **3.59** |
| Total Volume Discharging At DCP2 | | | | 1,833.22 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP2 = | **1,833.2** | **ac-ft** |

## 3. Volume Discharging At DCP3

| Area No. | Area (Square Miles) | Area (ac) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|---|
| **S6** | **0.03** | **21.47** | **5.29** | **9.46** |
| Total Volume Discharging At DCP3 | | | | 9.46 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP3 = | **9.5** | ac-ft |

**4. Volume Discharging At DCP 4**

| Area No. | Area (Square Miles) | Area (ac) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|---|
| **S7** | **0.05** | **32.83** | **5.29** | **14.47** |
| **DA8** | **0.07** | **54.83** | **4.07** | **18.60** |
| Total Volume Discharging At DCP4 | | | | 33.07 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP4 = | **33.1** | ac-ft |

**5. Volume Discharging At DCP5**

| Area No. | Area (Square Miles) | Area (ac) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|---|
| **O4** | **0.06** | **41.33** | **5.29** | **18.2** |
| **O5** | **0.01** | **4.04** | **5.52** | **1.9** |
| **O6** | **0.04** | **25.70** | **5.75** | **12.3** |
| **S3** | **0.04** | **23.39** | **5.29** | **10.3** |
| **P1** | **0.01** | **5.10** | **7.04** | **3.0** |
| **DA5** | **0.02** | **9.74** | **5.52** | **4.5** |
| **DA6** | **0.02** | **15.85** | **4.82** | **6.4** |
| **DA7** | **0.02** | **15.27** | **4.93** | **6.3** |
| **CH1** | **0.06** | **11.25** | **5.57** | **5.2** |
| **CH2** | **0.10** | **10.21** | **5.35** | **4.6** |
| **CH3** | **0.15** | **2.41** | **5.15** | **1.0** |
| Total Volume Discharging At DCP5 | | | | **73.6** |

| | | |
|---|---|---|
| Total Volume Discharging At DCP5 = | **73.6** | ac-ft |

| | | |
|---|---|---|
| **Total Volume Discharging At Permit Boundary =** | **1,978.0** | ac-ft |

# VELOCITY CALCULATIONS

**Required:** Determine the flow velocities entering and exiting the permit boundary using HYDROCALC HYDRAULICS (Version 2.01, 1996-2010) for the flows calculated for the 25-year storm event.

**Method:**
1. Use the flow data to determine velocity of runoff entering the landfill permit boundary.
2. Use the flow data to determine velocity of runoff exiting the landfill permit boundary.

1. Flow Velocity entering the landfill permit boundary

O1

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 261 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 261 | 0.0300 | 0.04 | 4.0 | 5.9 | 10.00 | 1.84 | 7.40 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O2

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 476 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 476 | 0.0355 | 0.04 | 4.9 | 1.6 | 13.01 | 2.35 | 9.82 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O3

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 6011 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 6011 | 0.0090 | 0.04 | 1.8 | 1.8 | 31.00 | 9.85 | 12.53 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O4

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 146 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 146 | 0.0475 | 0.04 | 16.9 | 5.8 | 17.00 | 0.89 | 6.05 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O5

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 24 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 24 | 0.0200 | 0.04 | 17.0 | 21.8 | 77.00 | 0.18 | 1.65 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O6

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 140 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 140 | 0.0500 | 0.04 | 100.0 | 100.0 | 680.00 | 0.11 | 1.88 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

2. Flow Velocity exiting the landfill permit boundary

DCP 1

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 197 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 197 | 0.0800 | 0.04 | 1.7 | 2.9 | 0.00 | 2.67 | 11.99 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

DCP 2

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 4122 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 4122 | 0.0093 | 0.04 | 1.4 | 2.0 | 80.00 | 4.89 | 9.54 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

developed by Dodson and Associates (Version 2.01, 1996-2010)

DCP 3

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 58 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 58 | 0.0300 | 0.04 | 50.2 | 28.0 | 238.00 | 0.14 | 1.72 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

DCP 4

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 355 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 355 | 0.020 | 0.04 | 8.6 | 40.3 | 52.00 | 1.03 | 4.44 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

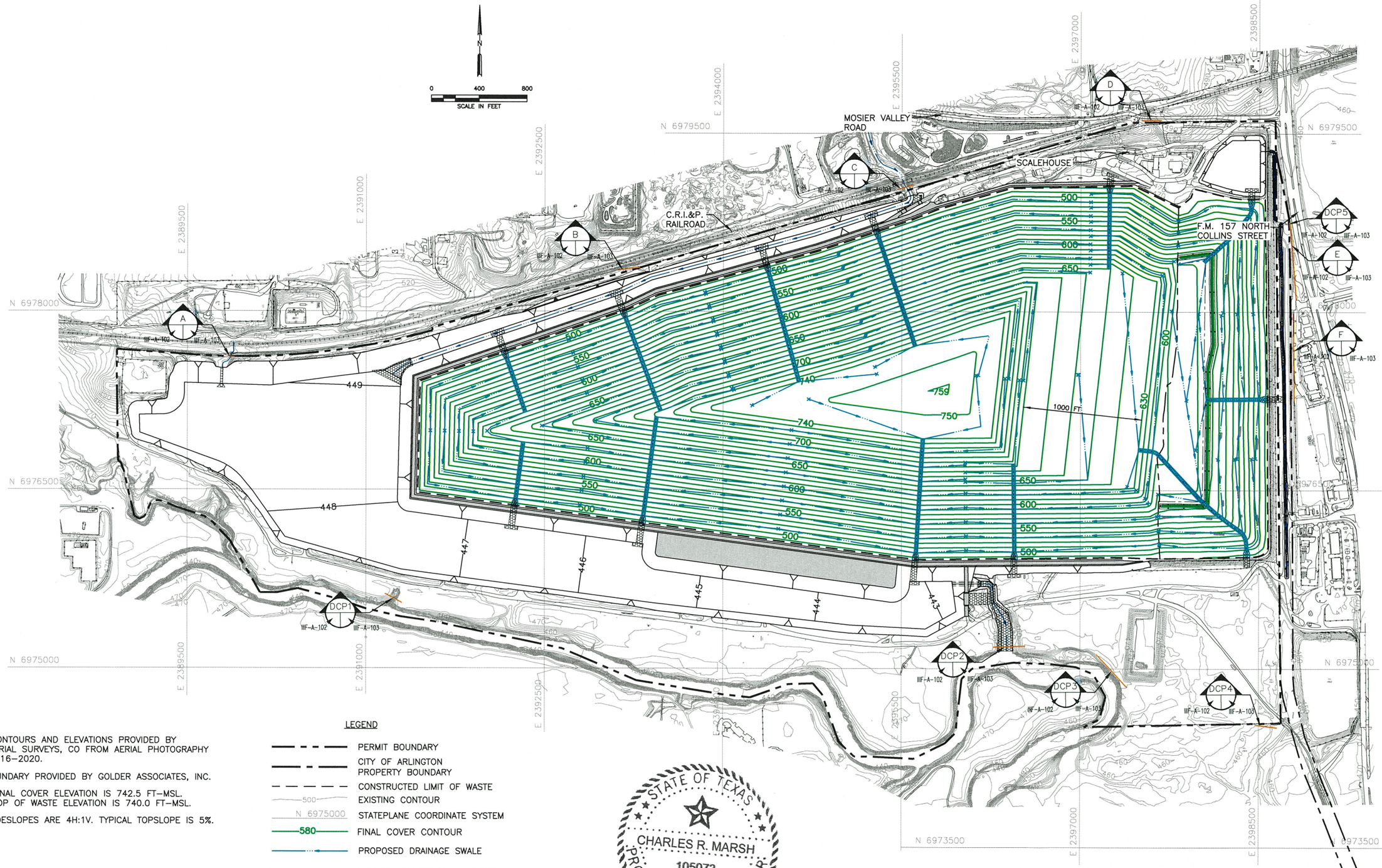
DCP 5

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-A for the offsite areas and are summarized below.

Q25 = 228 cfs

| Storm Year | Flow Rate (cfs) | Culvert Rise (ft) | Culvert Run (ft) | Culvert Length (ft) | Manning's n | Upstream Elevation (ft) | Downstream Elevation (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|---|
| 25 | 228 | 5 | 10 | 178 | 0.016 | 457.00 | 456.90 | 5.00 | 9.02 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)




NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED PROFESSIONAL ENGINEER
05.19.22

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

DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-A-102-SECTIONS.DWG

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

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
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# MAJOR PERMIT AMENDMENT
# POST-PROJECT VELOCITY CALCULATION SECTIONS

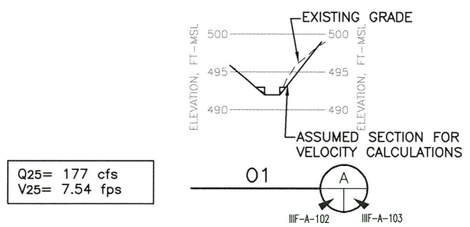
CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIIF-A-102

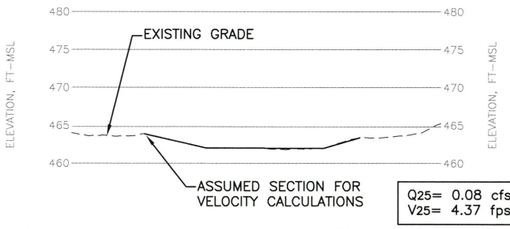
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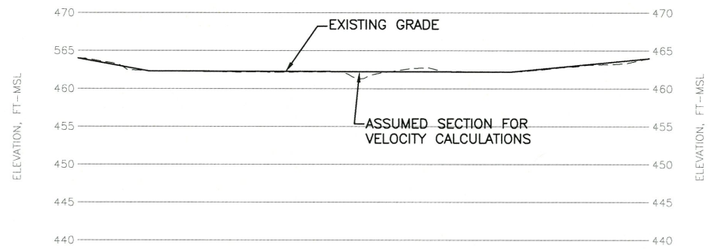

Q25= 177 cfs
V25= 7.54 fps

01 A IIIF-A-102 IIIF-A-103



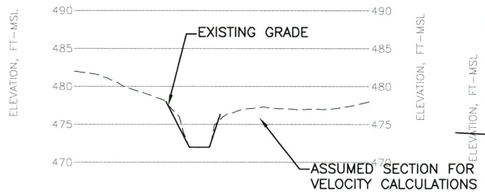

Q25= 0.08 cfs
V25= 4.37 fps

05 E IIIF-A-102 IIIF-A-103



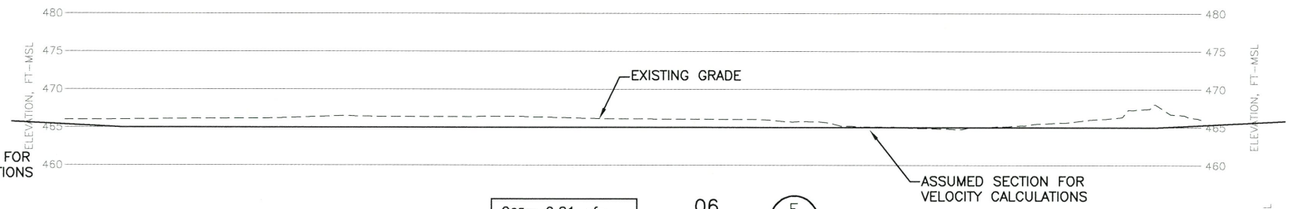

Q25= 0.05 cfs
V25= 2.10 fps

DISCHARGE POINT 3 DP3 IIIF-A-102 IIIF-A-103



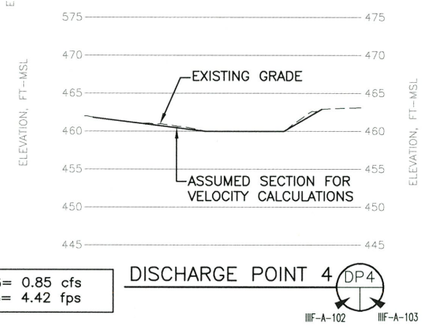

Q25= 0.71 cfs
V25= 6.59 fps

02 B IIIF-A-102 IIIF-A-103



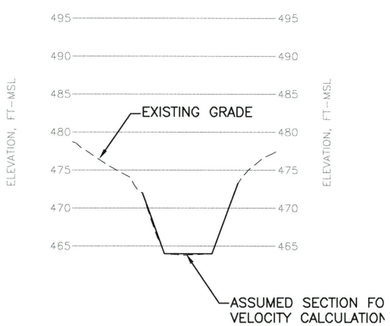

Q25= 0.81 cfs
V25= 6.32 fps

06 F IIIF-A-102 IIIF-A-103



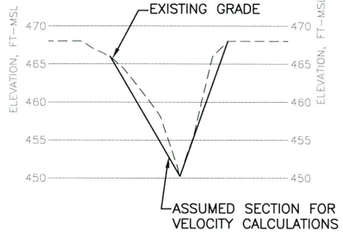

Q25= 0.85 cfs
V25= 4.42 fps

DISCHARGE POINT 4 DP4 IIIF-A-102 IIIF-A-103



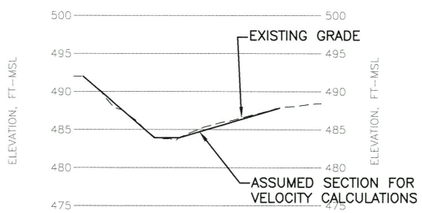

Q25= 4.08 cfs
V25= 17.95 fps

03 C IIIF-A-102 IIIF-A-103



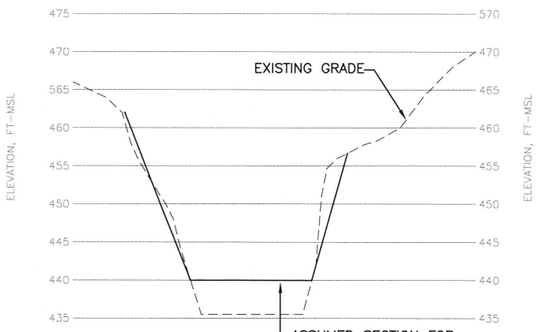

Q25= 1.21 cfs
V25= 10.87 fps

DISCHARGE POINT 1 DP1 IIIF-A-102 IIIF-A-103




Q25= 0.72 cfs
V25= 8.47 fps

04 D IIIF-A-102 IIIF-A-103

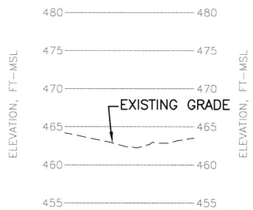



Q25= 6.70 cfs
V25= 4.81 fps

DISCHARGE POINT 2 DP2 IIIF-A-102 IIIF-A-103

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

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05.19.22




Q25= 4.14 cfs
V25= 6.04 fps

DISCHARGE POINT 5 DP5 IIIF-A-102 IIIF-A-103

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☐ ISSUED FOR CONSTRUCTION

DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-A-103-VELOCITY SECTONS.DWG

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

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

REVISIONS

| NO. | DATE | DESCRIPTION |
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# MAJOR PERMIT AMENDMENT
# POST PROJECT VELOCITY SECTIONS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIIF-A-103

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# APPENDIX IIIF-B

# PERIMETER CHANNEL, DETENTION POND, AND CULVERT DESIGN

Includes pages IIIF-B-1 through IIIF-B-22



# CONTENTS


| | |
|---|---|
| Perimeter Channel Design | IIIF-B-1 |
| Channel Erosion Control Design | IIIF-B-6 |
| Detention Pond Design | IIIF-B-7 |
| Culvert Design | IIIF-B-12 |




# PERIMETER CHANNEL DESIGN

Perimeter channels have been designed to contain stormwater runoff from the 25-year frequency storm events. A summary of the design information that is included in this Appendix is listed below.

- Flow rates used for the perimeter channel design were taken from the HEC-HMS analysis included in Appendix IIIF-A.
- Perimeter channel design system information is summarized on Drawing IIIF.4 in Appendix IIIF.
- Channel profiles are presented on Drawings IIIF.5 through IIIF.7 in Appendix IIIF.
- Hydraulic calculations are summarized on pages IIIF-B-2.
- Channel Erosion Control Design information is included on page IIIF-B-6.

| Channel[2] | Station[2] From | Station[2] To | Flow Rate[3] (cfs) | Bottom Slope (ft/ft) | Bottom Width (ft) | Left Side Slope (ft/ft) | Right Side Slope (ft/ft) | Manning's n-Value | Normal Depth (ft) | Flow Vel. (fps) | Froude No. | Vel. Head (ft) | Energy Head (ft) | Flow Area[1] (sq.ft.) | Top width of Flow[1] (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0+00.00 | 14+92.60 | 154.8 | 0.0011 | 10 | 3 | 3 | 0.03 | 3.08 | 2.62 | 0.320 | 0.11 | 3.18 | 59.19 | 28.47 |
| 2 | 14+92.60 | 29+86.06 | 233.8 | 0.0011 | 10 | 3 | 3 | 0.03 | 3.76 | 2.92 | 0.328 | 0.13 | 3.89 | 80.08 | 32.57 |
| 3 | 0+00.00 | 6+04.80 | 81.9 | 0.0008 | 10 | 3 | 3 | 0.03 | 2.42 | 1.96 | 0.264 | 0.06 | 2.48 | 41.83 | 24.54 |

| Channel[4] | Station | 100-Yr Flow Rate (cfs) | Min Chan Elev. (msl-ft) | WSEL (msl-ft) | Flow Depth (ft) | Flow Vel. (fps) | Froude No. | Flow Area (sq.ft.) | Top width of Flow (ft) |
|---|---|---|---|---|---|---|---|---|---|
| CH4 (Relocated Hurricane Creek) | 4230 | 8100.0 | 464.5 | 481.14 | 16.64 | 6.42 | 0.34 | 1967.68 | 399.87 |
| | 4140 | 8100.0 | 463.5 | 477.42 | 13.92 | 14.29 | 0.86 | 567.01 | 66.24 |
| | 4080 | 8100.0 | 462.0 | 478.83 | 16.80 | 4.03 | 0.24 | 2907.08 | 680.36 |
| | 4011 | 8100.0 | 463.0 | 478.57 | 15.58 | 5.57 | 0.30 | 1650.66 | 289.54 |
| | 3971 | 8100.0 | 463.0 | 477.34 | 14.34 | 10.15 | 0.53 | 880.92 | 179.52 |
| | 3811 | 8100.0 | 459.9 | 477.95 | 18.05 | 6.25 | 0.31 | 1294.99 | 100.13 |
| | 3611 | 8100.0 | 460.3 | 477.94 | 17.63 | 6.02 | 0.31 | 1345.36 | 113.58 |
| | 3411 | 8100.0 | 460.7 | 477.90 | 17.17 | 5.97 | 0.31 | 1357.58 | 114.77 |
| | 3211 | 8100.0 | 461.1 | 477.86 | 16.72 | 5.91 | 0.30 | 1369.85 | 115.78 |
| | 3011 | 8100.0 | 461.1 | 477.84 | 16.77 | 5.78 | 0.29 | 1400.55 | 117.03 |
| | 2811 | 8100.0 | 460.67 | 477.82 | 17.15 | 5.60 | 0.28 | 1445.80 | 118.57 |
| | 2611 | 8100.0 | 460.27 | 477.81 | 17.54 | 5.43 | 0.27 | 1492.13 | 120.14 |
| | 2411 | 8100.0 | 459.87 | 477.80 | 17.93 | 5.26 | 0.26 | 1538.93 | 121.69 |
| | 2211 | 8100.0 | 459.47 | 477.78 | 18.31 | 5.11 | 0.25 | 1586.23 | 123.23 |
| | 2011 | 8100.0 | 459.07 | 477.77 | 18.70 | 4.95 | 0.24 | 1634.79 | 124.81 |
| | 1811 | 8100.0 | 459.07 | 477.75 | 18.68 | 4.97 | 0.24 | 1631.36 | 124.70 |
| | 1611 | 8100.0 | 458.26 | 477.80 | 19.54 | 4.19 | 0.20 | 1933.61 | 145.69 |
| | 1411 | 8100.0 | 457.86 | 477.83 | 19.97 | 3.69 | 0.18 | 2194.18 | 169.80 |
| | 1211 | 8100.0 | 457.47 | 477.82 | 20.35 | 3.58 | 0.17 | 2260.91 | 172.15 |
| | 1011 | 8100.0 | 457.07 | 477.82 | 20.75 | 3.48 | 0.17 | 2329.46 | 174.53 |
| | 811 | 8100.0 | 456.67 | 477.82 | 21.15 | 3.38 | 0.16 | 2399.00 | 176.90 |
| | 611 | 8100.0 | 456.27 | 477.81 | 21.54 | 3.28 | 0.16 | 2469.75 | 179.28 |
| | 411 | 8100.0 | 455.87 | 477.81 | 21.94 | 3.19 | 0.15 | 2541.39 | 181.67 |
| | 211 | 8100.0 | 455.47 | 477.81 | 22.34 | 3.10 | 0.14 | 2614.00 | 184.05 |
| | 11 | 8100.0 | 455.07 | 477.80 | 22.73 | 3.01 | 0.14 | 2687.29 | 186.42 |
| | -189 | 8100.0 | 454.67 | 477.80 | 23.13 | 2.93 | 0.14 | 2761.81 | 188.79 |
| | -389 | 8100.0 | 454.27 | 477.80 | 23.53 | 2.85 | 0.13 | 2837.17 | 191.16 |
| | -589 | 8100.0 | 449.06 | 477.87 | 28.81 | 1.19 | 0.05 | 6815.14 | 350.44 |

Note:
1) Calculations were performed using the HYDROCALC HYDRAULIC FOR WINDOWS Computer Program developed by Dodson and Associates (Version 2.0.1, 1996-2010).
2) Refer to Drawing IIIF.4 for channel locations.
3) Flow rates shown are the peak flow rates obtained from the HEC-HMS model. See HEC-HMS Output-Post Project Conditions in Appendix IIIF-A.

**Example Calculation:** Calculate the normal depth for Channel 1 between stations 0+00.00 and 14+92.60

List of Symbols

$Q_d$ = peak flow rate for channel, cfs - obtained from HEC-HMS Analysis (Appendix IIIF-A)
R = hydraulic radius, ft
n = Manning's roughness coefficient
S = channel slope, ft/ft
b = bottom width of channel, ft
z = z-ratio (ratio of run to rise for channel sideslope)
$A_f$ = flow area, sf
g = gravitational acceleration = 32.2 $ft/s^2$
T = top width of flow, ft
d = normal depth of channel, ft

The program uses an iterative process to calculate the normal depth of the channel to satisfy Manning's Equation

$$Q = \frac{1.486}{n} A R^{0.67} S^{0.5}$$

Design Inputs:

| | | |
|---|---|---|
| $Q_d$ = | 154.8 | cfs (for Channel D including Area A11) |
| S = | 0.0011 | ft/ft |
| b = | 10 | ft |
| z = | 3 | (H) : 1 (V) |
| n = | 0.03 | |

Step 1 - Based on the geometry of the channel cross-section, solve for R and $A_f$

$$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{0.5}}$$

$$A_f = bd + zd^2$$

assume: d = 3.08 ft

R = 2.010 ft

$A_f$ = 59.19 sf

solve for Q: Q = 155

if Q is not equal to $Q_d$, select a new d and repeat calculations

Step 2 - solve for velocity, T, Froude number, velocity head, and energy head

$Q = VA \Rightarrow \quad V = Q/A$

$V = \quad 2.62$ ft/s

$T = b + 2(z \times d)$

$T = \quad 28.47$ ft

$$F_r = \frac{V}{(gA/T)^{0.5}}$$

$F_r = \quad 0.320$

$$\text{Velocity Head} = \frac{V^2}{2g}$$

Velocity Head = 0.11 ft

Energy Head = water elevation + velocity head

Energy Head = 3.18 ft

HEC-RAS Plan: POST River: HurricaneCreek Reach: HC-1 Profile: 100 YEAR

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| HC-1 | 19950 | 100 YEAR | 4000.00 | 531.80 | 549.19 | | 549.28 | 0.000516 | 2.85 | 2187.25 | 355.19 | 0.14 |
| HC-1 | 19900 | 100 YEAR | 4000.00 | 531.00 | 548.60 | 538.41 | 549.14 | 0.002092 | 5.89 | 679.07 | 372.61 | 0.25 |
| HC-1 | 19580 | | Bridge | | | | | | | | | |
| HC-1 | 19390 | 100 YEAR | 4000.00 | 529.60 | 545.17 | 536.51 | 545.32 | 0.000979 | 3.35 | 1493.11 | 330.66 | 0.16 |
| HC-1 | 19320 | 100 YEAR | 4000.00 | 529.60 | 544.99 | 536.50 | 545.23 | 0.001391 | 3.95 | 1011.98 | 303.01 | 0.20 |
| HC-1 | 19200 | | Bridge | | | | | | | | | |
| HC-1 | 19130 | 100 YEAR | 4000.00 | 526.00 | 541.95 | 534.55 | 542.11 | 0.001308 | 3.78 | 1643.15 | 320.10 | 0.18 |
| HC-1 | 19090 | 100 YEAR | 4000.00 | 526.00 | 541.89 | | 542.05 | 0.001341 | 3.82 | 1625.20 | 317.93 | 0.19 |
| HC-1 | 18360 | 100 YEAR | 4000.00 | 524.00 | 541.44 | | 541.47 | 0.000469 | 2.01 | 3016.34 | 485.33 | 0.10 |
| HC-1 | 17890 | 100 YEAR | 4000.00 | 520.00 | 539.33 | 532.03 | 540.78 | 0.007086 | 9.65 | 414.60 | 399.22 | 0.42 |
| HC-1 | 17850 | | Bridge | | | | | | | | | |
| HC-1 | 17770 | 100 YEAR | 4000.00 | 519.00 | 534.00 | 531.03 | 534.39 | 0.004751 | 6.46 | 979.37 | 213.74 | 0.33 |
| HC-1 | 17730 | 100 YEAR | 4000.00 | 519.50 | 533.86 | | 534.15 | 0.004888 | 6.35 | 1155.04 | 318.64 | 0.32 |
| HC-1 | 17620 | 100 YEAR | 4000.00 | 518.50 | 533.50 | | 533.69 | 0.003158 | 5.28 | 1364.67 | 332.28 | 0.26 |
| HC-1 | 16900 | 100 YEAR | 4000.00 | 513.20 | 528.11 | 524.31 | 529.68 | 0.010976 | 10.04 | 398.38 | 274.13 | 0.53 |
| HC-1 | 16760 | | Bridge | | | | | | | | | |
| HC-1 | 16670 | 100 YEAR | 4000.00 | 513.60 | 526.52 | 519.99 | 526.91 | 0.002990 | 5.24 | 886.98 | 160.01 | 0.28 |
| HC-1 | 16620 | 100 YEAR | 4000.00 | 513.60 | 526.35 | | 526.75 | 0.003188 | 5.35 | 859.73 | 151.29 | 0.29 |
| HC-1 | 16020 | 100 YEAR | 4000.00 | 511.50 | 522.75 | 521.85 | 523.54 | 0.010698 | 8.03 | 764.99 | 382.33 | 0.51 |
| HC-1 | 15920 | 100 YEAR | 3100.00 | 511.00 | 519.72 | 519.28 | 521.96 | 0.022709 | 12.00 | 258.32 | 46.87 | 0.90 |
| HC-1 | 15630 | 100 YEAR | 3100.00 | 509.50 | 519.28 | 516.80 | 520.53 | 0.001557 | 8.98 | 345.24 | 86.06 | 0.57 |
| HC-1 | 15580 | | Bridge | | | | | | | | | |
| HC-1 | 15550 | 100 YEAR | 3100.00 | 509.50 | 518.66 | 516.04 | 519.97 | 0.001277 | 9.18 | 338.88 | 50.58 | 0.58 |
| HC-1 | 15530 | 100 YEAR | 3100.00 | 509.50 | 518.71 | | 519.86 | 0.001412 | 8.61 | 361.30 | 69.87 | 0.64 |
| HC-1 | 14890 | 100 YEAR | 3100.00 | 505.70 | 515.24 | 514.93 | 518.00 | 0.003689 | 13.33 | 232.52 | 38.15 | 0.94 |
| HC-1 | 14740 | 100 YEAR | 3100.00 | 505.00 | 515.88 | | 516.85 | 0.000978 | 8.01 | 504.04 | 192.32 | 0.54 |
| HC-1 | 14540 | 100 YEAR | 4300.00 | 504.40 | 515.76 | | 516.63 | 0.000792 | 8.31 | 1092.08 | 344.31 | 0.51 |
| HC-1 | 14260 | 100 YEAR | 4300.00 | 501.90 | 515.96 | | 516.21 | 0.000264 | 4.88 | 2178.04 | 526.75 | 0.25 |
| HC-1 | 14000 | 100 YEAR | 4300.00 | 500.50 | 515.96 | | 516.02 | 0.000514 | 2.80 | 3013.99 | 690.14 | 0.15 |
| HC-1 | 13450 | 100 YEAR | 4300.00 | 498.30 | 515.64 | | 515.73 | 0.000534 | 3.17 | 2450.17 | 469.77 | 0.16 |
| HC-1 | 13180 | 100 YEAR | 4300.00 | 497.30 | 514.80 | 507.07 | 515.51 | 0.000626 | 6.79 | 633.52 | 803.28 | 0.32 |
| HC-1 | 13130 | | Bridge | | | | | | | | | |
| HC-1 | 13030 | 100 YEAR | 4300.00 | 497.00 | 510.86 | 508.37 | 511.07 | 0.000442 | 4.63 | 1527.38 | 470.83 | 0.25 |
| HC-1 | 12980 | 100 YEAR | 4300.00 | 497.00 | 510.58 | | 510.97 | 0.002675 | 6.10 | 1395.40 | 454.71 | 0.34 |
| HC-1 | 11790 | 100 YEAR | 6600.00 | 491.90 | 504.98 | | 505.88 | 0.006107 | 9.19 | 1246.66 | 299.42 | 0.51 |
| HC-1 | 9930 | 100 YEAR | 6600.00 | 485.70 | 500.21 | | 500.46 | 0.002218 | 6.35 | 2747.61 | 744.85 | 0.31 |
| HC-1 | 9870 | 100 YEAR | 6600.00 | 485.40 | 500.13 | 498.56 | 500.37 | 0.001093 | 5.08 | 1883.18 | 630.61 | 0.27 |
| HC-1 | 9840 | | Bridge | | | | | | | | | |

HEC-RAS Plan: POST River: HurricaneCreek Reach: HC-1 Profile: 100 YEAR (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| HC-1 | 9790 | 100 YEAR | 6600.00 | 485.70 | 499.79 | | 500.07 | 0.003394 | 6.50 | 2445.76 | 708.35 | 0.32 |
| HC-1 | 7800 | 100 YEAR | 6600.00 | 477.20 | 492.03 | | 492.55 | 0.005066 | 6.94 | 1607.20 | 419.77 | 0.39 |
| HC-1 | 6000 | 100 YEAR | 8100.00 | 470.10 | 486.12 | | 486.54 | 0.002717 | 7.12 | 2358.61 | 474.71 | 0.38 |
| HC-1 | 5120 | 100 YEAR | 8100.00 | 469.60 | 483.11 | | 483.69 | 0.003887 | 8.51 | 2054.86 | 419.27 | 0.45 |
| HC-1 | 5010 | 100 YEAR | 8100.00 | 468.10 | 482.99 | | 483.34 | 0.001755 | 3.47 | 1759.84 | 397.01 | 0.16 |
| HC-1 | 4970 | 100 YEAR | 8100.00 | 469.60 | 482.63 | | 483.18 | 0.004285 | 8.57 | 2030.11 | 413.20 | 0.48 |
| HC-1 | 4230 | 100 YEAR | 8100.00 | 464.50 | 481.14 | | 481.66 | 0.001969 | 6.42 | 1967.68 | 399.87 | 0.34 |
| HC-1 | 4140 | 100 YEAR | 8100.00 | 463.50 | 477.42 | 476.36 | 480.59 | 0.052387 | 14.29 | 567.01 | 66.24 | 0.86 |
| HC-1 | 4080 | 100 YEAR | 8100.00 | 462.03 | 478.83 | | 479.06 | 0.000267 | 4.03 | 2907.08 | 680.36 | 0.24 |
| HC-1 | 4011 | 100 YEAR | 8100.00 | 462.99 | 478.57 | | 479.03 | 0.000208 | 5.57 | 1650.66 | 289.54 | 0.30 |
| HC-1 | 3971 | 100 YEAR | 8100.00 | 463.00 | 477.34 | | 478.90 | 0.000707 | 10.15 | 880.92 | 179.52 | 0.53 |
| HC-1 | 3811 | 100 YEAR | 8100.00 | 459.90 | 477.95 | | 478.56 | 0.000220 | 6.25 | 1294.99 | 100.13 | 0.31 |
| HC-1 | 3611 | 100 YEAR | 8100.00 | 460.31 | 477.94 | | 478.50 | 0.000221 | 6.02 | 1345.36 | 113.58 | 0.31 |
| HC-1 | 3411 | 100 YEAR | 8100.00 | 460.73 | 477.90 | | 478.45 | 0.000216 | 5.97 | 1357.58 | 114.77 | 0.31 |
| HC-1 | 3211 | 100 YEAR | 8100.00 | 461.14 | 477.86 | | 478.41 | 0.000212 | 5.91 | 1369.85 | 115.78 | 0.30 |
| HC-1 | 3011 | 100 YEAR | 8100.00 | 461.07 | 477.84 | | 478.36 | 0.000199 | 5.78 | 1400.55 | 117.03 | 0.29 |
| HC-1 | 2811 | 100 YEAR | 8100.00 | 460.67 | 477.82 | | 478.31 | 0.000183 | 5.60 | 1445.80 | 118.57 | 0.28 |
| HC-1 | 2611 | 100 YEAR | 8100.00 | 460.27 | 477.81 | | 478.27 | 0.000167 | 5.43 | 1492.13 | 120.14 | 0.27 |
| HC-1 | 2411 | 100 YEAR | 8100.00 | 459.87 | 477.80 | | 478.23 | 0.000154 | 5.26 | 1538.93 | 121.69 | 0.26 |
| HC-1 | 2211 | 100 YEAR | 8100.00 | 459.47 | 477.78 | | 478.19 | 0.000142 | 5.11 | 1586.23 | 123.23 | 0.25 |
| HC-1 | 2011 | 100 YEAR | 8100.00 | 459.07 | 477.77 | | 478.15 | 0.000130 | 4.95 | 1634.79 | 124.81 | 0.24 |
| HC-1 | 1811 | 100 YEAR | 8100.00 | 459.07 | 477.75 | | 478.13 | 0.000131 | 4.97 | 1631.36 | 124.70 | 0.24 |
| HC-1 | 1611 | 100 YEAR | 8100.00 | 458.26 | 477.80 | | 478.07 | 0.000088 | 4.19 | 1933.61 | 145.69 | 0.20 |
| HC-1 | 1411 | 100 YEAR | 8100.00 | 457.86 | 477.83 | | 478.04 | 0.000069 | 3.69 | 2194.18 | 169.80 | 0.18 |
| HC-1 | 1211 | 100 YEAR | 8100.00 | 457.47 | 477.82 | | 478.02 | 0.000064 | 3.58 | 2260.91 | 172.15 | 0.17 |
| HC-1 | 1011 | 100 YEAR | 8100.00 | 457.07 | 477.82 | | 478.01 | 0.000059 | 3.48 | 2329.46 | 174.53 | 0.17 |
| HC-1 | 811 | 100 YEAR | 8100.00 | 456.67 | 477.82 | | 477.99 | 0.000054 | 3.38 | 2399.00 | 176.90 | 0.16 |
| HC-1 | 611 | 100 YEAR | 8100.00 | 456.27 | 477.81 | | 477.98 | 0.000050 | 3.28 | 2469.75 | 179.28 | 0.16 |
| HC-1 | 411 | 100 YEAR | 8100.00 | 455.87 | 477.81 | | 477.97 | 0.000047 | 3.19 | 2541.39 | 181.67 | 0.15 |
| HC-1 | 211 | 100 YEAR | 8100.00 | 455.47 | 477.81 | | 477.96 | 0.000043 | 3.10 | 2614.00 | 184.05 | 0.14 |
| HC-1 | 11 | 100 YEAR | 8100.00 | 455.07 | 477.80 | | 477.94 | 0.000040 | 3.01 | 2687.29 | 186.42 | 0.14 |
| HC-1 | -189 | 100 YEAR | 8100.00 | 454.67 | 477.80 | | 477.93 | 0.000037 | 2.93 | 2761.81 | 188.79 | 0.14 |
| HC-1 | -389 | 100 YEAR | 8100.00 | 454.27 | 477.80 | | 477.93 | 0.000035 | 2.85 | 2837.17 | 191.16 | 0.13 |
| HC-1 | -589 | 100 YEAR | 8100.00 | 449.06 | 477.87 | 454.24 | 477.89 | 0.000005 | 1.19 | 6815.14 | 350.44 | 0.05 |

HEC-RAS Plan: POST 10,50,100 River: West Fork Reach: wf3J Profile: 100 YEAR (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| wf3J | 154404 | 100 YEAR | 78000.00 | 447.00 | 485.43 | 483.48 | 486.06 | 0.002153 | 8.59 | 21599.27 | 4702.33 | 0.33 |
| wf3J | 154403 | 100 YEAR | 78000.00 | 446.00 | 485.69 | 476.43 | 485.95 | 0.000895 | 5.86 | 30175.59 | 4883.13 | 0.23 |
| wf3J | 154301 | 100 YEAR | 78000.00 | 446.00 | 485.58 | 476.43 | 485.86 | 0.000935 | 5.97 | 29653.51 | 4878.66 | 0.23 |
| wf3J | 153293 | 100 YEAR | 78000.00 | 445.00 | 485.01 | 479.76 | 485.14 | 0.000470 | 4.64 | 37371.34 | 5720.27 | 0.17 |
| wf3J | 151932 | 100 YEAR | 78000.00 | 444.50 | 483.89 | 481.80 | 484.32 | 0.001379 | 7.75 | 35602.21 | 7642.58 | 0.31 |
| wf3J | 151136 | 100 YEAR | 78000.00 | 444.00 | 482.69 | 479.56 | 483.22 | 0.001320 | 8.20 | 32611.04 | 7586.46 | 0.31 |
| wf3J | 150374 | 100 YEAR | 78000.00 | 443.50 | 482.01 | 478.26 | 482.46 | 0.001119 | 7.97 | 35819.88 | 8196.89 | 0.28 |
| wf3J | 149202 | 100 YEAR | 78000.00 | 443.20 | 479.79 | 478.77 | 480.76 | 0.003603 | 10.23 | 20571.67 | 5077.10 | 0.48 |
| wf3J | 148663 | 100 YEAR | 78000.00 | 443.40 | 480.06 | 474.03 | 480.12 | 0.000297 | 3.65 | 53312.75 | 8595.33 | 0.14 |
| wf3J | 148106 | 100 YEAR | 78000.00 | 443.50 | 479.89 | 473.19 | 479.92 | 0.000187 | 2.75 | 60509.55 | 8764.11 | 0.11 |
| wf3J | 147512 | 100 YEAR | 78000.00 | 442.50 | 479.79 | 472.51 | 479.81 | 0.000102 | 2.07 | 77005.53 | 9681.79 | 0.08 |
| wf3J | 144480 | 100 YEAR | 78000.00 | 442.00 | 479.66 | 472.41 | 479.68 | 0.000119 | 1.94 | 74196.77 | 10336.74 | 0.09 |
| wf3J | 142669 | 100 YEAR | 78000.00 | 440.50 | 479.57 | 472.20 | 479.59 | 0.000092 | 1.94 | 75053.22 | 10387.52 | 0.07 |
| wf3J | 140885 | 100 YEAR | 94900.00 | 440.50 | 479.45 | 472.81 | 479.48 | 0.000128 | 2.55 | 74073.87 | 8025.70 | 0.09 |
| wf3J | 138208 | 100 YEAR | 94900.00 | 439.00 | 479.27 | 471.01 | 479.31 | 0.000119 | 2.80 | 68585.98 | 6676.35 | 0.09 |
| wf3J | 136930 | 100 YEAR | 94900.00 | 439.50 | 479.19 | 470.01 | 479.22 | 0.000130 | 2.38 | 74606.09 | 6759.50 | 0.09 |
| wf3J | 133499 | 100 YEAR | 94900.00 | 440.00 | 478.86 | 472.20 | 478.94 | 0.000236 | 3.60 | 60516.43 | 7296.24 | 0.13 |
| wf3J | 133413 | 100 YEAR | 91000.00 | 440.00 | 478.85 | 471.95 | 478.91 | 0.000235 | 3.26 | 60426.47 | 7296.08 | 0.12 |
| wf3J | 133412 | 100 YEAR | 91000.00 | 440.00 | 478.81 | 473.77 | 478.91 | 0.000459 | 4.08 | 48651.85 | 7177.95 | 0.16 |
| wf3J | 133391 | | Bridge | | | | | | | | | |
| wf3J | 133370 | 100 YEAR | 91000.00 | 440.00 | 478.77 | 473.77 | 478.87 | 0.000466 | 4.11 | 48366.72 | 7173.95 | 0.16 |
| wf3J | 133369 | 100 YEAR | 91000.00 | 441.00 | 478.81 | 470.88 | 478.85 | 0.000209 | 2.80 | 65037.80 | 7576.50 | 0.11 |
| wf3J | 133290 | 100 YEAR | 91000.00 | 441.00 | 478.79 | 470.88 | 478.84 | 0.000210 | 2.80 | 64910.64 | 7576.39 | 0.11 |
| wf3J | 131467 | 100 YEAR | 91000.00 | 441.00 | 478.60 | 471.69 | 478.67 | 0.000253 | 3.88 | 60812.46 | 7002.33 | 0.14 |
| wf3J | 130918 | 100 YEAR | 91000.00 | 441.00 | 478.53 | 471.37 | 478.62 | 0.000257 | 4.24 | 58035.54 | 6292.16 | 0.14 |
| wf3J | 130407 | 100 YEAR | 91000.00 | 441.00 | 478.49 | 471.48 | 478.57 | 0.000305 | 3.88 | 56426.83 | 6294.67 | 0.14 |
| wf3J | 127989 | 100 YEAR | 91000.00 | 438.00 | 478.38 | 469.06 | 478.41 | 0.000107 | 2.69 | 84352.24 | 7300.55 | 0.09 |
| wf3J | 127889 | 100 YEAR | 91000.00 | 436.00 | 478.37 | 469.84 | 478.40 | 0.000132 | 2.49 | 78491.51 | 7040.85 | 0.08 |
| wf3J | 127888 | 100 YEAR | 91000.00 | 436.00 | 478.37 | 469.84 | 478.40 | 0.000132 | 2.49 | 78490.64 | 7040.83 | 0.08 |
| wf3J | 127880.5 | | Bridge | | | | | | | | | |
| wf3J | 127873 | 100 YEAR | 91000.00 | 436.00 | 478.37 | 469.84 | 478.39 | 0.000132 | 2.49 | 78456.27 | 7040.08 | 0.08 |
| wf3J | 127872 | 100 YEAR | 91000.00 | 436.00 | 478.36 | 470.20 | 478.39 | 0.000133 | 2.58 | 78158.63 | 7039.63 | 0.09 |
| wf3J | 127781 | 100 YEAR | 91000.00 | 437.00 | 478.36 | 462.38 | 478.39 | 0.000071 | 2.10 | 90684.17 | 7258.45 | 0.07 |
| wf3J | 126400 | 100 YEAR | 91000.00 | 435.00 | 478.27 | 469.80 | 478.31 | 0.000134 | 2.99 | 72886.36 | 5894.53 | 0.10 |
| wf3J | 125562 | 100 YEAR | 91000.00 | 430.00 | 477.96 | 471.14 | 478.11 | 0.000338 | 5.18 | 48236.46 | 4473.18 | 0.16 |
| wf3J | 125016 | 100 YEAR | 91000.00 | 430.00 | 477.93 | 470.50 | 477.98 | 0.000123 | 3.10 | 67116.75 | 4700.30 | 0.10 |
| wf3J | 123744 | 100 YEAR | 93100.00 | 432.50 | 477.87 | 464.60 | 477.89 | 0.000060 | 2.16 | 83463.98 | 4512.54 | 0.07 |
| wf3J | 122858 | 100 YEAR | 93100.00 | 435.00 | 477.70 | 469.69 | 477.79 | 0.000228 | 3.78 | 53150.26 | 3210.34 | 0.13 |

HEC-RAS Plan: POST 10,50,100 River: West Fork Reach: wf3J Profile: 100 YEAR (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| wf3J | 122304 | 100 YEAR | 93100.00 | 434.90 | 477.57 | 469.20 | 477.66 | 0.000239 | 3.58 | 51446.07 | 3082.80 | 0.13 |
| wf3J | 121401 | 100 YEAR | 93100.00 | 434.80 | 477.31 | 470.00 | 477.43 | 0.000269 | 4.42 | 47431.79 | 3007.94 | 0.14 |
| wf3J | 120930 | 100 YEAR | 93100.00 | 432.00 | 477.06 | 470.00 | 477.26 | 0.000474 | 5.48 | 37969.57 | 2626.41 | 0.18 |
| wf3J | 120428 | 100 YEAR | 93100.00 | 431.00 | 476.83 | 464.86 | 477.02 | 0.000427 | 5.08 | 39237.13 | 2759.81 | 0.16 |
| wf3J | 119740 | 100 YEAR | 93100.00 | 431.00 | 476.61 | 467.03 | 476.76 | 0.000315 | 4.48 | 33202.37 | 2274.85 | 0.14 |
| wf3J | 118369 | 100 YEAR | 93100.00 | 433.00 | 476.16 | 468.01 | 476.35 | 0.000522 | 5.29 | 34444.03 | 2311.49 | 0.17 |
| wf3J | 117965 | 100 YEAR | 93100.00 | 432.65 | 475.95 | 467.66 | 476.13 | 0.000493 | 5.16 | 35270.71 | 2357.23 | 0.16 |
| wf3J | 117831 | | Culvert | | | | | | | | | |
| wf3J | 117707 | 100 YEAR | 93100.00 | 432.43 | 475.88 | 464.54 | 476.04 | 0.000417 | 5.03 | 47483.28 | 4161.76 | 0.16 |
| wf3J | 116053 | 100 YEAR | 92200.00 | 431.00 | 475.05 | 468.90 | 475.38 | 0.000712 | 6.66 | 37585.87 | 3599.98 | 0.21 |
| wf3J | 112574 | 100 YEAR | 92200.00 | 429.00 | 471.75 | 462.97 | 472.83 | 0.001793 | 10.36 | 21710.20 | 3715.40 | 0.36 |

# CHANNEL EROSION CONTROL DESIGN

Channel erosion controls have been designed for flow velocities resulted from the 25-year frequency flow rates. As shown on pages IIIF-B-2, 25-year velocities in the perimeter channels range from 1.96 ft/s to 2.92 ft/s. 100-year flow velocities in the relocated Hurricane Creek range from 1.19 ft/s to 14.29 ft/s within the permit boundary as shown in the CLOMR (see Pages IIIF-B-5 and IIIF-B-6). The channel lining needed to protect against erosive velocities is shown on Drawings IIIF.4 through IIIF.7 in Appendix IIIF. All channels and drainage features will be inspected and maintained in accordance with the Site Operating Plan.

The following was used to select the type of channel lining material.

- Vegetation – used in all areas where velocities are less than 5 ft/s for channels.
- Turf reinforcement matting – used in channels for velocities between 5 ft/s and 13 ft/s. Please refer to page IIIF-B-10 for more information.
- 2-foot-thick Gabions, Flexamat, or FML – used at chute discharges in channels, areas in channels where flow velocities exceed 13 ft/s, and detention ponds (see Appendix IIIF-C – Final Cover Erosion Control Structure Design). Please refer to pages IIIF-B-11 and IIIF-B-12 for more information.

Channel lining details are presented on Drawing IIIF.8 in Appendix IIIF.

- Erosion control for the relocated alignment of Hurricane Creek (Channel 4) is based on the 100-year velocities included in the proposed CLOMR developed for the proposed landfill expansion.

# TECHNICAL DATA SHEET

## MACMAT® NC10

### Composite Turf Reinforcement Mat

MacMat® NC10 provides immediate erosion protection to prevent soil loss and creates the optimum micro-environment to enhance seed germination and plant emergence. The inclusion of the specially formulated MacMat® component, with its 95% open structure, adds the best permanent protection available. The biodegradable component of MacMat® NC10 is designed to create the right environment to enhance seed germination by insulating the seed bed, while absorbing and retaining optimal moisture.

| Technical Data | | | | |
|---|---|---|---|---|
| **Physical Properties** | **Property** | **Roll Value (MD)** | | **Test Method** |
| | Tensile Strength | 150 lbs/ft (2189 N/m²) | | ASTM D 5035 (modified) |
| | Thickness | 0.4 in (10 mm) | | ASTM D 5199 |
| | Mass Unit/Area | 15.0 oz/yd² (.508 kg/m²) | | ASTM D 5261 |
| | UV Stability | 80% (strength retained) | | ASTM D G53/D4355 ASATM D 5035 (modified) |
| | Resiliency | 80% (thickness retained) | | ASTM D 6524 |
| | Sediment Trapping Capacity | 376 in³/yd² (7367 cm³/m²) | | Calculated |
| **Performance Properties** | **Property** | **Roll Value** | | **Test Method** |
| | | Unvegetated | Vegetated* | |
| | Permissible Velocity-30 min | 13.0 ft/s (3.96 m/s) | 19.0 ft/s (5.79 m/s) | Large Scale Flume Test[1] |
| | Permissible Velocity-50 hr | 7.0 ft/s (2.13 m/s) | 14.0 ft/s (4.26 m/s) | Large Scale Flume Test[1] |
| | Permissible Shear-30 min | 3.1 lbs/ft² (.148 kN/m²) | 10.0 lbs/ft² (.478 kN/m²) | Large Scale Flume Test[1] |
| | Permissible Shear-50 hr | 2.2 lbs/ft² (.105 kN/m²) | 8.0 lbs/ft² (.383 kN/m²) | Large Scale Flume Test[1] |
| | *Vegetated data extrapolated from actual test data with historically predictable results.<br>[1]Flume test performed at independent laboratory-data and details available upon request. | | | |
| **Index Properties** | **Property** | **Roll Value (MD)** | | **Test Method** |
| | "Benchscale" Shear (unvegetated) | >5 lbs/ft² (.239 kN/m²) | | ECTC TM #3 |
| | Water Absorption | 400% | | ECTC Modified |

Seller makes no warranty, express or implied, concerning the product furnished hereunder other than at the time of delivery it shall be of the quality and specifications stated herein. *ANY IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS EXPRESSLY EXCLUDED AND, TO THE EXTENT THAT IT IS CONTRARY TO THE FOREGOING SENTENCE, ANY IMPLIED WARRANTY OF MERCHANTABILITY IS EXPRESSLY EXCLUDED.* Any recommendations made by the Seller concerning uses or applications of said product are believed reliable, and Seller makes no warranty of results to be obtained. The technical information supplied for this product type is subject to change at any time without notice.

This Data Sheet supersedes all previous Data Sheets for this style and is subject to change without notice.

MMAT-NC10 8/2006

| Type | Thickness m ft | Size mm | dm m ft | velocity m/s ft/sec | velocity m/s ft/sec |
|---|---|---|---|---|---|
| Reno mattress | 0.15 - 0.17 | 70 - 100 | 0.085 | 3.5 | 4.2 |
| | | 70 - 150 | 0.110 | 4.2 | 4.5 |
| | 0.23 - 0.25 | 70 - 100 | 0.085 | 3.6 | 5.5 |
| | | 70 - 150 | 0.120 | 4.5 | 6.1 |
| | 0.30 | 70 - 120 | 0.105 | 4.2 | 5.5 |
| | | 100 - 150 | 0.125 | 5.0 | 6.4 |
| Gabions | 0.50 1.64 | 100 - 200 | 0.150 0.49 | 5.8 19 | 7.6 25 |
| | | 120 - 250 | 0.190 0.62 | 6.4 21 | 8.0 26 |

Where the revetment has to be placed under water the thickness of the Reno mattress remains the same since it can be launched from a pontoon whereas rip rap has to be increased by 50% [12, 13, 49, 50, 51].

The big reduction in the revetment thickness, which is achieved using Reno mattress instead of rip rap, is of economic significance in protection projects in large rivers, given the same area of work, and, therefore, the quantity of material used.

## 2.2 Semi permeable and impermeable linings with sand asphalt mastic.

a) General characteristics of sand asphalt mastic grouted Reno mattress.

The combination of the stone filled Reno mattress and sand asphalt mastic has the characteristics of both gabion work and asphalt concrete. The addition of bituminous mastic to the Reno mattress produces a structure which combines the properties and performances of both materials. The mattress retains its flexibility, while the density of the filling is increased and therefore the efficiency of the protection. If all the voids between the stones in the layer are filled and the surface of the mattress covered, the lining will be completely impervious. The mastic also protects the wire mesh against corrosion and from abrasion by transported material.

The wire mesh reinforces the grouted stone layer and gives it strength in tension. Hence, the thickness of the combined structure can be considerably less than that of ordinary mastic grouted stone to withstand the same stresses. The resulting saving in bitumen and aggregate, and the increased flexibility due to the reduced thickness, have given rise to extensive use of this type of lining for protection in a variety of waterways.

b) Mix design of sand asphalt mastic.

To avoid excessive detail, only the fundamental data on mix design is given here. For fuller information, reference should be made to the specific publications listed in the bibliography [5, 6].

# Flexamat® Specifications

- Flexamat Standard Specification
- Flexamat Plus Specification
- Flexamat 10NW Specification

### Arid Applications

- Flexamat Plus UV-T Specification
- Flexamat 10NW UV-T Specification



| PROPERTY | DESCRIPTION |
|---|---|
| Mat Width & Length | Manufactured in standard widths of 4', 5.5', 8', 10', 12, 15.5' & 16'. Lengths can be cut to order per project requirements. Stocked lengths are 30', 40', & 50'. 4' x 4' mats stacked on pallets are also available. |
| Underlayment Options | Flexamat® Standard - a three-layered system, includes, in order from top to bottom, 1) Concrete block mat 2) 5-Pick Leno Weave and 3) Curlex® II. Flexamat® Plus - A four-layered system includes, in order from top to bottom, 1) Concrete block mat 2) 5-Pick Leno Weave 3) Recyclex TRM-V and 4) Curlex® II. Flexamat® 10NW - A two-layered system, includes, 1) Concrete block mat 2) 10oz. non-woven geotextile cast onto the back of the blocks, adhered to the concrete block. |
| Weight per Square Foot | 10 lbs per square foot |
| Block Size | The concrete blocks are 6.5" x 6.5" x 2.25". There is 1.5" spacing between the blocks. |
| Limiting Shear | 24+ PSF (non vegetated) |
| Limiting Velocity | 30+ft./second (non vegetated) |

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**Erosion Conrol Applications**

Airport Erosion Control
Flood Erosion Control
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Energy Erosion Control
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Cincinnati, Ohio 45209

# DETENTION POND DESIGN

Detention ponds have been analyzed by using HEC-HMS, storage routing method. The input parameters for the model are presented in Appendix IIIF-A. A summary of HEC-HMS results are presented on page IIIF-B-12. As can be seen on the table, during the 25-year storm event, none of the ponds will flow over their spillways. Downstream sides of the low-water outlets for each pond and for the culvert under FM 157 (DCP5) will be designed with either rock riprap or gabions as shown on pages IIIF-B-13 and IIIF-B-14.

**Purpose:** Demonstrate that the detention pond outlet structure designs are adequate to convey runoff from the various subbasins to their discharge points.

**Method:**
1. Use the 25-year, 24-hour flow rates and water surface elevations for the drainage areas that will discharge to each detention pond from the HEC-HMS analysis (see Appendix IIIF-A).
2. Use the Weir Equation to calculate the flow rate over the spillways as appropriate.

**Solution:**

| | P1 | P2 |
|---|---|---|
| Bottom ELEV, ft[1] | 462.0 | 443.0 |
| Spillway ELEV, ft | 472.0 | 463.0 |
| Spillway Length, ft | 100 | 100 |
| Top of Road/Berm, ft | 472.00 | 483.00 |
| Discharge Pipe Downstream Invert ELEV, ft | 462.00 | 442.36 |
| Peak Inflow $Q_{25}$, cfs | 340.9 | 6730.3 |
| Peak Outflow $Q_{25}$, cfs | 80.6 | 4105 |
| Peak Stage in Pond $Q_{25}$, ft | 467.00 | 451.90 |
| Est. Flow ($Q_{25}$) over Spillway, cfs | -- | -- |

Note: 1) Details of the pond outlet structures are presented on Drawings IIIF.13 through IIIF.15.

2) The flow over the spillway is estimated using the formula $Q = CLH^{3/2}$ where C = 2.64, L is the length of the spillway in feet, and H is the head on the spillway in feet. The flow over the spillway conservatively assumes no flow through the low water outlet.

ARLINGTON LANDFILL
0023-404-11-96
DETENTION POND OUTLET STRUCTURE AND CULVERT
EROSION PROTECTION CALCULATIONS



**Required:** Determine the minimum length and median diameter of riprap required at the detention pond outlet structures and creek culverts to control erosion in the detention pond outlet channels.

**Reference:**

1. Haan, Barfield, and Hayes, *Design Hydrology and Sedimentology for Small Catchments*, 1994.
2. Dodson's and Associates, Inc., *ProHec-1 Plus Program Documentation,* 1995.
3. Freeman, Gary E., J. Craig Fischenich, Gabion for Streambank Erosion Control, 2000. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-22), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

**Solution:** The riprap will be designed for the 25-year flow rates at the detention pond outlet structures and culverts. The flow at the outlet structures and culverts can be divided into two categories:

**1. Flow over the Spillway/Road**

As shown on page IIIF-B-14, none of the evaluated ponds or culverts are expected to have flow over the spillway during the 25-year event. Erosion protection calculations for the drainage structures will be based on flow through low water outlets/culverts only.

| Flow Structure Spillway Topslope | 25-Year Flow Rate (cfs) | 25-Year Velocity (ft/s) | 25-Year Flow Depth (ft) | 25-Year Foude Number | 25-Year Velocity Head (ft) | 25-Year Energy Head (ft) | 25-Year Flow Area (sq. ft.) | 25-Year Top Width (ft) |
|---|---|---|---|---|---|---|---|---|
| P1 | -- | -- | -- | -- | -- | -- | -- | -- |
| P2 | -- | -- | -- | -- | -- | -- | -- | -- |
| DCP5 | -- | -- | -- | -- | -- | -- | -- | -- |

**2. Flow through the Low Water Outlet**

The flow rate through the low water outlet (LWO) is summarized below.

| Flow Structure | Pond Bottom Elev (ft-msl) | LWO Invert Elev. Upstream (ft-msl) | LWO Invert Elev. Downstream (ft-msl) | LWO Diameter (in) | 25-Year Flow Rate[2] (cfs) | 25-Year Outlet Velocity[1] (ft/s) |
|---|---|---|---|---|---|---|
| P1 | 462.00 | 462.00 | 462.00 | 2 x 24" | 40.3 | 12.91 |
| P2 | 443.00 | 443.00 | 442.36 | 3 x 120" x 120" | 1368.0 | 13.68 |
| DCP5 | 457.00 | 457.00 | 457.00 | 60" x 120" | 228.3 | 9.02 |

[1] Velocities through the low water outlets were calculated using the HYDROCALC HYDRAULICS FOR WINDOWS program developed by Dodson and Associates (Version 1.2a, 1996).

[2] The flowrates for all low water outlets are the peak discharges for the respective areas as calculated by HEC-HMS since the spillway crest is not overtopped in the 25-year event. The total 25-year flowrate discharging from P1 is 80.6 cfs / 2 pipes = 40.3 cfs per pipe and from P2 = 4105 cfs / 3 boxes = 1368 cfs per box.

The flowrate through the low water outlet is used to design the riprap apron. The nomograph used for design of the length of the riprap and the median diameter are shown on page IIIF-B-17 (Figure 5.25).

The minimum riprap length and diameter for each outlet is summarized below. Riprap was not designed for culverts as they discharge into channels or ponds. The length of the riprap is increased by 20 percent to provide for a conservative design.

| Pond | Riprap Design Flowrate (cfs) | Pipe Diameter (in) | Riprap Length (ft) | Adjusted Length L x 1.2 (ft) | Median Rock Diameter (ft) |
|---|---|---|---|---|---|
| P1 | 40.3 | 24 | 48 | 58 | 0.80 |
| P2 | 1368.0 | 96 | 120 | 144 | 4.00 |
| DCP5 | 228.3 | 96 | 120 | 144 | 4.00 |

Apron width required for the ponds (e.g., width of erosion protection in outlet channel) are:
$W_{req}$=LWO diameter + 0.4*(RipRap Length)

| Pond | $W_{req}$ (ft) | $W_{provided}$ (ft) |
|---|---|---|
| P1 | 21.2 | 31.2 |
| P2 | 56.0 | 66.0 |
| DCP5 | 56.0 | 66.0 |

The median diameter of riprap is intended to determine the minimum diameter of the riprap that will be used. As an alternative, 2-foot thick gabions with a $d_{50}$ of 6-inches can be used.

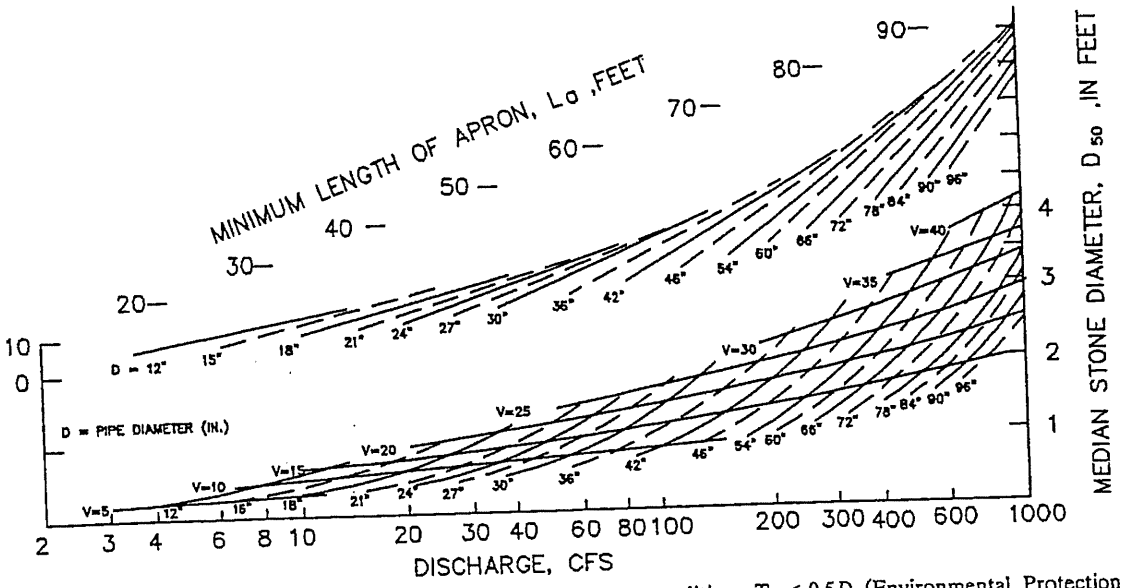



**Figure 5.24** Design of outlet protection—minimum tailwater condition, $T_w < 0.5D$ (Environmental Protection Agency, 1976).

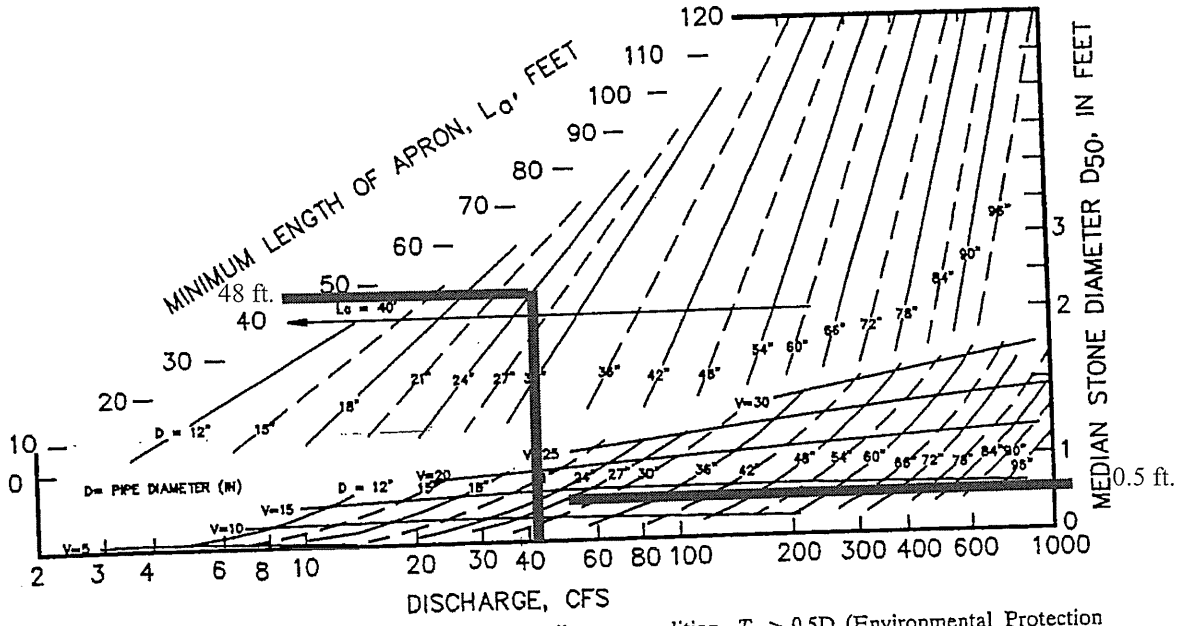



**Figure 5.25** Design of outlet protection—maximum tailwater condition, $T_w \geq 0.5D$ (Environmental Protection Agency, 1976).

into the riser 3 ft below its top, what discharge will pass through the four holes with the water level at 1, 2, 4, and 8 ft above the riser? (c) What is the total discharge through the pipe? (d) How might the orifices be sized to provide better stormwater control? (e) Explain whether you would expect two rows (each consisting of four holes) of 8-in.-diameter holes to provide better results? Assume that one row is 2 ft below the riser invert and the other row is 4 ft below the riser invert.

(5.6) A gravel roadway is constructed in a low-lying area such that the roadway is frequently overtopped as a result of severe storms. The roadway is 40 ft wide, and its elevation is 36 ft. (a) If the water level upstream of the roadway is 2 ft above the crest of the roadway, what is the discharge across the roadway? (b) If the roadway is paved, what upstream depth would be required to carry the same flow? (c) Would paving reduce flooding problems?

# CULVERT DESIGN

0 400 800
SCALE IN FEET

MOSIER VALLEY ROAD

C.R.I.&P. RAILROAD

SCALEHOUSE

F.M. 157 NORTH COLLINS STREET

CULVERT P1
2–24" CMP W/FLAPGATES
UPSTREAM FL =462.00 FT–MSL
UPSTREAM FL =462.00 FT–MSL

CULVERT DCP5
1–5'x10' RCB
UPSTREAM FL =457.00 FT–MSL
UPSTREAM FL =457.00 FT–MSL

CULVERT P2
3–10'x10' RCB
UPSTREAM FL =442.79 FT–MSL
UPSTREAM FL =442.36 FT–MSL

1000 FT.

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11–16–2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT–MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT–MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED PROFESSIONAL ENGINEER
05.19.22

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DATE: 03/2022
FILE: 0023–404–11
CAD: IIIF–B–19–CULVERT LOCATION.DWG

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

Weaver Consultants Group
TBPE REGISTRATION NO. F–3727

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# MAJOR PERMIT AMENDMENT
# CULVERT LOCATIONS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIIF–B–19

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ARLINGTON LANDFILL
0023-404-11-96
CULVERT DESIGN



**Required:** Design culverts to convey the flow.

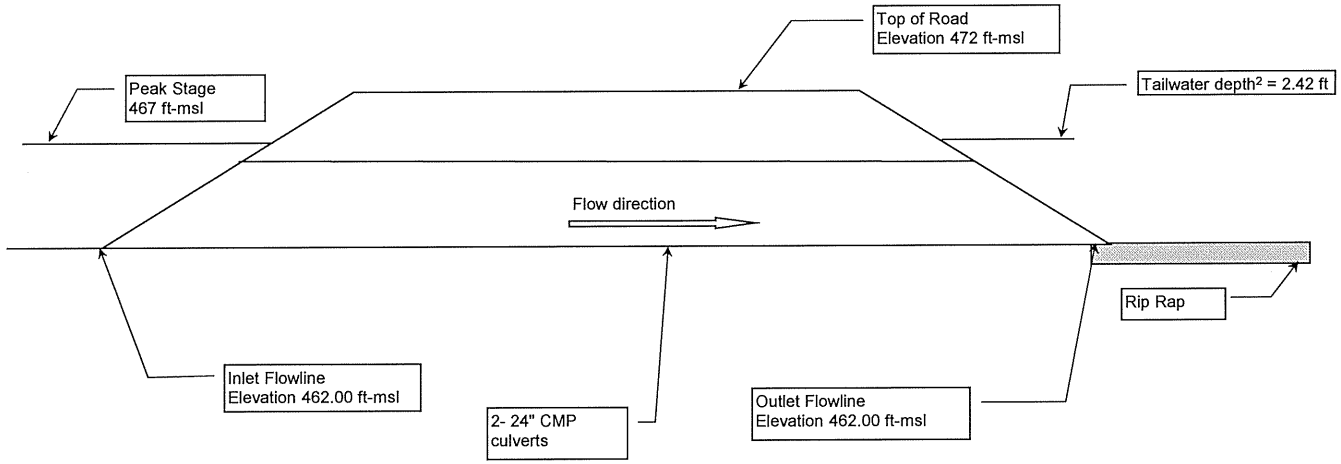
**Method:** Use HYDROCALC Hydraulics for Windows computer program to determine number and size of the culverts.
Use total 25-year frequency storm event flow estimated by HEC-HMS included in Appendix IIIF-A.

For proposed 2 - 24" CMP culvert at downstream end of pond P1

| | | |
|---|---|---|
| Total Flow= | 80.6 | cfs |
| No. of Culverts= | 2 | |
| Culvert Span= | -- | inches |
| Culvert Rise= | -- | inches |
| Culvert Diameter= | 24 | inches |

| Culvert ID | Culvert Span (ft) | Culvert Rise (ft) | FHWA Chart Number | FHWA Scale Number | Culvert Diameter (ft) | Manning's Coefficient | Entrance Loss Coefficient | Culvert Length (ft) | Downstream Invert Elevation (ft msl) | Upstream Invert Elevation (ft msl) | Flow Rate (cfs) | Peak Stage (ft) | Outlet Velocity (fps) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | -- | -- | 2 | 2 | 2 | 0.024 | 0.8 | 90.00 | 462.00 | 462.00 | 40.30 | 467.00 | 12.91 |

1. Calculations were performed using the HYDROCALC Hydraulics for Windows program developed by Dodson and Associates (Version 2.0, 1996-2010).
2. Tailwater depth is assumed to be the 25-year, 24-hour storm water surface elevation in Channel 1.

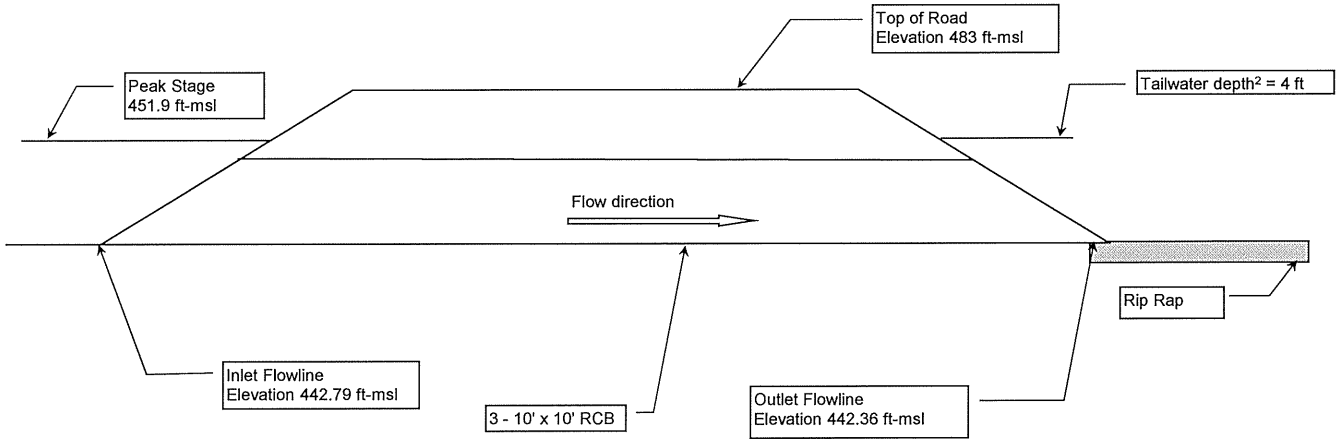


For proposed 3 - 10' x 10' RCB culvert at downstream end of pond P2

| | | |
|---|---|---|
| Total Flow= | 4105 | cfs |
| No. of Culverts= | 3 | |
| Culvert Span= | 10 | inches |
| Culvert Rise= | 10 | inches |
| Culvert Diameter= | -- | inches |

| Culvert ID | Culvert Span (ft) | Culvert Rise (ft) | FHWA Chart Number | FHWA Scale Number | Culvert Diameter (ft) | Manning's Coefficient | Entrance Loss Coefficient | Culvert Length (ft) | Downstream Invert Elevation (ft msl) | Upstream Invert Elevation (ft msl) | Flow Rate (cfs) | Peak Stage (ft) | Outlet Velocity (fps) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P2 | 10 | 10 | 9 | 2 | 10 | 0.016 | 0.8 | 240.00 | 442.79 | 442.36 | 1368.33 | 451.90 | 13.68 |

1. Calculations were performed using the HYDROCALC Hydraulics for Windows program developed by Dodson and Associates (Version 2.0, 1996-2010).
2. Tailwater depth is assumed to be the 25-year, 24-hour storm water surface elevation downstream of Pond P2.

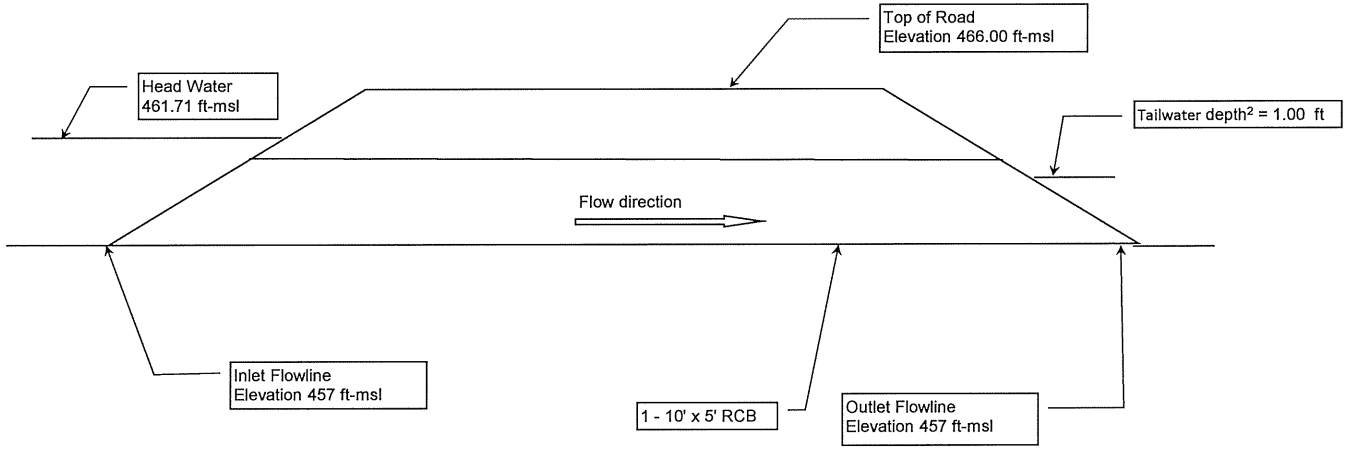


For proposed 5' x 10' RCB culvert under FM 157:

| | | |
|---|---|---|
| Total Flow= | 228.3 | cfs |
| No. of Culverts= | 1 | |
| Culvert Span= | 10 | inches |
| Culvert Rise= | 5 | inches |
| Culvert Diameter= | -- | inches |

| Culvert ID | Culvert Span (ft) | Culvert Rise (ft) | FHWA Chart Number | FHWA Scale Number | Culvert Diameter (ft) | Manning's Coefficient | Entrance Loss Coefficient | Culvert Length (ft) | Downstream Invert Elevation (ft msl) | Upstream Invert Elevation (ft msl) | Flow Rate (cfs) | Tailwater Depth[2] (ft) | Headwater Inlet Control (ft) | Headwater Outlet Control (ft) | Normal Depth (ft) | Critical Depth (ft) | Depth at Outlet (ft) | Outlet Velocity (fps) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DCP5 | 10 | 5 | 9 | 2 | 5 x 10 | 0.024 | 0.8 | 175.00 | 457.00 | 457.00 | 228.30 | 1.00 | 3.91 | 4.71 | 5.00 | 2.53 | 2.53 | 9.02 |

1. Calculations were performed using the HYDROCALC Hydraulics for Windows program developed by Dodson and Associates (Version 2.0, 1996-2010).
2. Tailwater depth is assumed to be the 25-year, 24-hour storm event flow depth downstream of FM 157.



# APPENDIX IIIF-C

# FINAL COVER EROSION CONTROL STRUCTURE DESIGN

Includes pages IIIF-C-1 through IIIF-C-22



# CONTENTS


| | |
|---|---|
| Drainage Swale Design | IIIF-C-1 |
| Drainage Letdown (or Chute) Design | IIIF-C-8 |




# DRAINAGE SWALE DESIGN

- The drainage swale layout is shown on Drawing IIIF.1 – Drainage Structure Plan. A swale detail is provided on Drawing IIIF.8 – Drainage Details.
- Typical Swale Design Summary:
  - Typical swale drainage areas analyzed are shown on sheet IIIF-C-3.
  - Hydraulic calculations are summarized on page IIIF-C-4.
  - Maximum normal depth is 1.84 feet (Drainage Area SW9).
  - Maximum flow velocity is 3.29 fps (Drainage Area SW9).
  - Vegetation will be established on the swales to protect against erosion.
  - Typical swale drainage areas were selected such that all slope conditions (5% and 25%) are included in this analysis. Additionally, swales with large individual drainage areas and short and long swale lengths are included in this analysis.

CITY OF ARLINGTON LANDFILL
0023-404-11-102
SWALE ANALYSIS



**Required:** Analyze swales to determine the adequacy of the swale design.

**Method:**

1. Determine the 25-year, 24-hour flow rates for the swale drainage areas by the Rational Method.

**Reference:**

1. State of Texas, Department of Transportation, Bridge Division, Hydraulic Manual, September 2019.
2. National Oceanic and Atmospheric Administration's Atlas 14 Point Precipitation Frequency Estimates.

**Solution:**

1. Determine the 25-year intensity flow rates.

$$Q = CIA$$

Where: C= 0.7 (runoff coefficient, Ref 1.)
I = intensity in/hr
A= drainage area, ac

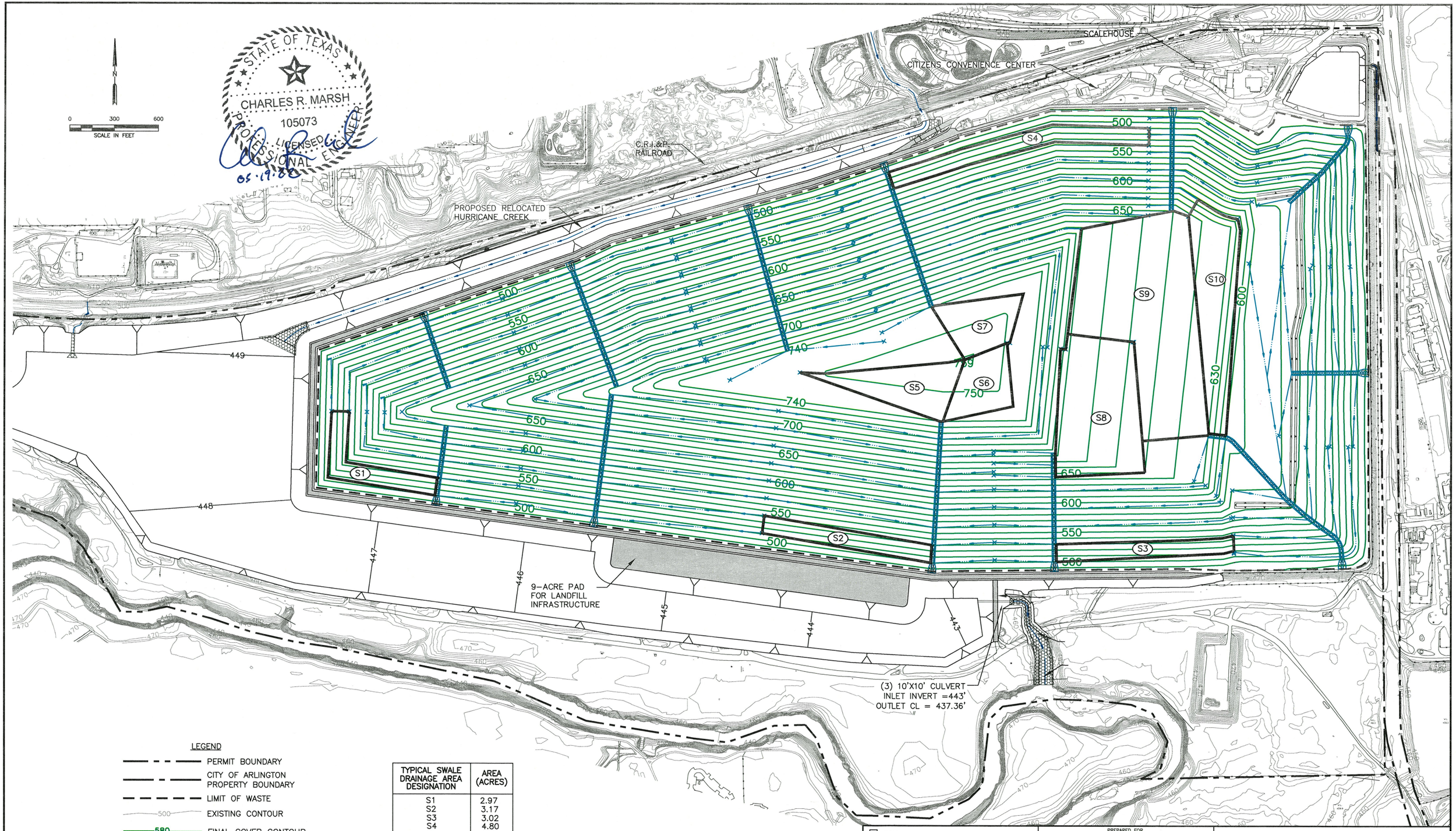
From Ref. 2, for
25-year storm event

$t_c$ is assumed to be 10 min.

I = 7.87 in/hr

| Swale | Area[1] (ac) | Flow Rate (cfs) |
|---|---|---|
| S1 | 2.97 | 16.4 |
| S2 | 3.17 | 17.5 |
| S3 | 3.02 | 16.6 |
| S4 | 4.80 | 26.4 |
| S5 | 4.95 | 27.3 |
| S6 | 3.59 | 19.8 |
| S7 | 3.85 | 21.2 |
| S8 | 11.75 | 64.7 |
| S9 | 22.09 | 121.7 |
| S10 | 8.36 | 46.1 |

[1] Swale drainage areas are shown on Sheet IIIF-C-3




STATE OF TEXAS
CHARLES R. MARSH
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05.17.22

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- LIMIT OF WASTE
- 500 EXISTING CONTOUR
- 580 FINAL COVER CONTOUR
- CREEK FLOW LINE
- (S6) SWALE DRAINAGE AREA DESIGNATION
- SWALE DRAINAGE AREAS

| TYPICAL SWALE DRAINAGE AREA DESIGNATION | AREA (ACRES) |
|---|---|
| S1 | 2.97 |
| S2 | 3.17 |
| S3 | 3.02 |
| S4 | 4.80 |
| S5 | 4.95 |
| S6 | 3.59 |
| S7 | 3.85 |
| S8 | 11.75 |
| S9 | 22.09 |
| S10 | 8.36 |

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 04-01-2021.

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DATE: 01/2022
FILE: 0023-404-11
CAD: SHEET IIIF-C-3.DWG
DRAWN BY: RDM
DESIGN BY: CRM
REVIEWED BY: CRM

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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|---|---|---|
| NO. | DATE | DESCRIPTION |
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# MAJOR PERMIT AMENDMENT
## TYPICAL SWALE DRAINAGE AREAS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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SHEET IIIF-C-3

O:\0023\404\EXPANSION 2021\PART III\IIIF\IIIF-C\SHEET IIIF-C-3.dwg, rarrington, 1:2

CITY OF ARLINGTON LANDFILL
0023-404-11-102
SWALE ANALYSIS



| Swale | Flow Rate (cfs) | Bottom Slope (ft/ft) | n-value | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude No. | Velocity Head (ft) | Energy Head (ft) | Flow Area (sq. ft.) | Top Width of Flow (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 | 16.4 | 0.005 | 0.03 | 2.0 | 4 | 0 | 1.43 | 2.68 | 0.560 | 0.11 | 1.54 | 6.11 | 8.56 |
| S2 | 17.5 | 0.005 | 0.03 | 2.0 | 4 | 0 | 1.46 | 2.73 | 0.560 | 0.12 | 1.58 | 6.40 | 8.76 |
| S3 | 16.6 | 0.005 | 0.03 | 2.0 | 4 | 0 | 1.43 | 2.69 | 0.561 | 0.11 | 1.55 | 6.17 | 8.60 |
| S4 | 26.4 | 0.005 | 0.03 | 2.0 | 4 | 0 | 1.70 | 3.03 | 0.580 | 0.14 | 0.85 | 8.71 | 10.22 |
| S5 | 27.3 | 0.005 | 0.03 | 2.0 | 20 | 0 | 1.05 | 2.25 | 0.549 | 0.08 | 1.13 | 12.11 | 23.08 |
| S6 | 19.8 | 0.005 | 0.03 | 2.0 | 20 | 0 | 0.93 | 2.08 | 0.539 | 0.07 | 1.00 | 9.51 | 20.45 |
| S7 | 21.2 | 0.005 | 0.03 | 2.0 | 20 | 0 | 0.95 | 2.13 | 0.543 | 0.07 | 1.02 | 9.98 | 20.95 |
| S8 | 64.7 | 0.005 | 0.03 | 2.0 | 20 | 0 | 1.45 | 2.80 | 0.579 | 0.12 | 1.57 | 23.12 | 31.90 |
| S9 | 121.7 | 0.005 | 0.03 | 2.0 | 20 | 0 | 1.84 | 3.29 | 0.605 | 0.17 | 2.00 | 37.04 | 40.37 |
| S10 | 46.1 | 0.005 | 0.03 | 2.0 | 20 | 0 | 1.28 | 2.57 | 0.568 | 0.10 | 1.38 | 17.92 | 28.08 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS program developed by Dodson and Associates (Version 2.01, 1996-2010).

Maximum flow depth is 1.84 ft < 2.0 ft (swale height).

Design is okay.

**Example Calculation:** Calculate the normal depth for the swale for drainage area S1 (See IIIF-C-4)

List of Symbols

$Q_d$ = design flow rate for channel, cfs
R = hydraulic radius, ft
n = Manning's roughness coefficient
S = channel slope, ft/ft
b = bottom width of channel, ft
$z_r$ = z-ratio (ratio of run to rise for channel sideslope) for right side slope of swale
$z_l$ = z-ratio (ratio of run to rise for channel sideslope) for left side slope of swale
$A_f$ = flow area, sf
g = gravitational acceleration = 32.2 $ft/s^2$
T = top width of flow, ft
d = normal depth of swale, ft

The program uses an iterative process to calculate the normal depth of the swale to satisfy Manning's Equation

$$Q = \frac{1.486}{n} A R^{0.67} S^{0.5}$$

Design Inputs:

| | | | |
|---|---|---|---|
| $Q_d$ = | 16.4 | cfs | (From page 6-B-3-3) |
| S = | 0.005 | ft/ft | |
| b = | 0 | ft | |
| $z_r$ = | 2 | (H) : 1 (V) | |
| $z_l$ = | 4 | (H) : 1 (V) | |
| n = | 0.03 | | |

Step 1 - Based on the geometry of the swale cross-section, solve for R and $A_f$

$$R = \frac{bd + 1/2d^2(z_r + z_l)}{b + d((z_l^2 + 1)^{0.5} + (z_r^2 + 1)^{0.5})}$$

$$A_f = bd + 1/2d^2(z_r + z_l)$$

assume: d = 1.43 ft

R = 0.67 ft

$A_f$ = 6.11 sf

solve for Q: $Q = 16.4$

if Q is not equal to $Q_d$, select a new d and repeat calculations

Step 2 - solve for velocity, T, Froude number, velocity head, and energy head

$Q = VA \Rightarrow \quad V = Q/A$

$V = 2.68$ ft/s

$T = b + d(z_l + z_r)$

$T = 8.56$ ft

$$F_r = \frac{V}{(gA/T)^{0.5}}$$

$F_r = 0.560$

$$\text{Velocity Head} = \frac{V^2}{2g}$$

Velocity Head = 0.11 ft

Energy Head = water elevation + velocity head

Energy Head = 1.54 ft

# DRAINAGE LETDOWN (OR CHUTE) DESIGN

## Chute Design

The letdown structures are designed using gabions, FML, or Flexamat as a liner. Bedding for the gabions will be prepared subgrade soil overlain by 8 oz/sy geotextile (refer to Drawing IIIF.10). The liner materials are placed along the entire chute to protect the chute bottom and the final cover from erosion due to potential erosive velocities. Tumbling flow energy dissipators will be placed at the bottom end of the letdown structure to dissipate excess energy present in the water as it travels down the 2 percent slopes in the low-water crossings over the perimeter road.

The following design information is included in this Appendix:

- 25-year flow rates used in the chutes are presented in the HEC-HMS computer program output file, pages IIIF-A-28 to IIIF-A-93.
- Hydraulic calculations are summarized on pages IIIF-C-10 and IIIF-C-11, and the calculation procedure is provided on pages IIIF-C-12 and IIIF-C-13.
- Chute layouts and drainage areas are shown on Sheet IIIF-C-9.
- The chute energy dissipator sizing calculation procedure is provided on pages IIIF-C-14 through IIIF-C-18.
- Additional stormwater details are included on Drawings IIIF.10 through IIIF.12.

**Flowrate Data**

Flowrate data are the result of hydrological modeling of the drainage areas by HEC-HMS software.

**Reference:**

1. State of Texas, Department of Transportation, Bridge Division, Hydraulic Manual, September 2019.
2. U.S. Army Corps of Engineers, Hydrologic Engineering Center. 2013. HEC-HMS Hydrologic Modeling System, User's Manual, Version 4.0, CPD-74A. Hydrologic Engineering Center, Davis, CA.

| Swale | Area[1] (ac) | Flow Rate[2] (cfs) |
|---|---|---|
| LD1 | 16.21 | 130.3 |
| LD2 | 24.35 | 202.8 |
| LD3 | 30.92 | 260.8 |
| LD4 | 53.58 | 458.8 |
| LD5 | 9.74 | 46.7 |
| LD6 | 15.85 | 137.8 |
| LD7 | 15.27 | 131.1 |
| LD8 | 54.83 | 295.1 |
| LD9 | 36.19 | 295.0 |
| LD10 | 47.89 | 397.9 |
| LD11 | 35.90 | 296.9 |
| LD12 | 16.82 | 151.4 |

[1] The letdown drainage areas are shown on Drawing IIIF-C-9.
[1] Flow rates are calculated with HEC-HMS.

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05/04/22

0 300 600
SCALE IN FEET

SCALEHOUSE
CITIZENS CONVENIENCE CENTER
C.R.I.&P. RAILROAD
PROPOSED RELOCATED HURRICANE CREEK
9-ACRE PAD FOR LANDFILL INFRASTRUCTURE
(3) 10'X10' CULVERT
INLET INVERT =443'
OUTLET CL = 437.36'
1000 FT

LD1 LD2 LD3 LD4 LD5 LD6 LD7 LD8 LD9 LD10 LD11 LD12

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- LIMIT OF WASTE
- 500 EXISTING CONTOUR
- 580 FINAL COVER CONTOUR
- CREEK FLOW LINE
- (LD6) LETDOWN DRAINAGE AREA DESIGNATION
- LETDOWN DRAINAGE AREAS

| LETDOWN DRAINAGE AREA DESIGNATION | AREA (ACRES) |
|---|---|
| LD1 | 16.21 |
| LD2 | 24.35 |
| LD3 | 30.92 |
| LD4 | 53.58 |
| LD5 | 9.74 |
| LD6 | 15.85 |
| LD7 | 15.27 |
| LD8 | 54.83 |
| LD9 | 36.19 |
| LD10 | 47.89 |
| LD11 | 35.90 |
| LD12 | 16.82 |

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 04-01-2021.

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

DATE: 01/2022
FILE: 0023-404-11
CAD: SHEET IIIF-C-9.DWG
DRAWN BY: RDM
DESIGN BY: CRM
REVIEWED BY: CRM

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| | | |
| | | |
| | | |
| | | |

# DRAINAGE PLAN
# LETDOWN DRAINAGE AREAS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

SHEET IIIF-C-9

O:\0023\404\EXPANSION 2021\PART III\IIIF\IIIF-C\SHEET IIIF-C-9.dwg, rarrington, 1:2

CITY OF ARLINGTON LANDFILL
0023-404-11-102
CHUTE ANALYSIS
NORMAL DEPTH CALCULATIONS FOR
GABION AND FLEXAMAT-LINED CHUTES



| Drainage Area | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SIDESLOPE (25%) AREAS** | | | | | | | | | | | | | |
| LD1 | 130.3 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 0.69 | 12.84 | 2.973 | 2.56 | 3.25 | 10.15 | 17.50 |
| LD2 | 202.8 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 0.88 | 14.80 | 3.077 | 3.40 | 4.29 | 13.71 | 19.06 |
| LD3 | 260.8 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 1.01 | 16.00 | 3.135 | 3.98 | 5.00 | 16.30 | 20.12 |
| LD4 | 458.8 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 1.38 | 18.99 | 3.268 | 5.60 | 6.98 | 24.17 | 23.04 |
| LD5 | 46.7 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 0.38 | 9.07 | 2.735 | 1.28 | 1.66 | 5.15 | 15.04 |
| LD6 | 137.8 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 0.71 | 13.08 | 2.986 | 2.66 | 3.37 | 10.54 | 17.68 |
| LD7 | 131.1 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 0.69 | 12.87 | 2.975 | 2.57 | 3.26 | 10.19 | 17.52 |
| LD8 | 295.1 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 1.09 | 16.62 | 3.162 | 4.29 | 5.38 | 17.76 | 20.69 |
| LD9 | 295.0 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 1.09 | 16.61 | 3.162 | 4.29 | 5.38 | 17.76 | 20.69 |
| LD10 | 397.9 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 1.28 | 18.20 | 3.235 | 5.15 | 6.42 | 21.86 | 22.22 |
| LD11 | 296.9 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 1.09 | 16.65 | 3.163 | 4.31 | 5.40 | 17.84 | 20.72 |
| LD12 | 151.4 | 0.25 | 0.04 | 4.0 | 4.0 | 12.0 | 0.75 | 13.48 | 3.008 | 2.82 | 3.57 | 11.23 | 17.99 |

| Drainage Area | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LOW WATER CROSSING (2%) AREAS** | | | | | | | | | | | | | |
| LD1 | 130.3 | 0.02 | 0.04 | 8.0 | 8.0 | 14.0 | 1.19 | 4.68 | 0.898 | 0.34 | 1.53 | 27.85 | 32.97 |
| LD2 | 202.8 | 0.02 | 0.04 | 8.0 | 8.0 | 22.0 | 1.25 | 5.07 | 0.916 | 0.40 | 1.65 | 39.99 | 42.00 |
| LD3 | 260.8 | 0.02 | 0.04 | 8.0 | 8.0 | 30.0 | 1.25 | 5.23 | 0.924 | 0.43 | 1.67 | 49.83 | 49.95 |
| LD4 | 458.8 | 0.02 | 0.04 | 8.0 | 8.0 | 50.0 | 1.33 | 5.69 | 0.943 | 0.50 | 1.83 | 80.62 | 71.27 |
| LD5 | 46.7 | 0.02 | 0.04 | 8.0 | 8.0 | 12.0 | 0.74 | 3.54 | 0.838 | 0.19 | 0.93 | 13.19 | 23.79 |
| LD6 | 137.8 | 0.02 | 0.04 | 8.0 | 8.0 | 16.0 | 1.16 | 4.69 | 0.898 | 0.34 | 1.50 | 29.35 | 34.57 |
| LD7 | 131.1 | 0.02 | 0.04 | 8.0 | 8.0 | 16.0 | 1.13 | 4.63 | 0.895 | 0.33 | 1.46 | 28.33 | 34.10 |
| LD8 | 295.1 | 0.02 | 0.04 | 8.0 | 8.0 | 32.0 | 1.30 | 5.38 | 0.930 | 0.45 | 1.75 | 54.84 | 52.72 |
| LD9 | 295.0 | 0.02 | 0.04 | 8.0 | 8.0 | 32.0 | 1.29 | 5.38 | 0.930 | 0.45 | 1.74 | 54.83 | 52.71 |
| LD10 | 397.9 | 0.02 | 0.04 | 8.0 | 8.0 | 42.0 | 1.34 | 5.63 | 0.941 | 0.49 | 1.83 | 70.66 | 63.44 |
| LD11 | 296.9 | 0.02 | 0.04 | 8.0 | 8.0 | 32.0 | 1.30 | 5.39 | 0.931 | 0.45 | 1.75 | 55.07 | 52.79 |
| LD12 | 151.4 | 0.02 | 0.04 | 8.0 | 8.0 | 16.0 | 1.22 | 4.82 | 0.904 | 0.36 | 1.58 | 31.39 | 35.50 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010).

Prep By: MB
Date: 1/26/2022

CITY OF ARLINGTON LANDFILL
0023-404-11-102
CHUTE ANALYSIS
NORMAL DEPTH CALCULATIONS FOR
FML-LINED CHUTES

Chkd By: CRM
Date: 1/26/2022

| Drainage Area | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SIDESLOPE (25%) AREAS** | | | | | | | | | | | | | |
| LD1 | 130.3 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.40 | 37.45 | 10.959 | 21.80 | 22.20 | 3.48 | 9.58 |
| LD2 | 202.8 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.51 | 43.74 | 11.357 | 29.74 | 30.25 | 4.64 | 10.05 |
| LD3 | 260.8 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.60 | 47.69 | 11.583 | 35.34 | 35.94 | 5.47 | 10.38 |
| LD4 | 458.8 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.83 | 57.57 | 12.087 | 51.50 | 52.33 | 7.97 | 11.30 |
| LD5 | 46.7 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.22 | 25.68 | 9.993 | 10.25 | 10.46 | 1.82 | 8.86 |
| LD6 | 137.8 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.41 | 38.21 | 11.009 | 22.68 | 23.09 | 3.61 | 9.64 |
| LD7 | 131.1 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.40 | 37.54 | 10.965 | 21.90 | 22.29 | 3.49 | 9.59 |
| LD8 | 295.1 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.64 | 49.73 | 11.693 | 38.43 | 39.07 | 5.93 | 10.56 |
| LD9 | 295.0 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.64 | 49.72 | 11.693 | 38.42 | 39.06 | 5.93 | 10.56 |
| LD10 | 397.9 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.76 | 54.94 | 11.960 | 46.91 | 47.67 | 7.24 | 11.04 |
| LD11 | 296.9 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.64 | 49.81 | 11.698 | 38.56 | 39.20 | 5.95 | 10.57 |
| LD12 | 151.4 | 0.25 | 0.01 | 2.0 | 2.0 | 8.0 | 0.43 | 39.50 | 11.094 | 24.24 | 24.68 | 3.83 | 9.73 |

| Drainage Area | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LOW WATER CROSSING (2%) AREAS** | | | | | | | | | | | | | |
| LD1 | 130.3 | 0.02 | 0.01 | 8.0 | 8.0 | 14.0 | 0.57 | 12.41 | 3.244 | 2.39 | 2.96 | 10.50 | 23.06 |
| LD2 | 202.8 | 0.02 | 0.01 | 8.0 | 8.0 | 22.0 | 0.58 | 13.13 | 3.292 | 2.68 | 3.26 | 15.45 | 31.28 |
| LD3 | 260.8 | 0.02 | 0.01 | 8.0 | 8.0 | 28.0 | 0.59 | 13.51 | 3.318 | 2.84 | 3.43 | 19.30 | 37.44 |
| LD4 | 458.8 | 0.02 | 0.01 | 8.0 | 8.0 | 52.0 | 0.58 | 13.91 | 3.345 | 3.01 | 3.59 | 32.97 | 61.31 |
| LD5 | 46.7 | 0.02 | 0.01 | 8.0 | 8.0 | 8.0 | 0.42 | 9.88 | 3.068 | 1.52 | 1.93 | 4.73 | 14.67 |
| LD6 | 137.8 | 0.02 | 0.01 | 8.0 | 8.0 | 16.0 | 0.55 | 12.34 | 3.241 | 2.37 | 2.92 | 11.16 | 24.76 |
| LD7 | 131.1 | 0.02 | 0.01 | 8.0 | 8.0 | 16.0 | 0.53 | 12.15 | 3.228 | 2.29 | 2.83 | 10.79 | 24.52 |
| LD8 | 295.1 | 0.02 | 0.01 | 8.0 | 8.0 | 32.0 | 0.59 | 13.63 | 3.326 | 2.89 | 3.48 | 21.64 | 41.43 |
| LD9 | 295.0 | 0.02 | 0.01 | 8.0 | 8.0 | 32.0 | 0.59 | 13.63 | 3.326 | 2.89 | 3.48 | 21.64 | 41.43 |
| LD10 | 397.9 | 0.02 | 0.01 | 8.0 | 8.0 | 44.0 | 0.59 | 13.89 | 3.343 | 3.00 | 3.59 | 28.65 | 53.41 |
| LD11 | 296.9 | 0.02 | 0.01 | 8.0 | 8.0 | 32.0 | 0.59 | 13.66 | 3.327 | 2.90 | 3.49 | 21.72 | 41.46 |
| LD12 | 151.4 | 0.02 | 0.01 | 8.0 | 8.0 | 16.0 | 0.58 | 12.72 | 3.265 | 2.51 | 3.09 | 11.90 | 25.24 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010).

CITY OF ARLINGTON LANDFILL
0023-404-11-102
CHUTE ANALYSIS
EXAMPLE CALCULATION FOR
GABION-LINED CHUTES



**Example Calculation:** Calculate the normal depth for the chute for the 25% slope portion of drainage area LD1.

List of Symbols

$Q_d$ = design flow rate for channel, cfs
R = hydraulic radius, ft
n = Manning's roughness coefficient
S = channel slope, ft/ft
b = bottom width of channel, ft
z = z-ratio (ratio of run to rise for channel sideslope)
$A_f$ = flow area, sf
g = gravitational acceleration = 32.2 $ft/s^2$
T = top width of flow, ft
d = normal depth of chute, ft

The program uses an iterative process to calculate the normal depth of the chute to satisfy Manning's Equation

$$Q = \frac{1.486}{n} A R^{0.67} S^{0.5}$$

| Design Inputs: | | | |
|---|---|---|---|
| | $Q_d$ = | 130.3 | cfs |
| | S = | 0.250 | ft/ft |
| | b = | 12 | ft |
| | z = | 4 | (H) : 1 (V) |
| | n = | 0.04 | |

Step 1 - Based on the geometry of the chute cross-section, solve for R and $A_f$

$$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{0.5}}$$

$$A_f = bd + zd^2$$

assume: d = 0.69 ft

R = 0.576 ft

$A_f$ = 10.15 sf

solve for Q: Q = 130.3 cfs

if Q is not equal to $Q_d$, select a new d and repeat calculations

Step 2 - solve for velocity, T, Froude number, velocity head, and energy head

$Q = VA \Rightarrow \quad V = Q/A$

$V = \quad 12.84 \text{ ft/s}$

$T = b + 2(z \times d)$

$T = \quad 17.50 \text{ ft}$

$$F_r = \frac{V}{(gA/T)^{0.5}}$$

$F_r = \quad 2.973$

$$\text{Velocity Head} = \frac{V^2}{2g}$$

Velocity Head = 2.56 ft

Energy Head = water elevation + velocity head

Energy Head = 3.25 ft

**Required:** Determine the hydraulic properties for the grouted ripraps as energy letdown structures (chutes).

**Method:**

1. Calculate the design flow rate of the chute section.
2. Estimate the normal and flow velocity from Hydrocalc using calculated design flow rate.
3. Calculate the critical depth and critical flow velocity.
4. Calculate the height of the roughness element and spacing between the rows of the roughness elements.
5. Calculate the total length of roughness elements.

**References:**

1. Henry M. Morris, *Hydraulic Dissipation in Steep, Rough Channels*, Bulletin19, Research Division, Virginia Polytechnic Institute, 1968.
2. "Open Channel Hydraulics" by V.T. Chow.
3. "Hydraulic Design of Energy Dissipators for Culverts and Channels", FHWA Hydraulics Engineering Circular Number 14, Third Edition.
4. "Hydraulic Considerations for Corrugated Plastic Pipes" Plastic Pipe Institute.
5. "Reclamation Managing Water in the West" Erosion and Sedimentation Manual. US Department of the Interior Bureau of Reclamation, November 2006.

**Solution:**

The design of energy dissipators for the 25 percent sideslope is based on tumbling flow in the chute. Tumbling flow consists of a series of hydraulic jumps on overfalls that maintain the critical velocity in the chute.

**For Chute LD1 (For the Upper Portion of a Chute):**

**1. Calculate the design flow rate of the chute section.**

According to the definition of the unit flow rate,

$$q = Q/b$$

where:

Q = flowrate, cfs (from Page IIIF-C-8) = 130.3 cfs
b = bottom width of chute, ft = 8 ft
q = unit flowrate, cfs/ft of chute width

$$q = 130.3 \text{ cfs} / 8 \text{ ft}$$
$$= 16.28 \text{ cfs/ft}$$

**2. Estimate the normal and flow velocity from Hydrocalc using flow rate and appropriate Manning's coefficient.**

Q = 130.3 cfs

Manning's coefficient selection (Reference 2, Page 14, Table 2)

**FML:**
n = 0.01
bottom slope = 0.25 ft/ft
side slope = 2 ft/ft
bottom width = 8ft

**Gabion/Flexmat:**
n = 0.04
bottom slope = 0.25 ft/ft
side slope = 4 ft/ft
bottom width = 12ft

From Hydrocalc

**FML:**

Normal depth = 0.4 ft
Flow Velocity = 37.46 ft/sec

**Gabion/Flexmat:**

Normal depth = 0.69 ft
Flow Velocity = 12.84 ft/sec

**For Chute LD1 (For the Lower Portion of the Chute):**

**1. Calculate the design flow rate of the chute section.**

According to the definition of the unit flow rate,

$q = Q/b$

where:

Q = flowrate, cfs = 130.3 cfs
b = bottom width of chute, ft = 25 ft
q = unit flowrate, cfs/ft of chute width

$q = 130.3 \text{ cfs} / 14 \text{ ft}$
$= 9.31 \text{ cfs/ft}$

**2. Estimate the normal and flow velocity from Hydrocalc using flow rate and appropriate Manning's coefficient.**

Q = flowrate, cfs = 130.3 cfs (Equation 5-12, Reference 2)

roughness coefficient, $n = (n_0+n_1+n_2+n_3+n_4)\, m_5$

where, (Reference 2, Page 109, Table 5-5)

$n_0$ = basic n value for straight, uniform, smooth channel based on material = 0.025 (Reference 2, Page 109, Table 5-5)

$n_1$ = value added for surface irregularities = 0.01 (Reference 2, Page 109, Table 5-5)

$n_2$ = value added for variation in channel cross section= 0.0 (Reference 2, Page 109, Table 5-5)

$n_3$ = value added for obstructions = 0.015 (Reference 2, Page 109, Table 5-5)

$n_4$ = value added for vegetation and flow conditions = 0.005 (Reference 2, Page 109, Table 5-5)

$m_5$ = correction factor for meandering of channel =1.0

$n = (0.025+.01+0.0+.015+.005)*1.0$

Therefore, n = 0.055

bottom slope = 0.25 ft/ft
side slope = 3 ft/ft
bottom width = 14 ft

From Hydrocalc

Normal depth = 0.77 ft
Flow Velocity = 10.33 ft/sec

**3. Calculate the critical depth and critical flow velocity.**

$Y_c = (q^2/g)^{1/3}$ (Reference 3, Equation 7.1)

$V_c = (gq)^{1/3}$ (Reference 3)

where:

$Y_c$ = critical depth, ft
q = unit flowrate, cfs/ft of chute width
g = acceleration due to gravity = 32.2 $ft/s^2$
$V_c$ = critical (also outlet) velocity, ft/s

$Y_c = ((5.21^2)/32.2)^{1/3}$
$= 1.39$ ft
$V_c = (32.2*5.21)^{1/3}$
$= 6.69$ ft/s

**4. Calculate the height of the roughness element and spacing between the rows of the roughness elements.**

$h = Y_c/((3-3.7S)^(2/3))$ (Reference 3, Equation 7.2)

where:

$Y_c$ = critical depth, ft
S = slope in percent
h = element height, ft

$h = 0.95/(3-3.7*0.25)^{2/3}$
$= 0.85$ ft
$= 10.2$ in

$h_{provided} = 12.00$ in

$h_{provided} > h$, so the design is adequate.

**5. Calculate the total length of roughness elements.**

L = spacing between the roughness elements, ft
$L_{Total}$ = Total length of roughened section, ft

(Reference 3)

L/h = 8.5 to 10 (L/h = 9.25 average)

$L = 9.25\ h = 9.25 * 0.66$
$= 7.9$ ft

The spacing and height of the roughness elements are designed based on 5 rows of roughness elements. (reference 3)

So, $L_{total\ (recommended)} = 5L$
$= 5*5.80$ ft
$= 39.4$ ft

$L_{total(provided)} = 40$ ft

$L_{total(provided)} > L_{total\ (recommended)}$, so the design is adequate.

The following table summarizes the calculations for gabion and flexamat chutes.

Upper Portion of Chutes

| Chute | [1]Q | $W_{Design}$ | q | n-value | Bottom Slope | Side Slope | Normal Depth | Flow Velocity |
|---|---|---|---|---|---|---|---|---|
| | (cfs) | (ft) | (cfs/ft) | | (ft/ft) | (ft/ft) | (ft) | (ft/sec) |
| LD1 | 130.3 | 12 | 10.86 | 0.04 | 0.250 | 4 | 0.69 | 12.84 |
| LD2 | 202.8 | 12 | 16.90 | 0.04 | 0.250 | 4 | 0.88 | 14.80 |
| LD3 | 260.8 | 12 | 21.73 | 0.04 | 0.250 | 4 | 1.01 | 16.00 |
| LD4 | 458.8 | 12 | 38.23 | 0.04 | 0.250 | 4 | 1.38 | 18.99 |
| LD5 | 46.7 | 12 | 3.89 | 0.04 | 0.250 | 4 | 0.38 | 9.07 |
| LD6 | 137.8 | 12 | 11.49 | 0.04 | 0.250 | 4 | 0.71 | 13.08 |
| LD7 | 131.1 | 12 | 10.93 | 0.04 | 0.250 | 4 | 0.69 | 12.87 |
| LD8 | 295.1 | 12 | 24.59 | 0.04 | 0.250 | 4 | 1.09 | 16.62 |
| LD9 | 295.0 | 12 | 24.58 | 0.04 | 0.250 | 4 | 1.09 | 16.61 |
| LD10 | 397.9 | 12 | 33.16 | 0.04 | 0.250 | 4 | 1.25 | 17.95 |
| LD11 | 296.9 | 12 | 24.7392 | 0.04 | 0.250 | 4 | 1.09 | 16.65 |
| LD12 | 151.4 | 12 | 12.6167 | 0.04 | 0.250 | 4 | 0.75 | 13.48 |

Lower Portion of Chutes

| Chute | [1]Q | $W_{Design}$ | q | n-value | Bottom Slope | Side Slope | Normal Depth | Flow Velocity | $Y_c$ | $V_c$ | h | L (=9.25h) | $h_{Design}$ | [2]$L_{Total}$ (Recommended) | $W_{Provided}$ | $h_{Provided}$ | $L_{Total}$ (Provided) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (cfs) | (ft) | (cfs/ft) | | (ft/ft) | (ft/ft) | (ft) | (ft/sec) | (ft) | (fps) | (ft) | (ft) | (in) | (ft) | (ft) | (in) | (ft) |
| LD1 | 130.3 | 14 | 9.31 | 0.055 | 0.250 | 3 | 0.77 | 10.32 | 1.39 | 6.69 | 0.85 | 7.9 | 10.2 | 39.4 | 14 | 12.0 | 40.0 |
| LD2 | 202.8 | 22 | 9.22 | 0.055 | 0.250 | 3 | 0.78 | 10.70 | 1.38 | 6.67 | 0.85 | 7.8 | 10.2 | 39.2 | 22 | 12.0 | 40.0 |
| LD3 | 260.8 | 30 | 8.69 | 0.055 | 0.250 | 3 | 0.76 | 10.68 | 1.33 | 6.54 | 0.81 | 7.5 | 9.8 | 37.7 | 30 | 12.0 | 40.0 |
| LD4 | 458.8 | 50 | 9.18 | 0.055 | 0.250 | 3 | 0.79 | 11.15 | 1.37 | 6.66 | 0.84 | 7.8 | 10.1 | 39.0 | 50 | 12.0 | 40.0 |
| LD5 | 46.7 | 12 | 3.89 | 0.055 | 0.250 | 3 | 0.46 | 7.54 | 0.78 | 5.00 | 0.48 | 4.4 | 5.7 | 22.2 | 12 | 12.0 | 40.0 |
| LD6 | 137.8 | 16 | 8.61 | 0.055 | 0.250 | 3 | 0.74 | 10.19 | 1.32 | 6.52 | 0.81 | 7.5 | 9.7 | 37.4 | 16 | 12.0 | 40.0 |
| LD7 | 131.1 | 16 | 8.20 | 0.055 | 0.250 | 3 | 0.72 | 10.01 | 1.27 | 6.41 | 0.78 | 7.2 | 9.4 | 36.2 | 16 | 12.0 | 40.0 |
| LD8 | 295.1 | 32 | 9.22 | 0.055 | 0.250 | 3 | 0.78 | 10.95 | 1.38 | 6.67 | 0.85 | 7.8 | 10.2 | 39.2 | 32 | 12.0 | 40.0 |
| LD9 | 295.0 | 32 | 9.22 | 0.055 | 0.250 | 3 | 0.78 | 10.95 | 1.38 | 6.67 | 0.85 | 7.8 | 10.2 | 39.2 | 32 | 12.0 | 40.0 |
| LD10 | 397.9 | 42 | 9.47 | 0.055 | 0.250 | 3 | 0.80 | 11.21 | 1.40 | 6.73 | 0.86 | 8.0 | 10.3 | 39.9 | 42 | 12.0 | 40.0 |
| LD11 | 296.9 | 32 | 9.28 | 0.055 | 0.250 | 3 | 0.67 | 10.04 | 1.38 | 6.68 | 0.85 | 7.9 | 10.2 | 39.3 | 32 | 12.0 | 40.0 |
| LD12 | 151.4 | 16 | 9.46 | 0.055 | 0.250 | 3 | 0.78 | 10.52 | 1.40 | 6.73 | 0.86 | 8.0 | 10.3 | 39.8 | 16 | 12.0 | 40.0 |

1. The flowrates were reproduced from Appendix IIIF-A.
2. Total length of the roughened section was calculated based on FHWA recommendation of 5 rows of roughened elements.

The following table summarizes the calculations for FML chutes.

Upper Portion of Chutes

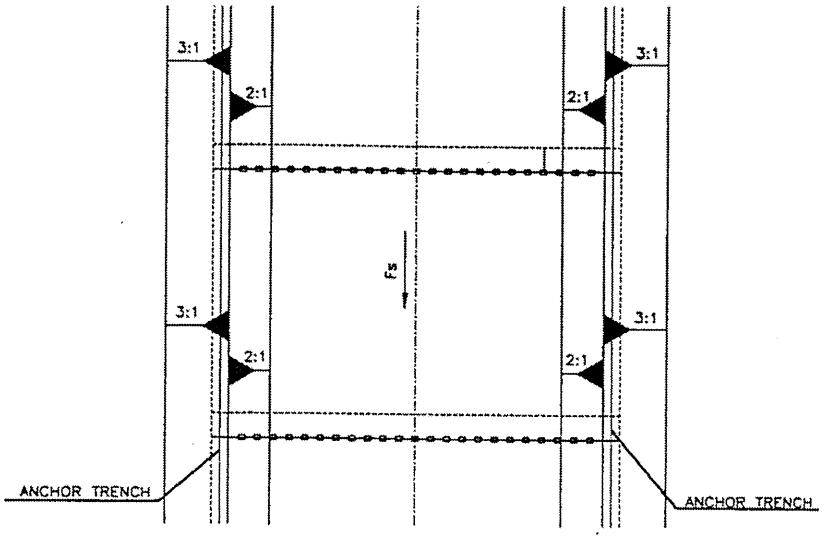
| Chute | [1]Q | $W_{Design}$ | q | n-value | Bottom Slope | Side Slope | Normal Depth | Flow Velocity |
|---|---|---|---|---|---|---|---|---|
| | (cfs) | (ft) | (cfs/ft) | | (ft/ft) | (ft/ft) | (ft) | (ft/sec) |
| LD1 | 130.3 | 8 | 16.28 | 0.01 | 0.250 | 2 | 0.40 | 37.46 |
| LD2 | 202.8 | 8 | 25.35 | 0.01 | 0.250 | 2 | 0.51 | 43.74 |
| LD3 | 260.8 | 8 | 32.60 | 0.01 | 0.250 | 2 | 0.60 | 47.69 |
| LD4 | 458.8 | 8 | 57.35 | 0.01 | 0.250 | 2 | 0.83 | 57.57 |
| LD5 | 46.7 | 8 | 5.84 | 0.01 | 0.250 | 2 | 0.22 | 25.68 |
| LD6 | 137.8 | 8 | 17.23 | 0.01 | 0.250 | 2 | 0.41 | 38.21 |
| LD7 | 131.1 | 8 | 16.39 | 0.01 | 0.250 | 2 | 0.40 | 37.54 |
| LD8 | 295.1 | 8 | 36.89 | 0.01 | 0.250 | 2 | 0.64 | 49.73 |
| LD9 | 295.0 | 8 | 36.87 | 0.01 | 0.250 | 2 | 0.64 | 49.72 |
| LD10 | 397.9 | 8 | 49.73 | 0.01 | 0.250 | 2 | 0.76 | 54.94 |
| LD11 | 296.9 | 8 | 37.11 | 0.01 | 0.250 | 2 | 0.64 | 49.83 |
| LD12 | 151.4 | 8 | 18.93 | 0.01 | 0.25 | 2 | 0.43 | 39.5 |

Lower Portion of Chutes

| Chute | [1]Q | $W_{Design}$ | q | n-value | Bottom Slope | Side Slope | Normal Depth | Flow Velocity | $Y_c$ | $V_c$ | h | L (=9.25h) | $h_{Design}$ | [2]$L_{Total}$ (Recommended) | $W_{Provided}$ | $h_{Provided}$ | $L_{Total}$ (Provided) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (cfs) | (ft) | (cfs/ft) | | (ft/ft) | (ft/ft) | (ft) | (ft/sec) | (ft) | (fps) | (ft) | (ft) | (in) | (ft) | (ft) | (in) | (ft) |
| LF1 | 130.3 | 14 | 9.31 | 0.055 | 0.250 | 3 | 0.77 | 10.33 | 1.39 | 6.69 | 0.85 | 7.9 | 10.2 | 39.4 | 14 | 12.0 | 40.0 |
| LF2 | 202.8 | 22 | 9.22 | 0.055 | 0.250 | 3 | 0.78 | 10.70 | 1.38 | 6.67 | 0.85 | 7.8 | 10.2 | 39.2 | 22 | 12.0 | 40.0 |
| LF3 | 260.8 | 28 | 9.31 | 0.055 | 0.250 | 3 | 0.79 | 10.91 | 1.39 | 6.69 | 0.85 | 7.9 | 10.2 | 39.4 | 28 | 12.0 | 40.0 |
| LF4 | 458.8 | 52 | 8.82 | 0.055 | 0.250 | 3 | 0.77 | 11.00 | 1.34 | 6.57 | 0.82 | 7.6 | 9.9 | 38.0 | 52 | 12.0 | 40.0 |
| LF5 | 46.7 | 8 | 5.84 | 0.055 | 0.250 | 3 | 0.58 | 8.31 | 1.02 | 5.73 | 0.63 | 5.8 | 7.5 | 29.0 | 8 | 12.0 | 40.0 |
| LF6 | 137.8 | 16 | 8.61 | 0.055 | 0.250 | 3 | 0.74 | 10.19 | 1.32 | 6.52 | 0.81 | 7.5 | 9.7 | 37.4 | 16 | 12.0 | 40.0 |
| LF7 | 131.1 | 16 | 8.20 | 0.055 | 0.250 | 3 | 0.72 | 10.01 | 1.27 | 6.41 | 0.78 | 7.2 | 9.4 | 36.2 | 16 | 12.0 | 40.0 |
| LF8 | 295.1 | 32 | 9.22 | 0.055 | 0.250 | 3 | 0.78 | 10.95 | 1.38 | 6.67 | 0.85 | 7.8 | 10.2 | 39.2 | 32 | 12.0 | 40.0 |
| LF9 | 295.0 | 32 | 9.22 | 0.055 | 0.250 | 3 | 0.78 | 10.95 | 1.38 | 6.67 | 0.85 | 7.8 | 10.2 | 39.2 | 32 | 12.0 | 40.0 |
| LF10 | 397.9 | 44 | 9.04 | 0.055 | 0.250 | 3 | 0.78 | 11.03 | 1.36 | 6.63 | 0.84 | 7.7 | 10.0 | 38.7 | 44 | 12.0 | 40.0 |
| LF11 | 296.9 | 32 | 9.28 | 0.055 | 0.250 | 3 | 0.79 | 10.98 | 1.38 | 6.68 | 0.85 | 7.9 | 10.2 | 39.3 | 32 | 12.0 | 40.0 |
| LF12 | 151.4 | 16 | 9.46 | 0.055 | 0.250 | 3 | 0.78 | 10.52 | 1.40 | 6.73 | 0.86 | 8.0 | 10.3 | 39.8 | 16 | 12.0 | 40.0 |

1. The flowrates were reproduced from Appendix IIIF-A.
2. Total length of the roughened section was calculated based on FHWA recommendation of 5 rows of roughened elements.

**Design anchor trench spacing and depths.**




Shear force pulling on geomembrane due to water:

The shear force acting on the geomembrane per square foot of water in the chute:

$T = \gamma_w \times D \times S$ where: $\gamma_w$ = unit weight of water (lb/cf)
D = maximum water depth (ft)
S = hydraulic gradient (ft/ft)

Shear force acting on the geomembrane per foot of anchor trench:

$F_{sl} = T \times P$

where:
P = wetted perimeter of the chute = $(W + 2 \times (a^2+D^2)^{1/2})$
a = h x D = horizontal distance from bottom of chute to the depth submerged on the sideslopes
h = Slope of sidewalls = 2 (H) : 1 (V)
W = Minimum bottom width of flow = 8 ft

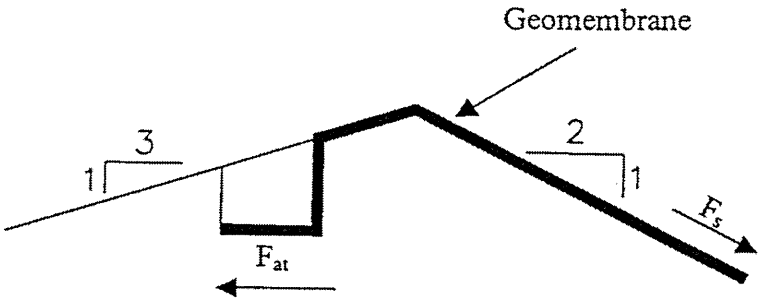
Conservatively, the maximum calculated water depth in the chutes will be used to verify the design. Thus, the water depth in the narrowest part of the chute with the highest depth will be used.

| Letdown | Maximum Water Depth (ft)[1] | Hydraulic Gradient (ft/ft) | T (lb/sf) | a (ft) | $F_{s1}$ (lb/ft) |
|---|---|---|---|---|---|
| LD1 | 0.40 | 0.25 | 6.24 | 0.8 | 61 |
| LD2 | 0.51 | 0.25 | 7.96 | 1.02 | 82 |
| LD3 | 0.60 | 0.25 | 9.36 | 1.2 | 100 |
| LD4 | 0.83 | 0.25 | 12.95 | 1.66 | 152 |
| LD5 | 0.22 | 0.25 | 3.43 | 0.44 | 31 |
| LD6 | 0.41 | 0.25 | 6.40 | 0.82 | 63 |
| LD7 | 0.40 | 0.25 | 6.24 | 0.80 | 61 |
| LD8 | 0.64 | 0.25 | 9.98 | 1.28 | 108 |
| LD9 | 0.64 | 0.25 | 9.98 | 1.28 | 108 |
| LD10 | 0.76 | 0.25 | 11.86 | 1.52 | 135 |
| LD11 | 0.64 | 0.25 | 9.98 | 1.28 | 108 |
| LD12 | 0.43 | 0.25 | 6.71 | 0.86 | 67 |

[1] See design depths on page IIIF-C-11.

Pullout Resistance from Edges, $F_{at1}$ [2]

Assuming pullout only opposed by trench (conservative assumption)




$$F_{at} = 2[\{K_o\gamma(D/2)\}\{\tan\zeta\}\{D\} + \{\gamma D\}\{\tan\zeta\}\{w\}] \quad \text{(Ref 3)}$$

where:
$\zeta$ = interface friction angle
$K_o = 1 - \sin\zeta$
$\gamma$ = unit weight of soil (lb/cf)
D = depth of anchor trench (ft)
w = bottom width of anchor trench (ft)

| | | |
|---|---|---|
| soil friction angle = | 20 | degrees |
| soil/geomembrane friction angle = | 18.2 | degrees |
| unit weight = | 112 | $lb/ft^3$ |
| depth of anchor trench = | 1 | ft |
| bottom width of anchor trench = | 1 | ft |

[2]See detail D22 - Anchor Trench Type 2 on Drawing IIIF-8 for dimensions.

$K_o$ = 0.66

| $F_{at1}$ = | 108 | lb/ft width on one side |
|---|---|---|

| Factor of Safety = $2F_{at1}/F_{s1}$ = | $\frac{217}{152}$ | FS = | 1.4 |
|---|---|---|---|

### 3. Upstream End Anchor Trench Design

Shear force pulling on geomembrane due to water:

$F_{s2} = T \times A$

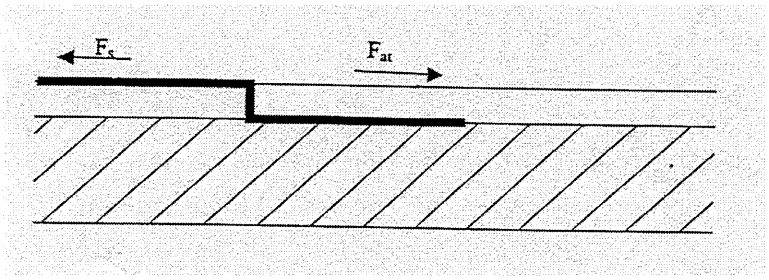
where: T = Maximum shear force acting on the geomembrane per square foot of water in the chute (lb/sf)
A = area of geomembrane at the top of the chute ($ft^2$)

Area of geomembrane at top of chute = 116 ft x 17 ft = 1,972 sf

Conservatively, use the maximum shear force per square foot calculated in Part 2

| $F_{s2}$ = | 25,533 | lbs |
|---|---|---|

Pullout resistance of upstream end, $F_{at2}$ [3]




$F_{at} = 2[\{K_o\gamma(D/2)\}\{\tan\zeta\}\{D\} + \{\gamma D\}\{\tan\zeta\}\{w\}]$ (Ref 3)

where: $\zeta$ = interface friction angle
$K_o$ = 1 - sin $\zeta$
$\gamma$ = unit weight of soil (lb/cf)
D = depth of anchor trench (ft)
w = bottom width of anchor trench (ft)

| | | |
|---|---|---|
| friction angle = | 18.2 | degrees |
| anchor trench soil unit weight = | 112 | $lb/ft^3$ |
| depth of anchor trench = | 0.5 | ft |
| bottom width of anchor trench = | 3 | ft |

$K_o$ = 0.69

$F_{at2}$ = 117 lb/ft width

Total End Anchor Length ($L_T$) [4] = 150 ft

| $F_{pr}$ = Pullout Resistance (End) = $F_{at2}$ x $L_T$ = | 17,520 | lbs |
|---|---|---|

| Factor of Safety = $F_{pr}/F_{s2}$ = | $\frac{17,520}{25,533}$ | FS = | 0.7 |
|---|---|---|---|

**Summary of Results**

Side Anchor Trench Pullout resistance:

$FS = \frac{2F_{AT2}}{F_{S1}}$ ==> FS = 1.6

Upstream End Anchor Trench Pullout resistance:

$FS = \frac{F_{pr}}{F_{s2}}$ ==> FS = 0.7

As it is stated on page 557 of Reference 4, the typical factors of safety for the proposed anchor trenches are between 0.7 to 5.0. Therefore, the design is acceptable.

# APPENDIX IIIF-D

# EROSION LAYER EVALUATION

Includes pages IIIF-D-1 through IIIF-D-33



# EROSION LAYER EVALUATION

This appendix presents the supporting documentation for evaluation of the thickness of the erosion layer for the final cover system at the City of Arlington Landfill. The evaluation is based on the premise of adding excess soil to increase the time required before maintenance is needed as recommended in the EPA Solid Waste Disposal Facility Criteria Technical Manual (EPA 530-R-93-017, November 1993).

The design procedure is as follows:

1. Minimum thickness of the erosion layer at the end of the 30-year postclosure period is evaluated based on the depth of frost penetration or 6 inches, whichever is greater. For Tarrant County, the approximate depth of frost penetration is approximately 6 inches (see IIIF-D-18). Therefore, the minimum erosion layer thickness is 6 inches.

2. Soil loss is calculated using the Universal Soil Loss Equation (USLE) by following SCS procedures. The soil loss is adjusted by a safety factor of 2 and is then converted to a thickness. The thickness of the soil loss over a 30-year postclosure period is added to the minimum thickness of the erosion layer (from Step 1) to yield an initial thickness to be placed at closure of the site. According to the USLE, the typical 5 percent and 4 percent topslope and 25 percent side slope require a minimum of 6.243 inches, 6.088 inches, and 7.141 inches, respectively, for the erosion layer. These USLE requirements include the 6-inch minimum required by regulations. Conservatively, a 12-inch erosion layer is proposed over final cover. These calculations begin on page IIIF-D-3.

3. Stormwater flows over the final cover system by (1) sheet flow over the topslope and sideslopes and (2) channelized flow in the drainage berms (or swales). As discussed in Section 2.2 and Appendix IIIF-C, flow also occurs in the letdown structures. The letdown structures are lined with gabions to prevent erosion given that the velocities in the letdowns are over 5 ft/sec.

   Sheet flow velocities for the topslope and sideslope cases for a 25-year storm event are calculated to be less than permissible nonerosive velocities. A permissible nonerosive velocity is defined as 5.0 ft/sec or less. Calculated sheet flow velocities range from 0.91 to 1.78 ft/sec for topslope and sideslope cases. The supporting calculations are presented on pages IIIF-D-21 through IIIF-D-24.

Channelized flow for drainage swales is also calculated to be less than permissible nonerosive velocities. Calculated channelized flow velocities range from 2.08 to 3.29 ft/sec for the drainage swales. The supporting calculations are presented on pages IIIF-C-2 through IIIF-C-6.

4. Vegetation for the site will be native and introduced grasses with root depths of 6 inches to 8 inches. The erosion layer shall also include a mixture of Bermuda, vetch, rye, wheat grass, wild flowers, and flowering plants. The seeding is specified on the attached pages IIIF-D-27 through IIIF-D-33. The seeding is specified by TxDOT for temporary and permanent erosion control for Tarrant County, Texas (Fort Worth).

5. Native and introduced grasses will be hydroseeded with fertilizer on the disked (parallel to contours) erosion layer upon final grading. Temporary cold weather vegetation will be established if needed. Irrigation will be employed for 6 to 8 weeks or until vegetation is well established. Erosion control measures such as silt fences and straw bales will be used to minimize erosion until the vegetation is established. Areas that experience erosion or do not readily vegetate after hydroseeding will be reseeded until vegetation is established or the soil will be replaced with soil that will support the grasses.

6. Slope stability information is included in Appendix IIIJ.

**Required:** Determine expected soil loss and minimum thickness for the erosion layer.

**Method:** Expected soil loss is calculated using the Universal Soil Loss Equation. Minimum erosion layer thickness is determined by adding the minimum thickness allowed by TCEQ to the expected soil loss.

**References:**

1. SCS National Engineering Handbook, Chapter 3 - Erosion.
2. TNRCC, *Use of the USLE in Final Cover/Configuration Design*, 1993.
3. United States Department of Agriculture, National Resource Conservation Service, Web Soil Survey for Tarrant County, Texas ( http://websoilsurvey.nrcs.usda.gov ).
4. United States Environmental Protection Agency, *Solid Waste Disposal Facility Criteria Technical Manual*, 1993.

**Solution:**

1. Soil Loss Equation: $A=RKL_SCP$

Where:

A= Soil loss (tons/ac/yr)
R= Rainfall factor
K= Soil erodibility factor
$L_S$= Slope length/slope gradient factor
C= Plant cover or cropping management factor
P= Erosion practice factor

The rainfall factor, R, represents the average intensity for the maximum intensity, 30 minute storms over a 22 year period of record compiled by the SCS. Using Figure 1 (Ref 1), Average Annual Values of the R Factor, the R factor for Tarrant County is:

R = 290

K based on values from TNRCC Use of Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural handbool, 1993, for combination sandy clay, silty clay loam with 2 percent organic matter (from Ref 2, p.10)

K = 0.2

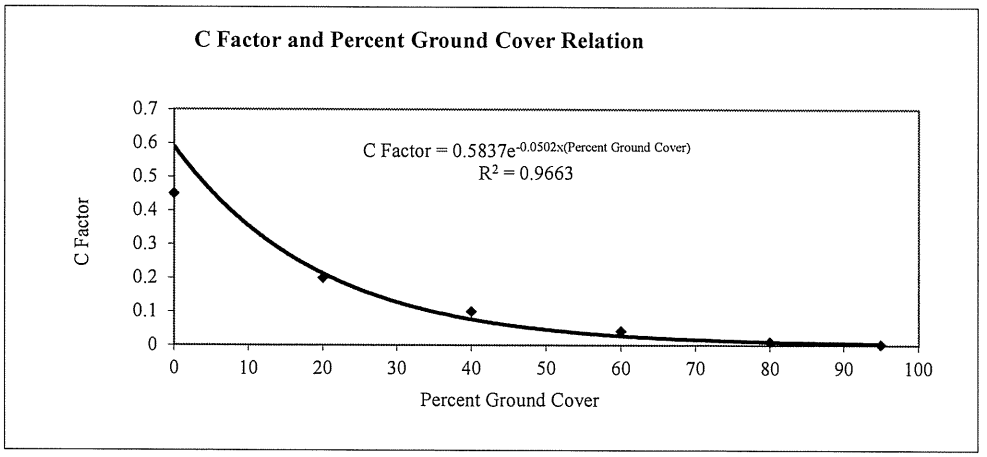
The slope length/slope gradient factor, $L_s$, represents the erosion of the soil due to both slope length and degree of slope. The slopes of interest are the typical side slope and top slope conditions.
See sheet IIIF-D-7 for the locations of the slopes analyzed.

| | | | | | |
|---|---|---|---|---|---|
| Case 1. | Typical Top Slope | | Case 2. | Longest Top Slope | |
| | slope = | 5 % | | slope = | 5 % |
| | length = | 200 ft | | length = | 900 ft |
| Case 3. | Typical Top Slope | | Case 4. | Longest Top Slope | |
| | slope = | 4 % | | slope = | 4 % |
| | length = | 200 ft | | length = | 300 ft |
| Case 5. | Typical Side Slope | | Case 6. | Longest Side Slope | |
| | slope = | 25 % | | slope = | 25 % |
| | length = | 120 ft | | length = | 200 ft |

| Case | Slope | | |
|---|---|---|---|
| | Slope | Length | $L_s$ |
| | (%) | (ft) | |
| 1. Typical Top Slope | 5 | 200 | 0.80 |
| 2. Longest Top Slope | 5 | 900 | 1.70 |
| 3. Typical Side Slope | 4 | 200 | 0.55 |
| 4. Longest Side Slope | 4 | 300 | 0.62 |
| 5. Typical Top Slope | 25 | 120 | 6.50 |
| 6. Longest Top Slope | 25 | 200 | 8.00 |

The plant cover or cropping management factor, C, represents the percentage of soil loss that would occur if the surface were partially protected by some combination of cover and management practices. C Factor for Permanent Pasture, Range, and Idle Land with No Appreciable Canopy has the following relation with percent ground cover (GC) (from Ref 3, p.11) .

| % GC | C Factor |
|---|---|
| 0 | 0.45 |
| 20 | 0.2 |
| 40 | 0.1 |
| 60 | 0.042 |
| 80 | 0.011 |
| 95 | 0.0030 |




C Factor= $0.5837e^{(-0.0502x60)}$
C Factor= 0.0287 (for 60% ground cover)

The erosion control practice factor, P, measures the effect of control practices that reduce the erosion potential of the runoff by influencing drainage patterns, runoff concentration , and runoff velocity. Contouring for this site will be done only to establish vegetation.

P = 1.00

2 Slope Condition Soil loss calculations

| | R | K | $L_s$ | C | P | A (tons/ac/yr) |
|---|---|---|---|---|---|---|
| 1. Typical Top Slope 5% slope 200 ft length | 290 | 0.2 | 0.80 | 0.0287 | 1.00 | 1.33 |
| 2. Longest Top Slope 5% slope 900 ft length | 290 | 0.2 | 1.70 | 0.0287 | 1.00 | 2.83 |
| 3. Typical Top Slope 4% slope 200 ft length | 290 | 0.2 | 0.55 | 0.0287 | 1.00 | 0.92 |
| 4. Longest Top Slope 4% slope 300 ft length | 290 | 0.2 | 0.62 | 0.0287 | 1.00 | 1.03 |
| 5. Typical Side Slope 25% slope 120 ft length | 290 | 0.2 | 6.50 | 0.0287 | 1.00 | 10.83 |
| 6. Typical Side Slope 25% slope 200 ft length | 290 | 0.2 | 8.00 | 0.0287 | 1.00 | 13.32 |

3. Note: Erosion layer will be maintained to provide 60% ground cover.

Erosion layer thickness calculations:

$$T_{el} = 6in + \frac{AYF(2000lb/ton)(12in/ft)}{w(43{,}560sf/ac)}$$

Where:
- $T_{el}$ = Erosion layer thickness
- A = Soil loss (ton/ac/yr)
- Y = Postclosure period (yr)
- F = Factor of Safety
- w = Specific weight of soil (pcf)

| | | |
|---|---|---|
| Y = | 30 | yr |
| F = | 2 | |
| w = | 110 | pcf |

| | | |
|---|---|---|
| 1. Typical 5% Top Slope Thickness: | | |
| $T_{el}$, Required thickness[1] = | 6.400 | in |
| Total estimated soil loss = | 0.400 | in |
| Specified thickness = | 12.000 | in |
| 2. Longest 5% Top Slope Thickness: | | |
| $T_{el}$, Required thickness[1] = | 6.851 | in |
| Total estimated soil loss = | 0.851 | in |
| Specified thickness = | 12.000 | in |
| 3. Typical 4% Top Slope Thickness: | | |
| $T_{el}$, Required thickness[1] = | 6.275 | in |
| Total estimated soil loss = | 0.275 | in |
| Specified thickness = | 12.000 | in |
| 4. Longest 4% Top Slope Thickness: | | |
| $T_{el}$, Required thickness[1] = | 6.310 | in |
| Total estimated soil loss = | 0.310 | in |
| Specified thickness = | 12.000 | in |
| 5. Typical Side Slope Thickness: | | |
| $T_{el}$, Required thickness[1] = | 9.253 | in |
| Total estimated soil loss = | 3.253 | in |
| Specified thickness = | 12.000 | in |
| 6. Longest Side Slope Thickness: | | |
| $T_{el}$, Required thickness[1] = | 10.004 | in |
| Total estimated soil loss = | 4.004 | in |
| Specified thickness = | 12.000 | in |

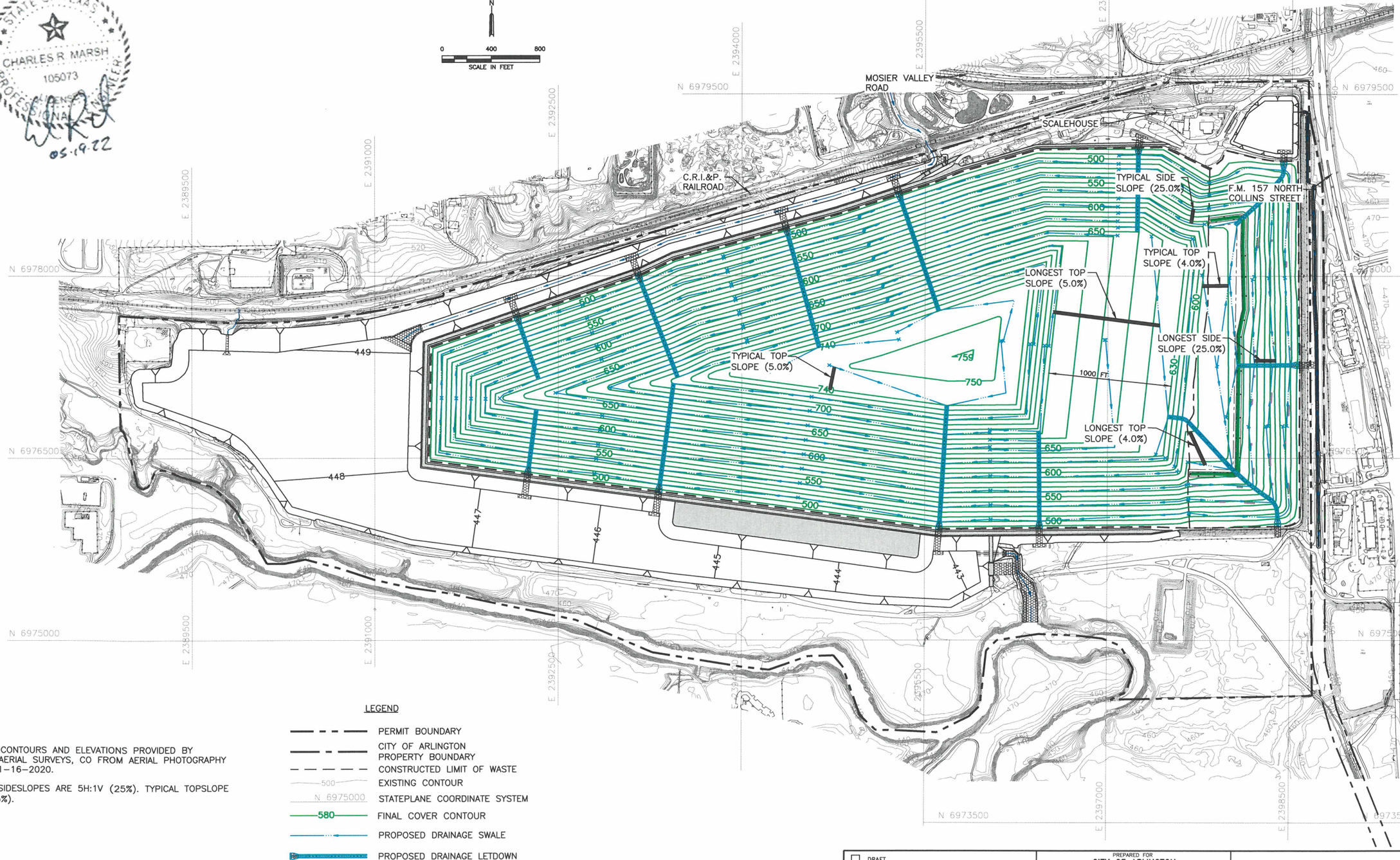
4. Note: [1]Required thicknesses include 6 inch minimum required and estimated soil loss.

Summary:

Calculated erosion losses are shown in Step 2 above.
The erosion layer will be a minimum of 12 inches thick.
As shown above, this is a conservative design considering
the maximum expected soil loss for a 30 year period is 1.14 inches.

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05.19.22

0 400 800
SCALE IN FEET




NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. TYPICAL SIDESLOPES ARE 5H:1V (25%). TYPICAL TOPSLOPE IS 4:1 (5%).

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN

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☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-D-7-SLOPE LENGTH.DWG

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

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| | | |
| | | |
| | | |
| | | |

# MAJOR PERMIT AMENDMENT
# EROSION LAYER EVALUATION
# TYPICAL SLOPE LENGTHS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

DRAWING IIIF-D-7

O:\0023\404\EXPANSION 2021\PART III\IIIF\IIIF-D\IIIF-D-7-SLOPE LENGTH.dwg, jwilson, 1:2

**SOIL LOSS ESTIMATE SUMMARY TABLE**

| Case | Slope (%) | Length (ft) | $L_s$ | Percent Ground Cover | C Factor | A (tons/ac/yr) |
|---|---|---|---|---|---|---|
| Typical Top Slope | 5 | 200 | 0.80 | 60 | 0.042 | 1.9 |
| Typical Top Slope | 5 | 200 | 0.80 | 70 | 0.017 | 0.8 |
| Typical Top Slope | 5 | 200 | 0.80 | 80 | 0.011 | 0.5 |
| Typical Top Slope | 5 | 200 | 0.80 | 85 | 0.0082 | 0.4 |
| Longest Top Slope | 5 | 900 | 1.70 | 60 | 0.042 | 4.1 |
| Longest Top Slope | 5 | 900 | 1.70 | 70 | 0.017 | 1.7 |
| Longest Top Slope | 5 | 900 | 1.70 | 80 | 0.011 | 1.1 |
| Longest Top Slope | 5 | 900 | 1.70 | 85 | 0.0082 | 0.8 |
| Typical Side Slope | 25 | 120 | 6.50 | 60 | 0.042 | 15.8 |
| Typical Side Slope | 25 | 120 | 6.50 | 70 | 0.017 | 6.4 |
| Typical Side Slope | 25 | 120 | 6.50 | 80 | 0.011 | 4.1 |
| Typical Side Slope | 25 | 120 | 6.50 | 85 | 0.0082 | 3.1 |
| Longest Side Slope | 25 | 200 | 8.00 | 60 | 0.042 | 19.5 |
| Longest Side Slope | 25 | 200 | 8.00 | 70 | 0.017 | 7.9 |
| Longest Side Slope | 25 | 200 | 8.00 | 80 | 0.011 | 5.1 |
| Longest Side Slope | 25 | 200 | 8.00 | 85 | 0.0082 | 3.8 |
| Typical Top Slope | 4 | 200 | 0.55 | 60 | 0.042 | 1.3 |
| Typical Top Slope | 4 | 200 | 0.55 | 70 | 0.017 | 0.5 |
| Typical Top Slope | 4 | 200 | 0.55 | 80 | 0.011 | 0.4 |
| Typical Top Slope | 4 | 200 | 0.55 | 85 | 0.0082 | 0.3 |
| Longest Top Slope | 4 | 300 | 0.62 | 60 | 0.042 | 1.5 |
| Longest Top Slope | 4 | 300 | 0.62 | 70 | 0.017 | 0.6 |
| Longest Top Slope | 4 | 300 | 0.62 | 80 | 0.011 | 0.4 |
| Longest Top Slope | 4 | 300 | 0.62 | 85 | 0.0082 | 0.3 |

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

# USE OF THE UNIVERSAL SOIL LOSS EQUATION IN FINAL COVER/CONFIGURATION DESIGN

## PROCEDURAL HANDBOOK

PERMITS SECTION
MUNICIPAL SOLID WASTE DIVISION

OCTOBER 1993

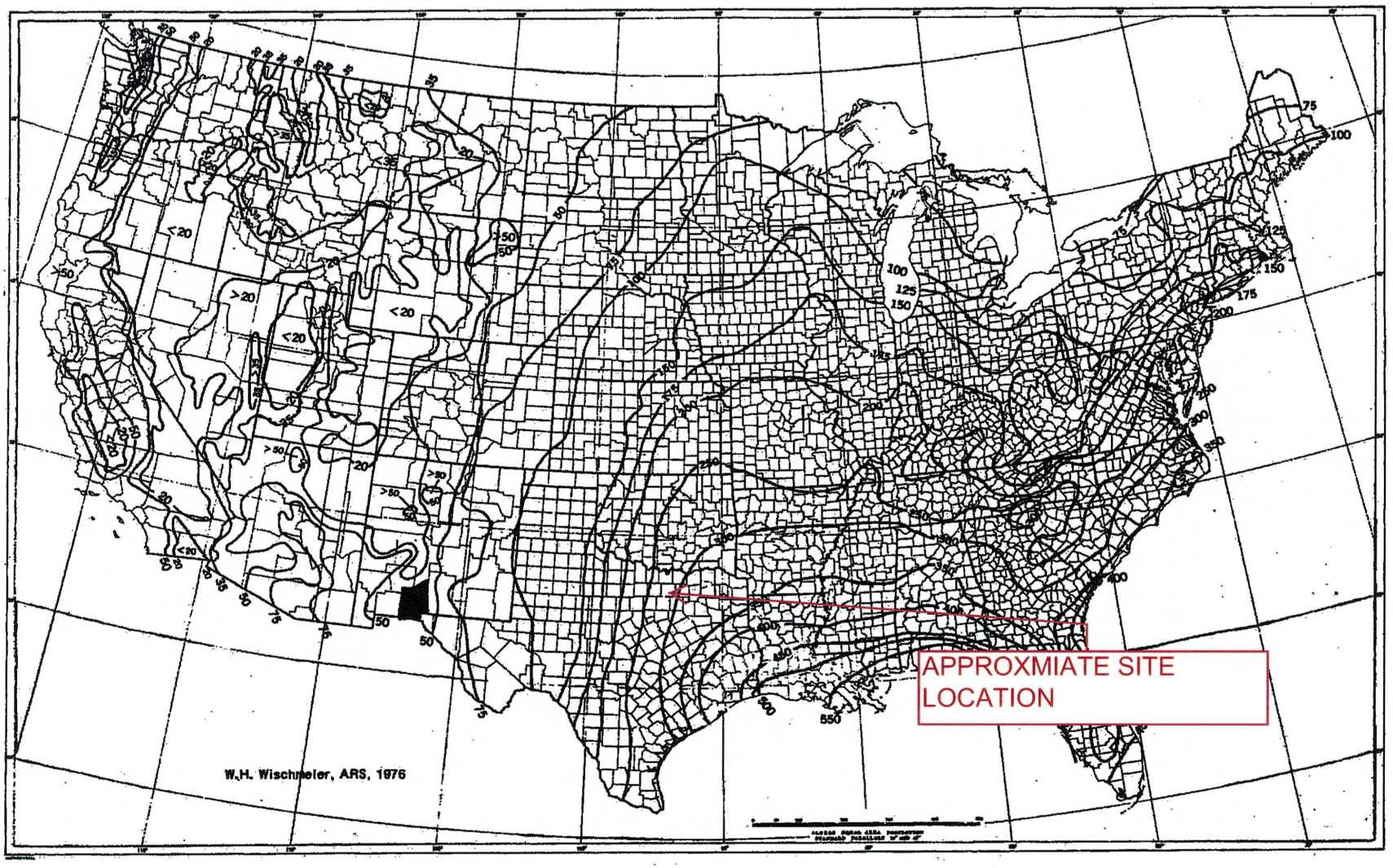



Figure 3–1.—Average annual values of the R factor.

tion and developmental areas can be obtained from table 5 if good judgment is exercised in comparing the surface conditions with those of agricultural conditions specified in lines of the table. Time intervals analogous to cropstage periods will be defined to begin and end with successive construction or management activities that appreciably change the surface conditions. The procedure is then similar to that described for cropland.

Establishing vegetation on the denuded areas as quickly as possible is highly important. A good sod has a C value of 0.01 or less (table 5-B), but such a low C value can be obtained quickly only by laying sod on the area, at a substantial cost. When grass or small grain is started from seed, the probable soil loss for the period while cover is developing can be computed by the procedure outlined for estimating cropstage-period soil losses. If the seeding is on topsoil, without a mulch, the soil loss ratios given in line 141 of table 5 are appropriate for cropstage C values. If the seeding is on a desurfaced area, where residual effects of prior vegetation are no longer significant, the ratios for periods SB, 1 and 2 are 1.0, 0.75 and 0.50, respectively, and line 141 applies for cropstage 3. When the seedbed is protected by a mulch, the pertinent mulch factor from the upper curve of figure 6 or table 9 is applicable until good canopy cover is attained. The combined effects of vegetative mulch and low-growing canopy are given in figure 7. When grass is established in small grain, it can usually be evaluated as established meadow about 2 mo after the grain is cut.

### C Values for Pasture, Range, and Idle Land

Factor C for a specific combination of cover conditions on these types of land may be obtained from table 10 (57). The cover characteristics that must be appraised before consulting this table are defined in the table and its footnotes. Cropstage periods and EI monthly distribution data are generally not necessary where perennial vegetation has become established and there is no mechanical disturbance of the soil.

Available soil loss data from undisturbed land were not sufficient to derive table 10 by direct comparison of measured soil loss rates, as was done for development of table 5. However, analyses of the assembled erosion data showed that the research information on values of C can be extended to completely different situations by combining subfactors that evaluate three separate and distinct, but interrelated, zones of influence: (a) vegetative cover in direct contact with the soil surface, (b) canopy cover, and (c) residual and tillage effects.

Subfactors for various percentages of surface cover by mulch are given by the upper curve of

TABLE 10.—*Factor C for permanent pasture, range, and idle land*[1]

| Vegetative canopy | | Cover that contacts the soil surface | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type and height[2] | Percent cover[3] | | Percent ground cover | | | | | |
| | | Type[4] | 0 | 20 | 40 | 60 | 80 | 95+ |
| No appreciable canopy | | G | 0.45 | 0.20 | 0.10 | 0.042 | 0.013 | 0.003 |
| | | W | .45 | .24 | .15 | .091 | .043 | .011 |
| Tall weeds or short brush with average drop fall height of 20 in | 25 | G | .36 | .17 | .09 | .038 | .013 | .003 |
| | | W | .36 | .20 | .13 | .083 | .041 | .011 |
| | 50 | G | .26 | .13 | .07 | .035 | .012 | .003 |
| | | W | .26 | .16 | .11 | .076 | .039 | .011 |
| | 75 | G | .17 | .10 | .06 | .032 | .011 | .003 |
| | | W | .17 | .12 | .09 | .068 | .038 | .011 |
| Appreciable brush or bushes, with average drop fall height of 6½ ft | 25 | G | .40 | .18 | .09 | .040 | .013 | .003 |
| | | W | .40 | .22 | .14 | .087 | .042 | .011 |
| | 50 | G | .34 | .16 | .08 | .038 | .012 | .003 |
| | | W | .34 | .19 | .13 | .082 | .041 | .011 |
| | 75 | G | .28 | .14 | .08 | .036 | .012 | .003 |
| | | W | .28 | .17 | .12 | .078 | .040 | .011 |
| Trees, but no appreciable low brush. Average drop fall height of 13 ft | 25 | G | .42 | .19 | .10 | .041 | .013 | .003 |
| | | W | .42 | .23 | .14 | .089 | .042 | .011 |
| | 50 | G | .39 | .18 | .09 | .040 | .013 | .003 |
| | | W | .39 | .21 | .14 | .087 | .042 | .011 |
| | 75 | G | .36 | .17 | .09 | .039 | .012 | .003 |
| | | W | .36 | .20 | .13 | .084 | .041 | .011 |

[1] The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G: cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 in deep.

W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

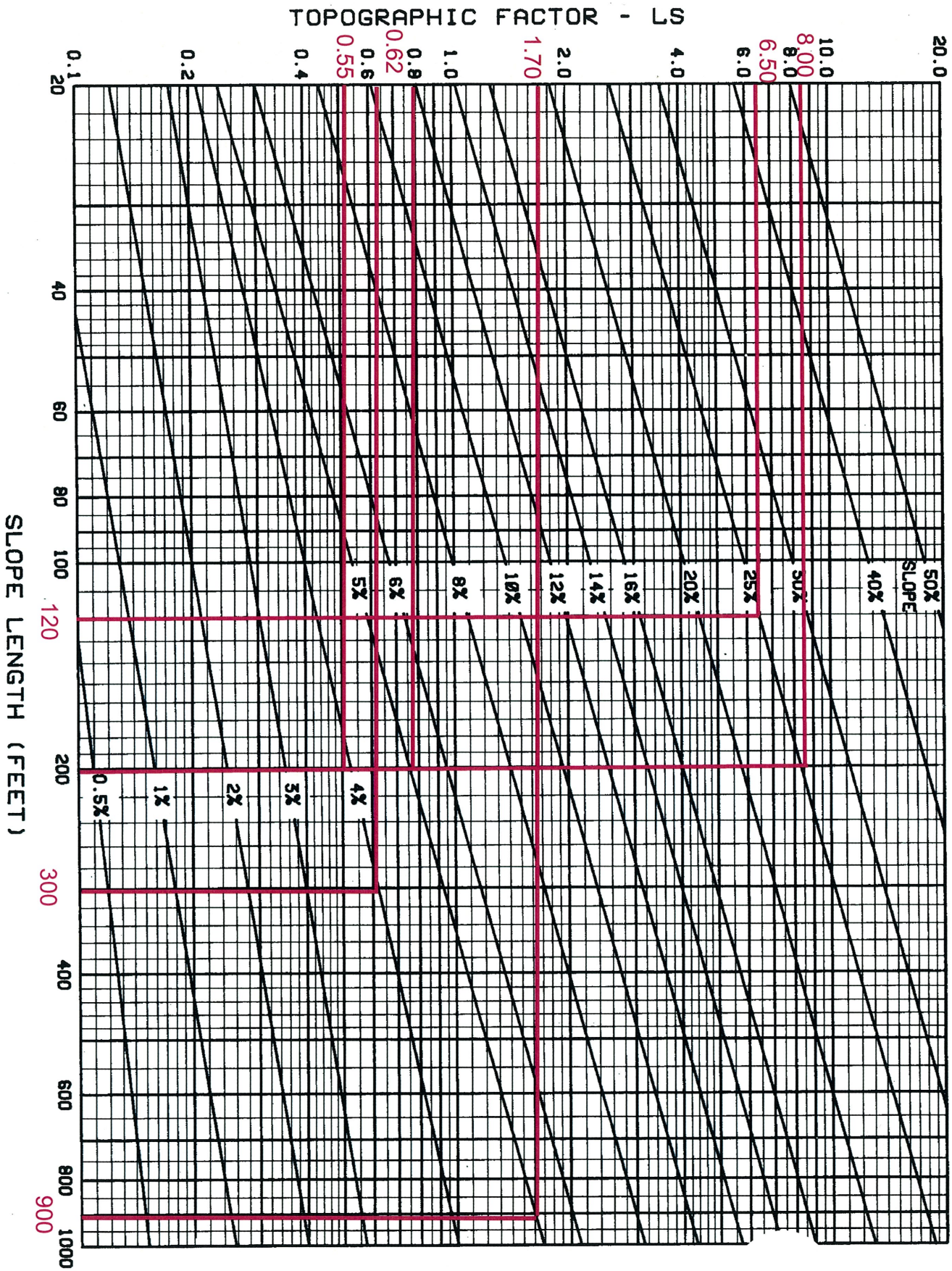
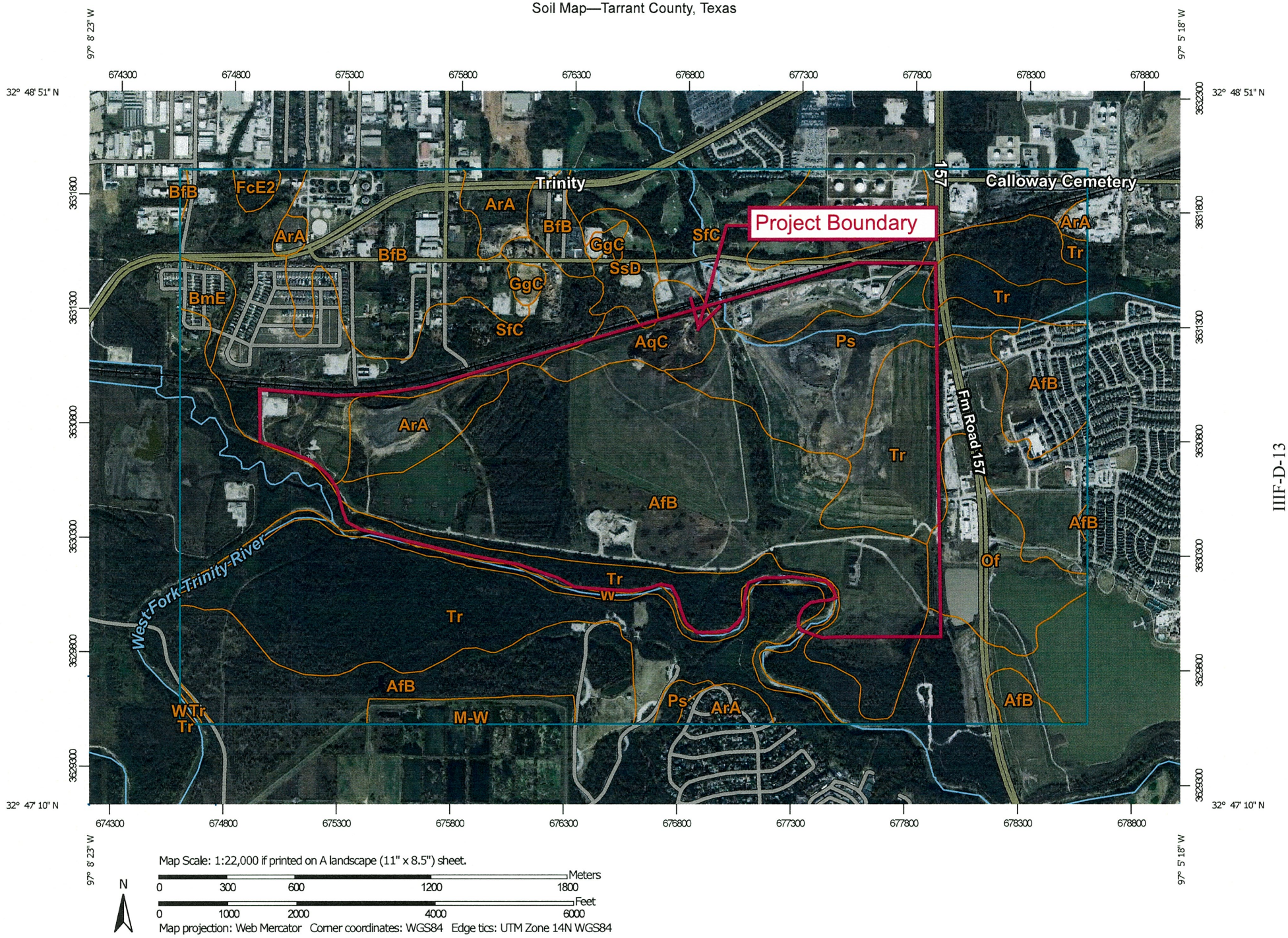



FIGURE 4.—Slope-effect chart (topographic factor, LS). $LS = (\lambda/72.6)^{m}$ $(65.41 \sin^2\theta + 4.56 \sin\theta + 0.065)$ where $\lambda$ = slope length in feet; $\theta$ = angle of slope; and $m = 0.2$ for gradients < 1 percent, 0.3 for 1 to 3 percent slopes, 0.4 for 3.5 to 4.5 percent slopes, and 0.5 for slopes of 5 percent or steeper.




USDA **Natural Resources Conservation Service**

Web Soil Survey
National Cooperative Soil Survey

## MAP LEGEND

**Area of Interest (AOI)**

- Area of Interest (AOI)

**Soils**

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

**Special Point Features**

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

**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 1:20,000.

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: Tarrant County, Texas
Survey Area Data: Version 19, Sep 10, 2021

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

Date(s) aerial images were photographed: Jan 18, 2020—Dec 10, 2020

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.

# Map Unit Legend

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| AfB | Arents, frequently flooded | 611.6 | 25.4% |
| AqC | Aquilla loamy fine sand, 1 to 5 percent slopes | 41.0 | 1.7% |
| ArA | Arents, loamy | 91.8 | 3.8% |
| BfB | Bastsil fine sandy loam, 0 to 3 percent slopes | 222.6 | 9.3% |
| BmE | Birome-Aubrey-Rayex complex, 5 to 15 percent slopes | 15.0 | 0.6% |
| FcE2 | Ferris clay, 5 to 12 percent slopes, eroded | 7.4 | 0.3% |
| GgC | Gasil sandy clay loam, graded, 1 to 5 percent slopes | 10.3 | 0.4% |
| M-W | Water, miscellaneous | 25.8 | 1.1% |
| Of | Ovan clay, frequently flooded | 84.7 | 3.5% |
| Ps | Pulexas fine sandy loam, frequently flooded | 152.2 | 6.3% |
| SfC | Silawa fine sandy loam, 3 to 8 percent slopes | 406.1 | 16.9% |
| SsD | Silstid loamy fine sand, 1 to 5 percent slopes | 25.7 | 1.1% |
| Tr | Trinity clay, 0 to 1 percent slopes, frequently flooded | 674.4 | 28.1% |
| W | Water | 35.1 | 1.5% |
| **Totals for Area of Interest** | | **2,403.8** | **100.0%** |

United States Environmental Protection Agency | Solid Waste and Emergency Response (5305) | EPA530-R-93-017 November 1993 www.epa.gov/osw

EPA

# Solid Waste Disposal Facility Criteria

## Technical Manual

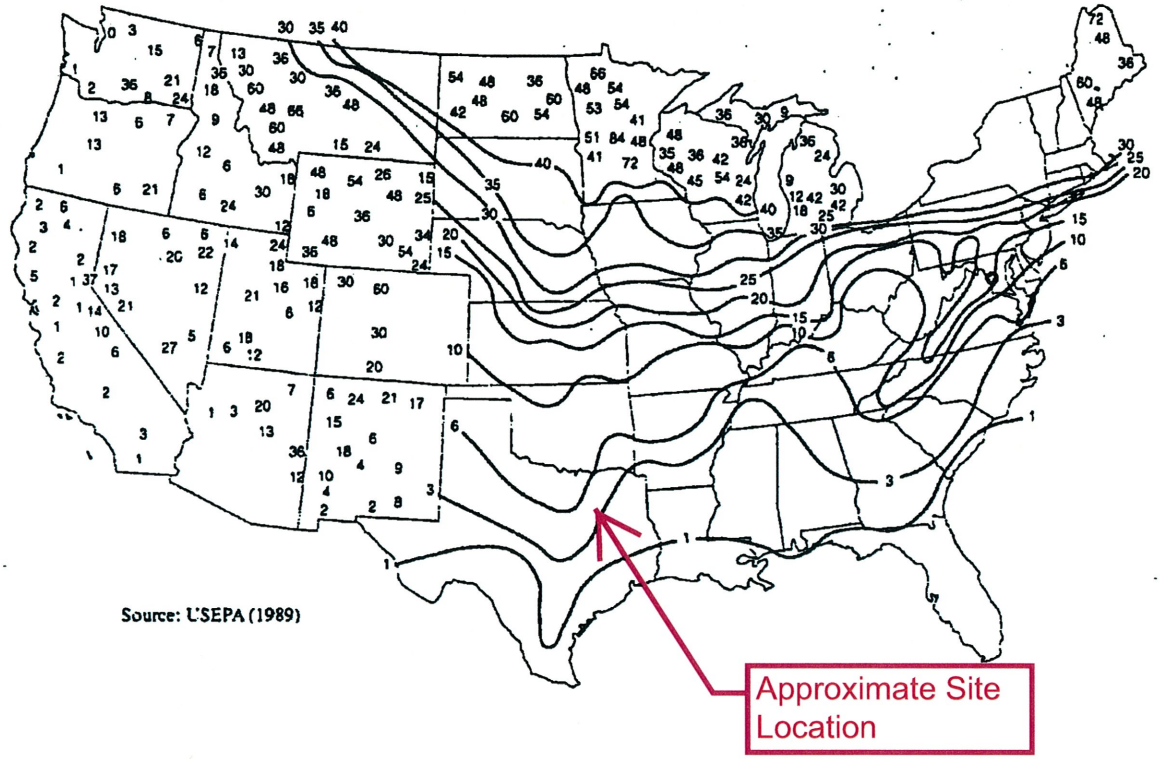



**Figure 6-4**
**Regional Depth of Frost Penetration in Inches**

**Required:** Determine the sheet flow velocity for the final cover system design and compare to the permissible non-erodible flow velocity.

**Method:**

1. Determine the flow using the Rational Method.
2. Calculate flow depth using Kinematic Wave procedures.
3. Compute flow velocity and compare to permissible non-erodibility velocity.

**References:**

1. *NOAA Atlas 14 for 2 years interval with a duration of 24 hours*
2. United States Soil Conservation Service, *TR-55 Hydrology for Small Watersheds*, June 1986.

**Solution:** Use the typical case scenarios from the USLE calculation to determine the expected sheet flow velocity.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Case 1. Typical top slope | | | | Case 2. Longest top slope | | | |
| | slope = | 0.05 | ft/ft | | slope = | 0.05 | ft/ft |
| | length = | 200 | ft | | length = | 900 | ft |
| Case 3. Typical side slope | | | | Case 4. Longest side slope | | | |
| | slope = | 0.04 | ft/ft | | slope = | 0.04 | ft/ft |
| | length = | 200 | ft | | length = | 300 | ft |
| Case 5. Typical top slope | | | | Case 6. Longest top slope | | | |
| | slope = | 0.25 | ft/ft | | slope = | 0.25 | ft/ft |
| | length = | 120 | ft | | length = | 200 | ft |

Time of Concentration:

$$t_c = \frac{0.007(nL)^{0.8}}{(P_{2,24})^{0.5} S^{0.4}}$$

Where:

| | |
|---|---|
| $t_c$ = | time of concentration (hr) |
| n = | Manning's roughness coefficient |
| L = | slope length |
| $P_{2,24}$ = | 2-year, 24-hour rainfall depth (in) |
| S = | slope (ft/ft) |



United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

**Conservation
Engineering
Division**

Technical
Release 55

June 1986

# Urban Hydrology for Small Watersheds

## TR-55

# Chapter 3 Time of Concentration and Travel Time

Travel time ( $T_t$ ) is the time it takes water to travel from one location to another in a watershed. $T_t$ is a component of time of concentration ( $T_c$ ), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. $T_c$ is computed by summing all the travel times for consecutive components of the drainage conveyance system.

$T_c$ influences the shape and peak of the runoff hydrograph. Urbanization usually decreases $T_c$, thereby increasing the peak discharge. But $T_c$ can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

## Factors affecting time of concentration and travel time

### Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

### Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

### Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

## Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time ( $T_t$ ) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

$T_t$ = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

Time of concentration ( $T_c$ ) is the sum of $T_t$ values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

$T_c$ = time of concentration (hr)
m = number of flow segments

Determine $P_{2,24}$:

$P_{2,24}$ = 3.91 in (Ref 1.)

Reference: NOAA Atlas 14 for 2 years interval with a duration of 24 hours

Calculate $t_c$:

Case 1:

| | | |
|---|---|---|
| n = | 0.24 | |
| L = | 200 | |
| $P_{2,24}$ = | 3.9 | |
| S = | 0.05 | |
| $t_c$ = | 0.26 | hr |
| | 15.58 | min |

Case 2:

| | | |
|---|---|---|
| n = | 0.24 | |
| L = | 900 | |
| $P_{2,24}$ = | 3.9 | |
| S = | 0.05 | |
| $t_c$ = | 0.86 | hr |
| | 51.90 | min |

Case 3:

| | | |
|---|---|---|
| n = | 0.24 | |
| L = | 200 | |
| $P_{2,24}$ = | 3.9 | |
| S = | 0.04 | |
| $t_c$ = | 0.28 | hr |
| | 17.03 | min |

Case 4:

| | | |
|---|---|---|
| n = | 0.24 | |
| L = | 300 | |
| $P_{2,24}$ = | 3.9 | |
| S = | 0.04 | |
| $t_c$ = | 0.39 | hr |
| | 23.56 | min |

Case 5:

| | | |
|---|---|---|
| n = | 0.24 | |
| L = | 120 | |
| $P_{2,24}$ = | 3.9 | |
| S = | 0.25 | |
| $t_c$ = | 0.09 | hr |
| | 5.44 | min |

Case 6:

| | | |
|---|---|---|
| n = | 0.24 | |
| L = | 200 | |
| $P_{2,24}$ = | 3.9 | |
| S = | 0.25 | |
| $t_c$ = | 0.14 | hr |
| | 8.18 | min |

Calculate the design 25-year frequency for each condition:

$Q = CiA$

Where:
- Q = flow rate (cfs)
- C = runoff coefficient
- i = rainfall intensity (in/hr)
- A = drainage area (ac)

Where: i = rainfall intensity (in/hr) = 7.87

Reference: NOAA Atlas 14 for 25 - years interval with a duration of 10 minutes

For a unit width of final cover, the flow lengths shown on sheet IIIF-D-7 for each case is used.

A=[ Length (ft) x Width (ft) ] / 43560 sq. ft/acre = A in acres

Case 1:

| | | |
|---|---|---|
| C = | 0.7 | |
| i = | 7.87 | in/hr |
| Length: | 200.00 | ft |
| A | 0.0046 | ac |
| Q = | 0.025 | cfs |

Case 2:

| | | |
|---|---|---|
| C = | 0.7 | |
| i = | 7.87 | in/hr |
| Length: | 900.00 | ft |
| A | 0.0207 | ac |
| Q = | 0.114 | cfs |

Case 3:

| | | |
|---|---|---|
| C = | 0.7 | |
| i = | 7.87 | in/hr |
| Length: | 200.00 | ft |
| A | 0.0046 | ac |
| Q = | 0.025 | cfs |

Case 4:

| | | |
|---|---|---|
| C = | 0.7 | |
| i = | 7.87 | in/hr |
| Length: | 300.00 | ft |
| A | 0.0069 | ac |
| Q = | 0.038 | cfs |

Case 5:

| | | |
|---|---|---|
| C = | 0.7 | |
| i = | 7.87 | in/hr |
| Length: | 120.00 | ft |
| A | 0.0028 | ac |
| Q = | 0.015 | cfs |

Case 6:

| | | |
|---|---|---|
| C = | 0.7 | |
| i = | 7.87 | in/hr |
| Length: | 200.00 | ft |
| A | 0.0046 | ac |
| Q = | 0.025 | cfs |

Approximate depth of flow:

Using Manning's Equation

$$V = (1.49/n)\, y^{0.67}\, S^{0.5}$$

$Q = VA \quad \Rightarrow \quad V = Q/A$

$A = y \times 1$ (assuming unit width of flow)

substituting for V

$$Q/y = (1.49/n)\, y^{0.67}\, S^{0.5}$$

$$Q = (1.49/n)\, y^{1.67}\, S^{0.5}$$

solve for y

$$y = (Qn/1.49\, S^{0.5})^{1/1.67}$$

$$y = (Qn/1.49 S^{0.5})^{0.6}$$

Case 1:

| | | |
|---|---|---|
| Q = | 0.025 | cfs |
| n = | 0.03 | |
| S = | 0.05 | ft/ft |
| y = | 0.026 | ft |

Case 2:

| | | |
|---|---|---|
| Q = | 0.114 | cfs |
| n = | 0.03 | |
| S = | 0.05 | ft/ft |
| y = | 0.064 | ft |

Case 3:

| | | |
|---|---|---|
| Q = | 0.025 | cfs |
| n = | 0.03 | |
| S = | 0.04 | ft/ft |
| y = | 0.028 | ft |

Case 4:

| | | |
|---|---|---|
| Q = | 0.038 | cfs |
| n = | 0.03 | |
| S = | 0.04 | ft/ft |
| y = | 0.035 | ft |

Case 5:

| | | |
|---|---|---|
| Q = | 0.015 | cfs |
| n = | 0.03 | |
| S = | 0.25 | ft/ft |
| y = | 0.012 | ft |

Case 6:

| | | |
|---|---|---|
| Q = | 0.025 | cfs |
| n = | 0.03 | |
| S = | 0.25 | ft/ft |
| y = | 0.016 | ft |

ARLINGTON LANDFILL
0023-404-11-96
EROSION LAYER EVALUATION



Determine sheet flow velocity:

V = Q/A (assume unit flow width for the flow area, A)

| | | |
|---|---|---|
| Case 1: | | |
| Q = | 0.025 | cfs |
| A = | 0.026 | sf |
| V = | 0.97 | ft/s |

| | | |
|---|---|---|
| Case 2: | | |
| Q = | 0.114 | cfs |
| A = | 0.064 | sf |
| V = | 1.78 | ft/s |

| | | |
|---|---|---|
| Case 3: | | |
| Q = | 0.025 | cfs |
| A = | 0.028 | sf |
| V = | 0.91 | ft/s |

| | | |
|---|---|---|
| Case 4: | | |
| Q = | 0.038 | cfs |
| A = | 0.035 | sf |
| V = | 1.07 | ft/s |

| | | |
|---|---|---|
| Case 5: | | |
| Q = | 0.015 | cfs |
| A = | 0.012 | sf |
| V = | 1.29 | ft/s |

| | | |
|---|---|---|
| Case 6: | | |
| Q = | 0.025 | cfs |
| A = | 0.016 | sf |
| V = | 1.58 | ft/s |

Permissible non-erodible velocity is 5.0 ft/s. Therefore, expected sheet flow velocity is acceptable on the final cover system top and side slopes.

**NOAA Atlas 14, Volume 11, Version 2**
**Location name: Euless, Texas, USA***
**Latitude: 32.8003°, Longitude: -97.1086°**
**Elevation: 468.87 ft****
* source: ESRI Maps
** source: USGS

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 0.413 (0.313-0.546) | 0.482 (0.369-0.632) | 0.596 (0.454-0.783) | 0.689 (0.517-0.918) | 0.818 (0.594-1.12) | 0.915 (0.648-1.28) | 1.01 (0.700-1.46) | 1.12 (0.751-1.65) | 1.26 (0.818-1.91) | 1.37 (0.865-2.13) |
| 10-min | 0.662 (0.501-0.874) | 0.773 (0.591-1.01) | 0.955 (0.728-1.25) | 1.11 (0.830-1.47) | 1.31 (0.955-1.80) | 1.47 (1.04-2.06) | 1.63 (1.12-2.34) | 1.79 (1.20-2.64) | 2.00 (1.30-3.04) | 2.16 (1.37-3.36) |
| 15-min | 0.824 (0.624-1.09) | 0.961 (0.735-1.26) | 1.19 (0.904-1.56) | 1.37 (1.03-1.83) | 1.63 (1.18-2.22) | 1.82 (1.28-2.55) | 2.01 (1.39-2.89) | 2.21 (1.49-3.26) | 2.49 (1.62-3.78) | 2.70 (1.71-4.20) |
| 30-min | 1.15 (0.868-1.51) | 1.33 (1.02-1.75) | 1.64 (1.25-2.16) | 1.90 (1.42-2.53) | 2.24 (1.63-3.06) | 2.50 (1.77-3.51) | 2.77 (1.91-3.98) | 3.05 (2.05-4.49) | 3.44 (2.24-5.23) | 3.75 (2.37-5.83) |
| 60-min | 1.49 (1.13-1.97) | 1.74 (1.33-2.28) | 2.15 (1.63-2.82) | 2.48 (1.86-3.30) | 2.94 (2.14-4.02) | 3.29 (2.33-4.61) | 3.65 (2.52-5.25) | 4.04 (2.72-5.95) | 4.58 (2.98-6.96) | 5.01 (3.17-7.79) |
| 2-hr | 1.82 (1.39-2.38) | 2.15 (1.65-2.77) | 2.68 (2.06-3.48) | 3.12 (2.37-4.11) | 3.75 (2.75-5.06) | 4.23 (3.02-5.86) | 4.74 (3.29-6.73) | 5.29 (3.58-7.68) | 6.06 (3.96-9.08) | 6.67 (4.24-10.2) |
| 3-hr | 2.01 (1.55-2.61) | 2.40 (1.85-3.06) | 3.01 (2.32-3.88) | 3.53 (2.69-4.61) | 4.26 (3.14-5.72) | 4.84 (3.47-6.66) | 5.45 (3.80-7.69) | 6.12 (4.15-8.82) | 7.05 (4.62-10.5) | 7.80 (4.97-11.9) |
| 6-hr | 2.37 (1.84-3.04) | 2.85 (2.22-3.59) | 3.60 (2.81-4.59) | 4.25 (3.27-5.50) | 5.18 (3.85-6.88) | 5.92 (4.28-8.05) | 6.71 (4.71-9.33) | 7.57 (5.17-10.8) | 8.77 (5.78-12.9) | 9.74 (6.24-14.6) |
| 12-hr | 2.78 (2.18-3.53) | 3.35 (2.63-4.18) | 4.25 (3.35-5.36) | 5.03 (3.90-6.43) | 6.13 (4.60-8.05) | 7.02 (5.11-9.43) | 7.95 (5.62-10.9) | 8.98 (6.17-12.6) | 10.4 (6.89-15.1) | 11.6 (7.45-17.1) |
| 24-hr | 3.24 (2.57-4.07) | 3.91 (3.11-4.83) | 4.96 (3.95-6.19) | 5.87 (4.60-7.42) | 7.16 (5.41-9.28) | 8.18 (6.00-10.9) | 9.27 (6.60-12.6) | 10.5 (7.23-14.5) | 12.1 (8.07-17.3) | 13.5 (8.72-19.6) |
| 2-day | 3.77 (3.01-4.68) | 4.53 (3.64-5.53) | 5.73 (4.60-7.07) | 6.77 (5.35-8.46) | 8.25 (6.29-10.6) | 9.43 (6.97-12.4) | 10.7 (7.67-14.3) | 12.1 (8.40-16.5) | 14.0 (9.37-19.7) | 15.6 (10.1-22.3) |
| 3-day | 4.11 (3.31-5.07) | 4.94 (3.99-5.99) | 6.24 (5.05-7.65) | 7.37 (5.86-9.15) | 8.97 (6.88-11.4) | 10.3 (7.61-13.3) | 11.6 (8.37-15.4) | 13.1 (9.16-17.8) | 15.2 (10.2-21.2) | 16.9 (11.0-24.0) |
| 4-day | 4.36 (3.52-5.35) | 5.24 (4.24-6.32) | 6.61 (5.37-8.06) | 7.80 (6.24-9.65) | 9.51 (7.32-12.0) | 10.9 (8.10-14.1) | 12.3 (8.90-16.3) | 13.9 (9.74-18.7) | 16.1 (10.9-22.4) | 18.0 (11.7-25.4) |
| 7-day | 4.88 (3.97-5.93) | 5.86 (4.79-7.01) | 7.40 (6.06-8.94) | 8.74 (7.04-10.7) | 10.7 (8.26-13.3) | 12.2 (9.14-15.6) | 13.8 (10.0-18.0) | 15.6 (11.0-20.8) | 18.1 (12.2-24.8) | 20.2 (13.2-28.1) |
| 10-day | 5.33 (4.36-6.44) | 6.39 (5.25-7.60) | 8.06 (6.63-9.68) | 9.50 (7.69-11.6) | 11.6 (9.00-14.4) | 13.2 (9.95-16.8) | 15.0 (10.9-19.4) | 16.9 (11.9-22.3) | 19.6 (13.3-26.5) | 21.7 (14.3-30.0) |
| 20-day | 6.88 (5.69-8.22) | 8.09 (6.75-9.57) | 10.0 (8.36-11.9) | 11.7 (9.56-14.1) | 14.0 (11.0-17.2) | 15.8 (12.0-19.7) | 17.6 (13.0-22.5) | 19.7 (14.0-25.7) | 22.6 (15.4-30.2) | 25.0 (16.5-34.0) |
| 30-day | 8.19 (6.82-9.72) | 9.53 (8.02-11.2) | 11.7 (9.83-13.9) | 13.5 (11.1-16.2) | 16.1 (12.6-19.5) | 18.0 (13.7-22.3) | 19.9 (14.7-25.3) | 22.1 (15.8-28.6) | 25.2 (17.3-33.4) | 27.7 (18.4-37.4) |
| 45-day | 10.0 (8.38-11.8) | 11.6 (9.83-13.6) | 14.2 (12.0-16.7) | 16.4 (13.6-19.5) | 19.5 (15.4-23.5) | 21.8 (16.7-26.8) | 24.1 (17.9-30.3) | 26.7 (19.1-34.2) | 30.2 (20.7-39.6) | 32.9 (21.9-44.0) |
| 60-day | 11.6 (9.77-13.6) | 13.5 (11.5-15.7) | 16.5 (14.0-19.3) | 19.1 (15.9-22.5) | 22.6 (18.0-27.3) | 25.4 (19.5-31.2) | 28.2 (21.0-35.2) | 31.1 (22.4-39.6) | 35.0 (24.1-45.6) | 38.0 (25.3-50.4) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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**NOAA Atlas 14, Volume 11, Version 2**
**Location name: Euless, Texas, USA***
**Latitude: 32.8003°, Longitude: -97.1086°**
**Elevation: 468.87 ft****
* source: ESRI Maps
** source: USGS

## POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

# PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 4.96 (3.76-6.55) | 5.78 (4.43-7.58) | 7.15 (5.45-9.40) | 8.27 (6.20-11.0) | 9.82 (7.13-13.4) | 11.0 (7.78-15.4) | 12.2 (8.40-17.5) | 13.4 (9.01-19.8) | 15.1 (9.82-22.9) | 16.4 (10.4-25.5) |
| 10-min | 3.97 (3.01-5.24) | 4.64 (3.55-6.07) | 5.73 (4.37-7.53) | 6.64 (4.98-8.83) | 7.87 (5.73-10.8) | 8.83 (6.25-12.4) | 9.78 (6.74-14.1) | 10.7 (7.22-15.8) | 12.0 (7.81-18.3) | 13.0 (8.21-20.2) |
| 15-min | 3.30 (2.50-4.36) | 3.84 (2.94-5.04) | 4.74 (3.62-6.24) | 5.49 (4.12-7.30) | 6.50 (4.72-8.88) | 7.26 (5.14-10.2) | 8.04 (5.54-11.6) | 8.85 (5.95-13.0) | 9.96 (6.47-15.1) | 10.8 (6.84-16.8) |
| 30-min | 2.29 (1.74-3.03) | 2.67 (2.04-3.50) | 3.29 (2.50-4.32) | 3.79 (2.85-5.05) | 4.49 (3.25-6.12) | 5.01 (3.54-7.01) | 5.54 (3.82-7.96) | 6.10 (4.10-8.99) | 6.88 (4.47-10.5) | 7.50 (4.74-11.7) |
| 60-min | 1.49 (1.13-1.97) | 1.74 (1.33-2.28) | 2.15 (1.63-2.82) | 2.48 (1.86-3.30) | 2.94 (2.14-4.02) | 3.29 (2.33-4.61) | 3.65 (2.52-5.25) | 4.04 (2.72-5.95) | 4.58 (2.98-6.96) | 5.01 (3.17-7.79) |
| 2-hr | 0.908 (0.694-1.19) | 1.07 (0.826-1.39) | 1.34 (1.03-1.74) | 1.56 (1.18-2.06) | 1.87 (1.37-2.53) | 2.12 (1.51-2.93) | 2.37 (1.65-3.36) | 2.64 (1.79-3.84) | 3.03 (1.98-4.54) | 3.34 (2.12-5.12) |
| 3-hr | 0.670 (0.515-0.869) | 0.798 (0.616-1.02) | 1.00 (0.773-1.29) | 1.17 (0.894-1.54) | 1.42 (1.05-1.91) | 1.61 (1.16-2.22) | 1.82 (1.27-2.56) | 2.04 (1.38-2.94) | 2.35 (1.54-3.49) | 2.60 (1.66-3.95) |
| 6-hr | 0.396 (0.307-0.508) | 0.476 (0.370-0.600) | 0.601 (0.469-0.767) | 0.710 (0.546-0.918) | 0.865 (0.643-1.15) | 0.989 (0.714-1.35) | 1.12 (0.787-1.56) | 1.26 (0.863-1.80) | 1.47 (0.964-2.15) | 1.63 (1.04-2.44) |
| 12-hr | 0.231 (0.181-0.293) | 0.278 (0.219-0.347) | 0.353 (0.278-0.445) | 0.417 (0.324-0.534) | 0.509 (0.382-0.668) | 0.582 (0.424-0.782) | 0.660 (0.467-0.907) | 0.745 (0.512-1.05) | 0.864 (0.572-1.25) | 0.961 (0.618-1.42) |
| 24-hr | 0.135 (0.107-0.170) | 0.163 (0.129-0.201) | 0.207 (0.164-0.258) | 0.244 (0.192-0.309) | 0.298 (0.225-0.387) | 0.341 (0.250-0.452) | 0.386 (0.275-0.524) | 0.436 (0.301-0.603) | 0.506 (0.336-0.721) | 0.562 (0.363-0.818) |
| 2-day | 0.079 (0.063-0.097) | 0.094 (0.076-0.115) | 0.119 (0.096-0.147) | 0.141 (0.112-0.176) | 0.172 (0.131-0.220) | 0.196 (0.145-0.257) | 0.223 (0.160-0.298) | 0.251 (0.175-0.343) | 0.292 (0.195-0.410) | 0.325 (0.211-0.465) |
| 3-day | 0.057 (0.046-0.070) | 0.069 (0.055-0.083) | 0.087 (0.070-0.106) | 0.102 (0.081-0.127) | 0.125 (0.096-0.158) | 0.142 (0.106-0.185) | 0.161 (0.116-0.214) | 0.182 (0.127-0.247) | 0.211 (0.142-0.294) | 0.235 (0.153-0.334) |
| 4-day | 0.045 (0.037-0.056) | 0.055 (0.044-0.066) | 0.069 (0.056-0.084) | 0.081 (0.065-0.100) | 0.099 (0.076-0.125) | 0.113 (0.084-0.146) | 0.128 (0.093-0.169) | 0.145 (0.101-0.195) | 0.168 (0.113-0.233) | 0.187 (0.122-0.264) |
| 7-day | 0.029 (0.024-0.035) | 0.035 (0.028-0.042) | 0.044 (0.036-0.053) | 0.052 (0.042-0.064) | 0.063 (0.049-0.079) | 0.073 (0.054-0.093) | 0.082 (0.060-0.107) | 0.093 (0.065-0.124) | 0.108 (0.073-0.148) | 0.120 (0.079-0.167) |
| 10-day | 0.022 (0.018-0.027) | 0.027 (0.022-0.032) | 0.034 (0.028-0.040) | 0.040 (0.032-0.048) | 0.048 (0.038-0.060) | 0.055 (0.041-0.070) | 0.062 (0.045-0.081) | 0.070 (0.050-0.093) | 0.081 (0.055-0.111) | 0.091 (0.059-0.125) |
| 20-day | 0.014 (0.012-0.017) | 0.017 (0.014-0.020) | 0.021 (0.017-0.025) | 0.024 (0.020-0.029) | 0.029 (0.023-0.036) | 0.033 (0.025-0.041) | 0.037 (0.027-0.047) | 0.041 (0.029-0.053) | 0.047 (0.032-0.063) | 0.052 (0.034-0.071) |
| 30-day | 0.011 (0.009-0.013) | 0.013 (0.011-0.016) | 0.016 (0.014-0.019) | 0.019 (0.015-0.022) | 0.022 (0.018-0.027) | 0.025 (0.019-0.031) | 0.028 (0.020-0.035) | 0.031 (0.022-0.040) | 0.035 (0.024-0.046) | 0.039 (0.025-0.052) |
| 45-day | 0.009 (0.008-0.011) | 0.011 (0.009-0.013) | 0.013 (0.011-0.015) | 0.015 (0.013-0.018) | 0.018 (0.014-0.022) | 0.020 (0.015-0.025) | 0.022 (0.017-0.028) | 0.025 (0.018-0.032) | 0.028 (0.019-0.037) | 0.031 (0.020-0.041) |
| 60-day | 0.008 (0.007-0.009) | 0.009 (0.008-0.011) | 0.011 (0.010-0.013) | 0.013 (0.011-0.016) | 0.016 (0.013-0.019) | 0.018 (0.014-0.022) | 0.020 (0.015-0.024) | 0.022 (0.016-0.027) | 0.024 (0.017-0.032) | 0.026 (0.018-0.035) |

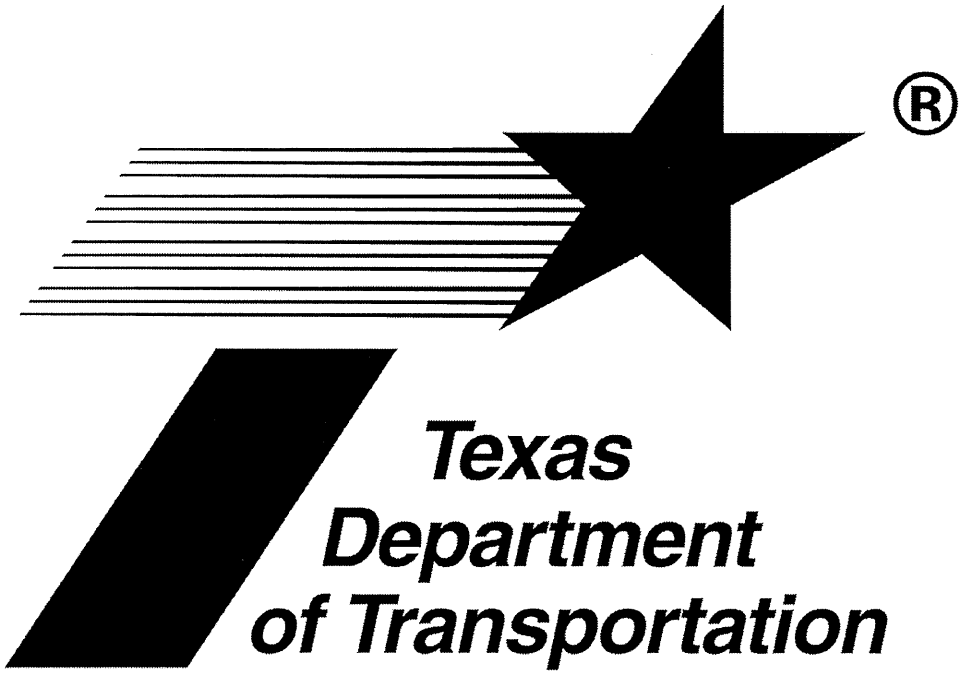
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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# PF graphical




# Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges

**Adopted by the**
**Texas Department of Transportation**

**November 1, 2014**

# Item 164
# Seeding for Erosion Control

## 1. DESCRIPTION

Provide and install temporary or permanent seeding for erosion control as shown on the plans or as directed.

## 2. MATERIALS

2.1. **Seed.** Provide seed from the previous season's crop meeting the requirements of the Texas Seed Law, including the testing and labeling for pure live seed (PLS = Purity × Germination). Furnish seed of the designated species, in labeled unopened bags or containers to the Engineer before planting. Use within 12 mo. from the date of the analysis. When Buffalograss is specified, use seed that is treated with $KNO_3$ (potassium nitrate) to overcome dormancy.

Use Tables 1–4 to determine the appropriate seed mix and rates as specified on the plans. If a plant species is not available by the producers, the other plant species in the recommended seed mixture will be increased proportionally by the PLS/acre of the missing plant species.

**Table 1**
**Permanent Rural Seed Mix**

| District and Planting Dates | Clay Soils Species and Rates (lb. PLS/acre) | | Sandy Soils Species and Rates (lb. PLS/acre) | |
|---|---|---|---|---|
| 1 (Paris)<br>Feb. 1–May 15 | Green Sprangletop<br>Sideoats Grama (Haskell)<br>Bermudagrass<br>Little Bluestem (Native)<br>Illinois Bundleflower | 0.3<br>3.2<br>1.8<br>1.7<br>1.0 | Green Sprangletop<br>Bermudagrass<br>Bahiagrass (Pensacola)<br>Sand Lovegrass<br>Weeping Lovegrass (Ermelo)<br>Partridge Pea | 0.3<br>1.5<br>6.0<br>0.6<br>0.8<br>1.0 |
| 2 (Ft. Worth)<br>Feb. 1–May 15 | Green Sprangletop (Van Horn)<br>Sideoats Grama (Haskell)<br>Texas Grama (Atascosa)<br>Hairy Grama (Chaparral)<br>Shortspike Windmillgrass (Welder)<br>Little Bluestem (OK Select)<br>Purple Prairie Clover (Cuero)<br>Engelmann Daisy (Eldorado)<br>Illinois Bundleflower<br>Awnless Bushsunflower (Plateau) | 1.0<br>1.0<br>1.0<br>0.4<br>0.2<br>0.8<br>0.6<br>0.75<br>1.3<br>0.2 | Green Sprangletop (Van Horn)<br>Hooded Windmillgrass (Mariah)<br>Shortspike Windmillgrass (Welder)<br>Hairy Grama (Chaparral)<br>Slender Grama (Dilley)<br>Sand Lovegrass (Mason)<br>Sand Dropseed (Borden County)<br>Partridge Pea (Comanche)<br>Little Bluestem (OK Select)<br>Englemann Daisy (Eldorado)<br>Purple Prairie Clover | 1.0<br>0.2<br>0.2<br>0.4<br>1.0<br>0.2<br>0.2<br>0.6<br>0.8<br>0.75<br>0.3 |
| 3 (Wichita Falls)<br>Feb. 1–May 15 | Green Sprangletop (Van Horn)<br>Sideoats Grama (Haskell)<br>Texas Grama (Atascosa)<br>Hairy Grama (Chaparral)<br>Shortspike Windmillgrass (Welder)<br>Little Bluestem (OK Select)<br>Blue Grama (Hachita)<br>Western Wheatgrass (Barton)<br>Galleta Grass (Viva)<br>Engelmann Daisy (Eldorado)<br>Awnless Bushsunflower (Plateau) | 0.6<br>1.0<br>1.0<br>0.4<br>0.2<br>0.8<br>0.4<br>1.2<br>0.6<br>0.75<br>0.2 | Green Sprangletop (Van Horn)<br>Hooded Windmillgrass (Mariah)<br>Shortspike Windmillgrass (Welder)<br>Hairy Grama (Chaparral)<br>Sand Lovegrass (Mason)<br>Sand Dropseed (Borden County)<br>Partridge Pea (Comanche)<br>Little Bluestem (OK Select)<br>Englemann Daisy (Eldorado)<br>Purple Prairie Clover (Cuero) | 1.0<br>0.2<br>0.2<br>0.4<br>0.2<br>0.2<br>0.6<br>0.8<br>0.75<br>0.3 |
| 4 (Amarillo)<br>Feb. 15–May 15 | Green Sprangletop<br>Sideoats Grama (Haskell)<br>Blue Grama (Hachita)<br>Buffalograss (Texoka)<br>Illinois Bundleflower | 0.3<br>3.6<br>1.2<br>1.6<br>1.0 | Green Sprangletop<br>Weeping Lovegrass (Ermelo)<br>Blue Grama (Hachita)<br>Sand Dropseed (Borden Co.)<br>Sand Bluestem<br>Purple Prairie Clover | 0.3<br>0.8<br>1.0<br>0.3<br>1.8<br>0.5 |

**Table 1 (continued)**
**Permanent Rural Seed Mix**

| District and Planting Dates | Clay Soils Species and Rates (lb. PLS/acre) | | Sandy Soils Species and Rates (lb. PLS/acre) | |
|---|---|---|---|---|
| 5 (Lubbock) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 15–May 15 | Sideoats Grama (El Reno) | 3.6 | Weeping Lovegrass (Ermelo) | 0.8 |
| | Blue Grama (Hachita) | 1.2 | Blue Grama (Hachita) | 1.0 |
| | Buffalograss (Texoka) | 1.6 | Sand Dropseed (Borden Co.) | 0.3 |
| | Illinois Bundleflower | 1.0 | Sand Bluestem | 1.8 |
| | | | Purple Prairie Clover | 0.5 |
| 6 (Odessa) | Green Sprangletop (Van Horn) | 1.0 | Green Sprangletop (Van Horn) | 1.0 |
| Feb. 1–May 15 | Sideoats Grama (South Texas) | 1.0 | Hooded Windmillgrass (Mariah) | 0.2 |
| | Blue Grama (Hachita) | 0.4 | Blue Grama (Hachita) | 0.4 |
| | Galleta Grass (Viva) | 0.6 | Hairy Grama (Chaparral) | 0.4 |
| | Shortspike Windmillgrass (Welder) | 0.2 | Sand Lovegrass (Mason) | 0.2 |
| | Pink Pappusgrass (Maverick) | 0.6 | Sand Dropseed (Borden County) | 0.2 |
| | Alkali Sacaton (Saltalk) | 0.2 | Indian Ricegrass (Rim Rock) | 1.6 |
| | Plains Bristlegrass (Catarina Blend) | 0.2 | Sand Bluestem (Cottle County) | 1.2 |
| | False Rhodes Grass (Kinney) | 0.1 | Little Bluestem (Pastura) | 0.8 |
| | Whiplash Pappusgrass (Webb) | 0.6 | Purple Prairie Clover (Cuero) | 0.3 |
| | Arizona Cottontop (La Salle) | 0.2 | | |
| 7 (San Angelo) | Green Sprangletop (Van Horn) | 1.0 | Green Sprangletop (Van Horn) | 1.0 |
| Feb. 1–May 1 | Sideoats Grama (Haskell) | 1.0 | Hooded Windmillgrass (Mariah) | 0.2 |
| | Texas Grama (Atascosa) | 1.0 | Shortspike Windmillgrass (Welder) | 0.2 |
| | Hairy Grama (Chaparral) | 0.4 | Hairy Grama (Chaparral) | 0.4 |
| | Shortspike Windmillgrass (Welder) | 0.2 | Sand Lovegrass (Mason) | 0.2 |
| | Little Bluestem (OK Select) | 0.4 | Sand Dropseed (Borden County) | 0.2 |
| | Blue Grama (Hachita) | 0.4 | Sand Bluestem (Cottle County) | 1.2 |
| | Western Wheatgrass (Barton) | 1.2 | Partridge Pea (Comanche) | 0.6 |
| | Galleta Grass (Viva) | 0.6 | Little Bluestem (OK Select) | 0.8 |
| | Engelmann Daisy (Eldorado) | 0.75 | Englemann Daisy (Eldorado) | 0.75 |
| | Illinois Bundleflower (Sabine) | 1.0 | Purple Prairie Clover (Cuero) | 0.3 |
| 8 (Abilene) | Green Sprangletop (Van Horn) | 1.0 | Green Sprangletop (Van Horn) | 1.0 |
| Feb. 1–May 15 | Sideoats Grama (Haskell) | 1.0 | Hooded Windmillgrass (Mariah) | 0.2 |
| | Texas Grama (Atascosa) | 1.0 | Shortspike Windmillgrass (Welder) | 0.2 |
| | Hairy Grama (Chaparral) | 0.4 | Hairy Grama (Chaparral) | 0.4 |
| | Shortspike Windmillgrass (Welder) | 0.2 | Sand Lovegrass (Mason) | 0.2 |
| | Little Bluestem (OK Select) | 0.4 | Sand Dropseed (Borden County) | 0.2 |
| | Blue Grama (Hachita) | 0.4 | Sand Bluestem (Cottle County) | 1.2 |
| | Western Wheatgrass (Barton) | 1.2 | Partridge Pea (Comanche) | 0.6 |
| | Galleta Grass (Viva) | 0.6 | Little Bluestem (OK Select) | 0.8 |
| | Engelmann Daisy (Eldorado) | 0.75 | Englemann Daisy (Eldorado) | 0.75 |
| | Illinois Bundleflower (Sabine) | 1.0 | Purple Prairie Clover (Cuero) | 0.3 |
| 9 (Waco) | Green Sprangletop (Van Horn) | 1.0 | Green Sprangletop (Van Horn) | 1.0 |
| Feb. 1–May 15 | Sideoats Grama (Haskell) | 1.0 | Hooded Windmillgrass (Mariah) | 0.2 |
| | Texas Grama (Atascosa) | 1.0 | Shortspike Windmillgrass (Welder) | 0.2 |
| | Hairy Grama (Chaparral) | 0.4 | Hairy Grama (Chaparral) | 0.4 |
| | Shortspike Windmillgrass (Welder) | 0.2 | Slender Grama (Dilley) | 1.0 |
| | Little Bluestem (OK Select) | 0.8 | Sand Lovegrass (Mason) | 0.2 |
| | Purple Prairie Clover (Cuero) | 0.6 | Sand Dropseed (Borden County) | 0.2 |
| | Engelmann Daisy (Eldorado) | 0.75 | Partridge Pea (Comanche) | 0.6 |
| | Illinois Bundleflower | 1.3 | Little Bluestem (OK Select) | 0.8 |
| | Awnless Bushsunflower (Plateau) | 0.2 | Englemann Daisy (Eldorado) | 0.75 |
| | | | Purple Prairie Clover | 0.3 |
| 10 (Tyler) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 1.8 | Bermudagrass | 1.8 |
| | Bahiagrass (Pensacola) | 9.0 | Bahiagrass (Pensacola) | 9.0 |
| | Sideoats Grama (Haskell) | 2.7 | Weeping Lovegrass (Ermelo) | 0.5 |
| | Illinois Bundleflower | 1.0 | Sand Lovegrass | 0.5 |
| | | | Lance-Leaf Coreopsis | 1.0 |
| 11 (Lufkin) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 1.8 | Bermudagrass | 2.1 |
| | Bahiagrass (Pensacola) | 9.0 | Bahiagrass (Pensacola) | 9.0 |
| | Sideoats Grama (Haskell) | 2.7 | Sand Lovegrass | 0.5 |
| | Illinois Bundleflower | 1.0 | Lance-Leaf Coreopsis | 1.0 |

**Table 1 (continued)**
**Permanent Rural Seed Mix**

| District and Planting Dates | Clay Soils Species and Rates (lb. PLS/acre) | | Sandy Soils Species and Rates (lb. PLS/acre) | |
|---|---|---|---|---|
| 24 (El Paso) | Green Sprangletop (Van Horn) | 1.0 | Green Sprangletop (Van Horn) | 1.0 |
| Feb. 1–May 15 | Sideoats Grama (South Texas) | 1.0 | Hooded Windmillgrass (Mariah) | 0.2 |
| | Blue Grama (Hachita) | 0.4 | Blue Grama (Hachita) | 0.4 |
| | Galleta Grass (Viva) | 0.6 | Hairy Grama (Chaparral) | 0.4 |
| | Shortspike Windmillgrass (Welder) | 0.2 | Sand Lovegrass (Mason) | 0.2 |
| | Pink Pappusgrass (Maverick) | 0.6 | Sand Dropseed (Borden County) | 0.2 |
| | Alkali Sacaton (Saltalk) | 0.2 | Indian Ricegrass (Rim Rock) | 1.6 |
| | Plains Bristlegrass (Catarina Blend) | 0.2 | Sand Bluestem (Cottle County) | 1.2 |
| | False Rhodes Grass (Kinney) | 0.1 | Little Bluestem (Pastura) | 0.8 |
| | Whiplash Pappusgrass (Webb) | 0.6 | Purple Prairie Clover (Cuero) | 0.3 |
| | Arizona Cottontop (La Salle) | 0.2 | | |
| 25 (Childress) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (El Reno) | 2.7 | Weeping Lovegrass (Ermelo) | 1.2 |
| | Blue Grama (Hachita) | 0.9 | Sand Dropseed (Borden Co.) | 0.5 |
| | Western Wheatgrass | 2.1 | Sand Lovegrass | 0.8 |
| | Galleta | 1.6 | Purple Prairie Clover | 0.5 |
| | Illinois Bundleflower | 1.0 | | |

**Table 2**
**Permanent Urban Seed Mix**

| District and Planting Dates | Clay Soils Species and Rates (lb. PLS/acre) | | Sandy Soils Species and Rates (lb. PLS/acre) | |
|---|---|---|---|---|
| 1 (Paris) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 2.4 | Bermudagrass | 5.4 |
| | Sideoats Grama (Haskell) | 4.5 | | |
| 2 (Ft. Worth) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (El Reno) | 3.6 | Sideoats Grama (El Reno) | 3.6 |
| | Bermudagrass | 2.4 | Bermudagrass | 2.1 |
| | Buffalograss (Texoka) | 1.6 | Sand Dropseed (Borden Co.) | 0.3 |
| 3 (Wichita Falls) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (El Reno) | 4.5 | Sideoats Grama (El Reno) | 3.6 |
| | Bermudagrass | 1.8 | Bermudagrass | 1.8 |
| | Buffalograss (Texoka) | 1.6 | Sand Dropseed (Borden Co.) | 0.4 |
| 4 (Amarillo) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 15–May 15 | Sideoats Grama (El Reno) | 3.6 | Sideoats Grama (El Reno) | 2.7 |
| | Blue Grama (Hachita) | 1.2 | Blue Grama (Hachita) | 0.9 |
| | Buffalograss (Texoka) | 1.6 | Sand Dropseed (Borden Co.) | 0.4 |
| | | | Buffalograss (Texoka) | 1.6 |
| 5 (Lubbock) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 15–May 15 | Sideoats Grama (El Reno) | 3.6 | Sideoats Grama (El Reno) | 2.7 |
| | Blue Grama (Hachita) | 1.2 | Blue Grama (Hachita) | 0.9 |
| | Buffalograss (Texoka) | 1.6 | Sand Dropseed (Borden Co.) | 0.4 |
| | | | Buffalograss (Texoka) | 1.6 |
| 6 (Odessa) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (Haskell) | 3.6 | Sideoats Grama (Haskell) | 2.7 |
| | Blue Grama (Hachita) | 1.2 | Sand Dropseed (Borden Co.) | 0.4 |
| | Buffalograss (Texoka) | 1.6 | Blue Grama (Hachita) | 0.9 |
| | | | Buffalograss (Texoka) | 1.6 |
| 7 (San Angelo) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 1 | Sideoats Grama (Haskell) | 7.2 | Sideoats Grama (Haskell) | 3.2 |
| | Buffalograss (Texoka) | 1.6 | Sand Dropseed (Borden Co.) | 0.3 |
| | | | Blue Grama (Hachita) | 0.9 |
| | | | Buffalograss (Texoka) | 1.6 |
| 8 (Abilene) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (Haskell) | 3.6 | Sand Dropseed (Borden Co.) | 0.3 |
| | Blue Grama (Hachita) | 1.2 | Sideoats Grama (Haskell) | 3.6 |
| | Buffalograss (Texoka) | 1.6 | Blue Grama (Hachita) | 0.8 |
| | | | Buffalograss (Texoka) | 1.6 |

Table 2 (continued)

Permanent Urban Seed Mix

| District and Planting Dates | Clay Soils Species and Rates (lb. PLS/acre) | | Sandy Soils Species and Rates (lb. PLS/acre) | |
|---|---|---|---|---|
| 9 (Waco) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 1.8 | Buffalograss (Texoka) | 1.6 |
| | Buffalograss (Texoka) | 1.6 | Bermudagrass | 3.6 |
| | Sideoats Grama (Haskell) | 4.5 | Sand Dropseed (Borden Co.) | 0.4 |
| 10 (Tyler) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 2.4 | Bermudagrass | 5.4 |
| | Sideoats Grama (Haskell) | 4.5 | | |
| 11 (Lufkin) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 2.4 | Bermudagrass | 5.4 |
| | Sideoats Grama (Haskell) | 4.5 | | |
| 12 (Houston) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Jan. 15–May 15 | Sideoats Grama (Haskell) | 4.5 | Bermudagrass | 5.4 |
| | Bermudagrass | 2.4 | | |
| 13 (Yoakum) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Jan. 15–May 15 | Sideoats Grama (South Texas) | 4.5 | Bermudagrass | 5.4 |
| | Bermudagrass | 2.4 | | |
| 14 (Austin) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 2.4 | Bermudagrass | 4.8 |
| | Sideoats Grama (South Texas) | 3.6 | Buffalograss (Texoka) | 1.6 |
| | Buffalograss (Texoka) | 1.6 | | |
| 15 (San Antonio) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 1 | Sideoats Grama (South Texas) | 3.6 | Bermudagrass | 4.8 |
| | Bermudagrass | 2.4 | Buffalograss (Texoka) | 1.6 |
| | Buffalograss (Texoka) | 1.6 | | |
| 16 (Corpus Christi) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Jan. 1–May 1 | Sideoats Grama (South Texas) | 3.6 | Bermudagrass | 4.8 |
| | Bermudagrass | 2.4 | Buffalograss (Texoka) | 1.6 |
| | Buffalograss (Texoka) | 1.6 | | |
| 17 (Bryan) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 2.4 | Bermudagrass | 5.4 |
| | Sideoats Grama (Haskell) | 4.5 | | |
| 18 (Dallas) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (El Reno) | 3.6 | Buffalograss (Texoka) | 1.6 |
| | Buffalograss (Texoka) | 1.6 | Bermudagrass | 3.6 |
| | Bermudagrass | 2.4 | Sand Dropseed (Borden Co.) | 0.4 |
| 19 (Atlanta) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Bermudagrass | 2.4 | Bermudagrass | 5.4 |
| | Sideoats Grama (Haskell) | 4.5 | | |
| 20 (Beaumont) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Jan. 15–May 15 | Bermudagrass | 2.4 | Bermudagrass | 5.4 |
| | Sideoats Grama (Haskell) | 4.5 | | |
| 21 (Pharr) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Jan. 15–May 15 | Sideoats Grama (South Texas) | 3.6 | Buffalograss (Texoka) | 1.6 |
| | Buffalograss (Texoka) | 1.6 | Bermudagrass | 3.6 |
| | Bermudagrass | 2.4 | Sand Dropseed (Borden Co.) | 0.4 |
| 22 (Laredo) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Jan. 15–May 1 | Sideoats Grama (South Texas) | 4.5 | Buffalograss (Texoka) | 1.6 |
| | Buffalograss (Texoka) | 1.6 | Bermudagrass | 3.6 |
| | Bermudagrass | 1.8 | Sand Dropseed | 0.4 |
| 23 (Brownwood) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (Haskell) | 3.6 | Buffalograss (Texoka) | 1.6 |
| | Bermudagrass | 1.2 | Bermudagrass | 3.6 |
| | Blue Grama (Hachita) | 0.9 | Sand Dropseed (Borden Co.) | 0.4 |
| 24 (El Paso) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (South Texas) | 3.6 | Buffalograss (Texoka) | 1.6 |
| | Blue Grama (Hachita) | 1.2 | Sand Dropseed (Borden Co.) | 0.4 |
| | Buffalograss (Texoka) | 1.6 | Blue Grama (Hachita) | 1.8 |
| 25 (Childress) | Green Sprangletop | 0.3 | Green Sprangletop | 0.3 |
| Feb. 1–May 15 | Sideoats Grama (El Reno) | 3.6 | Sand Dropseed (Borden Co.) | 0.4 |
| | Blue Grama (Hachita) | 1.2 | Buffalograss (Texoka) | 1.6 |
| | Buffalograss (Texoka) | 1.6 | Bermudagrass | 1.8 |

**Table 3**
**Temporary Cool Season Seeding**

| Districts | Dates | Seed Mix and Rates (lb. PLS/acre) | |
|---|---|---|---|
| Paris (1), Amarillo (4), Lubbock (5), Dallas (18) | September 1–November 30 | Tall Fescue<br>Western Wheatgrass<br>Wheat (Red, Winter) | 4.5<br>5.6<br>34 |
| Odessa (6), San Angelo (7), El Paso (24) | September 1–November 30 | Western Wheatgrass<br>Wheat (Red, Winter) | 8.4<br>50 |
| Waco (9), Tyler (10), Lufkin (11), Austin (14), San Antonio (15),<br>Bryan (17), Atlanta (19) | September 1–November 30 | Tall Fescue<br>Oats<br>Wheat | 4.5<br>24<br>34 |
| Houston (12), Yoakum (13), Corpus Christi (16), Beaumont (20),<br>Pharr (21), Laredo (22) | September 1–November 30 | Oats | 72 |
| Ft. Worth (2), Wichita Falls (3), Abilene (8), Brownwood (23), Childress (25) | September 1–November 30 | Tall Fescue<br>Western Wheatgrass<br>Cereal Rye | 4.5<br>5.6<br>34 |

**Table 4**
**Temporary Warm Season Seeding**

| Districts | Dates | Seed Mix and Rates (lb. PLS/acre) | |
|---|---|---|---|
| All | May 1–August 31 | Foxtail Millet | 34 |

2.2. **Fertilizer**. Use fertilizer in conformance with Article 166.2., "Materials."

2.3. **Vegetative Watering**. Use water that is clean and free of industrial wastes and other substances harmful to the growth of vegetation.

2.4. **Mulch**.

2.4.1. **Straw or Hay Mulch**. Use straw or hay mulch in conformance with Section 162.2.5., "Mulch."

2.4.2. **Cellulose Fiber Mulch**. Use only cellulose fiber mulches that are on the Approved Products List, *Erosion Control Approved Products*. (http://www.txdot.gov/business/resources/erosion-control.html) Submit one full set of manufacturer's literature for the selected material. Keep mulch dry until applied. Do not use molded or rotted material.

2.5. **Tacking Methods.** Use a tacking agent applied in accordance with the manufacturer's recommendations or a crimping method on all straw or hay mulch operations. Use tacking agents as approved or as specified on the plans.

## 3. CONSTRUCTION

Cultivate the area to a depth of 4 in. before placing the seed unless otherwise directed. Use approved equipment to vertically track the seedbed as shown on the plans or as directed. Cultivate the seedbed to a depth of 4 in. or mow the area before placement of the permanent seed when performing permanent seeding after an established temporary seeding. Plant the seed specified and mulch, if required, after the area has been completed to lines and grades as shown on the plans.

3.1. **Broadcast Seeding**. Distribute the seed or seed mixture uniformly over the areas shown on the plans using hand or mechanical distribution or hydro-seeding on top of the soil unless otherwise directed. Apply the mixture to the area to be seeded within 30 min. of placement of components in the equipment when seed and water are to be distributed as a slurry during hydro-seeding. Roll the planted area with a light roller or other suitable equipment. Roll sloped areas along the contour of the slopes.

3.2. **Straw or Hay Mulch Seeding**. Plant seed according to Section 164.3.1., "Broadcast Seeding." Apply straw or hay mulch uniformly over the seeded area immediately after planting the seed or seed mixture. Apply straw mulch at 2 to 2.5 tons per acre. Apply hay mulch at 1.5 to 2 tons per acre. Use a tacking method over the mulched area.

3.3. **Cellulose Fiber Mulch Seeding**. Plant seed in accordance with Section 164.3.1., "Broadcast Seeding." Apply cellulose fiber mulch uniformly over the seeded area immediately after planting the seed or seed mixture at the following rates.

- Sandy soils with slopes of 3:1 or less—2,500 lb. per acre.
- Sandy soils with slopes greater than 3:1—3,000 lb. per acre.
- Clay soils with slopes of 3:1 or less—2,000 lb. per acre.
- Clay soils with slopes greater than 3:1—2,300 lb. per acre.

Cellulose fiber mulch rates are based on dry weight of mulch per acre. Mix cellulose fiber mulch and water to make a slurry and apply uniformly over the seeded area using suitable equipment.

3.4. **Drill Seeding**. Plant seed or seed mixture uniformly over the area shown on the plans at a depth of 1/4 to 1/3 in. using a pasture or rangeland type drill unless otherwise directed. Plant seed along the contour of the slopes.

3.5. **Straw or Hay Mulching**. Apply straw or hay mulch uniformly over the area as shown on the plans. Apply straw mulch at 2 to 2.5 tons per acre. Apply hay mulch at 1.5 to 2 tons per acre. Use a tacking method over the mulched area.

Apply fertilizer in conformance with Article 166.3., "Construction." Seed and fertilizer may be distributed simultaneously during "Broadcast Seeding" operations, provided each component is applied at the specified rate. Apply half of the required fertilizer during the temporary seeding operation and the other half during the permanent seeding operation when temporary and permanent seeding are both specified for the same area.

Water the seeded areas at the rates and frequencies as shown on the plans or as directed.

## 4. MEASUREMENT

This Item will be measured by the square yard or by the acre.

## 5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Broadcast Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Broadcast Seeding (Temp)" of warm or cool season specified, "Straw or Hay Mulch Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Straw or Hay Mulch Seeding (Temp)" of warm or cool season specified, "Cellulose Fiber Mulch Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Cellulose Fiber Mulch Seeding (Temp)" of warm or cool season specified, "Drill Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Drill Seeding (Temp)" of warm or cool season specified, and "Straw or Hay Mulching." This price is full compensation for furnishing materials, including water for hydro-seeding and hydro-mulching operations, mowing, labor, equipment, tools, supplies, and incidentals. Fertilizer will not be paid for directly but will be subsidiary to this Item. Water for irrigating the seeded area, when specified, will be paid for under Item 168, "Vegetative Watering."

# APPENDIX IIIF-E

# PERMITTED LANDFILL CONDITION HYDROLOGIC CALCULATIONS

Includes pages IIIF-E-1 through IIIF-E-170



# CONTENTS


| | |
|---|---|
| Updated Permitted Condition Hydraulic Calculations | IIIF-E-1 |
| Hypothetical Storm Data | IIIF-E-2 |
| Precipitation Loss Data | IIIF-E-4 |
| Hydrograph Development Information | IIIF-E-6 |
| HEC-HMS Output – Updated Permitted 25-year, 24-Hour Storm Event | IIIF-E-15 |
| Volume Calculations | IIIF-E-89 |
| Velocity Calculations | IIIF-E-94 |
| Existing Permitted Drainage Calculation Excerpts | IIIF-E-99 |




# UPDATED PERMITTED CONDITION HYDROLOGIC CALCULATIONS

Appendix IIIF-E presents the hydrologic calculations for the updated permitted conditions summarized on Drawings IIIF-E-13 and IIF-E-14. The following summarizes the content of this appendix:

- Hypothetical Storm data are provided on page IIIF-E-3.
- Precipitation loss information is included on pages IIIF-E-4 and IIIF-E-5.
- Hydrograph development information is presented on IIIF-E-6 through IIIF-E-11.
- A comparison between the existing permitted, updated permitted, and proposed drainage conditions is presented in Section 4 of Appendix IIIF – Drainage Design Report.
- The HEC-HMS output for the 25-year storm event for the updated permitted conditions is presented on IIIF-E-16 through IIIF-E-88.
- Volume and Velocity Calculations are presented on Pages IIIF-E-89 through IIIF-E-93 and IIIF-E-94 through 98, respectively.
- Excerpts from the currently permitted drainage analysis are included on Pages IIIF-E-100 to IIIF-E-170.

# HYPOTHETICAL STORM DATA

**Hypothetical Storm Data**

Precipitation data taken from NOAA Atlas 14 rainfall data.

| Time | 5 min | 15 min | 60 min | 2 hr | 3 hr | 6 hr | 12 hr | 24 hr |
|---|---|---|---|---|---|---|---|---|
| 25-Year Event | 0.818 | 1.63 | 2.94 | 3.75 | 4.26 | 5.18 | 6.13 | 7.16 |

NOAA Atlas 14 - Precipitation-Frequency Atlas of the United States, Volume 11, Version 2.0: Texas (*U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, 2018*) was used to identify precipitation values for storm durations ranging from 5 minutes to 24 hours.

# PRECIPITATION LOSS DATA

**Required:** Determine the SCS curve numbers for both on-site and off-site drainage areas for use in the HEC-HMS analysis.

**References:**

1. Dodson's and Associates, Inc., *ProHec-1 Plus Program Documentation*, 1995.
2. United States Department of Agriculture, National Resource Conservation Service, Web Soil Survey for Tarrant County, Texas ( http://websoilsurvey.nrcs.usda.gov ).

**Note:** Web Soil Survey data for permit boundary area shown on SCS map (page IIIF-A-5).

**Solution:** Based on the soil survey information found in Ref. 2, hydrologic group A and B soils predominate the areas within the permit boundary (see pages IIIF-A-5 through IIIF-A-8). For a conservative estimate of runoff and to account for the use of clays and/or geosynthetics, drainage areas within the landfill area, group D soils were used for Curve Number selection.

All non-landfill on-site drainage areas and most off-site drainage areas (O1, O2, O3, and O4) were considered pasture land in fair conditions. A curve number was selected using the table on page IIIF-A-11.

| Use: | 84 |
|---|---|

Off-site drainage areas O5 and O6 were modeled assuming most of the area within the drainage area is paved or otherwise impervious. A composite curve number was selected assuming an unpaved CN = 84 and a paved CN = 99.

The final cover system was assumed to be in place and the erosion layer will control precipitation loss. A curve number that is corrected for the surface slope of the erosion layer may be computed first using the chart on page IIIF-A-10 to select an un-adjusted curve number. Calculate the adjusted curve number using equation 34 from Ref. 3 (see page IIIF-A-11).

$$CN_{II} = 100 - ( 100 - CN_{II\,o} ) * ( L^{*\,2} / S^{*} ) \wedge (CN_{II\,o}^{-0.81})$$

| | | |
|---|---|---|
| Use: | $CN_{II\,o} = 84$ , $L^{*} = (300/500)$ , $S^{*} = (.05/.04)$ | for top dome surfaces |
| Use: | $CN_{II\,o} = 84$ , $L^{*} = (120/500)$ , $S^{*} = (.25/.04)$ | for side slopes |

| | | |
|---|---|---|
| Calculate: | CN = 85 | for top dome surfaces |
| Calculate: | CN = 86 | for side slopes |

The pond areas are assumed to collect all precipitation for their areas:

| Use: | CN = 100 |
|---|---|

# HYDROGRAPH DEVELOPMENT INFORMATION

## Landfill Areas

Direct runoff methods (i.e., kinematic wave) have been used for the landfill final cover areas. The kinematic wave method has been used to model the five and four percent slope top dome areas before flow is intercepted by top dome swales. The kinematic wave method is a physically based method using slope, surface roughness, catchment lengths and areas. This method does not consider attenuation for flood wave; as a consequence, this method provides for a conservative analysis. The following typical parameters for the direct runoff method have been developed for the landfill areas consistent with the parameters used in the currently approved hydrologic analysis (HEC-HMS output file included in pages IIIF-E-16 through IIIF-E-88.

Kinematic wave parameters for overland flow:

Slope: Varies from 0.04 to 0.50 ft/ft landfill slopes

N: 0.30 Manning's friction coefficient for sheet flow

L: Represents a typical distance between swales for overland flow.

Percentage of drainage area represented by this element is 100 percent.

Muskingum-Cunge routing is used along with the kinematic wave method to estimate hydrographs at the outfall of each separate drainage area analyzed using the direct runoff method.

Muskingum-Cunge routing data for swale:

- Swale length (ft): Typical swale lengths for each drainage area were used.
- Swale bottom slope (ft/ft): 0.005 ft/ft
- Swale roughness coefficient: 0.03
- Swale type: A trapezoidal channel was used with no bottom width to simulate a triangular channel.

Muskingum-Cunge routing data for channels:

- Channel length (ft): The length of the channel section.
- Channel slope (ft/ft): Varies from 0.001 to 0.011.
- Channel roughness coefficient: 0.03 for grass lined.
- Channel type: A trapezoidal channel was used with varying bottom width and 3:1 side slopes.

## Non-Landfill Final Cover Areas

Hydrographs for a portion of the non-landfill final cover areas within the permit boundary (e.g., pond areas) and all off-site areas were developed using the Snyder unit hydrograph method. Espey "10-Minute" method has been used to estimate Snyder parameters. Snyder parameter estimations are provided on the pages IIIF-E-10 and IIIF-E-11.

As discussed in Section 2 of Appendix IIIF, hydrographs for the areas outside of the permit boundary (O1 through O6), and larger areas inside the permit boundary (S1 through S7) were developed using the Snyder unit hydrograph method. The percent imperviousness ranges from 2 percent to 50 percent for the non-landfill on-site and off-site areas. Pond areas are assumed to be 99 percent impervious, and areas with significant channel surface or paved surfaces were assigned higher percentages of impervious area, as shown on IIIF-E-5.

## Drainage Areas

The drainage areas used for this analysis are shown on Sheet IIIF-E-13 and Sheet IIIF-E-14. The routing scheme for the updated permitted condition is shown in the HEC-HMS output file presented on pages IIIF-E-16 through IIIF-E-88.

# ESPEY 10-MINUTE METHOD PARAMETERS

Snyder's Hydrograph Coefficients (Espey's 10 Minute Method)

Permitted Conditions

| Area No. | Area (acres) | Max. Flow Length (L) (ft) | S (ft/ft) | I (%) | Manning "n" | $\Phi$[1] | $T_r$[2] (min) | $T_{lag}$[3] (min) | $T_{lag}$ (hr) | Area[4] (sq mi) | $q_p$[5] (cfs/sq mi) | $C_p$[6] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O1 | 81.63 | 3,997 | 0.0200 | 15 | 0.04 | 0.82 | 25.0 | 22.5 | 0.37 | 0.1275 | 1097.0 | 0.64 |
| O2 | 160.32 | 5,556 | 0.0180 | 15 | 0.04 | 0.82 | 27.7 | 25.2 | 0.42 | 0.2505 | 957.1 | 0.63 |
| O3 | 3520.00 | 15,979 | 0.0043 | 16 | 0.04 | 0.82 | 50.0 | 47.5 | 0.79 | 5.5000 | 449.2 | 0.56 |
| O4 | 41.33 | 1,878 | 0.0266 | 10 | 0.04 | 0.84 | 21.8 | 19.3 | 0.32 | 0.0646 | 1301.3 | 0.66 |
| O5 | 4.04 | 212 | 0.0330 | 25 | 0.03 | 0.75 | 8.9 | 6.4 | 0.11 | 0.0063 | 3731.5 | 0.62 |
| O6 | 25.70 | 639 | 0.0099 | 50 | 0.03 | 0.68 | 11.7 | 9.2 | 0.15 | 0.0402 | 2579.0 | 0.62 |
| S1 | 115.67 | 1,714 | 0.0362 | 2 | 0.04 | 0.87 | 28.0 | 25.5 | 0.42 | 0.1807 | 958.8 | 0.64 |
| S2 | 3.30 | 645 | 0.0651 | 25 | 0.03 | 0.75 | 9.7 | 7.2 | 0.12 | 0.0052 | 3433.5 | 0.64 |
| S3 | 4.82 | 979 | 0.0225 | 25 | 0.03 | 0.75 | 13.9 | 11.4 | 0.19 | 0.0075 | 2295.7 | 0.68 |
| S4 | 19.85 | 1,557 | 0.0218 | 25 | 0.03 | 0.75 | 15.6 | 13.1 | 0.22 | 0.0310 | 1921.1 | 0.66 |
| S5 | 7.69 | 1,128 | 0.0337 | 10 | 0.04 | 0.84 | 18.3 | 15.8 | 0.26 | 0.0120 | 1680.7 | 0.69 |
| S6 | 21.47 | 754 | 0.0349 | 10 | 0.04 | 0.84 | 16.5 | 14.0 | 0.23 | 0.0335 | 1798.5 | 0.66 |
| S7 | 32.29 | 1,398 | 0.0029 | 10 | 0.04 | 0.84 | 35.6 | 33.1 | 0.55 | 0.0505 | 778.3 | 0.67 |

[1] Conveyance efficiency coefficient from Dodson & Associates Inc., *ProHec-1 Program Documentation*, 1995, pages 6-19 and 6-20.
[2] $T_r = 3.1(L^{0.23})(S^{-0.25})(I^{-0.18})(\Phi^{1.57})$
[3] $T_{lag} = T_r - \Delta t/2$
[4] From area summary sheet
[5] $q_p = 31600(A^{-0.04})(T_r^{-1.07})$
[6] $C_p = 49.375(A^{-0.04})(T_r^{-1.07})(T_{lag})$

$T_r$ = surface runoff to unit hydrograph peak (min)
L = distance along main channel from study point to watershed boundary (ft)
S = main channel slope (ft/ft)
I = impervious cover within the watershed (%)
$T_{lag}$ = watershed lag time (min)
$\Delta t$= computation interval (minutes)
$q_p$ = unit hydrograph peak discharge (cfs/sq mi)
$C_p$ = Snyder's peaking coefficient

Snyder Unit Hydrograph uses lag time ($T_{lag}$) and peaking coefficient accounting for flood wave and watershed storage conditions.

Drainage area "S7" in the post-project condition is used in this example.

Estimated Watershed specific parameters

| | | | |
|---|---|---|---|
| A = | 32.29 | acres | watershed area |
| L = | 1398 | feet | maximun flow length with this watershed |
| S = | 0.0029 | feet/feet | watershed slope |
| I = | 10 | percent (%) | watershed imperviousness |
| n = | 0.04 | | Manning's coefficient |

Calculate Tr: time beginning of surface runoff to the unit hydrograph peak in minutes

$T_r = 3.1(L^{0.23})(S^{-0.25})(I^{-0.18})(\Phi^{1.57})$

Estimate : conveyance efficiency coefficient

$\Phi$ = for 2 percent impervious cover and n = 0.06

$\Phi = 0.84$

$T_r = 3.1(783^{0.23})(0.0204^{-0.25})(10^{-0.18})(0.84^{1.57})$

$T_r = 35.6$ min

Calculate $T_{lag}$: watershed lag time

$T_{lag} = Tr - (\Delta t/2)$ $\Delta t$ is calculation interval, and 5 minutes is used

$T_{lag} = 33.1$ minutes in the HEC - 1 modeling in this project

$T_{lag} = 0.55$ hours

$A = A/640$

$A = 0.0505$ square miles

Calculate $q_p$: peak discharge of unit hydrograph per unit area (cfs/sq. mi).

$q_p = 31600(A^{-0.04})(T_r^{-1.07})$

$q_p = 31600(0.0038^{-0.04})(19.1^{-1.07})$

$q_p = 778.3$ cfs/sq. mi

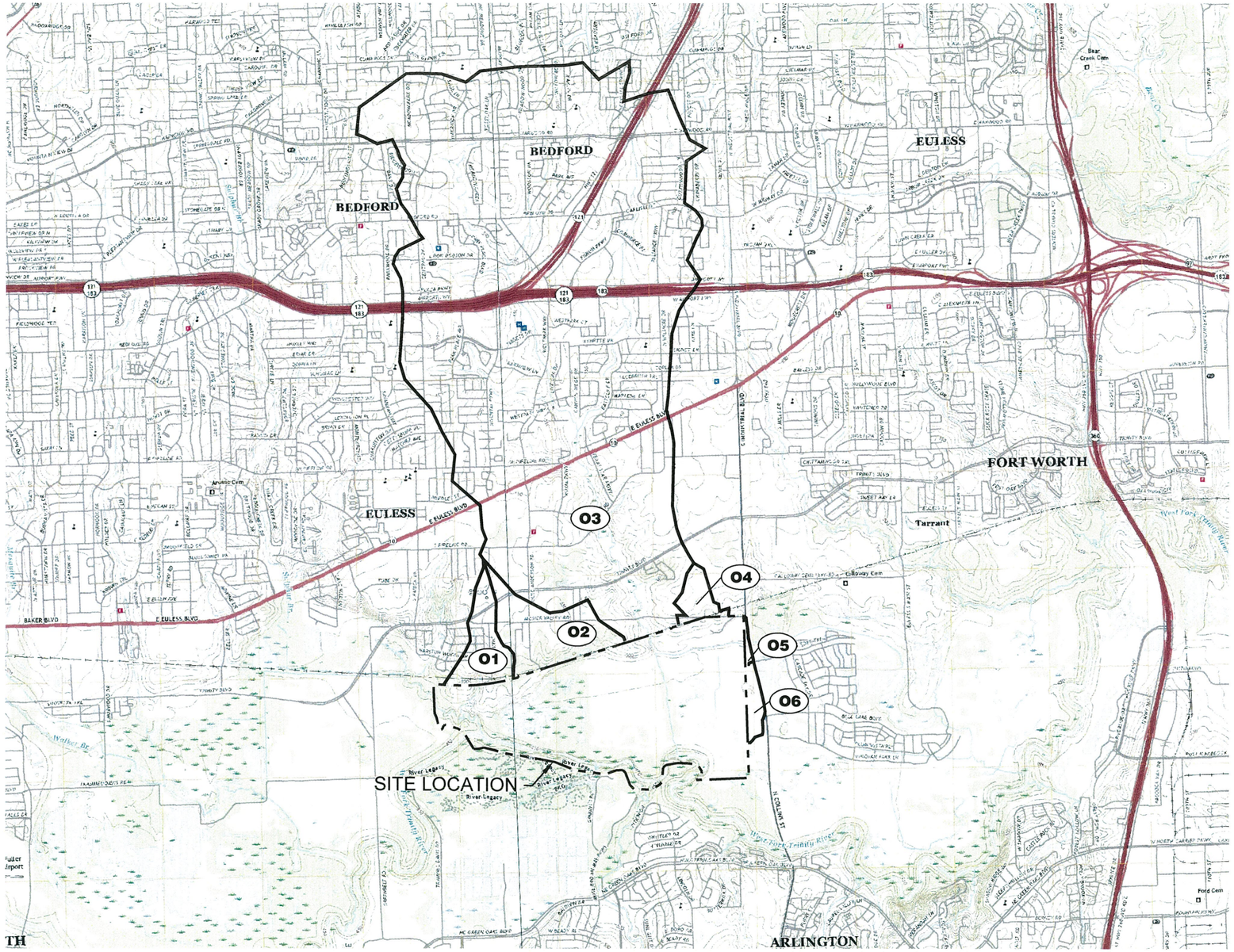
Calculate Peaking coefficient $C_p$:

$C_p = 49.375(A^{-0.04})(T_r^{-1.07})(T_{lag})$

$C_p = 49.375(0.0038^{-0.04})(19.1^{-1.07})(0.28)$

$C_p = 0.67$

# UPATED PERMITTED HEC-HMS ANALYSIS DRAINAGE AREAS




| DRAINAGE AREA NO. | AREA (ACRES) |
|---|---|
| 01 | 81.63 |
| 02 | 160.32 |
| 03 (SEE NOTE 2) | 3520.00 |
| 04 | 41.33 |
| 05 | 4.04 |
| 06 | 25.70 |
| TOTAL | 3833.01 |

N

0 2000 4000

SCALE IN FEET

NOTES:

1. REPRODUCED FROM 7.5 MINUTE, HURST, TEXAS QUADRANGLE USGS MAP DATED 2019 AND 7.5 MINUTE, EULESS, TEXAS QUADRANGLE USGS MAP DATED 2019.
2. THE DRAINAGE ARE FOR BASIN 03 (5.5 SQUARE MILES OR 3,520 ACRES) WAS REPRODUCED FROM THE EFFECTIVE FEMA FLOOD INSURANCE STUDY NUMBER 48439CV001B, DATED MARCH 21, 2019.

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05-19-22

LEGEND

PERMIT BOUNDARY

DRAINAGE AREA BOUNDARY

01 DRAINAGE AREA DESIGNATION

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☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-E-13 OFFSITE DRAINAGE.DWG

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

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

REVISIONS

| NO. | DATE | DESCRIPTION |
|---|---|---|
| | | |
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| | | |
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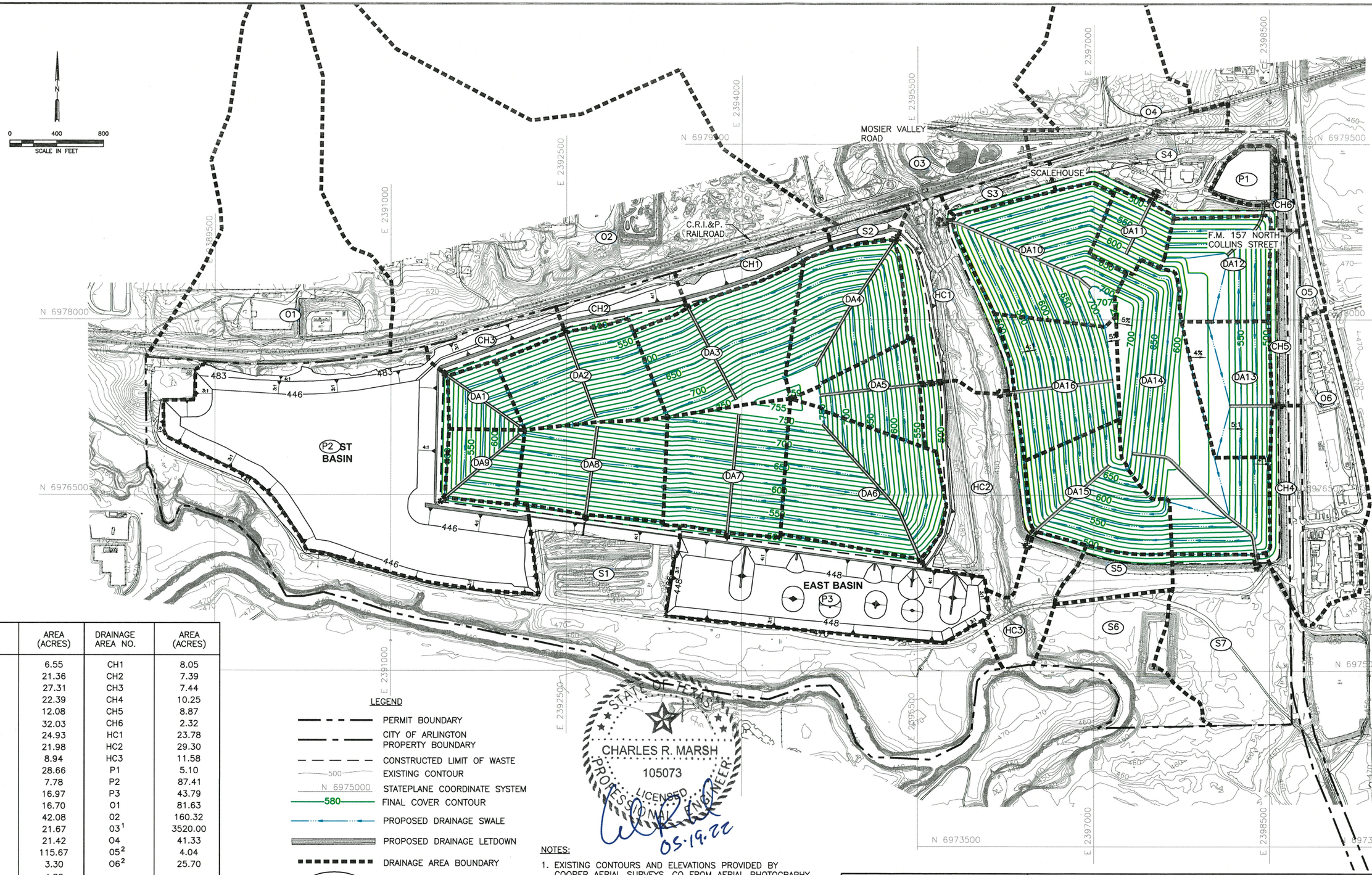
# MAJOR PERMIT AMENDMENT
# OFFSITE DRAINAGE AREA MAP

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

DRAWING IIIF-E-13

O:\0023\404\EXPANSION 2021\PART III\IIIF\IIIF-E\IIIF-E-13-OFFSITE DRAINAGE.dwg, jwilson, 1:2




| DRAINAGE AREA NO. | AREA (ACRES) | DRAINAGE AREA NO. | AREA (ACRES) |
|---|---|---|---|
| DA1 | 6.55 | CH1 | 8.05 |
| DA2 | 21.36 | CH2 | 7.39 |
| DA3 | 27.31 | CH3 | 7.44 |
| DA4 | 22.39 | CH4 | 10.25 |
| DA5 | 12.08 | CH5 | 8.87 |
| DA6 | 32.03 | CH6 | 2.32 |
| DA7 | 24.93 | HC1 | 23.78 |
| DA8 | 21.98 | HC2 | 29.30 |
| DA9 | 8.94 | HC3 | 11.58 |
| DA10 | 28.66 | P1 | 5.10 |
| DA11 | 7.78 | P2 | 87.41 |
| DA12 | 16.97 | P3 | 43.79 |
| DA13 | 16.70 | O1 | 81.63 |
| DA14 | 42.08 | O2 | 160.32 |
| DA15 | 21.67 | O3[1] | 3520.00 |
| DA16 | 21.42 | O4 | 41.33 |
| S1 | 115.67 | O5[2] | 4.04 |
| S2 | 3.30 | O6[2] | 25.70 |
| S3 | 4.82 | | |
| S4 | 19.85 | | |
| S5 | 7.69 | | |
| S6 | 21.47 | | |
| S7 | 32.29 | | |

[1] O2 AREA FROM FIS. FLOW RATES WERE MODELED TO MATCH.

[2] SCS CURVE NUMBERS DERIVED FROM COMMERCIAL AND

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LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- CONSTRUCTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 FINAL COVER CONTOUR
- PROPOSED DRAINAGE SWALE
- PROPOSED DRAINAGE LETDOWN
- DRAINAGE AREA BOUNDARY
- DA4 DRAINAGE AREA DESIGNATION

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05.19.22

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 03/2022
FILE: 0023-404-11
CAD: IIIF-E-14-PERMITTED DRAINAGE.DWG

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

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| | | |
| | | |
| | | |
| | | |
| | | |

# MAJOR PERMIT AMENDMENT
# UPDATED PERMITTED PROJECT DRAINAGE AREAS

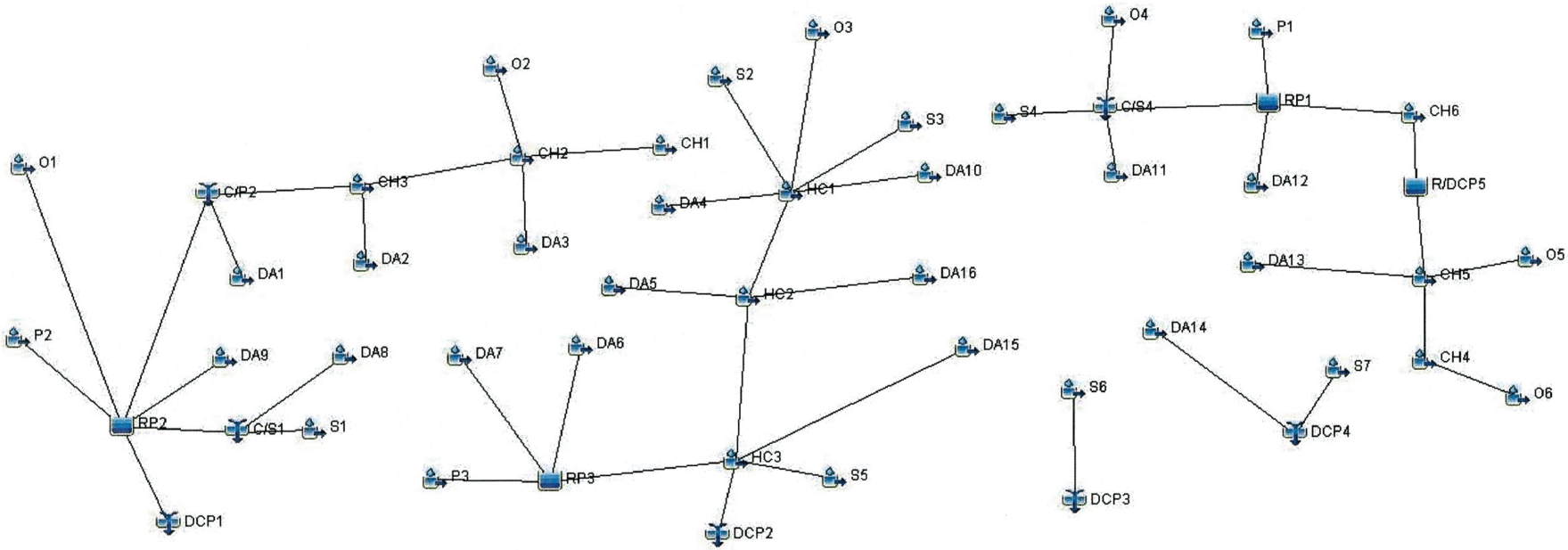
CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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DRAWING IIIF-E-14

O:\0023\404\EXPANSION 2021\PART III\IIIF-E\IIIF-E-14-PERMITTED DRAINAGE.dwg, jwilson, 1:2

# HEC-HMS OUTPUT – UPDATED PERMITTED 25-YEAR, 24-HOUR STORM EVENT


O1
C/P2
CH3
CH2
CH1
O2
DA1
DA2
DA3
P2
DA9
DA8
RP2
C/S1
S1
DCP1
O3
S2
S3
DA10
HC1
DA4
DA5
HC2
DA16
DA7
DA6
DA15
P3
RP3
HC3
S5
DCP2
S6
DCP3
O4
P1
S4
C/S4
RP1
CH6
DA11
DA12
R/DCP5
DA13
CH5
O5
DA14
S7
CH4
O6
DCP4

**Project:** Arlington_LF___Updated_Perm
**Simulation Run:** Basin A - 25-Year
**Simulation Start:** 29 December 2020, 01:00
**Simulation End:** 31 December 2020, 13:00

**HMS Version:** 4.8
**Executed:** 21 January 2022, 15:08

## Global Parameter Summary - Subbasin

**Area (ft²)**

| Element Name | Area (ft²) |
|---|---|
| O2 | 0.25 |
| Da3 | 0.04 |
| Ch1 | 0.01 |
| Ch2 | 0.01 |
| Da2 | 0.03 |
| Ch3 | 0.01 |
| Da1 | 0.01 |
| S1 | 0.18 |
| Da8 | 0.03 |
| P2 | 0.14 |
| O1 | 0.13 |
| Da9 | 0.01 |
| Da7 | 0.04 |
| Hc3 | 0.02 |
| P3 | 0.07 |
| Da6 | 0.05 |
| O3 | 5.5 |
| Da4 | 0.04 |
| Hc1 | 0.04 |
| Da16 | 0.03 |
| S2 | 0.01 |
| Da5 | 0.02 |
| Hc2 | 0.05 |
| S3 | 0.01 |
| Da10 | 0.04 |
| Da15 | 0.03 |
| S5 | 0.01 |

| | |
|---|---|
| S6 | 0.03 |
| Da14 | 0.07 |
| S7 | 0.05 |
| O4 | 0.06 |
| S4 | 0.03 |
| Da11 | 0.01 |
| Da12 | 0.03 |
| P1 | 0.01 |
| Ch6 | 0 |
| O6 | 0.04 |
| Ch4 | 0.02 |
| Da13 | 0.03 |
| O5 | 0.01 |
| Ch5 | 0.01 |

**Downstream**

| Element Name | Downstream |
|---|---|
| O2 | Ch2 |
| Da3 | Ch2 |
| Ch1 | Ch2 |
| Ch2 | Ch3 |
| Da2 | Ch3 |
| Ch3 | C/p2 |
| Da1 | C/p2 |
| S1 | C/s1 |
| Da8 | C/s1 |
| P2 | Rp2 |
| O1 | Rp2 |
| Da9 | Rp2 |
| Da7 | Rp3 |
| Hc3 | Dcp2 |
| P3 | Rp3 |
| Da6 | Rp3 |
| O3 | Hc1 |
| Da4 | Hc1 |
| Hc1 | Hc2 |
| Da16 | Hc2 |
| S2 | Hc1 |
| Da5 | Hc2 |
| Hc2 | Hc3 |
| S3 | Hc1 |
| Da10 | Hc1 |
| Da15 | Hc3 |
| S5 | Hc3 |
| S6 | Dcp3 |
| Da14 | Dcp4 |
| S7 | Dcp4 |
| O4 | C/s4 |
| S4 | C/s4 |
| Da11 | C/s4 |
| Da12 | Rp1 |
| P1 | Rp1 |
| Ch6 | R/dcp5 |
| O6 | Ch4 |
| Ch4 | Ch5 |
| Da13 | Ch5 |
| O5 | Ch5 |
| Ch5 | R/dcp5 |

**Loss Rate: Scs**

| Element Name | Percent Impervious Area | Curve Number |
|---|---|---|
| O2 | 0 | 84 |
| S1 | 0 | 84 |
| P2 | 0 | 99 |
| O1 | 0 | 84 |
| P3 | 0 | 99 |
| O3 | 10 | 80 |
| S2 | 0 | 84 |
| S3 | 0 | 84 |
| S5 | 0 | 84 |
| S6 | 0 | 84 |
| S7 | 0 | 84 |
| O4 | 0 | 84 |
| S4 | 25 | 84 |
| P1 | 100 | 99 |
| O6 | 0 | 88 |
| O5 | 0 | 86 |

**Transform: Snyder**

| Element Name | Snyder Method | Snyder Tp | Snyder Cp |
|---|---|---|---|
| O2 | Standard | 0.42 | 0.63 |
| S1 | Standard | 0.42 | 0.64 |
| O1 | Standard | 0.37 | 0.64 |
| O3 | Standard | 0.79 | 0.56 |
| S2 | Standard | 0.12 | 0.64 |
| S3 | Standard | 0.19 | 0.68 |
| S5 | Standard | 0.26 | 0.69 |
| S6 | Standard | 0.23 | 0.66 |
| S7 | Standard | 0.55 | 0.67 |
| O4 | Standard | 0.32 | 0.66 |
| S4 | Standard | 0.22 | 0.66 |
| O6 | Standard | 0.15 | 0.62 |
| O5 | Standard | 0.11 | 0.62 |

**Transform: Kinematic Wave**

| Element Name | Transform |
|---|---|
| Da3 | Kinematic Wave |
| Ch1 | Kinematic Wave |
| Ch2 | Kinematic Wave |
| Da2 | Kinematic Wave |
| Ch3 | Kinematic Wave |
| Da1 | Kinematic Wave |
| Da8 | Kinematic Wave |
| Da9 | Kinematic Wave |
| Da7 | Kinematic Wave |
| Hc3 | Kinematic Wave |
| Da6 | Kinematic Wave |
| Da4 | Kinematic Wave |
| Hc1 | Kinematic Wave |
| Da16 | Kinematic Wave |
| Da5 | Kinematic Wave |
| Hc2 | Kinematic Wave |
| Da10 | Kinematic Wave |
| Da15 | Kinematic Wave |
| Da14 | Kinematic Wave |
| Da11 | Kinematic Wave |
| Da12 | Kinematic Wave |
| Ch6 | Kinematic Wave |
| Ch4 | Kinematic Wave |
| Da13 | Kinematic Wave |
| Ch5 | Kinematic Wave |

**Transform: Scs**

| Element Name | Lag | Unitgraph Type |
|---|---|---|
| P2 | 0.1 | Standard |
| P3 | 0.1 | Standard |
| P1 | 0.1 | Standard |

# Global Results Summary

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (IN) |
|---|---|---|---|---|
| O2 | 0.25 | 475.6 | 29Dec2020, 13:30 | 5.29 |
| Da3 | 0.04 | 221.54 | 29Dec2020, 13:05 | 4.51 |
| Ch1 | 0.01 | 53.17 | 29Dec2020, 13:05 | 4.11 |
| Ch2 | 0.32 | 521.07 | 29Dec2020, 13:30 | 5.14 |
| Da2 | 0.03 | 170.44 | 29Dec2020, 13:05 | 5.55 |

| | | | | |
|---|---|---|---|---|
| Ch3 | 0.36 | 581.41 | 29Dec2020, 13:15 | 5.18 |
| Da1 | 0.01 | 54.27 | 29Dec2020, 13:05 | 5.01 |
| C/p2 | 0.37 | 600.12 | 29Dec2020, 13:15 | 5.17 |
| S1 | 0.18 | 347.29 | 29Dec2020, 13:30 | 5.29 |
| Da8 | 0.03 | 180.38 | 29Dec2020, 13:05 | 4.63 |
| C/s1 | 0.21 | 372.35 | 29Dec2020, 13:25 | 5.19 |
| P2 | 0.14 | 759.77 | 29Dec2020, 13:05 | 7.04 |
| O1 | 0.13 | 260.66 | 29Dec2020, 13:25 | 5.29 |
| Da9 | 0.01 | 75.85 | 29Dec2020, 13:05 | 5.09 |
| Rp2 | 0.87 | 255.84 | 29Dec2020, 15:00 | 5.49 |
| Da7 | 0.04 | 207.37 | 29Dec2020, 13:05 | 4.83 |
| Dcp2 | 5.95 | 6142.73 | 29Dec2020, 13:55 | 5.08 |
| Hc3 | 5.95 | 6142.73 | 29Dec2020, 13:55 | 5.08 |
| P3 | 0.07 | 380.44 | 29Dec2020, 13:05 | 7.04 |
| Da6 | 0.05 | 254.23 | 29Dec2020, 13:05 | 4.34 |
| O3 | 5.5 | 6011.26 | 29Dec2020, 13:50 | 5.07 |
| Da4 | 0.04 | 186.91 | 29Dec2020, 13:05 | 4.82 |
| Hc1 | 5.63 | 6051.33 | 29Dec2020, 13:55 | 5.07 |
| Da16 | 0.03 | 179.3 | 29Dec2020, 13:05 | 4.62 |
| S2 | 0.01 | 18.8 | 29Dec2020, 13:10 | 5.29 |
| Da5 | 0.02 | 100.04 | 29Dec2020, 13:05 | 4.79 |
| Hc2 | 5.73 | 6057.56 | 29Dec2020, 13:55 | 5.07 |
| S3 | 0.01 | 22.77 | 29Dec2020, 13:15 | 5.29 |
| Da10 | 0.04 | 253.84 | 29Dec2020, 13:05 | 5.01 |
| Da15 | 0.03 | 170.54 | 29Dec2020, 13:05 | 4.2 |
| Rp3 | 0.16 | 65.02 | 29Dec2020, 14:00 | 5.63 |
| S5 | 0.01 | 31.58 | 29Dec2020, 13:20 | 5.29 |
| Dcp1 | 0.87 | 255.84 | 29Dec2020, 15:00 | 5.49 |
| S6 | 0.03 | 90.46 | 29Dec2020, 13:15 | 5.29 |
| Da14 | 0.07 | 374.71 | 29Dec2020, 13:05 | 4.85 |
| S7 | 0.05 | 84.98 | 29Dec2020, 13:35 | 5.29 |
| O4 | 0.06 | 146.21 | 29Dec2020, 13:20 | 5.29 |
| S4 | 0.03 | 89.34 | 29Dec2020, 13:15 | 5.76 |
| Da11 | 0.01 | 65.86 | 29Dec2020, 13:05 | 4.95 |
| C/s4 | 0.11 | 243.51 | 29Dec2020, 13:20 | 5.39 |
| Da12 | 0.03 | 145.06 | 29Dec2020, 13:05 | 4.9 |
| P1 | 0.01 | 44.53 | 29Dec2020, 13:05 | 7.16 |
| Rp1 | 0.14 | 79.17 | 29Dec2020, 14:05 | 5.2 |
| Ch6 | 0.15 | 80.51 | 29Dec2020, 14:00 | 5.22 |
| O6 | 0.04 | 139.7 | 29Dec2020, 13:10 | 5.75 |
| Ch4 | 0.06 | 151.98 | 29Dec2020, 13:15 | 5.7 |
| Da13 | 0.03 | 141.08 | 29Dec2020, 13:05 | 4.82 |
| O5 | 0.01 | 23.99 | 29Dec2020, 13:10 | 5.52 |

| | | | | |
|---|---|---|---|---|
| Ch5 | 0.1 | 233.85 | 29Dec2020, 13:15 | 5.45 |
| R/dcp5 | 0.25 | 228.71 | 29Dec2020, 13:35 | 4.74 |
| Dcp4 | 0.12 | 404.25 | 29Dec2020, 13:05 | 5.04 |
| Dcp3 | 0.03 | 90.46 | 29Dec2020, 13:15 | 5.29 |

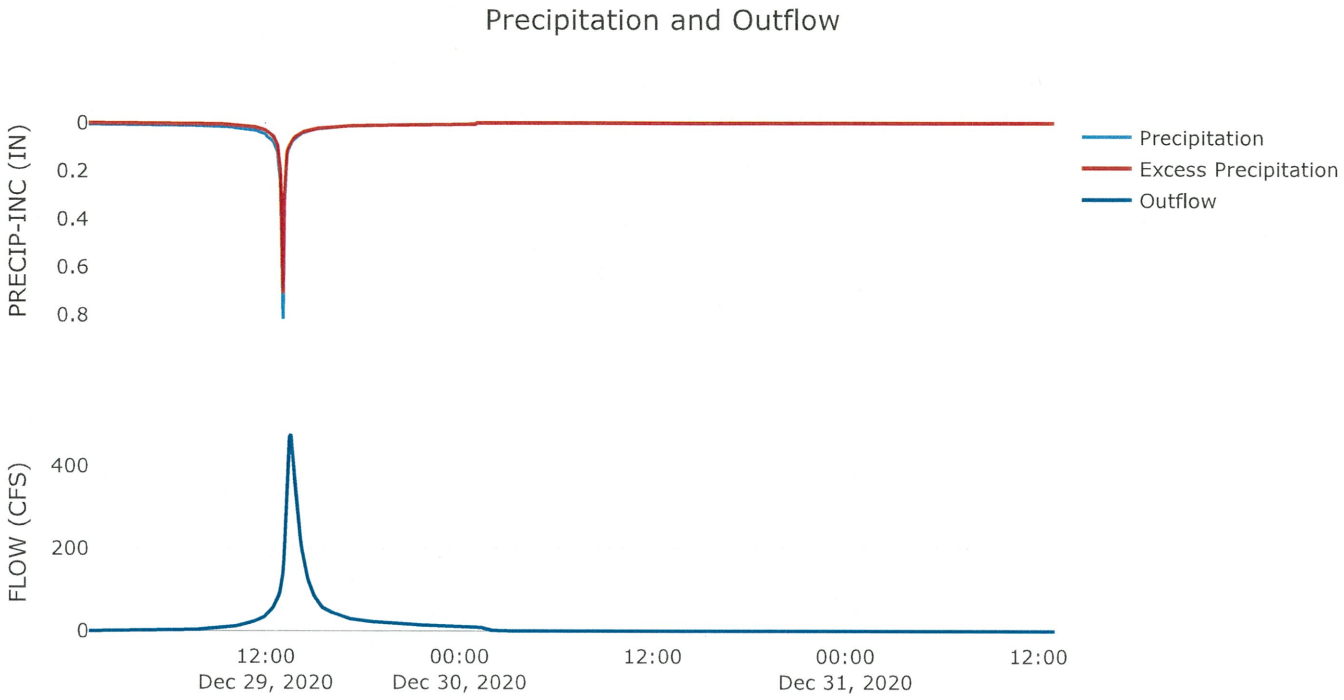
# Subbasin: O2

**Area ($ft^2$)** : 0.25
**Downstream** : Ch2

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.42 |
| Snyder Cp | 0.63 |

| Results: O2 | |
|---|---|
| Peak Discharge (CFS) | 475.6 |
| Time of Peak Discharge | 29Dec2020, 13:30 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 95.66 |
| Loss Volume (AC - FT) | 24.96 |
| Excess Volume (AC - FT) | 70.7 |
| Direct Runoff Volume (AC - FT) | 70.7 |
| Baseflow Volume (AC - FT) | 0 |

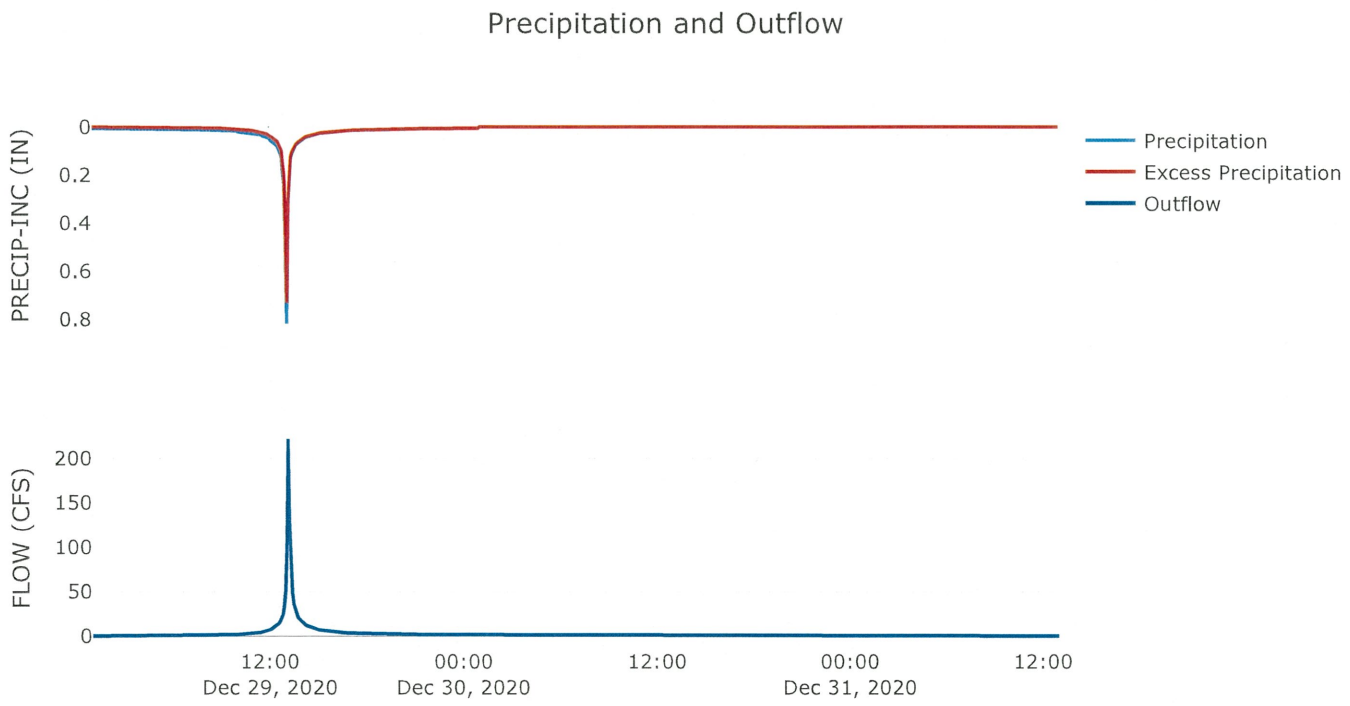

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
400
200
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA3

**Area (ft²)** : 0.04
**Downstream** : Ch2
**Transform** : Kinematic Wave

**Results: DA3**

| | |
|---|---|
| Peak Discharge (CFS) | 221.54 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.51 |
| Precipitation Volume (AC - FT) | 16.31 |
| Loss Volume (AC - FT) | 3.74 |
| Excess Volume (AC - FT) | 12.57 |
| Direct Runoff Volume (AC - FT) | 10.26 |
| Baseflow Volume (AC - FT) | 0 |

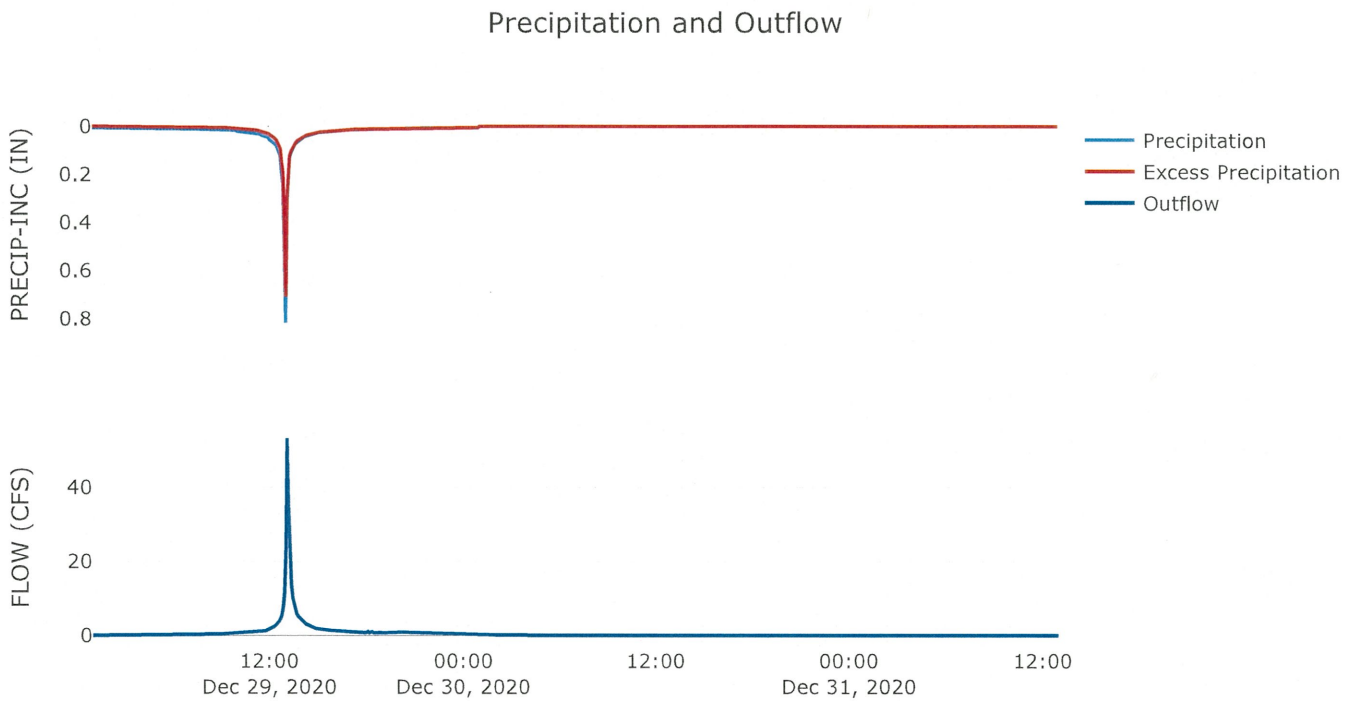


# Subbasin: CH1

**Area (ft²)** : 0.01
**Downstream** : Ch2
**Transform** : Kinematic Wave

**Results: CH1**

| | |
|---|---|
| Peak Discharge (CFS) | 53.17 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.11 |
| Precipitation Volume (AC - FT) | 4.81 |
| Loss Volume (AC - FT) | 1.26 |
| Excess Volume (AC - FT) | 3.56 |
| Direct Runoff Volume (AC - FT) | 2.76 |
| Baseflow Volume (AC - FT) | 0 |

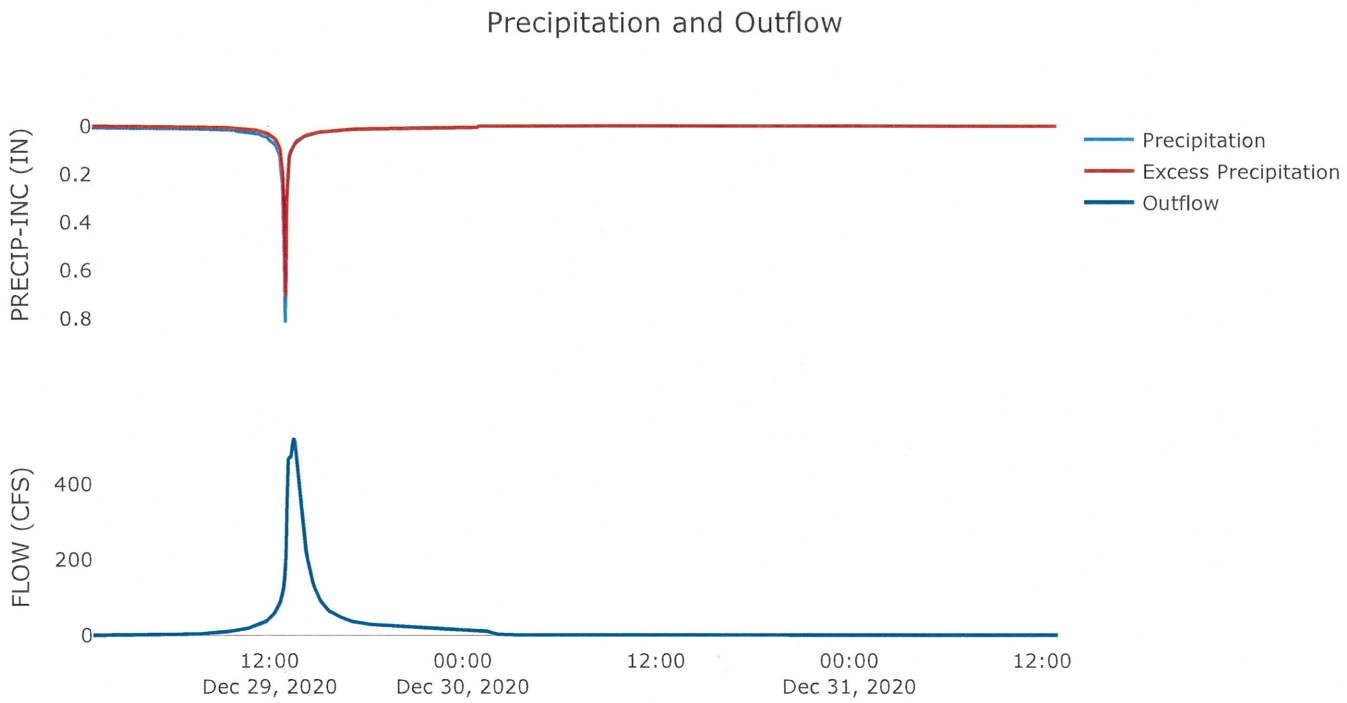


# Subbasin: CH2

**Area (ft²)** : 0.01
**Downstream** : Ch3
**Transform** : Kinematic Wave

**Results: CH2**

| | |
|---|---|
| Peak Discharge (CFS) | 521.07 |
| Time of Peak Discharge | 29Dec2020, 13:30 |
| Volume (IN) | 5.14 |
| Precipitation Volume (AC - FT) | 121.17 |
| Loss Volume (AC - FT) | 31.61 |
| Excess Volume (AC - FT) | 89.56 |
| Direct Runoff Volume (AC - FT) | 86.92 |
| Baseflow Volume (AC - FT) | 0 |

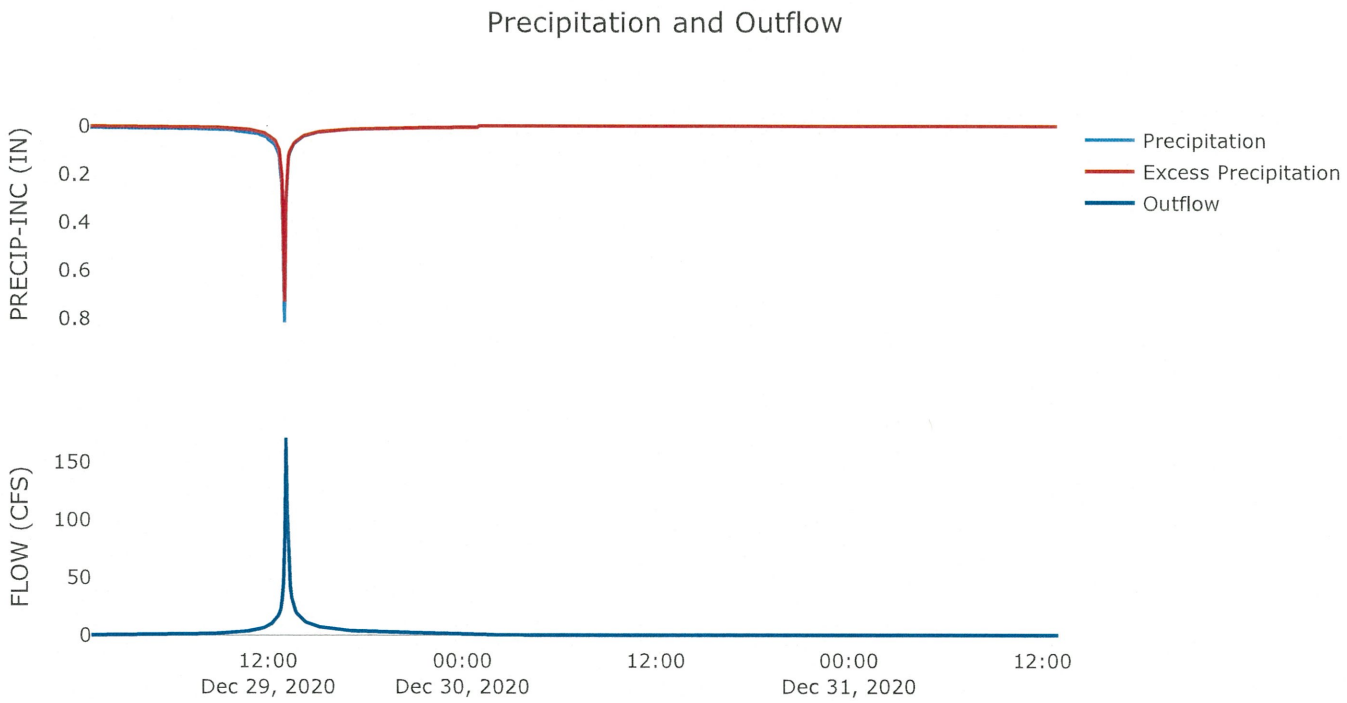


# Subbasin: DA2

**Area (ft²)** : 0.03
**Downstream** : Ch3
**Transform** : Kinematic Wave

**Results: DA2**

| | |
|---|---|
| Peak Discharge (CFS) | 170.44 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 5.55 |
| Precipitation Volume (AC - FT) | 12.75 |
| Loss Volume (AC - FT) | 2.92 |
| Excess Volume (AC - FT) | 9.83 |
| Direct Runoff Volume (AC - FT) | 9.88 |
| Baseflow Volume (AC - FT) | 0 |

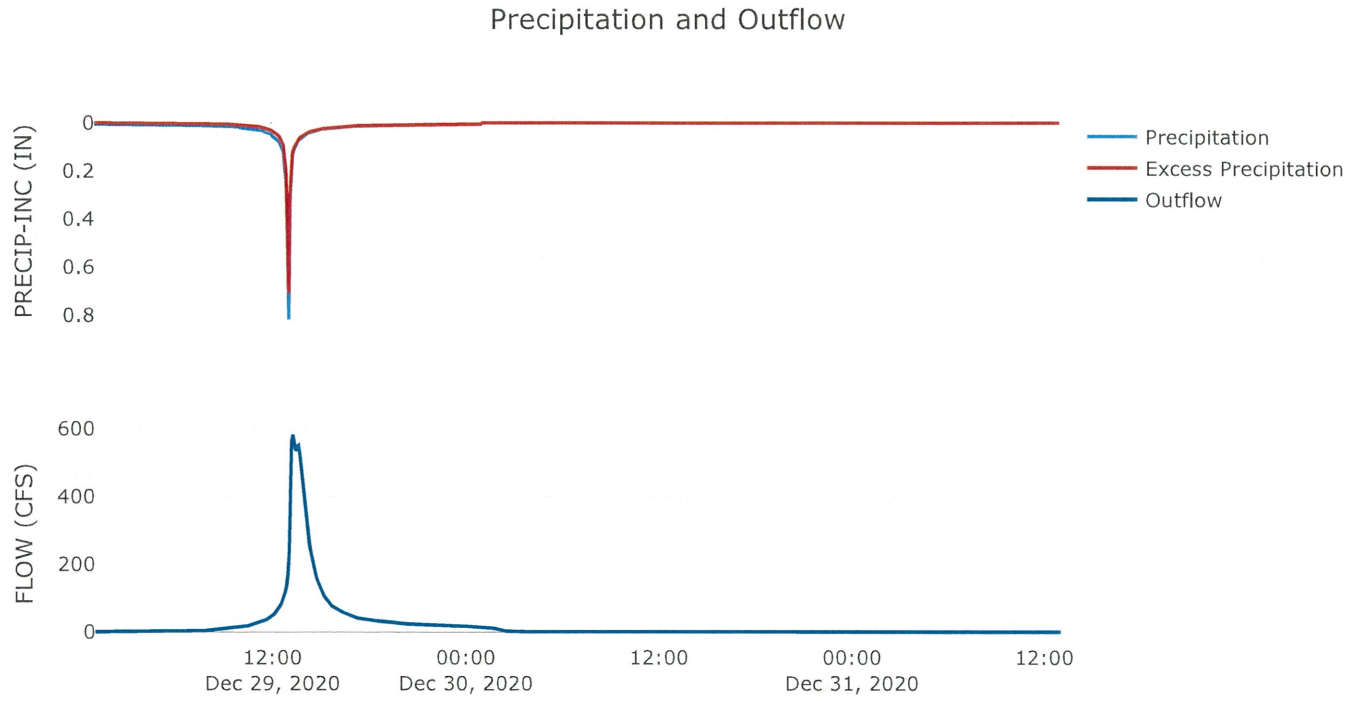


# Subbasin: CH3

**Area (ft²)** : 0.01
**Downstream** : C/p2
**Transform** : Kinematic Wave

**Results: CH3**

| | |
|---|---|
| Peak Discharge (CFS) | 581.41 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.18 |
| Precipitation Volume (AC - FT) | 138.35 |
| Loss Volume (AC - FT) | 36.09 |
| Excess Volume (AC - FT) | 102.26 |
| Direct Runoff Volume (AC - FT) | 100.06 |
| Baseflow Volume (AC - FT) | 0 |

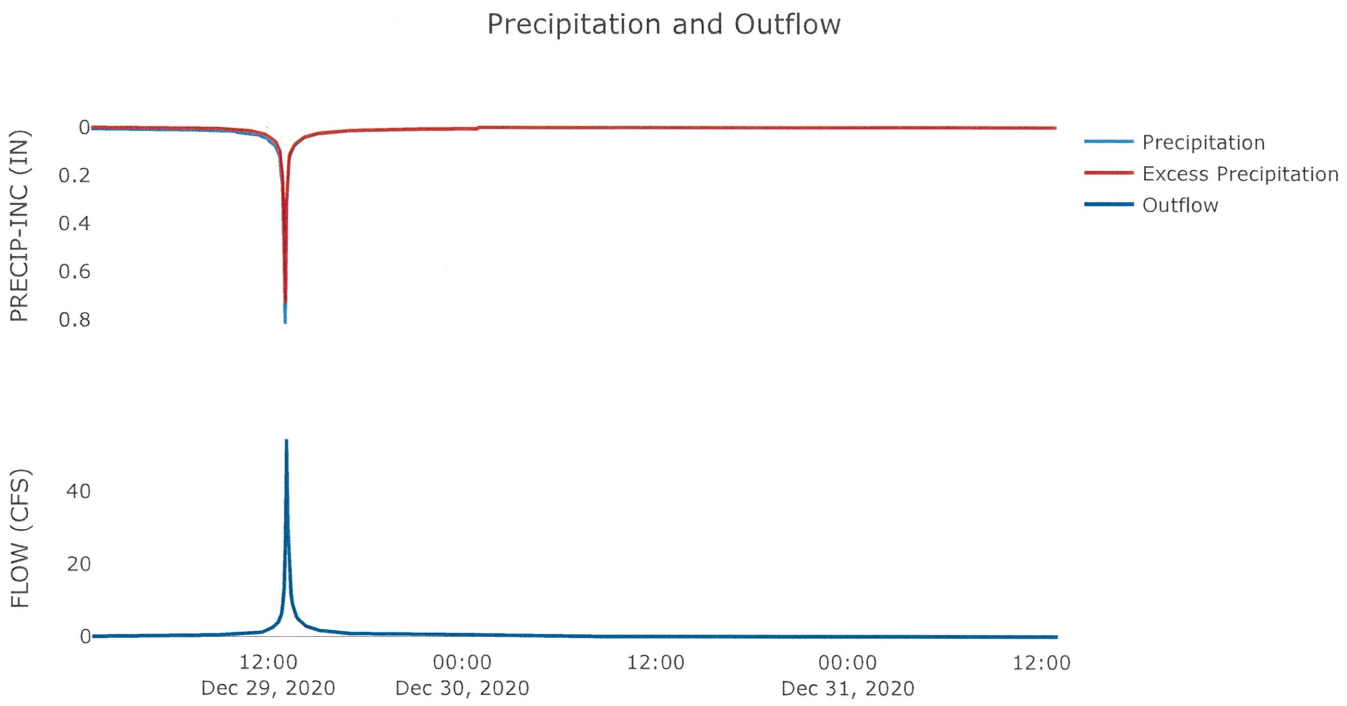


# Subbasin: DA1

**Area (ft²)** : 0.01
**Downstream** : C/p2
**Transform** : Kinematic Wave

**Results: DA1**

| | |
|---|---|
| Peak Discharge (CFS) | 54.27 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 5.01 |
| Precipitation Volume (AC - FT) | 3.9 |
| Loss Volume (AC - FT) | 0.89 |
| Excess Volume (AC - FT) | 3 |
| Direct Runoff Volume (AC - FT) | 2.73 |
| Baseflow Volume (AC - FT) | 0 |

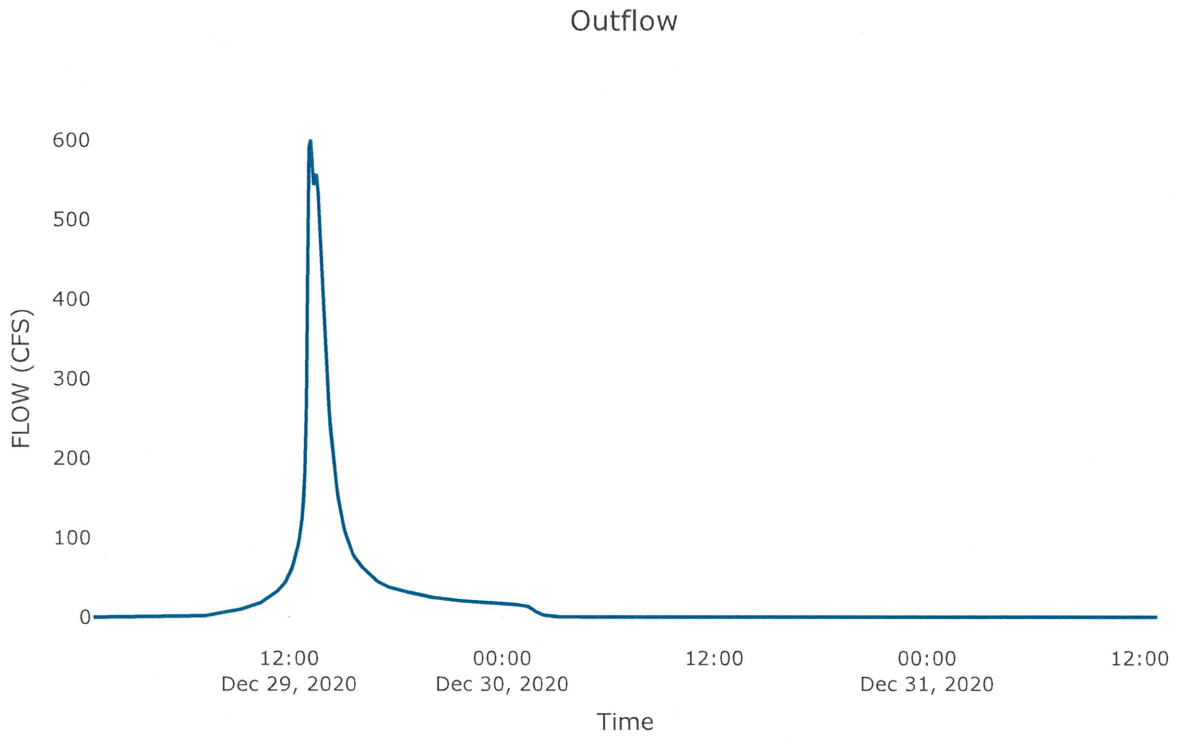


# Junction: C/P2

**Downstream** : Rp2

**Results: C/P2**

| | |
|---|---|
| Peak Discharge (CFS) | 600.12 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.17 |



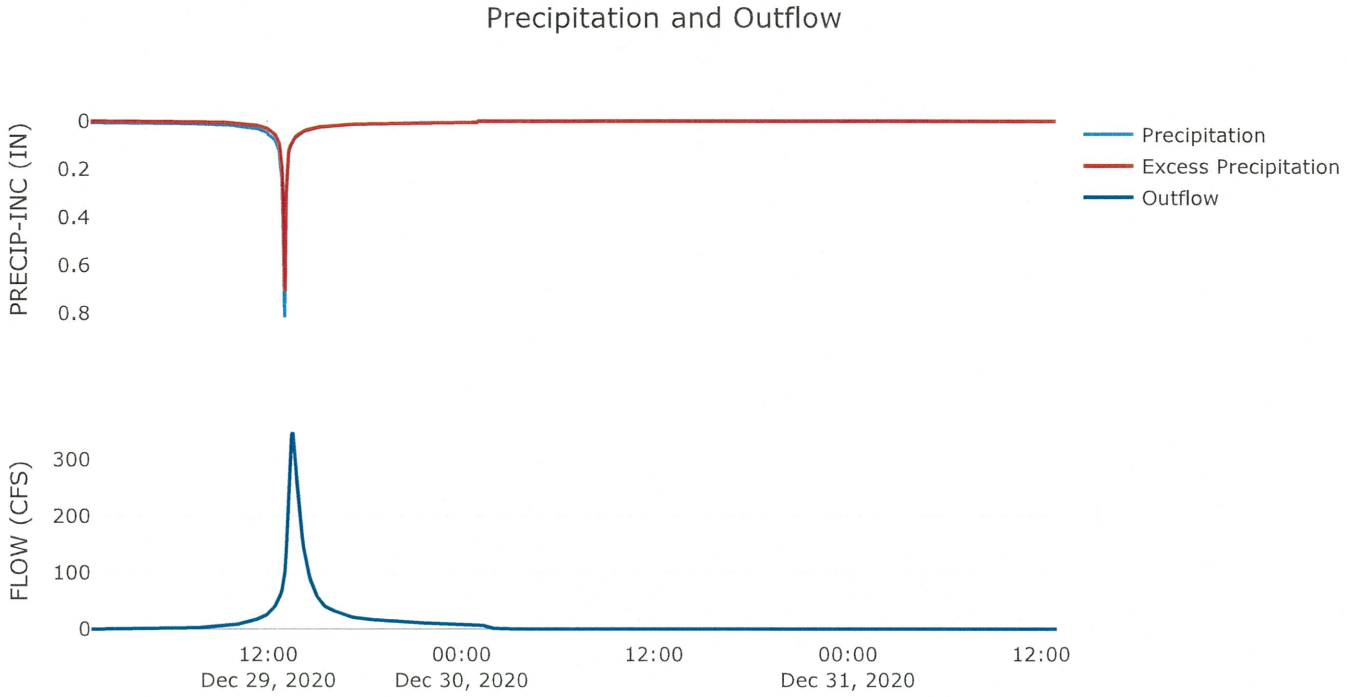
# Subbasin: S1

**Area (ft²)** : 0.18
**Downstream** : C/S1

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.42 |
| Snyder Cp | 0.64 |

| Results: S1 | |
|---|---|
| Peak Discharge (CFS) | 347.29 |
| Time of Peak Discharge | 29Dec2020, 13:30 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 69 |
| Loss Volume (AC - FT) | 18 |
| Excess Volume (AC - FT) | 51 |
| Direct Runoff Volume (AC - FT) | 51 |
| Baseflow Volume (AC - FT) | 0 |

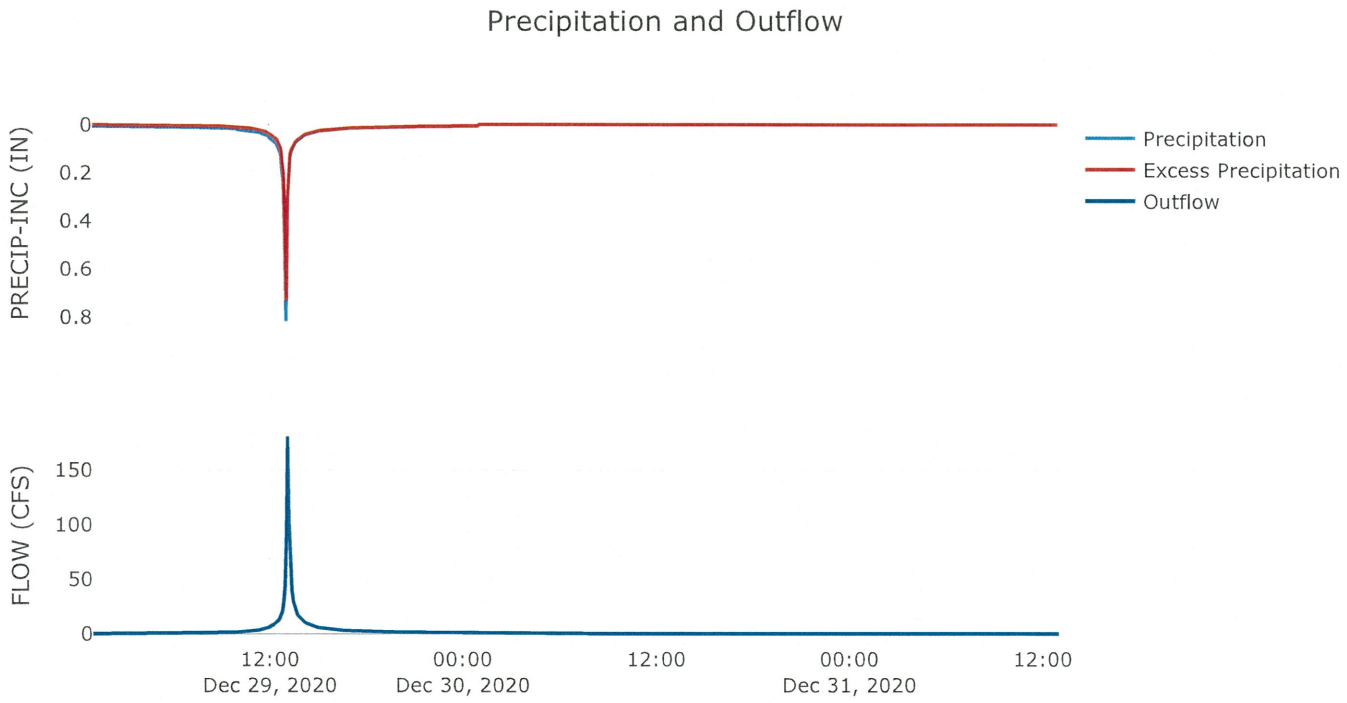

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
300
200
100
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA8

**Area (ft²)** : 0.03
**Downstream** : C/s1
**Transform** : Kinematic Wave

**Results: DA8**

| | |
|---|---|
| Peak Discharge (CFS) | 180.38 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.63 |
| Precipitation Volume (AC - FT) | 13.1 |
| Loss Volume (AC - FT) | 3 |
| Excess Volume (AC - FT) | 10.1 |
| Direct Runoff Volume (AC - FT) | 8.47 |
| Baseflow Volume (AC - FT) | 0 |

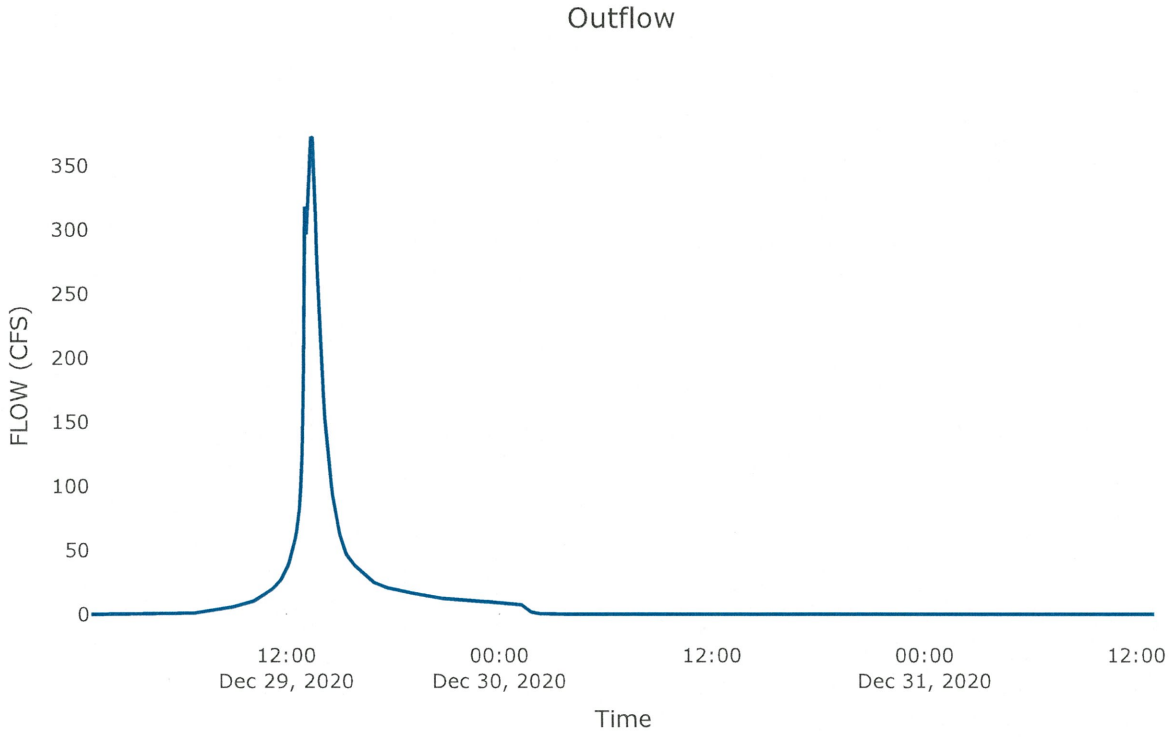


# Junction: C/S1

**Downstream** : Rp2

**Results: C/S1**

| | |
|---|---|
| Peak Discharge (CFS) | 372.35 |
| Time of Peak Discharge | 29Dec2020, 13:25 |
| Volume (IN) | 5.19 |



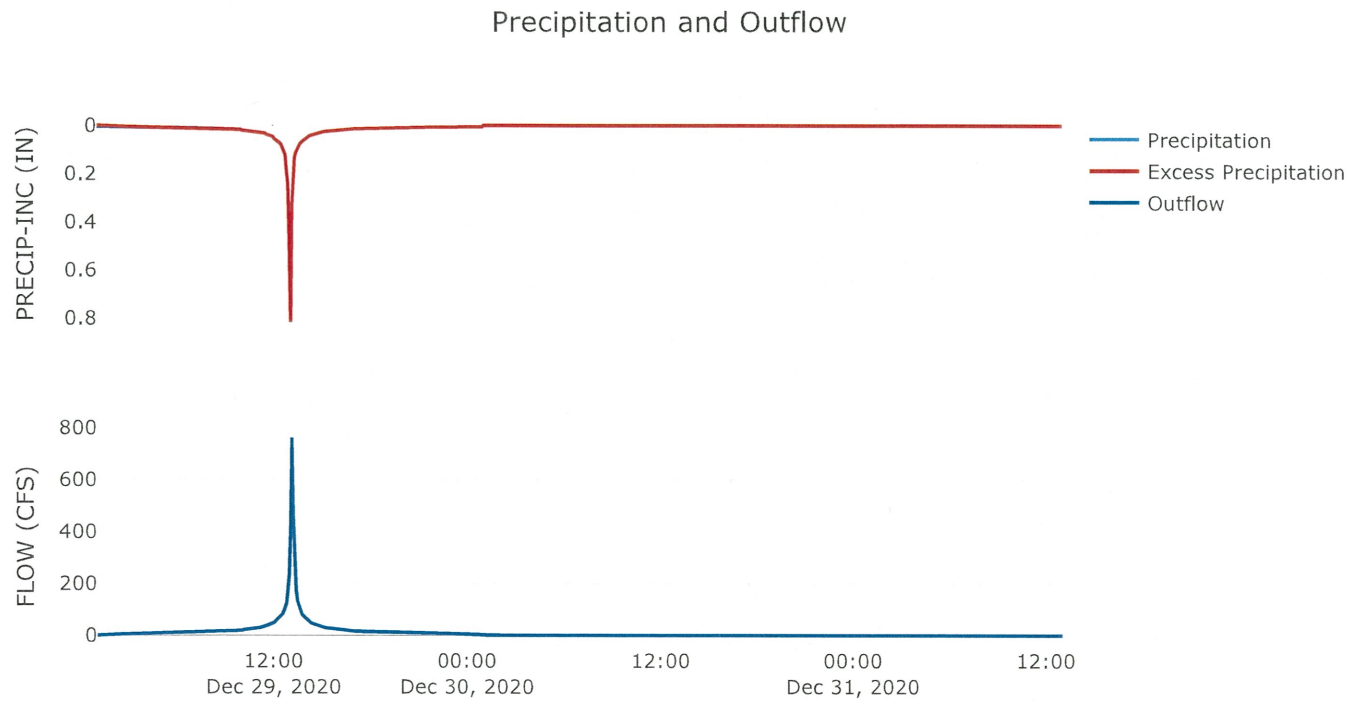
# Subbasin: P2

**Area (ft²)** : 0.14
**Downstream** : Rp2

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 99 |

| Transform: Scs | |
|---|---|
| Lag | 0.1 |
| Unitgraph Type | Standard |

| Results: P2 | |
|---|---|
| Peak Discharge (CFS) | 759.77 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 7.04 |
| Precipitation Volume (AC - FT) | 52.16 |
| Loss Volume (AC - FT) | 0.87 |
| Excess Volume (AC - FT) | 51.29 |
| Direct Runoff Volume (AC - FT) | 51.29 |
| Baseflow Volume (AC - FT) | 0 |



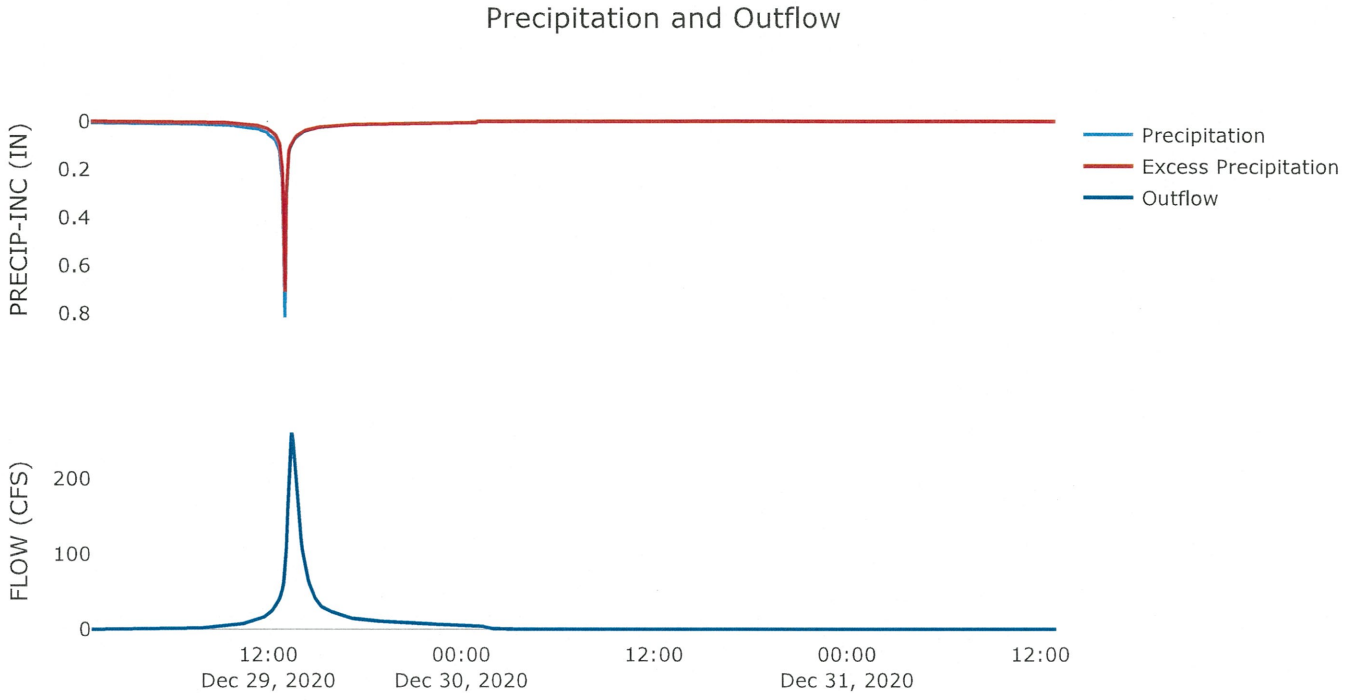
# Subbasin: O1

**Area ($ft^2$)** : 0.13
**Downstream** : Rp2

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.37 |
| Snyder Cp | 0.64 |

| Results: O1 | |
|---|---|
| Peak Discharge (CFS) | 260.66 |
| Time of Peak Discharge | 29Dec2020, 13:25 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 48.69 |
| Loss Volume (AC - FT) | 12.7 |
| Excess Volume (AC - FT) | 35.99 |
| Direct Runoff Volume (AC - FT) | 35.99 |
| Baseflow Volume (AC - FT) | 0 |

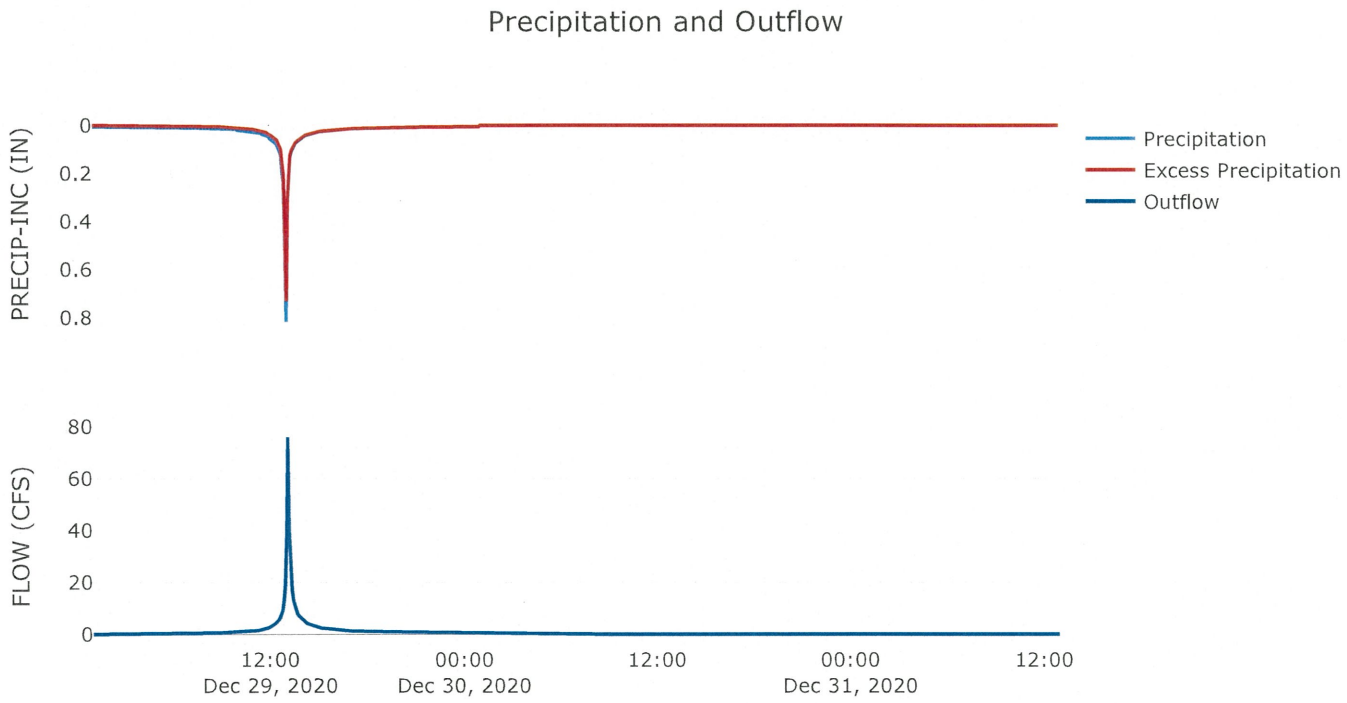

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
200
100
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA9

**Area (ft²)** : 0.01
**Downstream** : Rp2
**Transform** : Kinematic Wave

**Results: DA9**

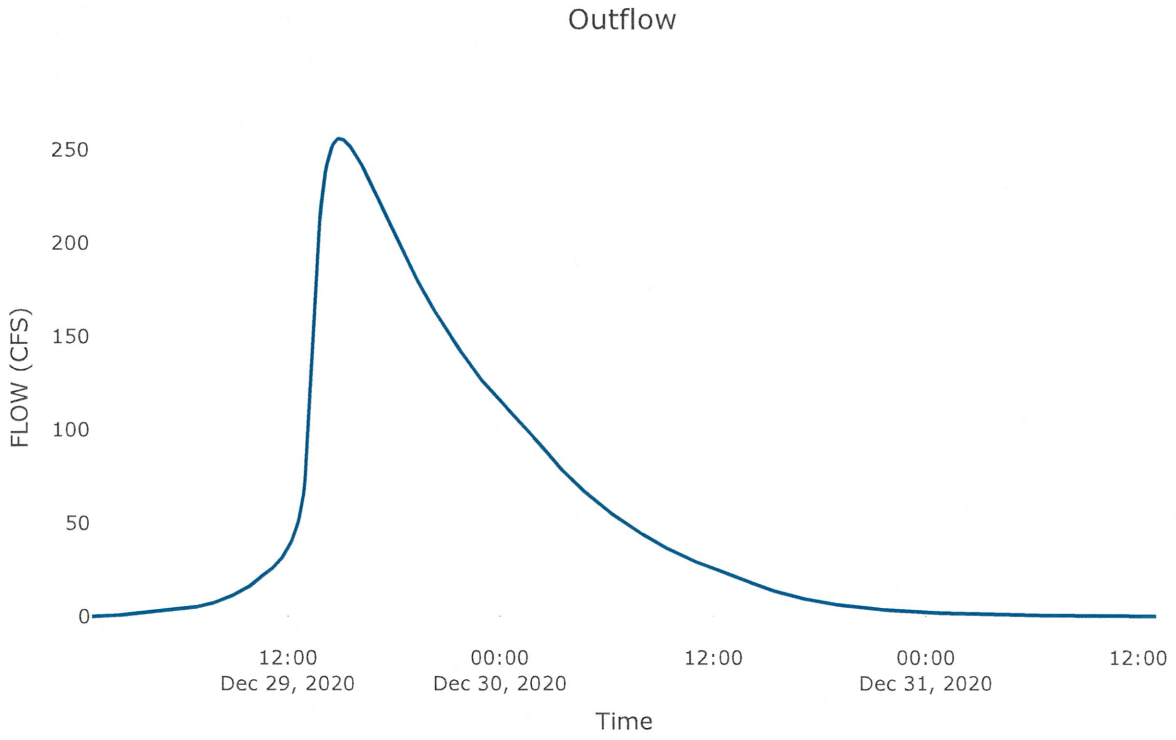
| | |
|---|---|
| Peak Discharge (CFS) | 75.85 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 5.09 |
| Precipitation Volume (AC - FT) | 5.35 |
| Loss Volume (AC - FT) | 1.22 |
| Excess Volume (AC - FT) | 4.12 |
| Direct Runoff Volume (AC - FT) | 3.8 |
| Baseflow Volume (AC - FT) | 0 |



# Reservoir: RP2

**Downstream** : Dcp1

| Results: RP2 | |
|---|---|
| Peak Discharge (CFS) | 255.84 |
| Time of Peak Discharge | 29Dec2020, 15:00 |
| Volume (IN) | 5.49 |
| Peak Inflow (CFS) | 1731.27 |
| Time of Peak Inflow | 29Dec2020, 13:05 |
| Inflow Volume (AC - FT) | 253.33 |
| Maximum Storage (AC - FT) | 143.82 |
| Peak Elevation (FT) | 449.83 |
| Discharge Volume (AC - FT) | 253.28 |

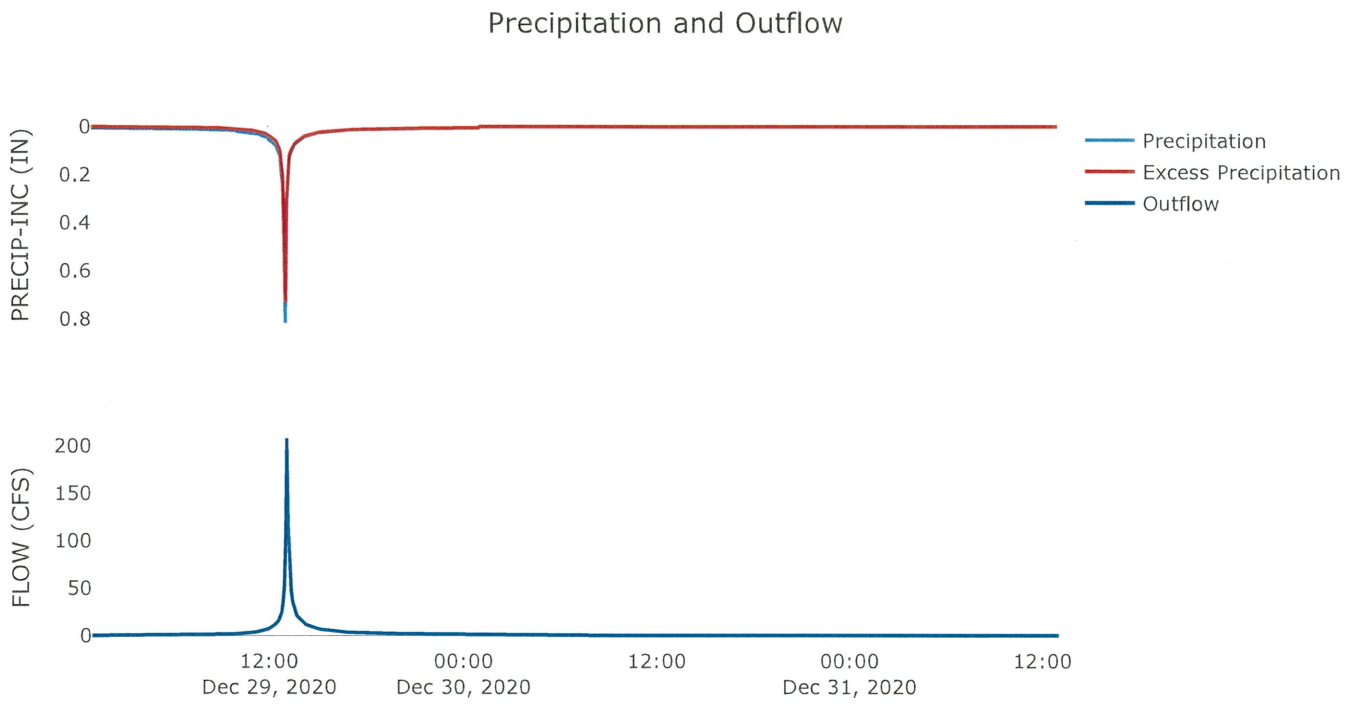


# Subbasin: DA7

**Area (ft²)** : 0.04
**Downstream** : Rp3
**Transform** : Kinematic Wave

**Results: DA7**

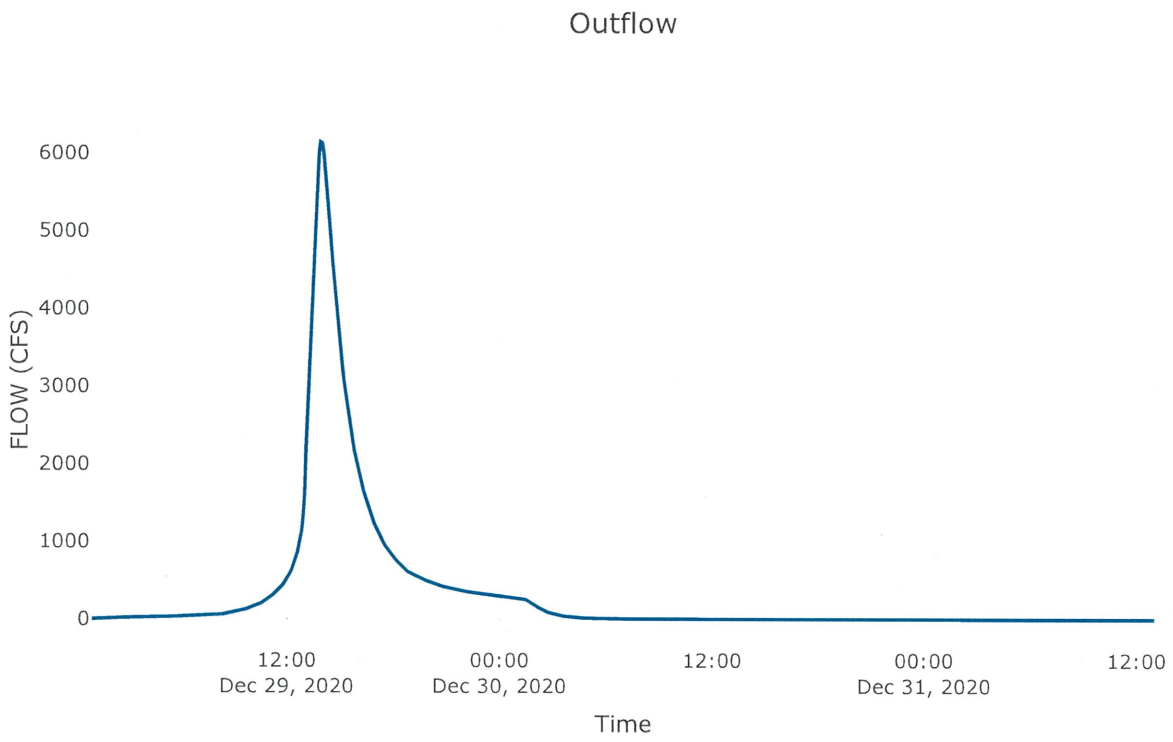
| | |
|---|---|
| Peak Discharge (CFS) | 207.37 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.83 |
| Precipitation Volume (AC - FT) | 14.89 |
| Loss Volume (AC - FT) | 3.41 |
| Excess Volume (AC - FT) | 11.48 |
| Direct Runoff Volume (AC - FT) | 10.04 |
| Baseflow Volume (AC - FT) | 0 |



# Junction: DCP2

**Results: DCP2**

| | |
|---|---|
| Peak Discharge (CFS) | 6142.73 |
| Time of Peak Discharge | 29Dec2020, 13:55 |
| Volume (IN) | 5.08 |

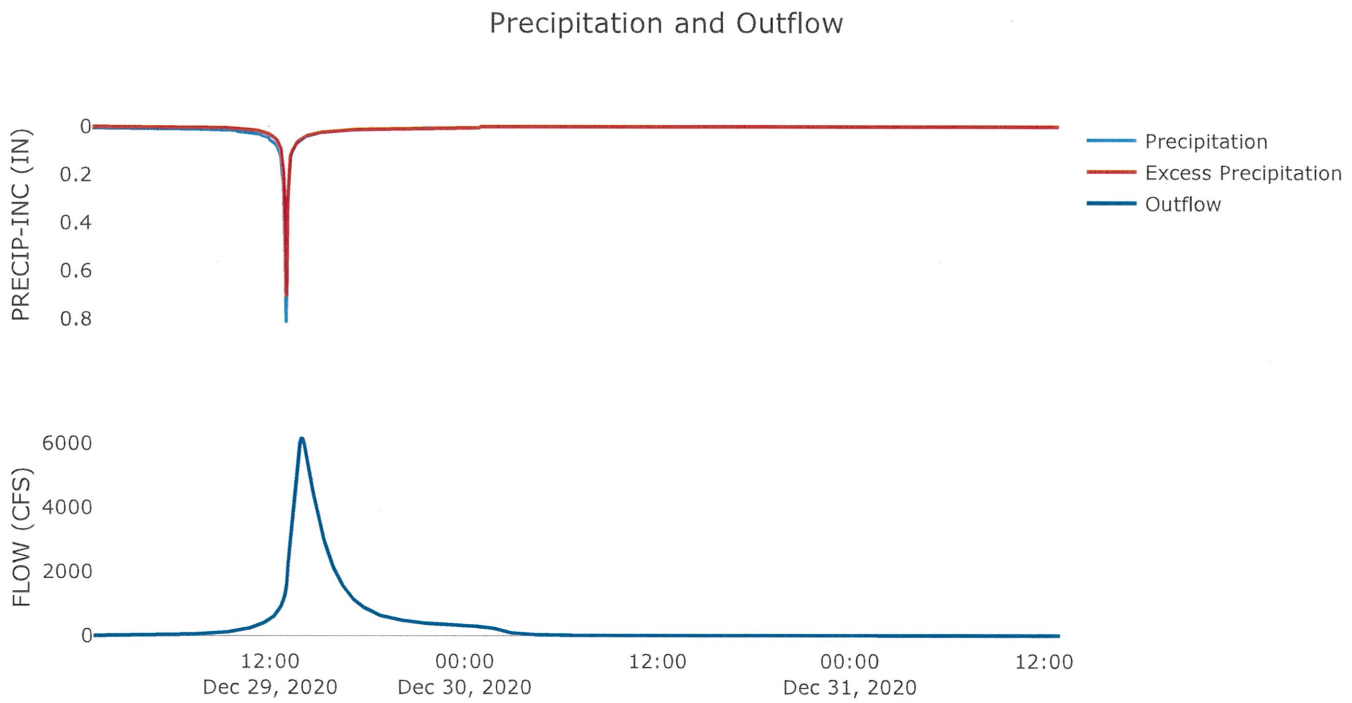


# Subbasin: HC3

**Area (ft²)** : 0.02
**Downstream** : Dcp2
**Transform** : Kinematic Wave

**Results: HC3**

| | |
|---|---|
| Peak Discharge (CFS) | 6142.73 |
| Time of Peak Discharge | 29Dec2020, 13:55 |
| Volume (IN) | 5.08 |
| Precipitation Volume (AC - FT) | 2271.84 |
| Loss Volume (AC - FT) | 592.68 |
| Excess Volume (AC - FT) | 1679.16 |
| Direct Runoff Volume (AC - FT) | 1612.61 |
| Baseflow Volume (AC - FT) | 0 |



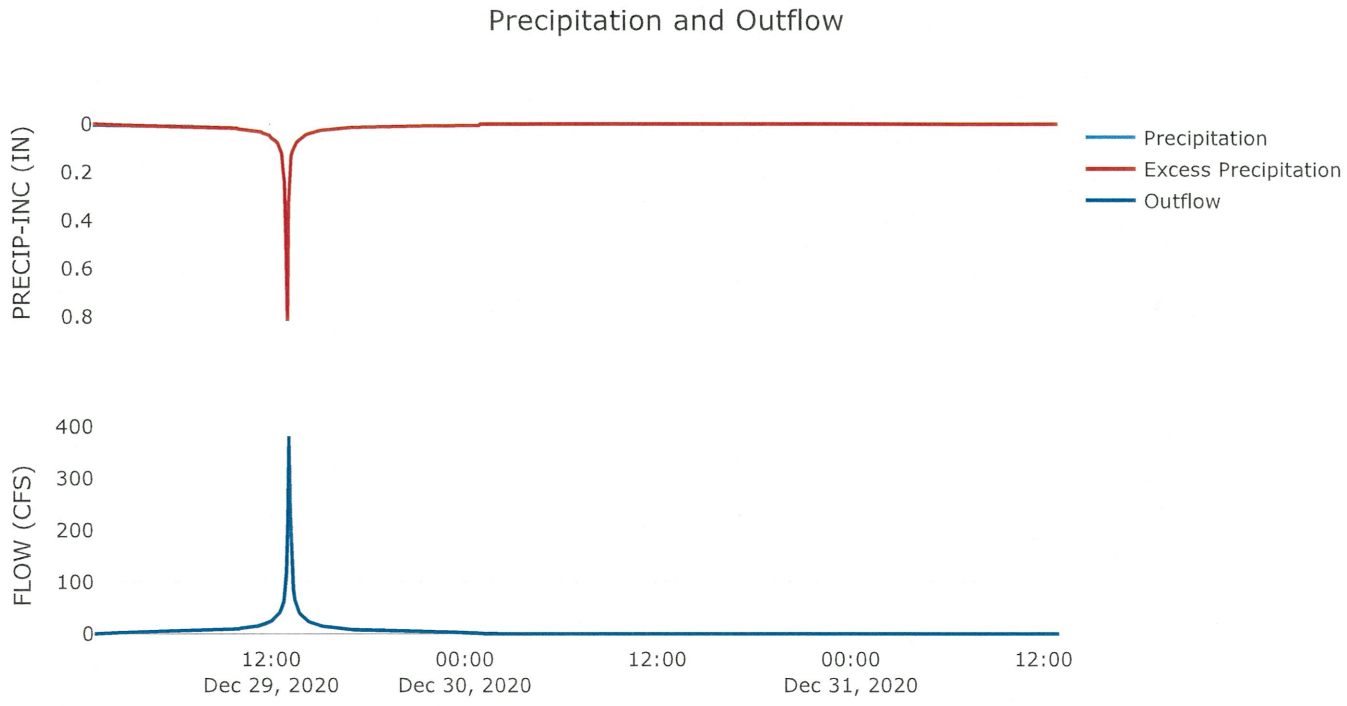
# Subbasin: P3

**Area (ft²)** : 0.07
**Downstream** : Rp3

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 99 |

| Transform: Scs | |
|---|---|
| Lag | 0.1 |
| Unitgraph Type | Standard |

| Results: P3 | |
|---|---|
| Peak Discharge (CFS) | 380.44 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 7.04 |
| Precipitation Volume (AC - FT) | 26.12 |
| Loss Volume (AC - FT) | 0.44 |
| Excess Volume (AC - FT) | 25.68 |
| Direct Runoff Volume (AC - FT) | 25.68 |
| Baseflow Volume (AC - FT) | 0 |

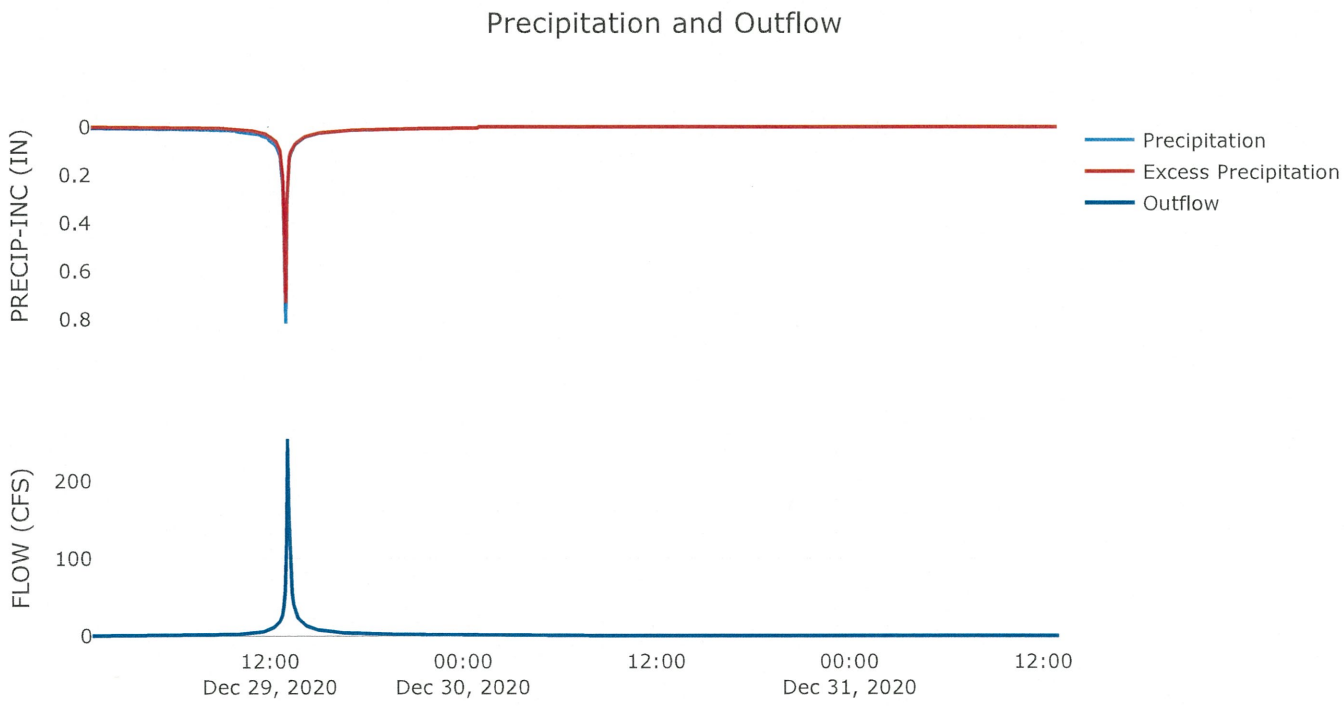


# Subbasin: DA6

**Area (ft²)** : 0.05
**Downstream** : Rp3
**Transform** : Kinematic Wave

**Results: DA6**

| | |
|---|---|
| Peak Discharge (CFS) | 254.23 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.34 |
| Precipitation Volume (AC - FT) | 19.09 |
| Loss Volume (AC - FT) | 4.37 |
| Excess Volume (AC - FT) | 14.72 |
| Direct Runoff Volume (AC - FT) | 11.58 |
| Baseflow Volume (AC - FT) | 0 |



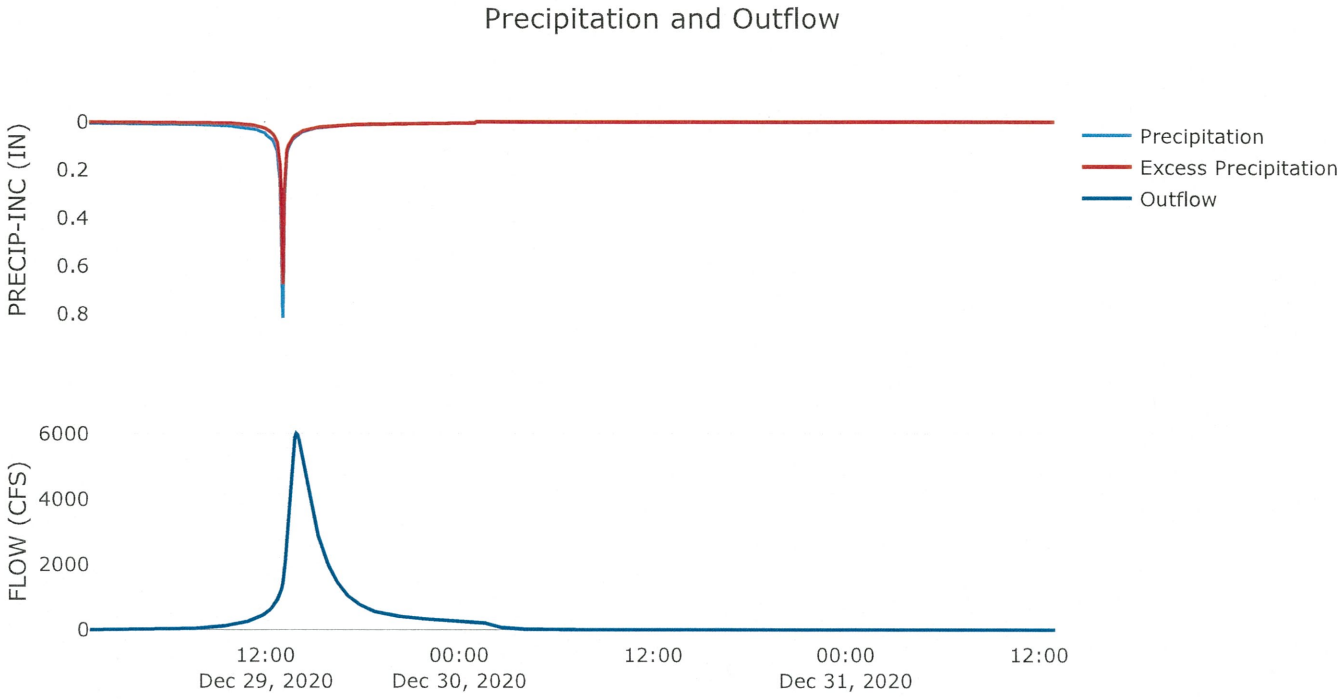
# Subbasin: O3

**Area ($ft^2$)** : 5.5
**Downstream** : HC1

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 10 |
| Curve Number | 80 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.79 |
| Snyder Cp | 0.56 |

| Results: O3 | |
|---|---|
| Peak Discharge (CFS) | 6011.26 |
| Time of Peak Discharge | 29Dec2020, 13:50 |
| Volume (IN) | 5.07 |
| Precipitation Volume (AC - FT) | 2100.27 |
| Loss Volume (AC - FT) | 611.87 |
| Excess Volume (AC - FT) | 1488.4 |
| Direct Runoff Volume (AC - FT) | 1488.4 |
| Baseflow Volume (AC - FT) | 0 |

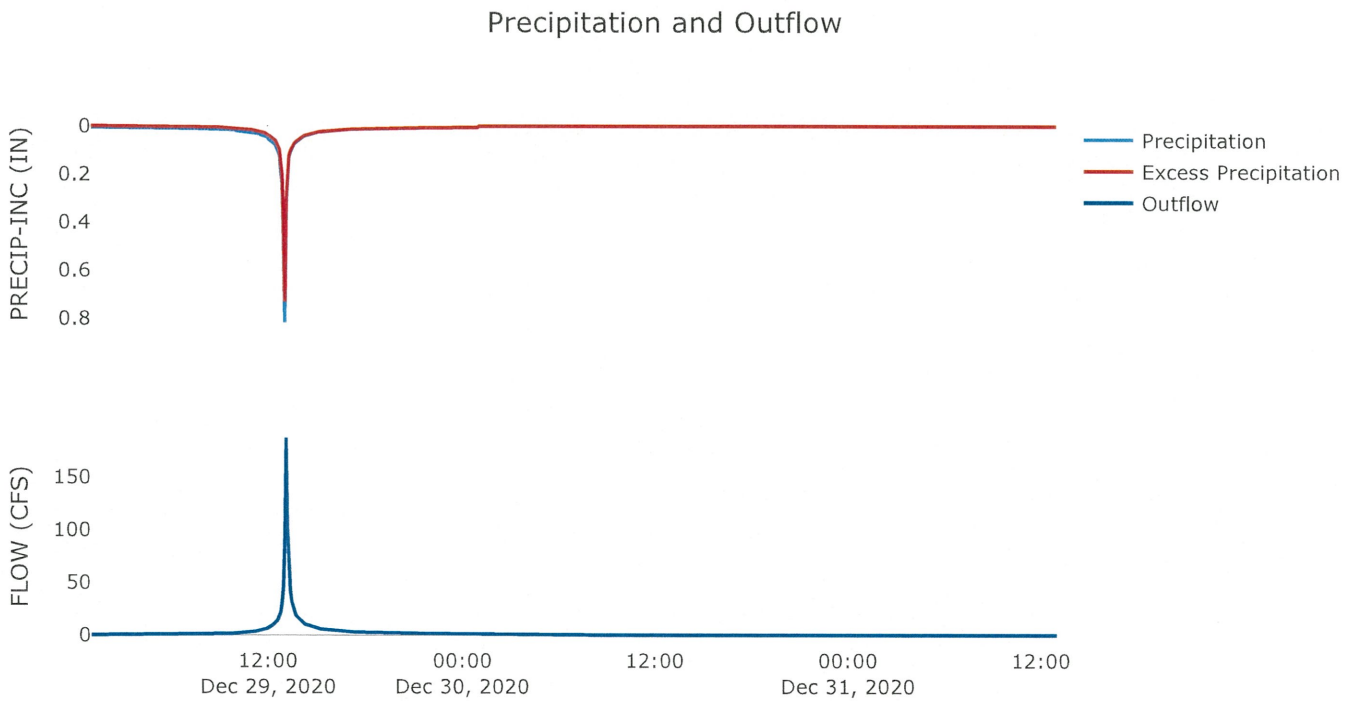

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
6000
4000
2000
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA4

**Area (ft²)** : 0.04
**Downstream** : Hc1
**Transform** : Kinematic Wave

**Results: DA4**

| | |
|---|---|
| Peak Discharge (CFS) | 186.91 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.82 |
| Precipitation Volume (AC - FT) | 13.37 |
| Loss Volume (AC - FT) | 3.06 |
| Excess Volume (AC - FT) | 10.3 |
| Direct Runoff Volume (AC - FT) | 9 |
| Baseflow Volume (AC - FT) | 0 |

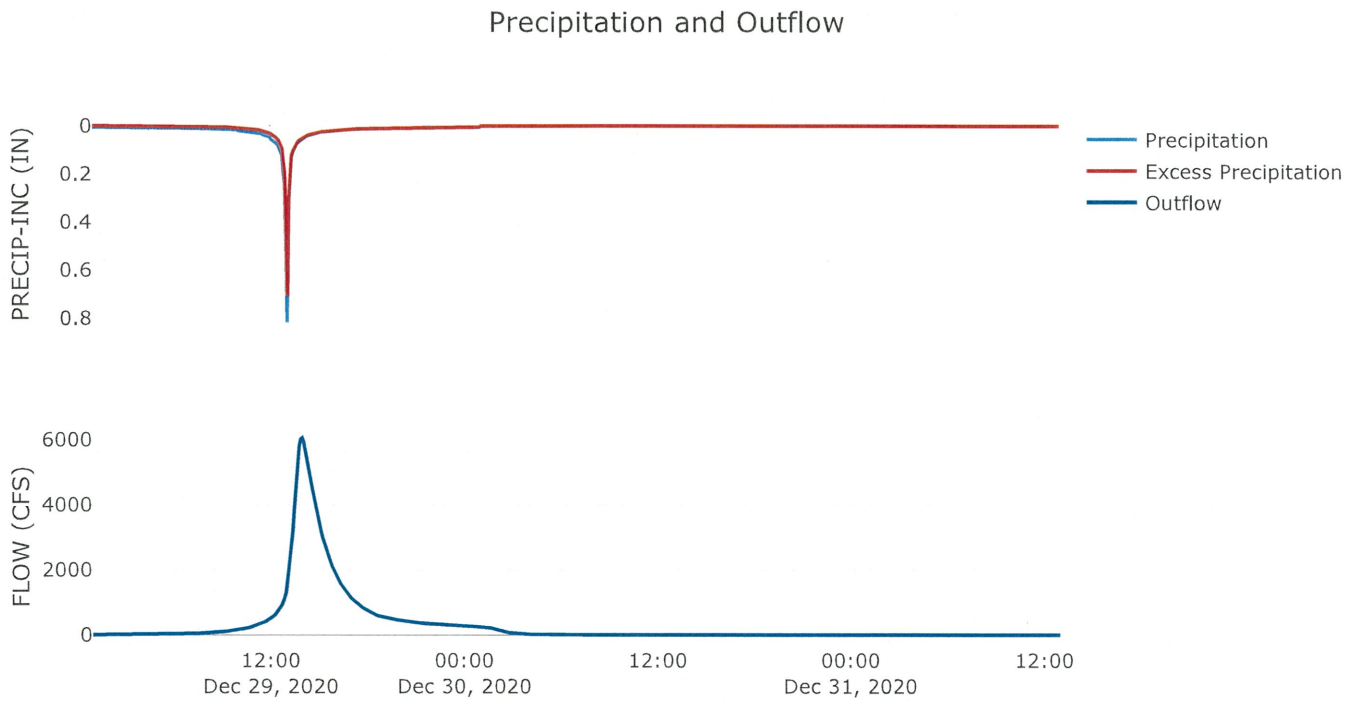


# Subbasin: HC1

**Area (ft²)** : 0.04
**Downstream** : Hc2
**Transform** : Kinematic Wave

**Results: HC1**

| | |
|---|---|
| Peak Discharge (CFS) | 6051.33 |
| Time of Peak Discharge | 29Dec2020, 13:55 |
| Volume (IN) | 5.07 |
| Precipitation Volume (AC - FT) | 2149.79 |
| Loss Volume (AC - FT) | 560.84 |
| Excess Volume (AC - FT) | 1588.95 |
| Direct Runoff Volume (AC - FT) | 1523.4 |
| Baseflow Volume (AC - FT) | 0 |

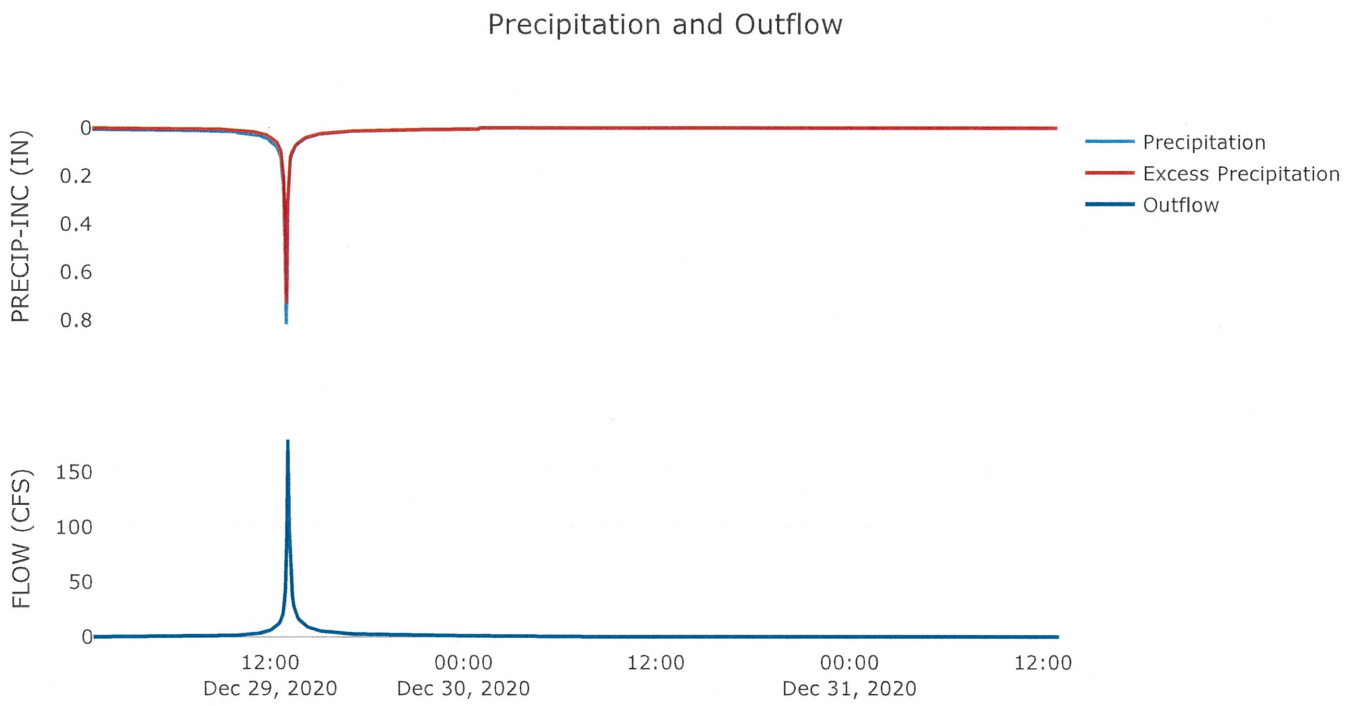


# Subbasin: DA16

**Area (ft²)** : 0.03
**Downstream** : Hc2
**Transform** : Kinematic Wave

**Results: DA16**

| | |
|---|---|
| Peak Discharge (CFS) | 179.3 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.62 |
| Precipitation Volume (AC - FT) | 12.79 |
| Loss Volume (AC - FT) | 2.93 |
| Excess Volume (AC - FT) | 9.86 |
| Direct Runoff Volume (AC - FT) | 8.25 |
| Baseflow Volume (AC - FT) | 0 |



# Subbasin: S2

**Area (ft²)** : 0.01
**Downstream** : HC1

**Loss Rate: Scs**

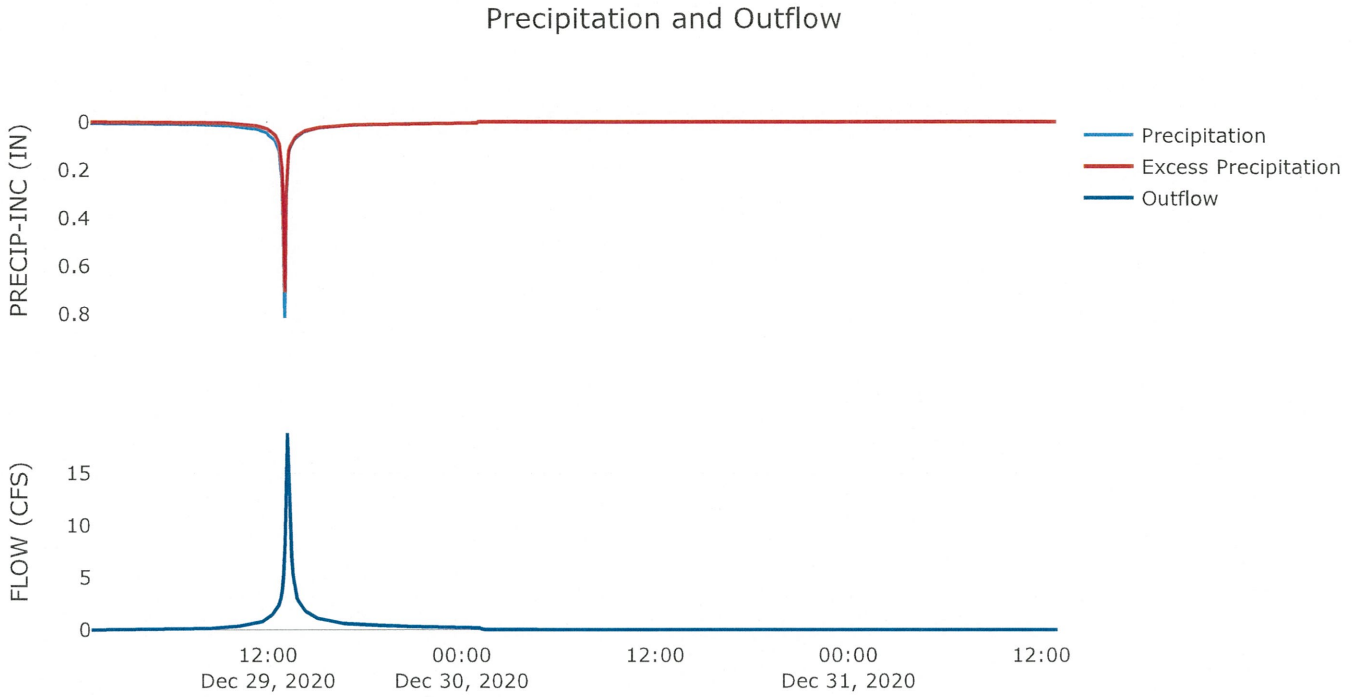
| | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

**Transform: Snyder**

| | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.12 |
| Snyder Cp | 0.64 |

**Results: S2**

| | |
|---|---|
| Peak Discharge (CFS) | 18.8 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 1.99 |
| Loss Volume (AC - FT) | 0.52 |
| Excess Volume (AC - FT) | 1.47 |
| Direct Runoff Volume (AC - FT) | 1.47 |
| Baseflow Volume (AC - FT) | 0 |

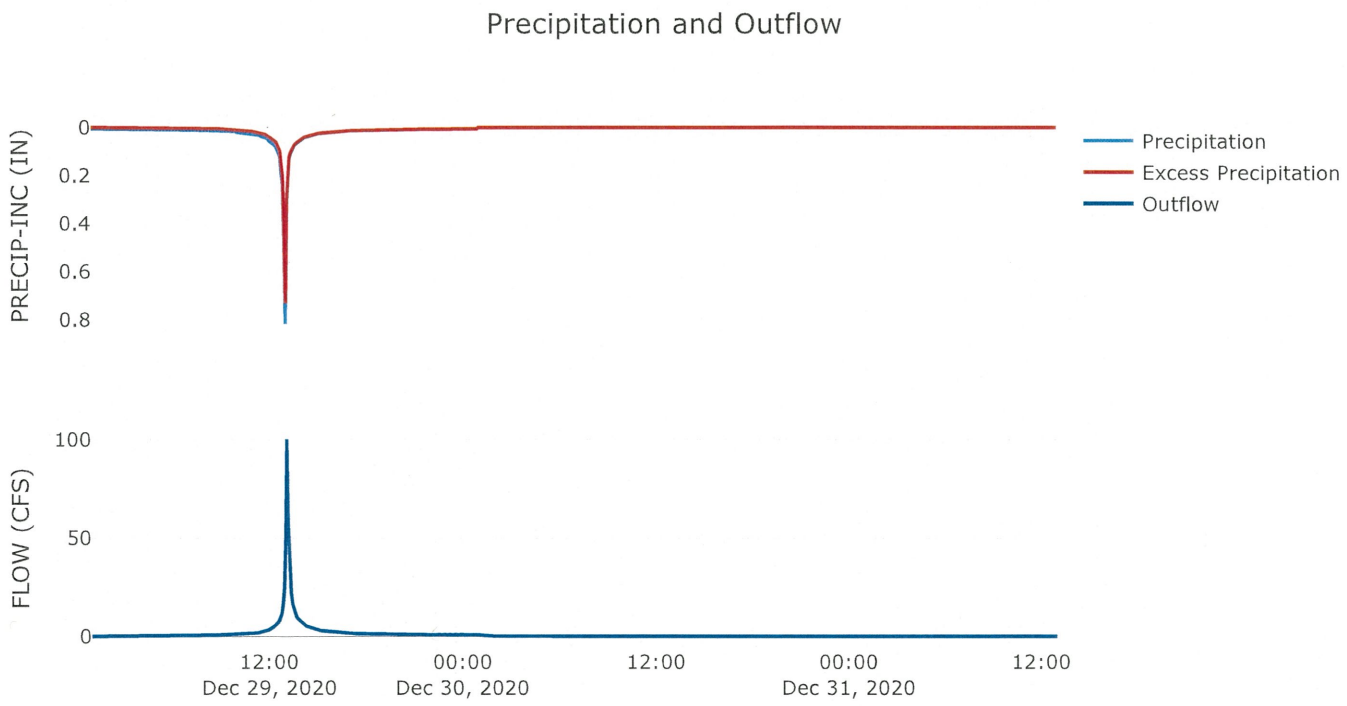

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
15
10
5
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA5

**Area (ft²)** : 0.02
**Downstream** : Hc2
**Transform** : Kinematic Wave

**Results: DA5**

| | |
|---|---|
| Peak Discharge (CFS) | 100.04 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.79 |
| Precipitation Volume (AC - FT) | 7.22 |
| Loss Volume (AC - FT) | 1.65 |
| Excess Volume (AC - FT) | 5.56 |
| Direct Runoff Volume (AC - FT) | 4.83 |
| Baseflow Volume (AC - FT) | 0 |

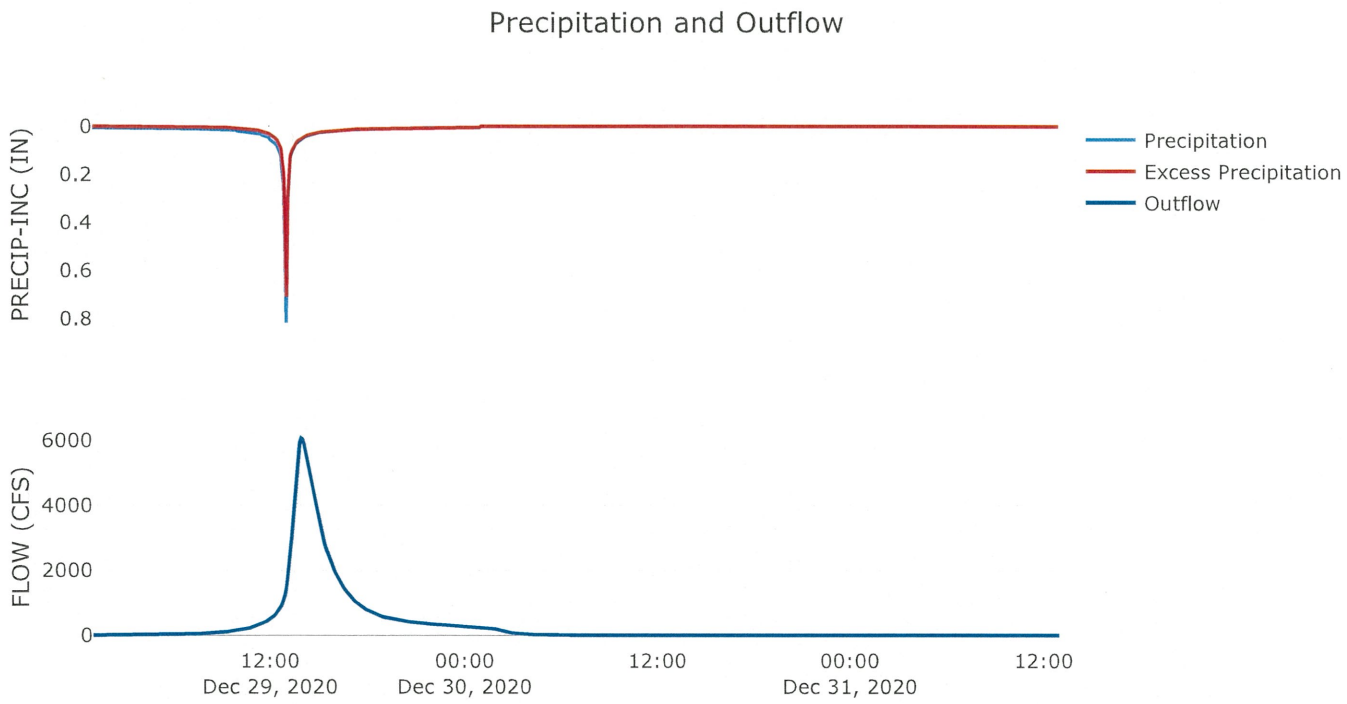


# Subbasin: HC2

**Area (ft²)** : 0.05
**Downstream** : Hc3
**Transform** : Kinematic Wave

**Results: HC2**

| | |
|---|---|
| Peak Discharge (CFS) | 6057.56 |
| Time of Peak Discharge | 29Dec2020, 13:55 |
| Volume (IN) | 5.07 |
| Precipitation Volume (AC - FT) | 2187.29 |
| Loss Volume (AC - FT) | 570.62 |
| Excess Volume (AC - FT) | 1616.67 |
| Direct Runoff Volume (AC - FT) | 1549.14 |
| Baseflow Volume (AC - FT) | 0 |



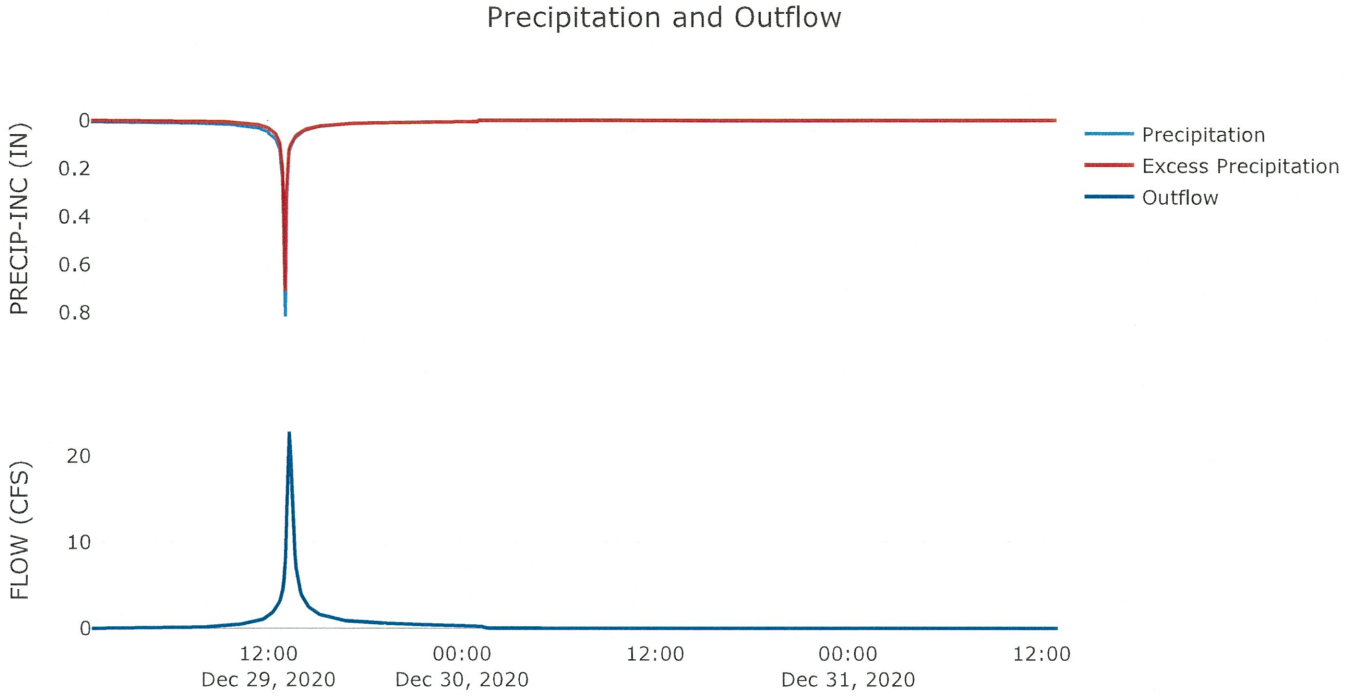
# Subbasin: S3

**Area ($ft^2$)** : 0.01
**Downstream** : HC1

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.19 |
| Snyder Cp | 0.68 |

| Results: S3 | |
|---|---|
| Peak Discharge (CFS) | 22.77 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 2.86 |
| Loss Volume (AC - FT) | 0.75 |
| Excess Volume (AC - FT) | 2.12 |
| Direct Runoff Volume (AC - FT) | 2.12 |
| Baseflow Volume (AC - FT) | 0 |

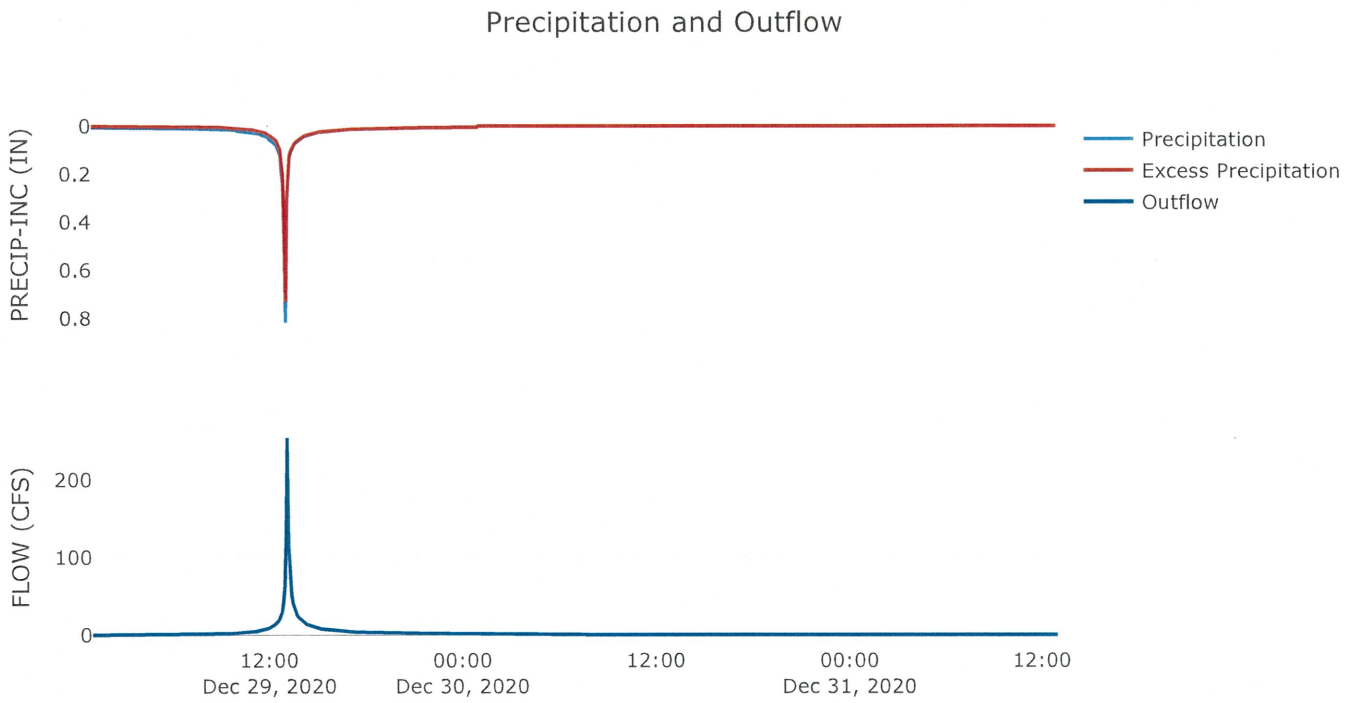

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
20
10
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA10

**Area (ft²)** : 0.04
**Downstream** : HC1
**Transform** : Kinematic Wave

**Results: DA10**

| | |
|---|---|
| Peak Discharge (CFS) | 253.84 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 5.01 |
| Precipitation Volume (AC - FT) | 17.11 |
| Loss Volume (AC - FT) | 3.92 |
| Excess Volume (AC - FT) | 13.19 |
| Direct Runoff Volume (AC - FT) | 11.98 |
| Baseflow Volume (AC - FT) | 0 |

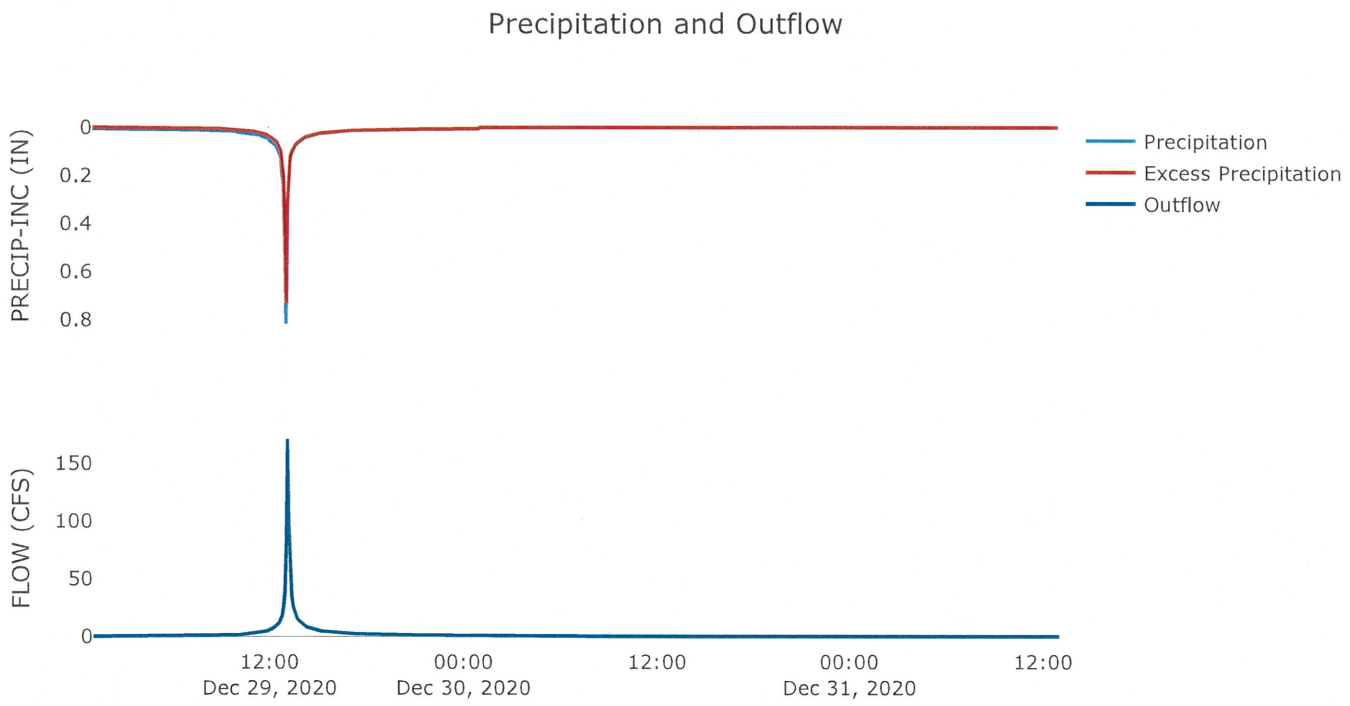


# Subbasin: DA15

**Area (ft²)** : 0.03
**Downstream** : Hc3
**Transform** : Kinematic Wave

**Results: DA15**

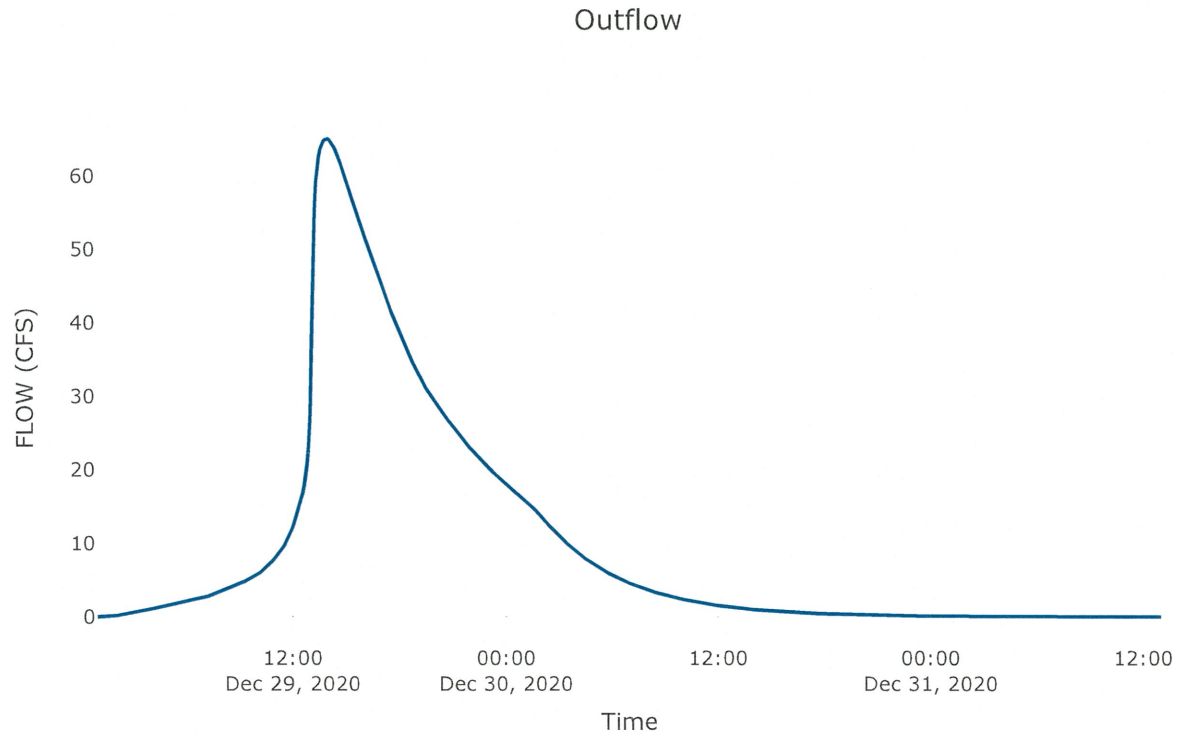
| | |
|---|---|
| Peak Discharge (CFS) | 170.54 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.2 |
| Precipitation Volume (AC - FT) | 12.95 |
| Loss Volume (AC - FT) | 2.97 |
| Excess Volume (AC - FT) | 9.98 |
| Direct Runoff Volume (AC - FT) | 7.59 |
| Baseflow Volume (AC - FT) | 0 |



# Reservoir: RP3

**Downstream** : Hc3

| Results: RP3 | |
|---|---|
| Peak Discharge (CFS) | 65.02 |
| Time of Peak Discharge | 29Dec2020, 14:00 |
| Volume (IN) | 5.63 |
| Peak Inflow (CFS) | 842.03 |
| Time of Peak Inflow | 29Dec2020, 13:05 |
| Inflow Volume (AC - FT) | 47.31 |
| Maximum Storage (AC - FT) | 26.14 |
| Peak Elevation (FT) | 450.16 |
| Discharge Volume (AC - FT) | 47.3 |



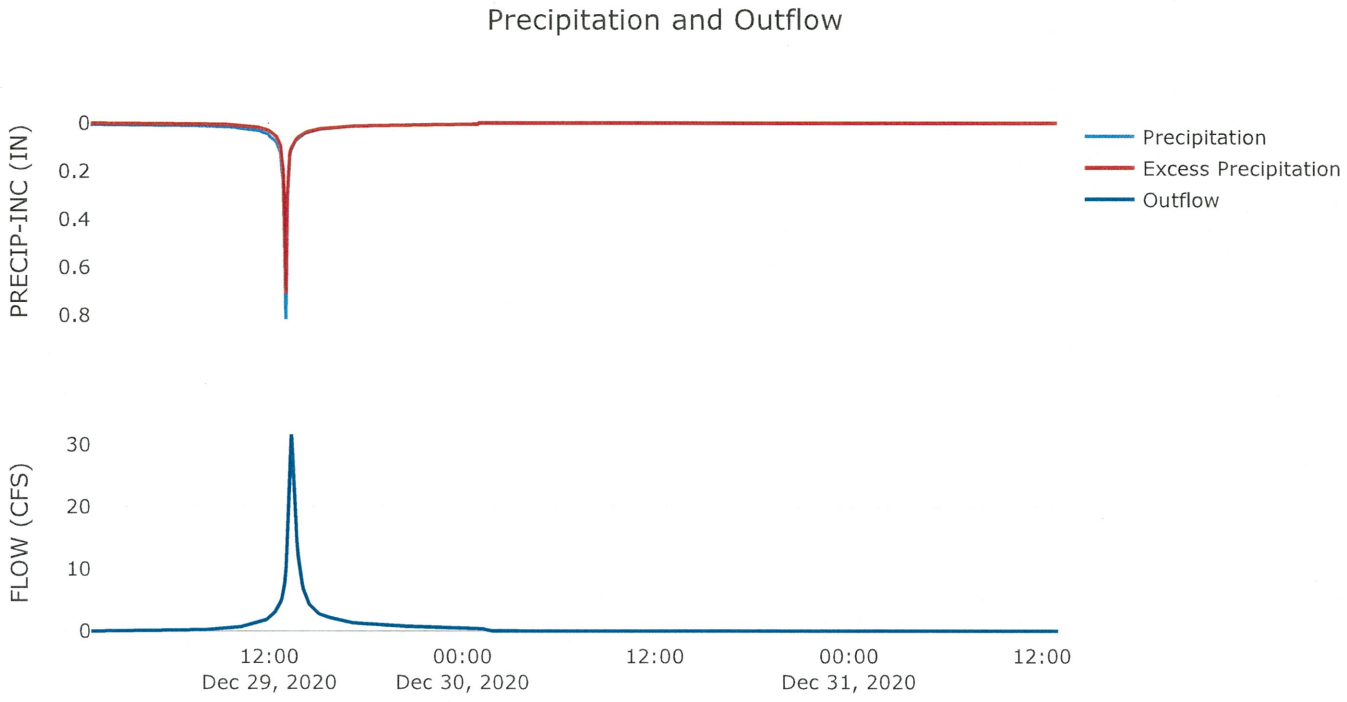
# Subbasin: S5

**Area ($ft^2$)** : 0.01
**Downstream** : Hc3

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.26 |
| Snyder Cp | 0.69 |

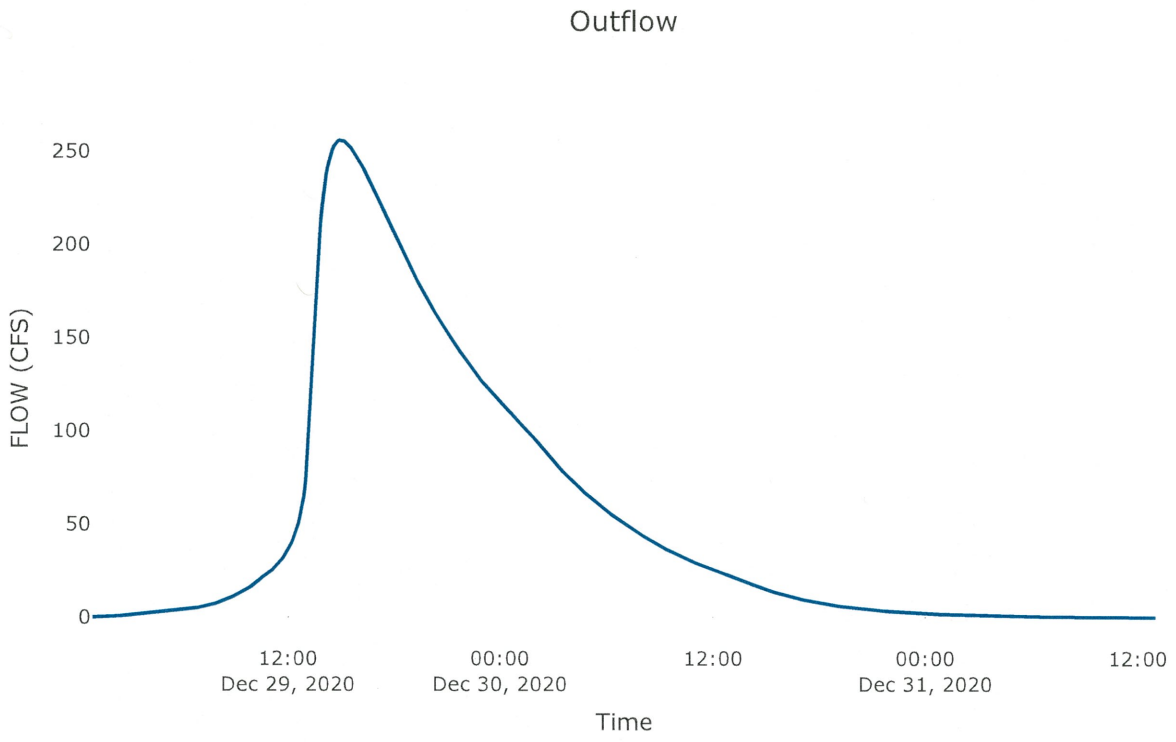
| Results: S5 | |
|---|---|
| Peak Discharge (CFS) | 31.58 |
| Time of Peak Discharge | 29Dec2020, 13:20 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 4.58 |
| Loss Volume (AC - FT) | 1.2 |
| Excess Volume (AC - FT) | 3.39 |
| Direct Runoff Volume (AC - FT) | 3.39 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
30
20
10
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Junction: DCP1

**Results: DCP1**

| | |
|---|---|
| Peak Discharge (CFS) | 255.84 |
| Time of Peak Discharge | 29Dec2020, 15:00 |
| Volume (IN) | 5.49 |



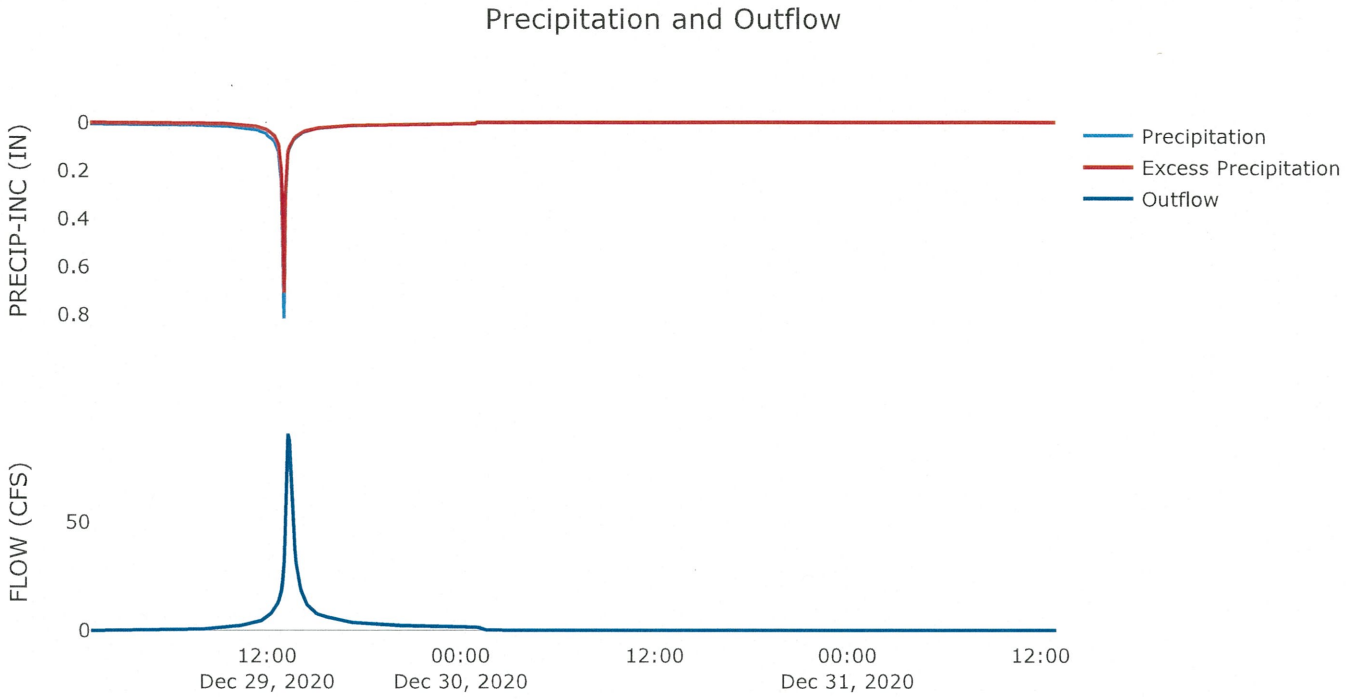
# Subbasin: S6

**Area ($ft^2$)** : 0.03
**Downstream** : Dcp3

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.23 |
| Snyder Cp | 0.66 |

| Results: S6 | |
|---|---|
| Peak Discharge (CFS) | 90.46 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 12.79 |
| Loss Volume (AC - FT) | 3.34 |
| Excess Volume (AC - FT) | 9.46 |
| Direct Runoff Volume (AC - FT) | 9.46 |
| Baseflow Volume (AC - FT) | 0 |

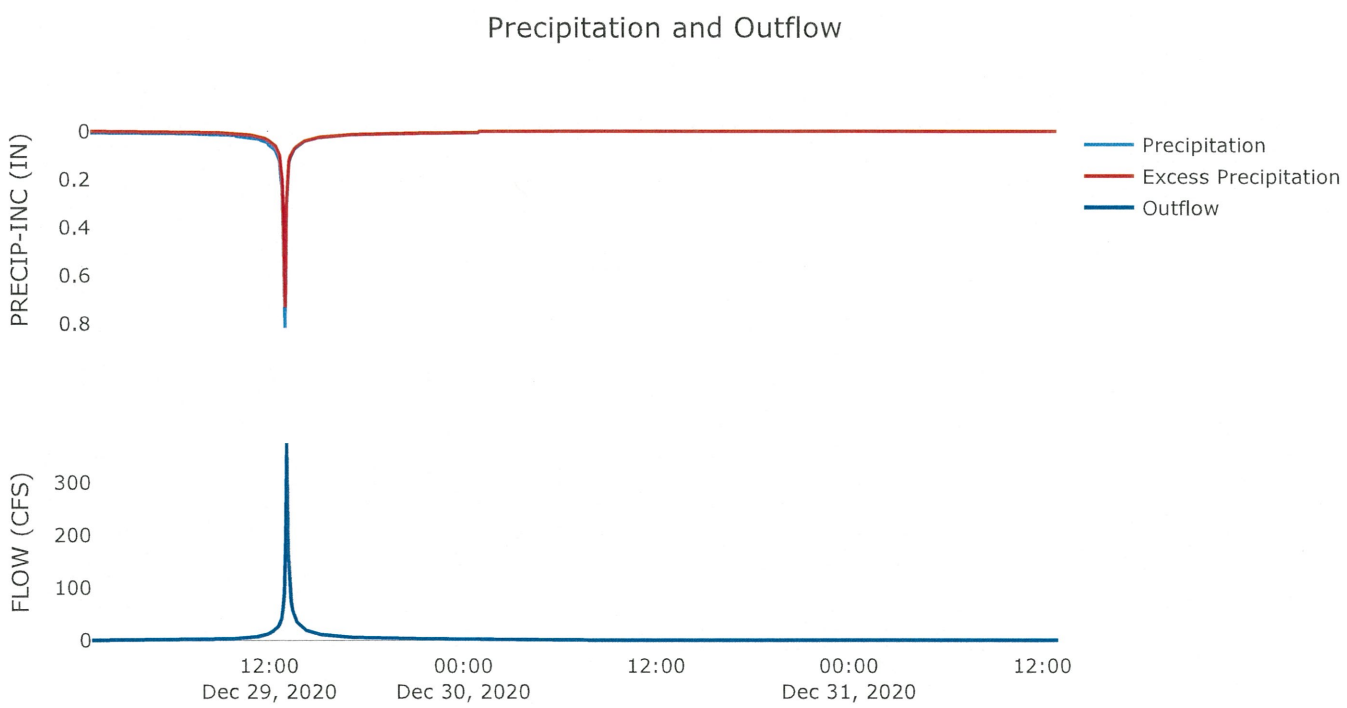

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
50
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA14

**Area (ft²)** : 0.07
**Downstream** : Dcp4
**Transform** : Kinematic Wave

**Results: DA14**

| | |
|---|---|
| Peak Discharge (CFS) | 374.71 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.85 |
| Precipitation Volume (AC - FT) | 25.13 |
| Loss Volume (AC - FT) | 5.76 |
| Excess Volume (AC - FT) | 19.37 |
| Direct Runoff Volume (AC - FT) | 17.04 |
| Baseflow Volume (AC - FT) | 0 |



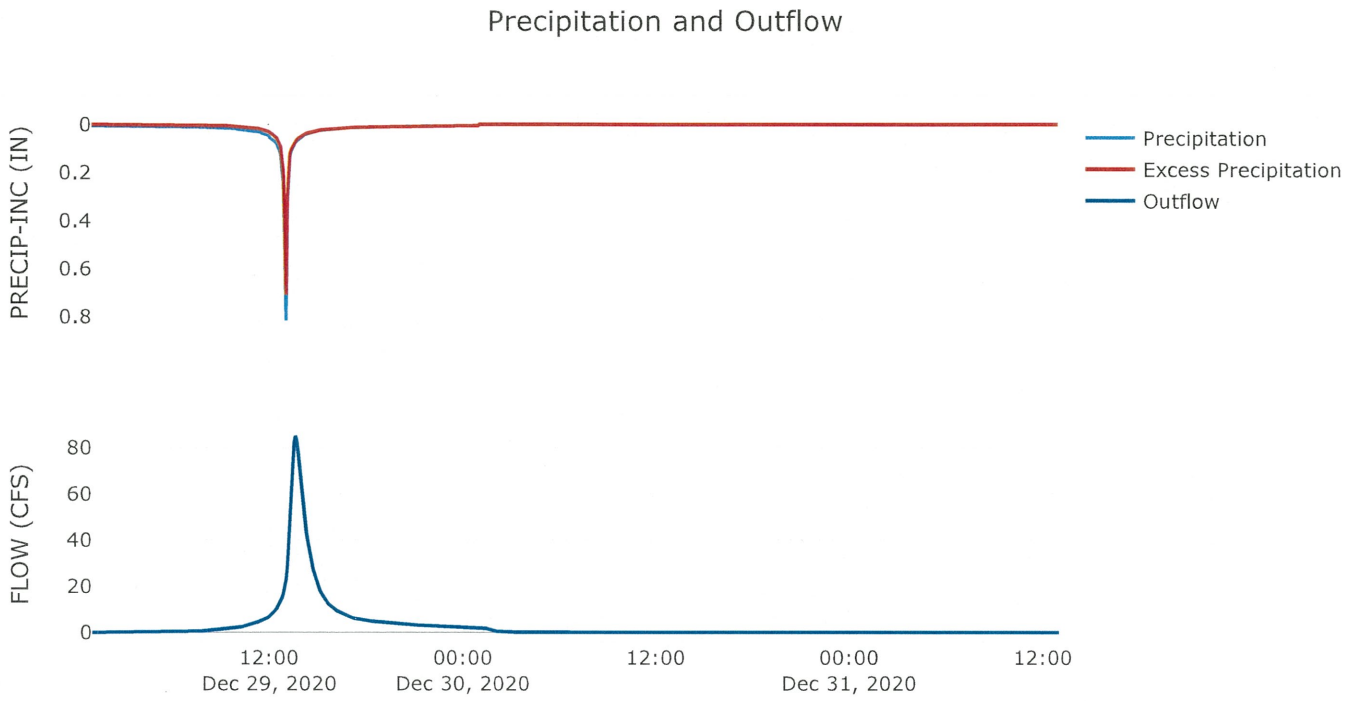
# Subbasin: S7

**Area ($ft^2$)** : 0.05
**Downstream** : Dcp4

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.55 |
| Snyder Cp | 0.67 |

| Results: S7 | |
|---|---|
| Peak Discharge (CFS) | 84.98 |
| Time of Peak Discharge | 29Dec2020, 13:35 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 19.28 |
| Loss Volume (AC - FT) | 5.03 |
| Excess Volume (AC - FT) | 14.25 |
| Direct Runoff Volume (AC - FT) | 14.25 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
80
60
40
20
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

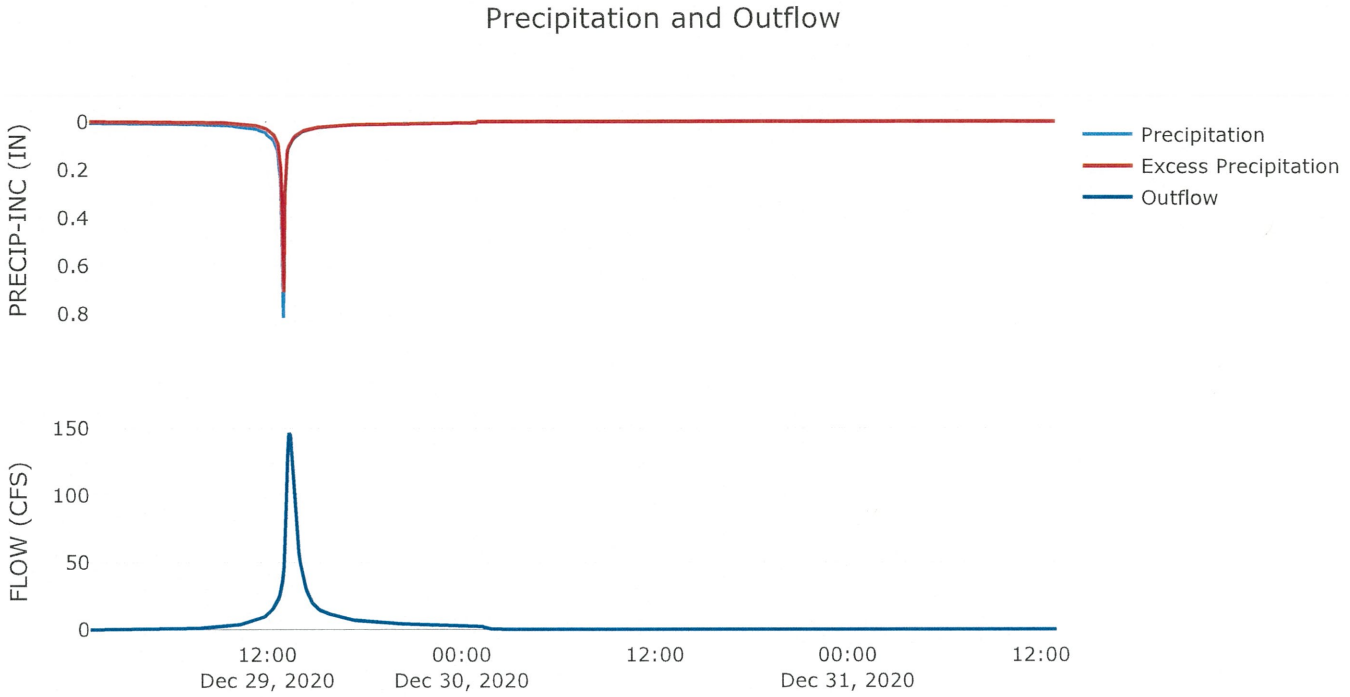
# Subbasin: O4

**Area ($ft^2$)** : 0.06
**Downstream** : C/s4

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.32 |
| Snyder Cp | 0.66 |

| Results: O4 | |
|---|---|
| Peak Discharge (CFS) | 146.21 |
| Time of Peak Discharge | 29Dec2020, 13:20 |
| Volume (IN) | 5.29 |
| Precipitation Volume (AC - FT) | 24.67 |
| Loss Volume (AC - FT) | 6.44 |
| Excess Volume (AC - FT) | 18.23 |
| Direct Runoff Volume (AC - FT) | 18.23 |
| Baseflow Volume (AC - FT) | 0 |


Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
150
100
50
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

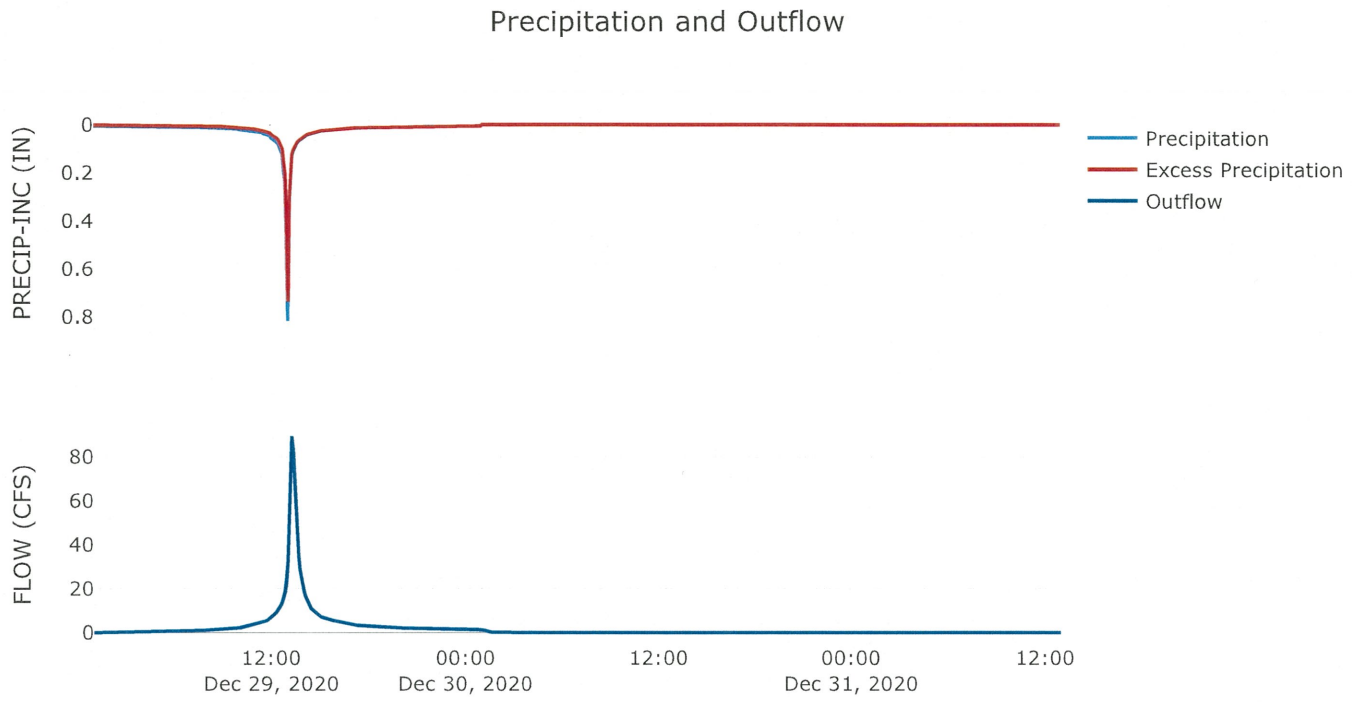
# Subbasin: S4

**Area ($ft^2$)** : 0.03
**Downstream** : C/s4

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 25 |
| Curve Number | 84 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.22 |
| Snyder Cp | 0.66 |

| Results: S4 | |
|---|---|
| Peak Discharge (CFS) | 89.34 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.76 |
| Precipitation Volume (AC - FT) | 11.84 |
| Loss Volume (AC - FT) | 2.32 |
| Excess Volume (AC - FT) | 9.52 |
| Direct Runoff Volume (AC - FT) | 9.52 |
| Baseflow Volume (AC - FT) | 0 |

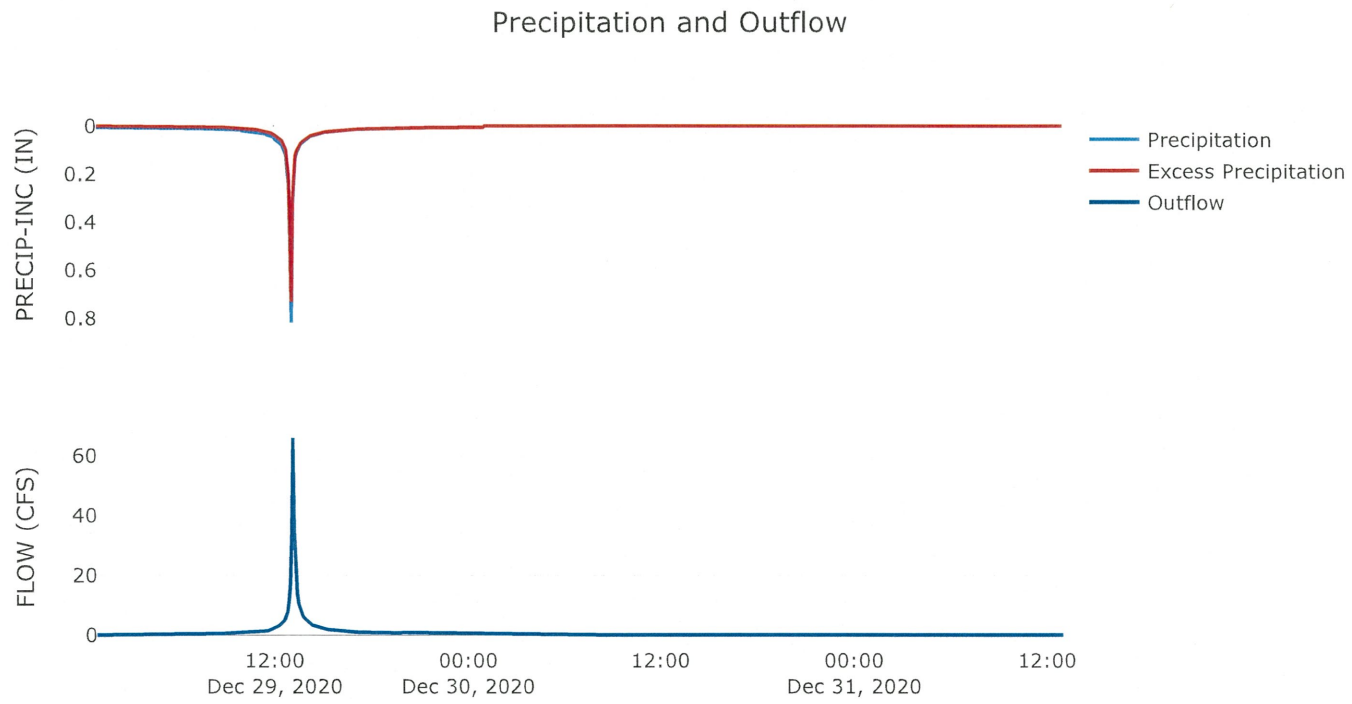

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
80
60
40
20
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: DA11

**Area (ft²)** : 0.01
**Downstream** : C/s4
**Transform** : Kinematic Wave

**Results: DA11**

| | |
|---|---|
| Peak Discharge (CFS) | 65.86 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.95 |
| Precipitation Volume (AC - FT) | 4.66 |
| Loss Volume (AC - FT) | 1.07 |
| Excess Volume (AC - FT) | 3.59 |
| Direct Runoff Volume (AC - FT) | 3.22 |
| Baseflow Volume (AC - FT) | 0 |

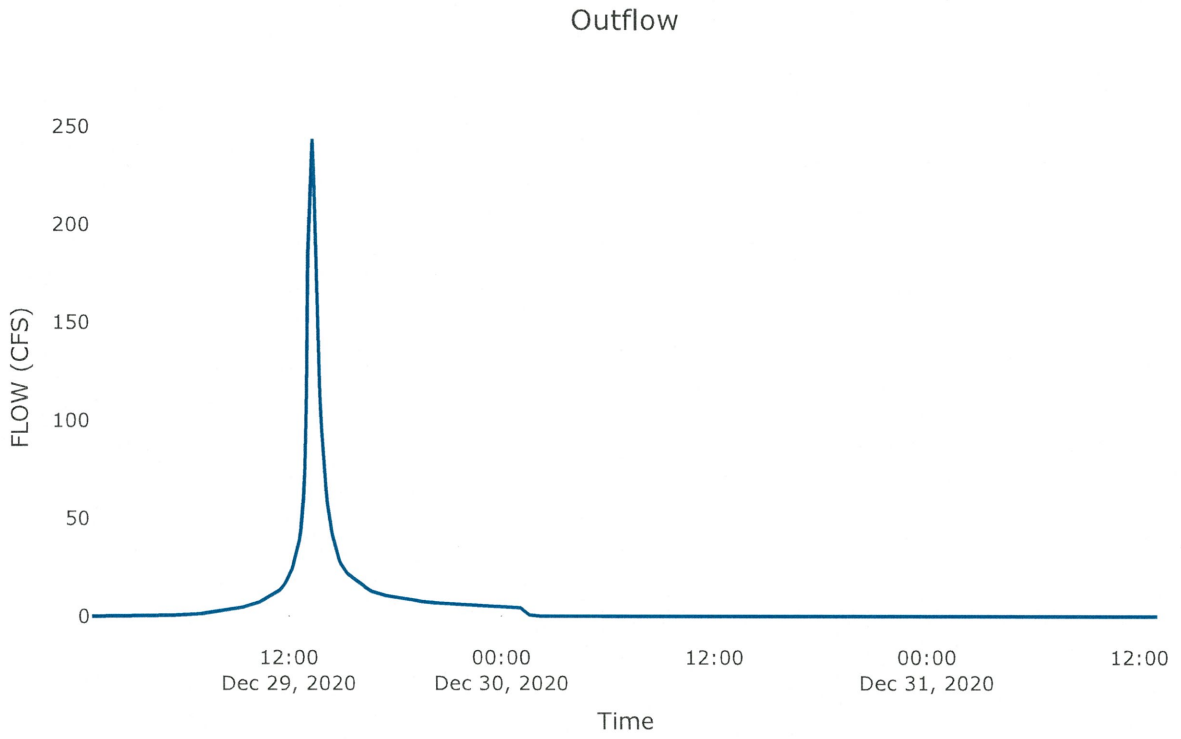


# Junction: C/S4

**Downstream** : Rp1

**Results: C/S4**

| | |
|---|---|
| Peak Discharge (CFS) | 243.51 |
| Time of Peak Discharge | 29Dec2020, 13:20 |
| Volume (IN) | 5.39 |

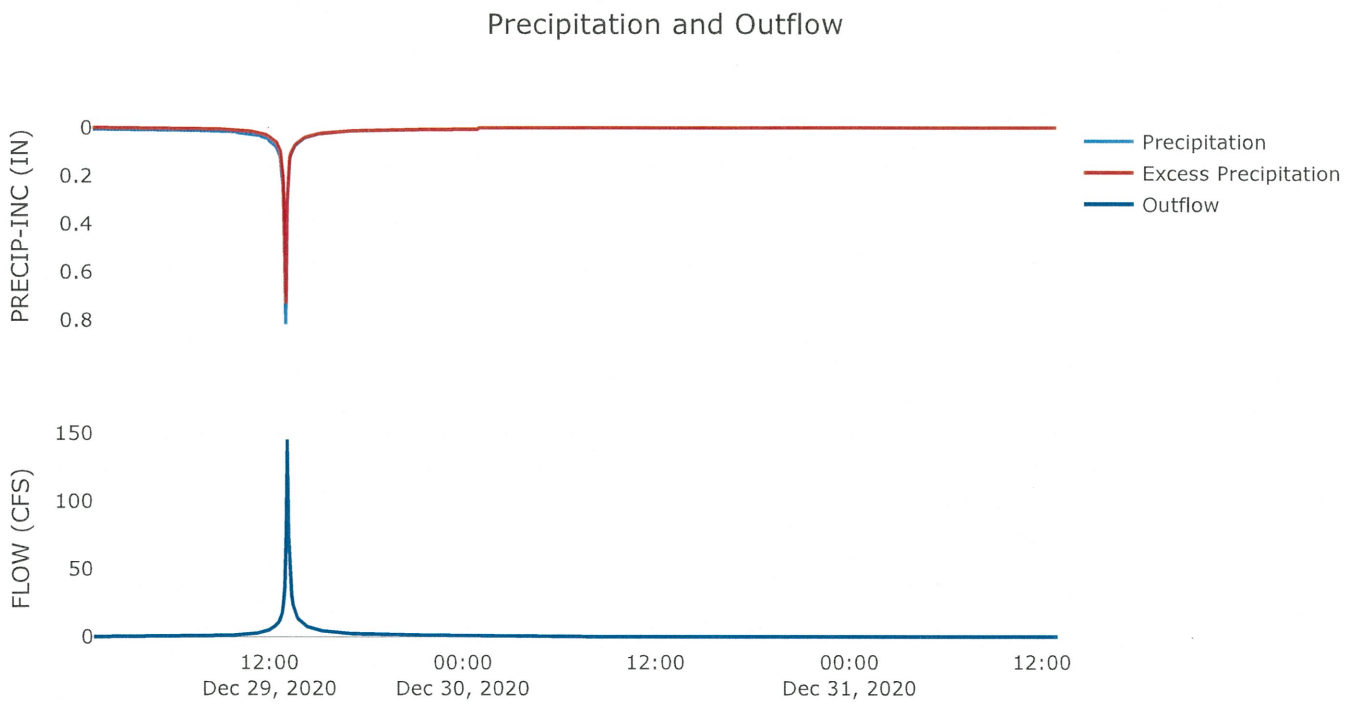


# Subbasin: DA12

**Area (ft²)** : 0.03
**Downstream** : Rp1
**Transform** : Kinematic Wave

**Results: DA12**

| | |
|---|---|
| Peak Discharge (CFS) | 145.06 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.9 |
| Precipitation Volume (AC - FT) | 10.12 |
| Loss Volume (AC - FT) | 2.32 |
| Excess Volume (AC - FT) | 7.8 |
| Direct Runoff Volume (AC - FT) | 6.92 |
| Baseflow Volume (AC - FT) | 0 |



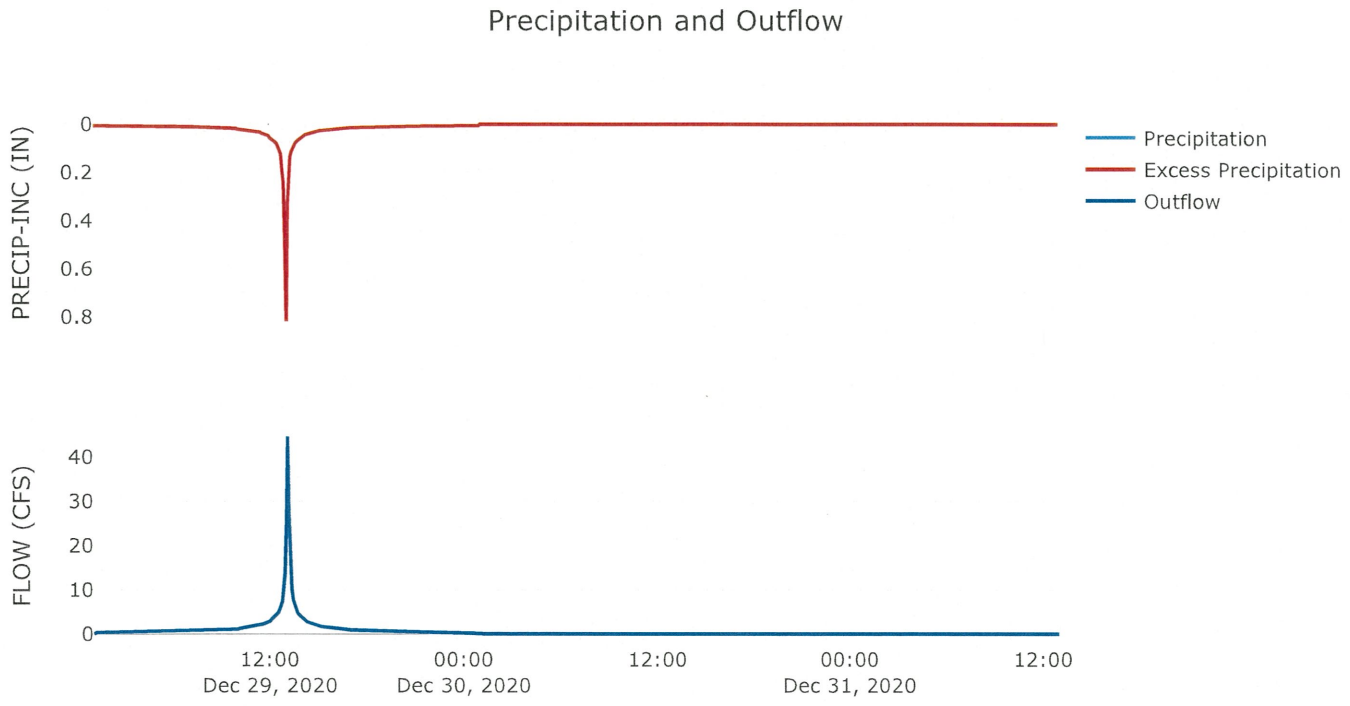
# Subbasin: P1

**Area (ft²)** : 0.01
**Downstream** : Rp1

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 100 |
| Curve Number | 99 |

| Transform: Scs | |
|---|---|
| Lag | 0.1 |
| Unitgraph Type | Standard |

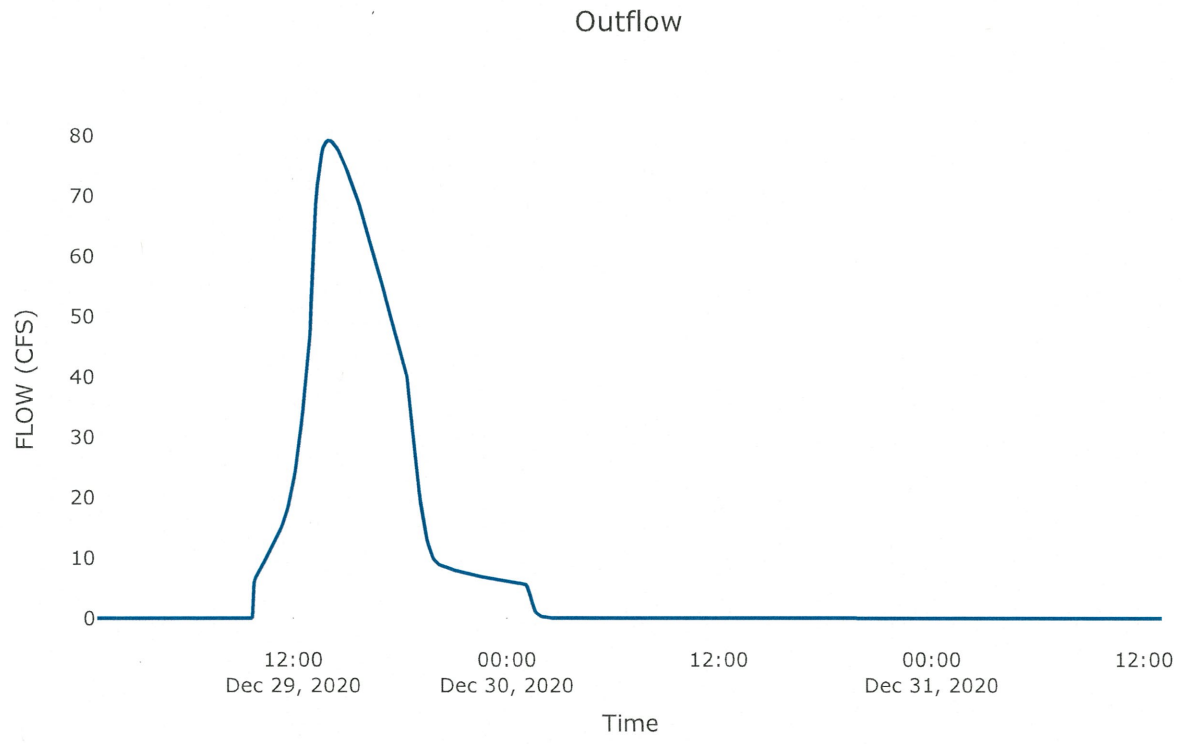
| Results: P1 | |
|---|---|
| Peak Discharge (CFS) | 44.53 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 7.16 |
| Precipitation Volume (AC - FT) | 3.05 |
| Loss Volume (AC - FT) | 0 |
| Excess Volume (AC - FT) | 3.05 |
| Direct Runoff Volume (AC - FT) | 3.05 |
| Baseflow Volume (AC - FT) | 0 |



# Reservoir: RP1

**Downstream** : Ch6

| Results: RP1 | |
|---|---|
| Peak Discharge (CFS) | 79.17 |
| Time of Peak Discharge | 29Dec2020, 14:05 |
| Volume (IN) | 5.2 |
| Peak Inflow (CFS) | 374.35 |
| Time of Peak Inflow | 29Dec2020, 13:05 |
| Inflow Volume (AC - FT) | 40.95 |
| Maximum Storage (AC - FT) | 16.48 |
| Peak Elevation (FT) | 466.86 |
| Discharge Volume (AC - FT) | 39.5 |

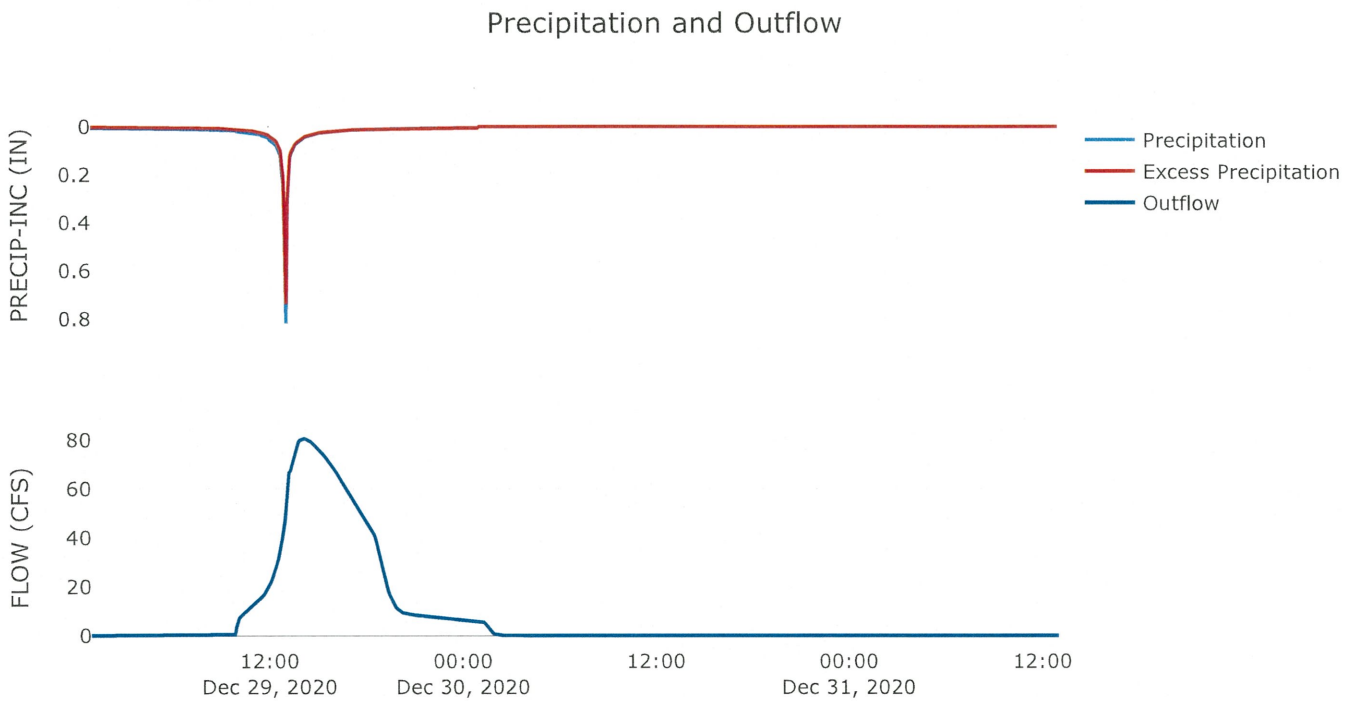


# Subbasin: CH6

**Area (ft²)** : 0
**Downstream** : R/dcp5
**Transform** : Kinematic Wave

**Results: CH6**

| | |
|---|---|
| Peak Discharge (CFS) | 80.51 |
| Time of Peak Discharge | 29Dec2020, 14:00 |
| Volume (IN) | 5.22 |
| Precipitation Volume (AC - FT) | 55.71 |
| Loss Volume (AC - FT) | 10.9 |
| Excess Volume (AC - FT) | 44.81 |
| Direct Runoff Volume (AC - FT) | 40.6 |
| Baseflow Volume (AC - FT) | 0 |



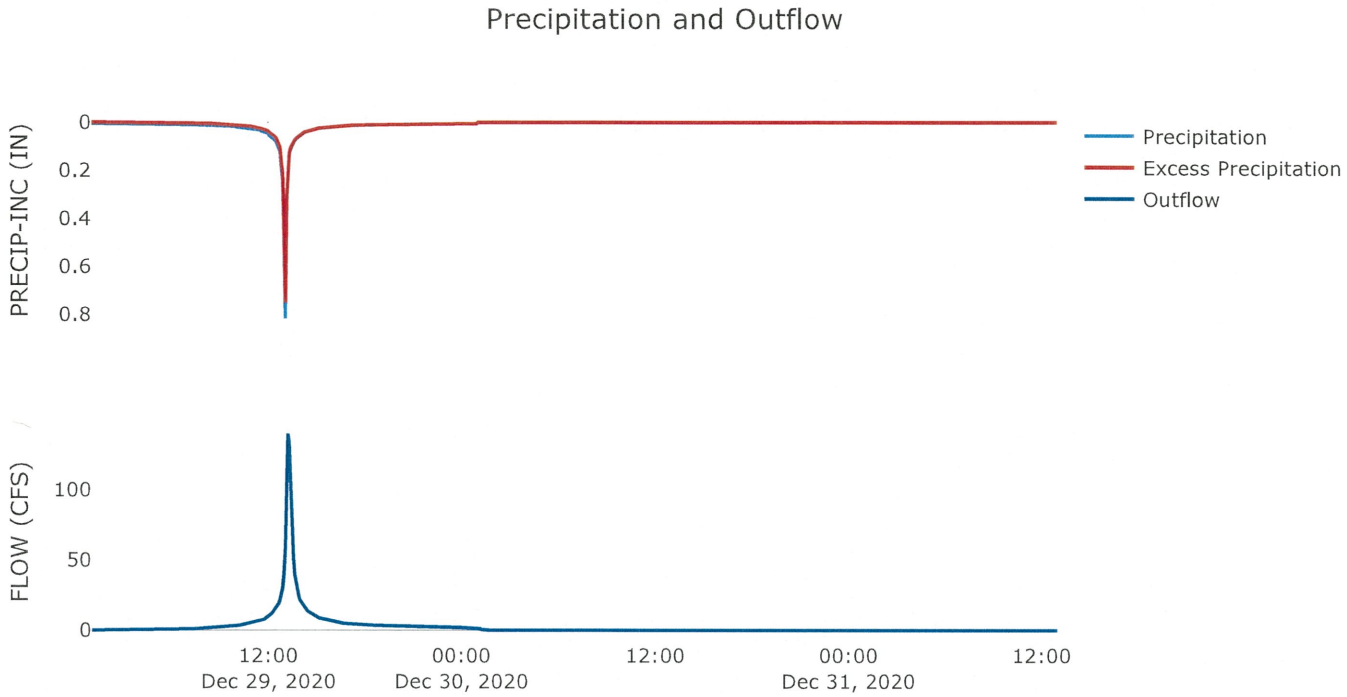
# Subbasin: O6

**Area ($ft^2$)** : 0.04
**Downstream** : Ch4

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 88 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.15 |
| Snyder Cp | 0.62 |

| Results: O6 | |
|---|---|
| Peak Discharge (CFS) | 139.7 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 5.75 |
| Precipitation Volume (AC - FT) | 15.35 |
| Loss Volume (AC - FT) | 3.03 |
| Excess Volume (AC - FT) | 12.33 |
| Direct Runoff Volume (AC - FT) | 12.33 |
| Baseflow Volume (AC - FT) | 0 |

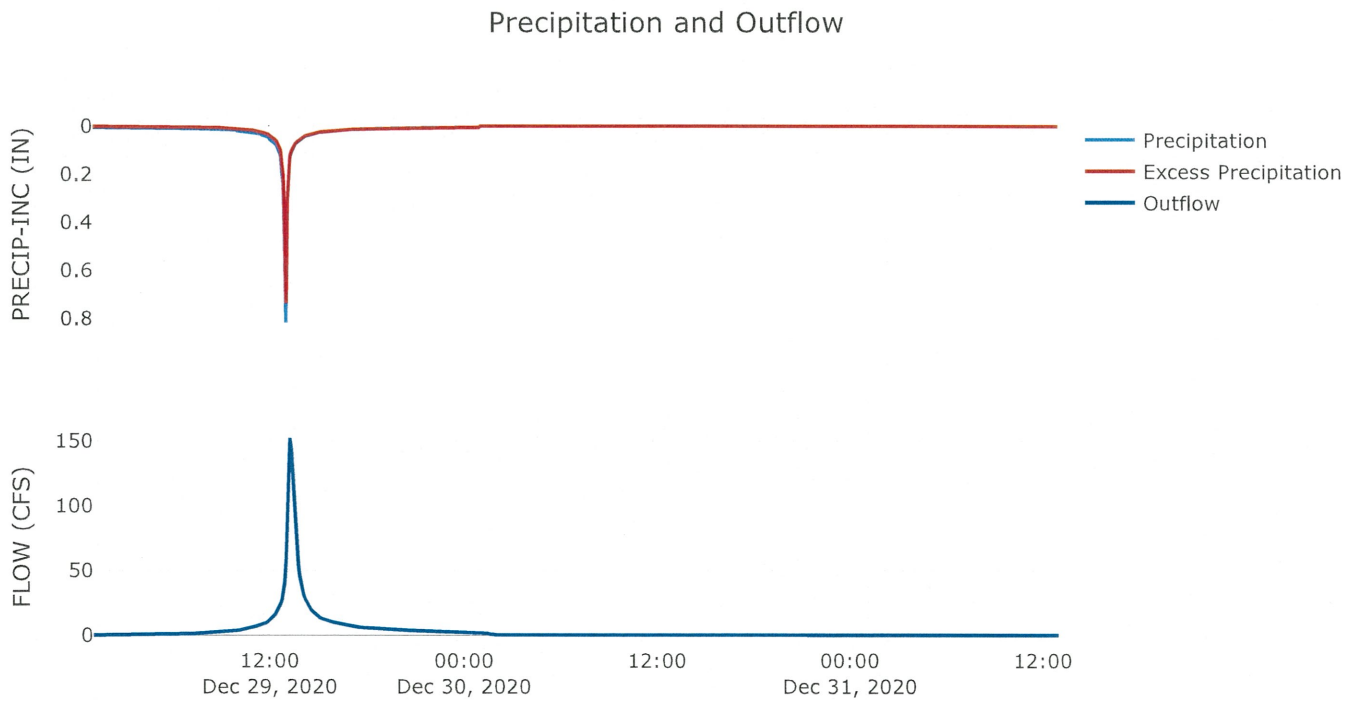

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
100
50
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: CH4

**Area (ft²)** : 0.02
**Downstream** : Ch5
**Transform** : Kinematic Wave

**Results: CH4**

| | |
|---|---|
| Peak Discharge (CFS) | 151.98 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.7 |
| Precipitation Volume (AC - FT) | 21.46 |
| Loss Volume (AC - FT) | 4.2 |
| Excess Volume (AC - FT) | 17.26 |
| Direct Runoff Volume (AC - FT) | 17.09 |
| Baseflow Volume (AC - FT) | 0 |

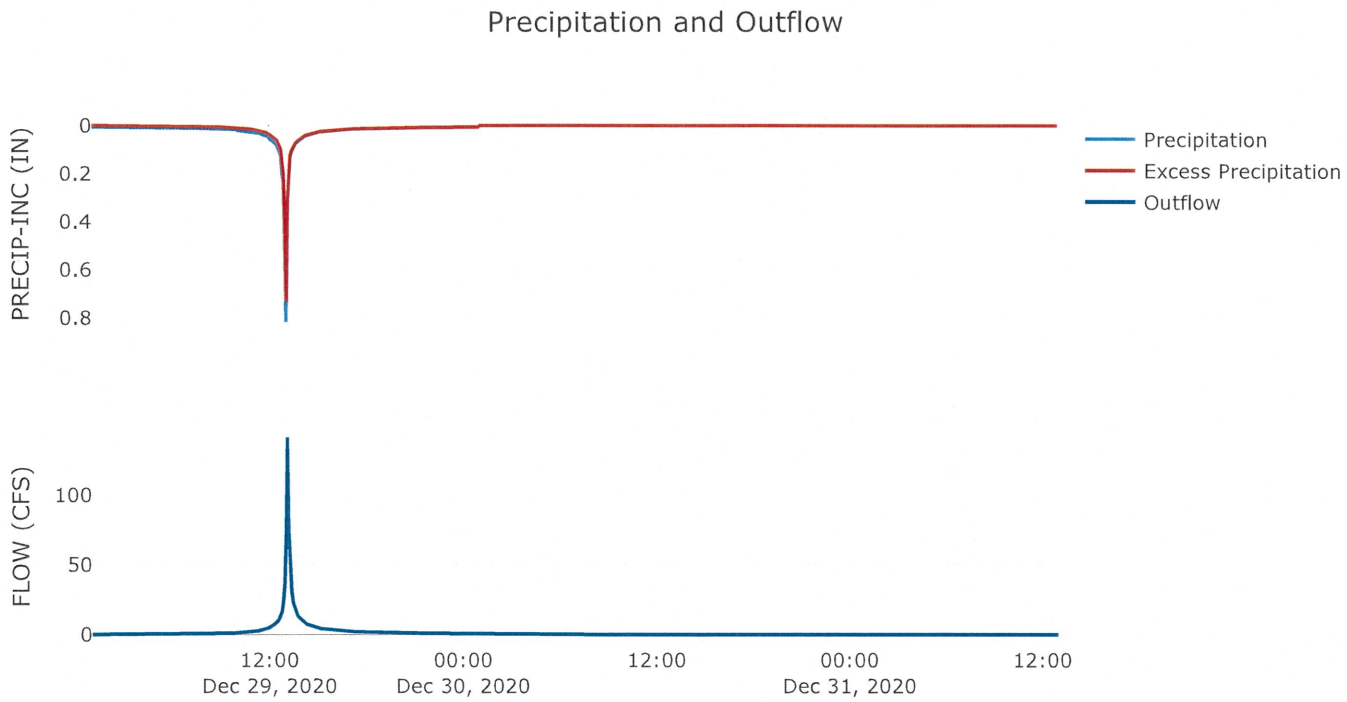


# Subbasin: DA13

**Area (ft²)** : 0.03
**Downstream** : Ch5
**Transform** : Kinematic Wave

**Results: DA13**

| | |
|---|---|
| Peak Discharge (CFS) | 141.08 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 4.82 |
| Precipitation Volume (AC - FT) | 9.97 |
| Loss Volume (AC - FT) | 2.28 |
| Excess Volume (AC - FT) | 7.68 |
| Direct Runoff Volume (AC - FT) | 6.71 |
| Baseflow Volume (AC - FT) | 0 |



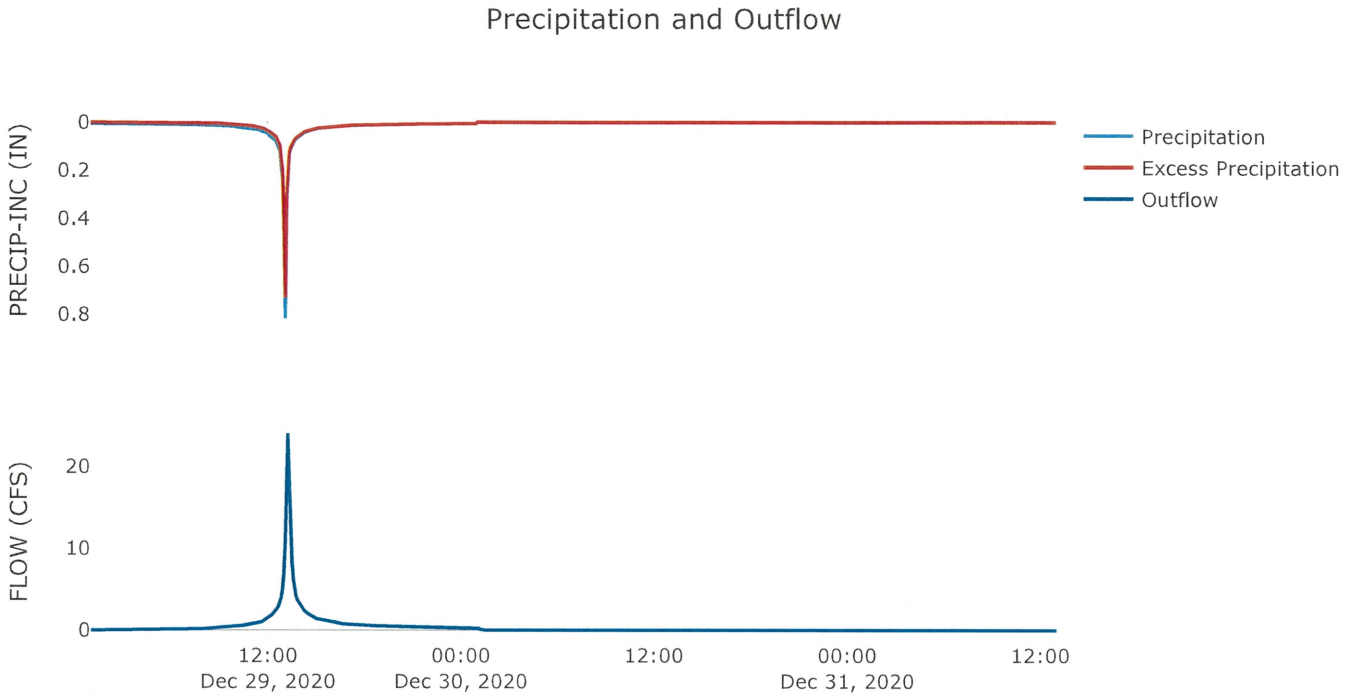
# Subbasin: O5

**Area ($ft^2$)** : 0.01
**Downstream** : Ch5

| Loss Rate: Scs | |
|---|---|
| Percent Impervious Area | 0 |
| Curve Number | 86 |

| Transform: Snyder | |
|---|---|
| Snyder Method | Standard |
| Snyder Tp | 0.11 |
| Snyder Cp | 0.62 |

| Results: O5 | |
|---|---|
| Peak Discharge (CFS) | 23.99 |
| Time of Peak Discharge | 29Dec2020, 13:10 |
| Volume (IN) | 5.52 |
| Precipitation Volume (AC - FT) | 2.41 |
| Loss Volume (AC - FT) | 0.55 |
| Excess Volume (AC - FT) | 1.85 |
| Direct Runoff Volume (AC - FT) | 1.85 |
| Baseflow Volume (AC - FT) | 0 |

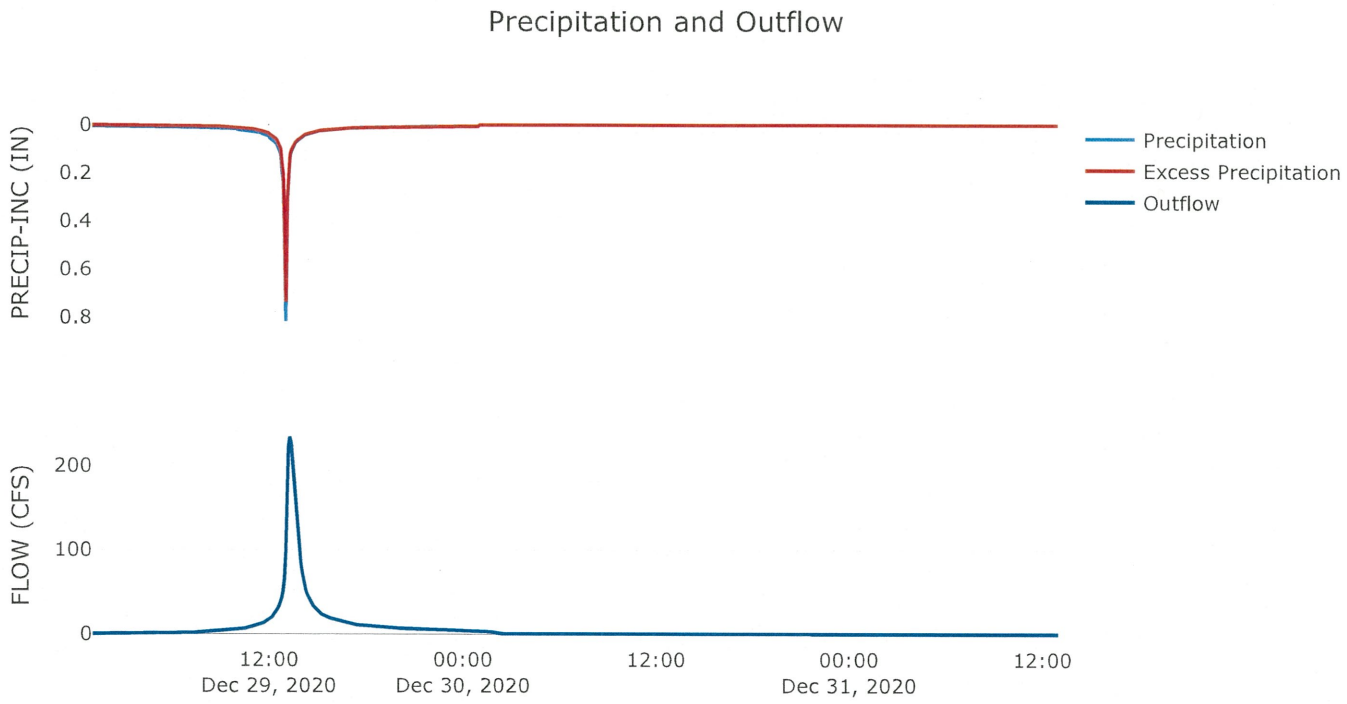

Precipitation and Outflow
PRECIP-INC (IN)
0
0.2
0.4
0.6
0.8
FLOW (CFS)
20
10
0
12:00
Dec 29, 2020
00:00
Dec 30, 2020
12:00
00:00
Dec 31, 2020
12:00
Precipitation
Excess Precipitation
Outflow

# Subbasin: CH5

**Area (ft²)** : 0.01
**Downstream** : R/dcp5
**Transform** : Kinematic Wave

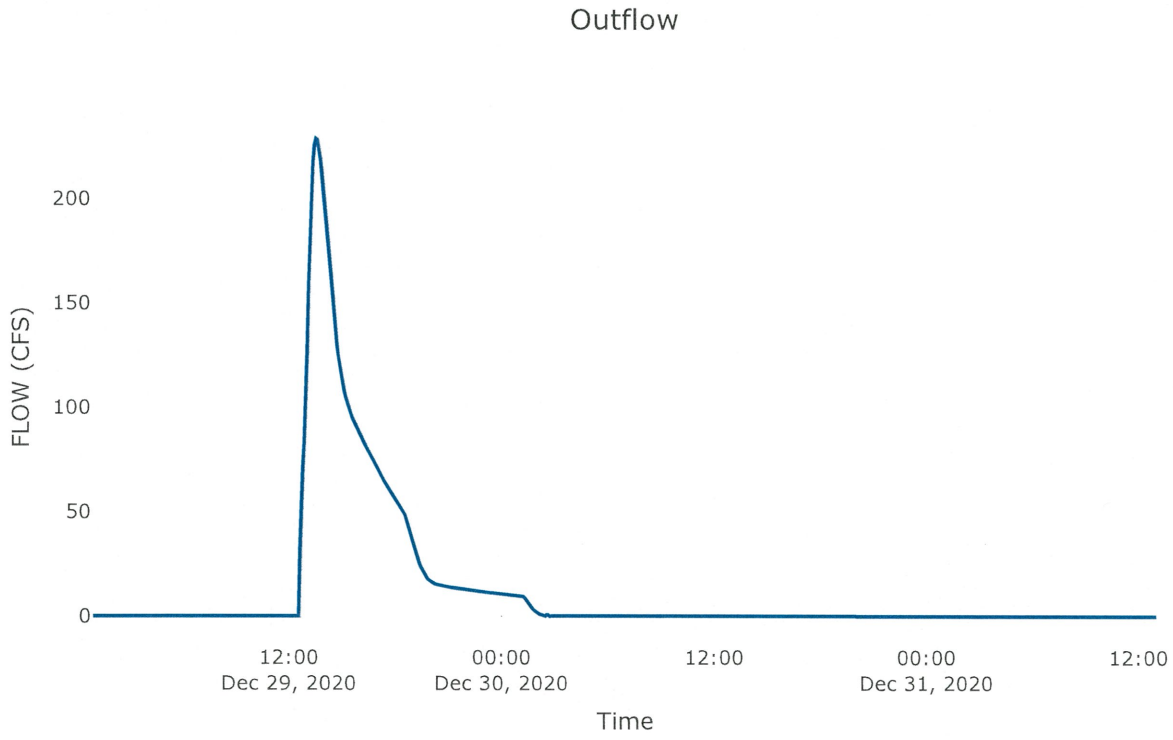
**Results: CH5**

| | |
|---|---|
| Peak Discharge (CFS) | 233.85 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.45 |
| Precipitation Volume (AC - FT) | 39.14 |
| Loss Volume (AC - FT) | 7.66 |
| Excess Volume (AC - FT) | 31.48 |
| Direct Runoff Volume (AC - FT) | 29.77 |
| Baseflow Volume (AC - FT) | 0 |



# Reservoir: R/DCP5

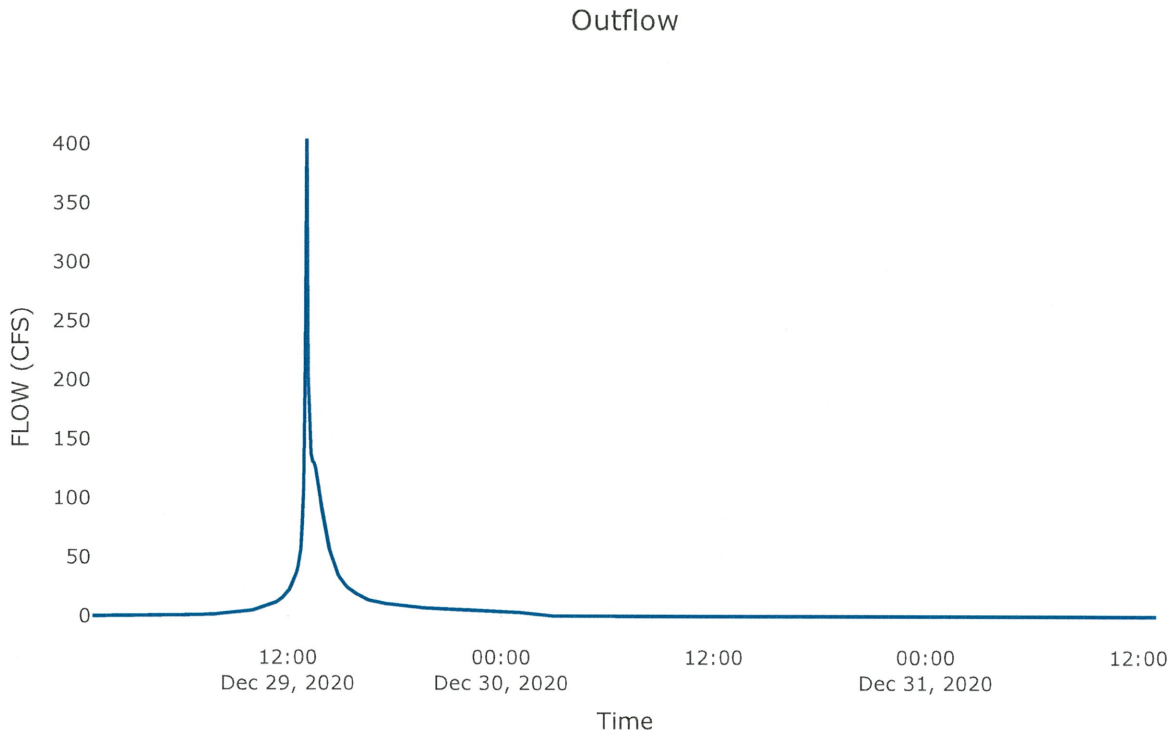
| Results: R/DCP5 | |
|---|---|
| Peak Discharge (CFS) | 228.71 |
| Time of Peak Discharge | 29Dec2020, 13:35 |
| Volume (IN) | 4.74 |
| Peak Inflow (CFS) | 301.15 |
| Time of Peak Inflow | 29Dec2020, 13:15 |
| Inflow Volume (AC - FT) | 70.37 |
| Maximum Storage (AC - FT) | 12.49 |
| Peak Elevation (FT) | 462.51 |
| Discharge Volume (AC - FT) | 62.83 |



# Junction: DCP4

**Results: DCP4**

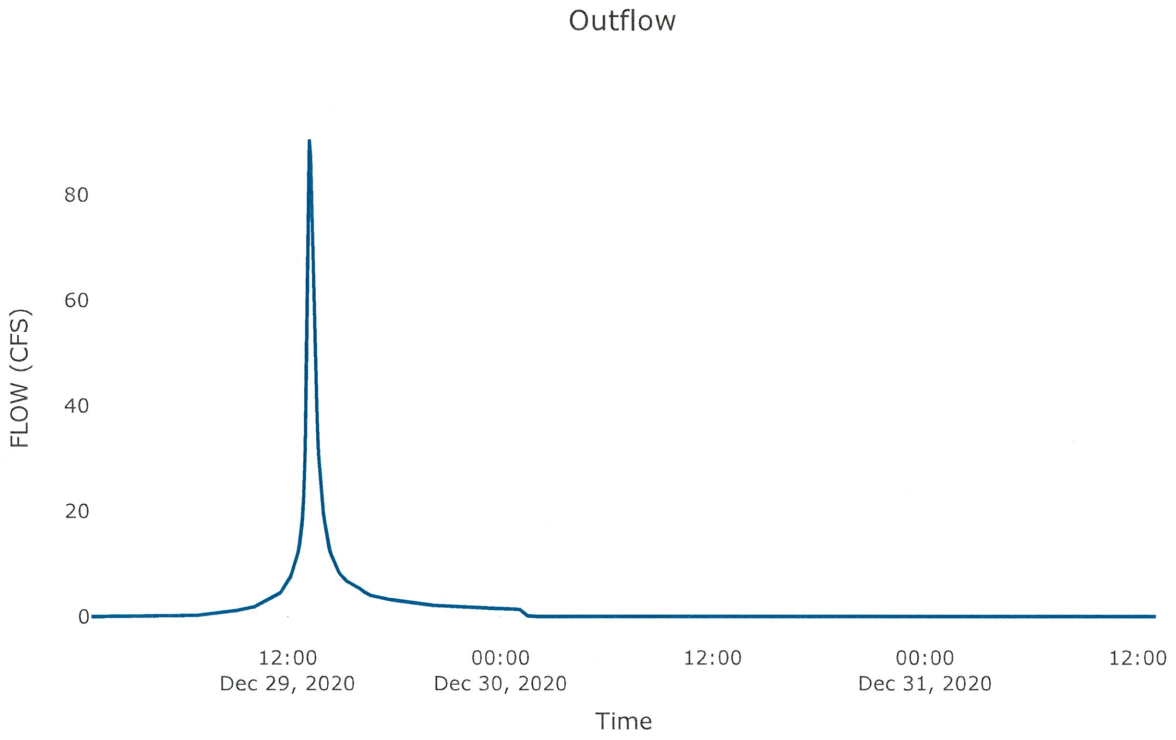
| | |
|---|---|
| Peak Discharge (CFS) | 404.25 |
| Time of Peak Discharge | 29Dec2020, 13:05 |
| Volume (IN) | 5.04 |



# Junction: DCP3

**Results: DCP3**

| | |
|---|---|
| Peak Discharge (CFS) | 90.46 |
| Time of Peak Discharge | 29Dec2020, 13:15 |
| Volume (IN) | 5.29 |



# VOLUME CALCULATIONS

# EXCESS RAINFALL VOLUME CALCULATION

The volume generated by the site and the surrounding properties is calculated for the 25-year storm event. A summary of the design information that is included in this Appendix and related appendices are listed below.

- Excess rainfall and drainage areas used in the volume calculations were taken from the HEC-HMS analysis located on pages IIIF-E-16 through IIIF-E-88.
- Updated permitted condition volume information is summarized on pages IIIF-E-91 through IIIF-E-93.

ARLINGTON LANDFILL
0023-404-11-102-05
25-YEAR EXCESS RAINFALL
VOLUME CALCULATIONS



**Required:** Determine the 25-year 24-hour storm volume generated by the site and offsite areas using the excess rainfall calculated in the HEC-HMS analysis of the expansion site conditions.

**Method:** Use the excess rainfall data generated by the HEC-HMS analysis (pages IIIF-E-15 through IIIF-E-88) to determine the volume produced by the site for the updated permitted conditions.

Existing Permit Conditions

**1. Volume Discharging At DCP1**

Areas Discharging into DCP1

| Area No. | Area (Acre) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|
| **P2** | **87.41** | **7.04** | **51.28** |
| **O1** | **81.63** | **5.29** | **35.99** |
| **O2** | **160.30** | **5.29** | **70.67** |
| **DA1** | **6.55** | **5.01** | **2.73** |
| **DA2** | **21.36** | **5.55** | **9.88** |
| **DA3** | **27.31** | **4.51** | **10.26** |
| **DA8** | **21.98** | **4.63** | **8.48** |
| **DA9** | **8.94** | **5.09** | **3.79** |
| **CH1** | **8.05** | **4.11** | **2.76** |
| **CH2** | **7.39** | **5.14** | **3.17** |
| **CH3** | **7.44** | **5.18** | **3.21** |
| **S1** | **115.67** | **5.29** | **50.99** |
| Total Volume Discharging At DCP1 | | | 253.21 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP1 = | **253.2** | **ac-ft** |

**2. Volume Discharging At DCP 2**

| Area No. | Area (Acre) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|
| **P3** | **43.79** | **7.04** | **25.69** |
| **HC 1** | **23.78** | **5.07** | **10.05** |
| **HC 2** | **29.30** | **5.07** | **12.38** |
| **HC 3** | **11.58** | **5.08** | **4.90** |
| **O3** | **3520.00** | **5.07** | **1487.20** |
| **DA4** | **22.39** | **4.82** | **8.99** |
| **DA5** | **12.08** | **4.79** | **4.82** |
| **DA6** | **32.03** | **4.34** | **11.58** |
| **DA7** | **24.93** | **4.83** | **10.03** |
| **DA10** | **28.66** | **5.01** | **11.97** |
| **DA15** | **21.67** | **4.20** | **7.58** |
| **DA16** | **21.41** | **4.62** | **8.24** |
| **S2** | **3.30** | **5.29** | **1.45** |
| **S3** | **4.82** | **5.29** | **2.12** |
| **S5** | **7.69** | **5.29** | **3.39** |
| Total Volume Discharging At DCP2 | | | 1610.41 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP2 = | **1,610.4** | **ac-ft** |

**3. Volume Discharging At DCP3**

| Area No. | Area (ac) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|
| **S6** | **21.47** | **5.29** | **9.46** |
| Total Volume Discharging At DCP3 | | | 9.46 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP3 = | **9.5** | **ac-ft** |

**4. Volume Discharging At DCP 4**

| Area No. | Area (ac) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|
| **DA14** | **42.08** | **4.85** | **17.0** |
| **S7** | **32.29** | **5.29** | **14.23** |
| Total Volume Entering DCP4 | | | 31.24 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP4 = | **31.2** | **ac-ft** |

**5. Volume Discharging At DCP 5**

| Area No. | Area (ac) | Excess Rainfall (in) | Excess Rainfall Volume (Acre-Ft) |
|---|---|---|---|
| **CH4** | **10.25** | **5.70** | **4.9** |
| **O6** | **25.70** | **5.75** | **12.3** |
| **DA13** | **16.70** | **4.82** | **6.7** |
| **CH5** | **8.87** | **5.45** | **4.0** |
| **O4** | **41.33** | **5.29** | **18.2** |
| **O5** | **4.04** | **5.52** | **1.9** |
| **DA11** | **7.78** | **4.95** | **3.2** |
| **DA12** | **16.97** | **4.90** | **6.9** |
| **CH6** | **2.32** | **5.22** | **1.0** |
| **P1** | **5.10** | **7.16** | **3.0** |
| **S4** | **19.85** | **5.76** | **9.5** |
| Total Volume Entering DCP5 | | | 71.72 |

| | | |
|---|---|---|
| Total Volume Discharging At DCP5 = | **71.7** | **ac-ft** |

| | | |
|---|---|---|
| **Total Volume Discharging At Permit Boundary =** | **1,976.0** | **ac-ft** |

# VELOCITY CALCULATIONS

**Required:** Determine the flow velocities entering and exiting the permit boundary using HYDROCALC HYDRAULICS (Version 2.01, 1996-2010) for the flows calculated for the 25-year storm event.

**Method:**
1. Use the flow data to determine velocity of runoff entering the landfill permit boundary.
2. Use the flow data to determine velocity of runoff exiting the landfill permit boundary.

1. Flow Velocity entering the landfill permit boundary

O1

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-Efor the offsite areas and are summarized below.

Q25 = 261 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 261 | 0.0300 | 0.04 | 4.0 | 5.9 | 10.00 | 1.84 | 7.40 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O2

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 476 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 476 | 0.0355 | 0.04 | 4.90 | 1.6 | 13.01 | 2.35 | 9.82 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O3

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 6011 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 6011 | 0.0090 | 0.04 | 1.8 | 1.8 | 31.00 | 9.85 | 12.53 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O4

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 146 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 146 | 0.0475 | 0.04 | 16.9 | 5.8 | 17.00 | 0.89 | 6.05 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O5

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 24 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 24 | 0.0200 | 0.04 | 17.0 | 21.8 | 77.00 | 0.18 | 1.65 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

O6

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 140 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 140 | 0.0500 | 0.04 | 100.0 | 100.0 | 680.00 | 0.11 | 1.88 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

2. Flow Velocity exiting the landfill permit boundary

DCP 1

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 256 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 256 | 0.0800 | 0.04 | 1.7 | 2.9 | 0.00 | 2.95 | 12.80 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

DCP 2

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 6143 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 6143 | 0.0093 | 0.04 | 1.4 | 2.0 | 80.00 | 6.19 | 10.97 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

developed by Dodson and Associates (Version 2.01, 1996-2010)

DCP 3

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 91 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 91 | 0.0300 | 0.04 | 50.2 | 28.0 | 238.00 | 0.18 | 2.03 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

DCP 4

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 404 cfs

| Storm Year | Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|
| 25 | 404 | 0.020 | 0.04 | 8.6 | 40.3 | 52.00 | 1.11 | 4.62 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)

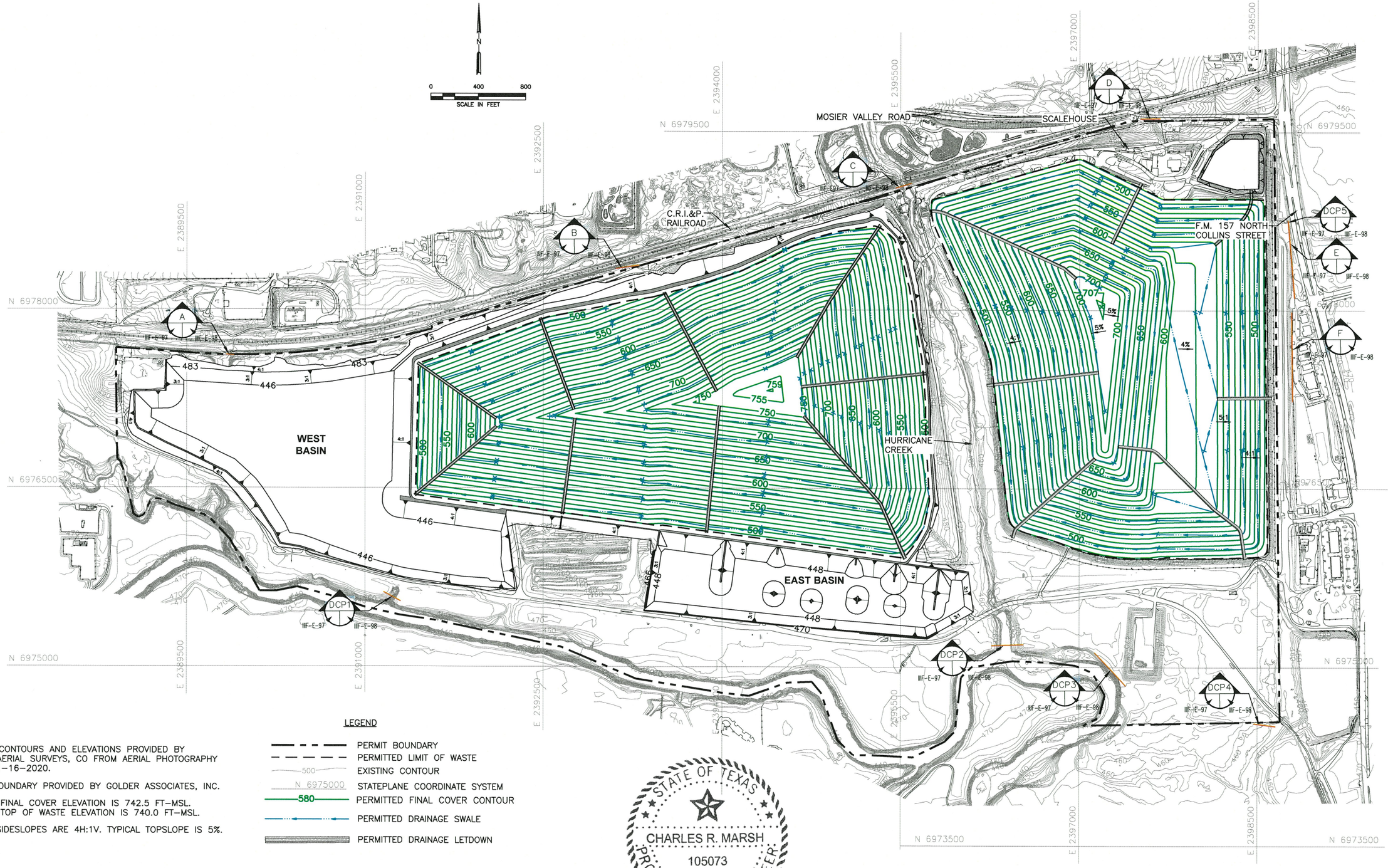
DCP 5

Flows were obtained from the Hydrologic Calculations included in Appendix IIIF-E for the offsite areas and are summarized below.

Q25 = 229 cfs

| Storm Year | Flow Rate (cfs) | Culvert Rise (ft) | Culvert Run (ft) | Culvert Length (ft) | Manning's n | Upstream Elevation (ft) | Downstream Elevation (ft) | Normal Depth (ft) | Flow Vel. (fps) |
|---|---|---|---|---|---|---|---|---|---|
| 25 | 229 | 5 | 10 | 178 | 0.016 | 457.00 | 456.90 | 5.00 | 9.03 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010)




NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO FROM AERIAL PHOTOGRAPHY FLOWN 11-16-2020.
2. PERMIT BOUNDARY PROVIDED BY GOLDER ASSOCIATES, INC.
3. MAXIMUM FINAL COVER ELEVATION IS 742.5 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 740.0 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V. TYPICAL TOPSLOPE IS 5%.

LEGEND

- PERMIT BOUNDARY
- PERMITTED LIMIT OF WASTE
- 500 EXISTING CONTOUR
- N 6975000 STATEPLANE COORDINATE SYSTEM
- 580 PERMITTED FINAL COVER CONTOUR
- PERMITTED DRAINAGE SWALE
- PERMITTED DRAINAGE LETDOWN

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER
05.19.22

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DRAWN BY: JDW
DESIGN BY: JBM
REVIEWED BY: CAM

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

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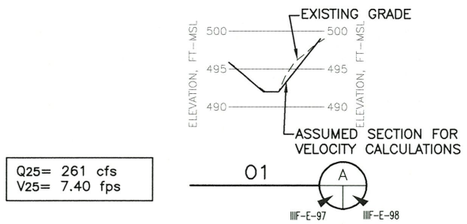
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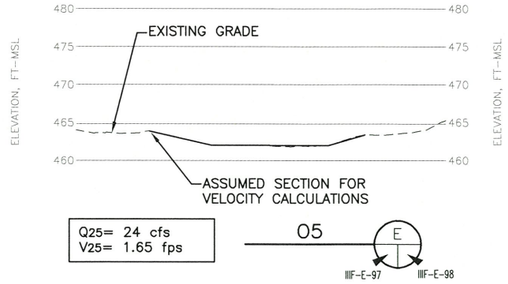
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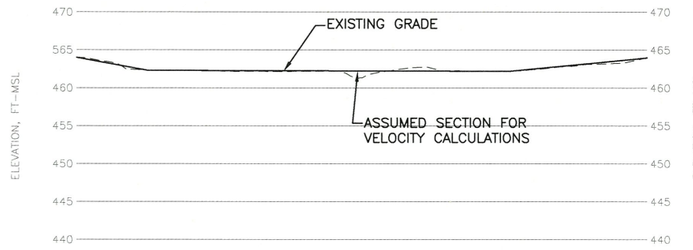
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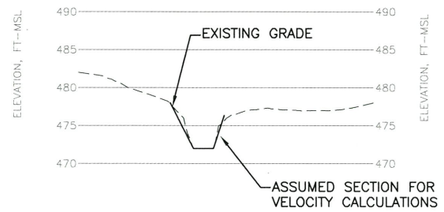
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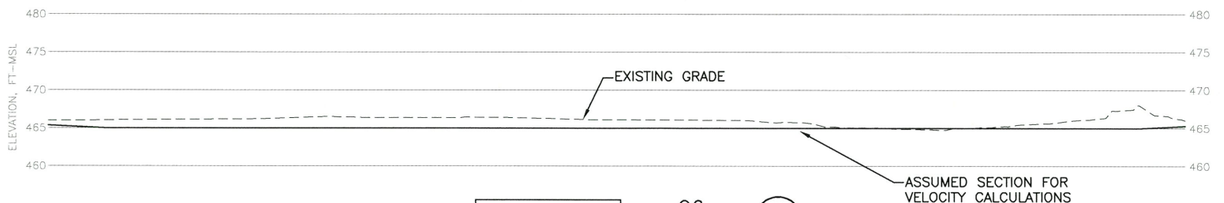
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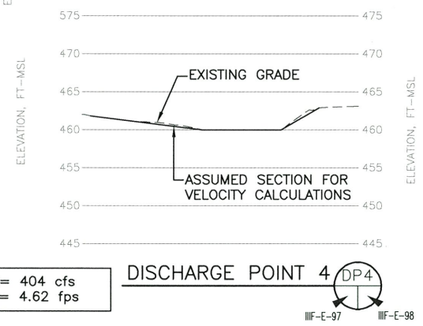


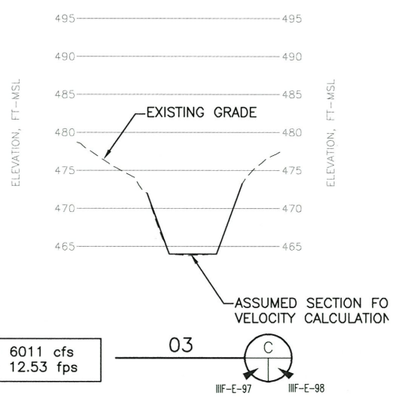



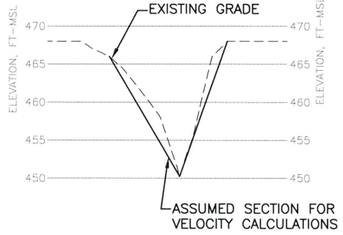



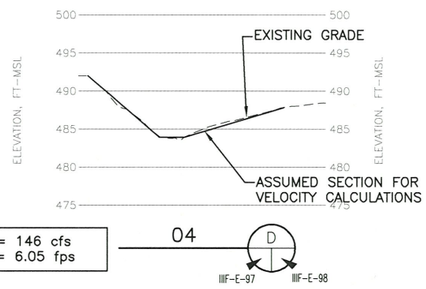



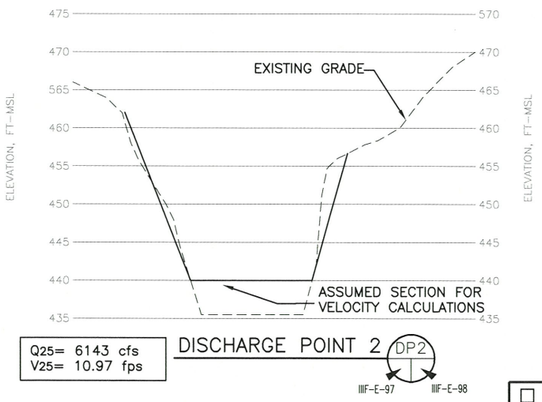



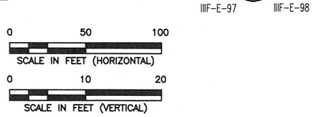



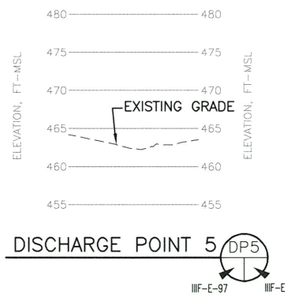







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# EXISTING PERMITTED DRAINAGE CALCULATION EXCERPTS

# CITY OF ARLINGTON LANDFILL
# TARRANT COUNTY – MSW PERMIT NO. 358B

## PART III

## ATTACHMENT 2
## FACILITY SURFACE WATER MANAGEMENT REPORT

**Prepared for:**

**City of Arlington, Texas**

**and:**

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

Permit Issued: February 12, 2014
Revised October 2017
Revised December 2018

Revised ~~May~~ June 2019




Prepared by

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WCG Project No. 0023-404-11-57-01

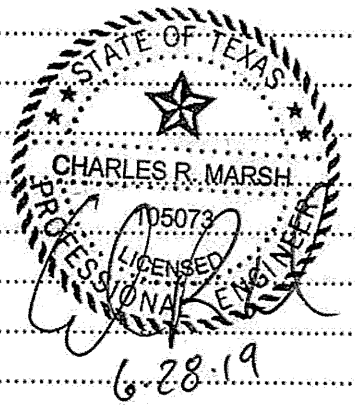
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# TARRANT COUNTY – MSW PERMIT NO. 358B

## PART III – SITE DEVELOPMENT PLAN

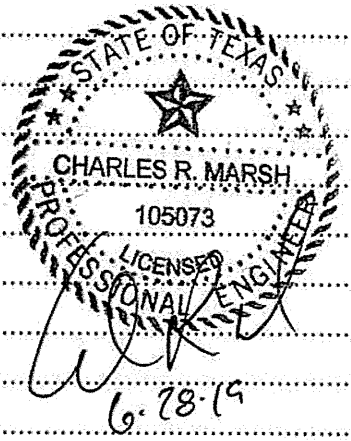
## ATTACHMENT 2
## FACILITY SURFACE WATER MANAGEMENT REPORT

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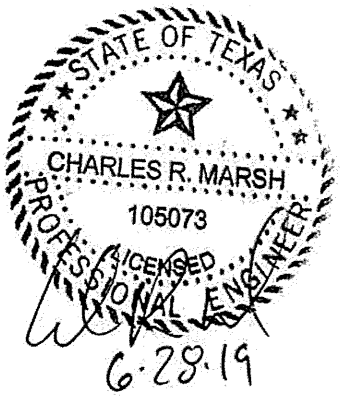
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## 1.0 INTRODUCTION

This report provides a description of the hydrologic and hydraulic analyses performed for the permit amendment application for expansion of the City of Arlington Landfill (Facility). As demonstrated within this report, the Facility expansion design will not adversely alter existing drainage patterns.

This report was prepared to meet the requirements of Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste (MSW) regulations, as set forth in Title 30 of the Texas Administrative Code (30 TAC), Chapter 330, Subchapters 330.303 and 330.305. Regulatory citations noted throughout the Attachment 2 text refer to corresponding sections of 30 TAC.

The City of Arlington Landfill is a Type I MSW management facility located west of Farm to Market (FM) 157 (North Collins Street), and south of Mosier Valley Road in the City of Arlington, Tarrant County, Texas.

The City of Arlington Landfill is currently comprised of two discrete disposal areas, the East Disposal Area (EDA) and West Disposal Area (WDA), which are separated by Hurricane Creek. The EDA, located east of Hurricane Creek, will be expanded vertically above currently permitted grades as part of the permit amendment. The WDA, located west of Hurricane Creek, was closed in 2000, and will be reactivated and vertically expanded as part of the permit amendment. Additionally, currently undeveloped property west and south of the existing WDA will be developed for landfilling as part of the permit amendment. The combined vertical and lateral expansion of the WDA (west of Hurricane Creek) is referred to as the Expanded West Disposal Area (EWDA).

Two areas of historic filling are located within the Facility boundary, both being located between the southern boundary of the permitted waste disposal units (WDA and EDA), and the West Fork Trinity River. The historic fill area south of the EDA will not be disturbed for this permit amendment. The historic fill area south of the WDA will be removed during construction of flood control and wetlands mitigation detention basins at the EWDA. Excavations from the historic fill will be disposed into the landfill.

Design calculations and operational considerations for the collection, control, detention of stormwater run-on, and the discharge of stormwater runoff are presented in Appendices 2-A through 2-L of this report.

### 1.1 Surface Water Design Overview

As previously stated, the Facility property includes the currently permitted and operational EDA, the WDA, and the expansion area located to the south and west of the WDA. Hurricane Creek transects the Facility property in a north-south alignment, at a location situated between the EDA and the WDA. For this amendment, all property west of Hurricane Creek is referred to as

the Expanded West Disposal Area, or EWDA. Hurricane Creek contributes run-on onto the Facility property by means of channel flow crossing the northern Facility boundary at the location of the Trinity Railway Express railroad bridge crossing, flows through the Facility property in a north to south direction, ultimately discharging into the West Fork Trinity River at a location along the Facility's south permit boundary.

The overall design approach to surface water control has been to collect and manage both the surface flows from off-site areas (referred to as run-on) and from on-site areas (runoff) and to discharge those flows to downstream properties in a manner that does not adversely alter existing drainage patterns upstream or downstream of the Facility property. The locations of discharge points on the Facility property (for both the EDA and EWDA) have generally remained consistent for the pre-development and post-development conditions.

Three analysis scenarios were developed for evaluation of the proposed Facility expansion, based on the existing conditions (which include the currently permitted conditions for the EDA, existing grades at the EWDA, and existing conditions of Hurricane Creek), and the proposed development and landfill expansion. The analysis scenarios are described below.

## 1.2 Analysis Scenario 1 – EDA

The EDA expansion, which includes a vertical landfill expansion over the Subtitle D portion of the existing permitted (active) landfill only, was analyzed by developing pre- and post-development surface water models for currently permitted conditions (as set forth in the 2003 permit amendment) and for the proposed vertical expansion conditions (post-development conditions). Surface water models were developed for both landfill and non-landfill areas, including upstream off-site areas that contribute surface water onto the Facility property. Previous surface water modeling, as presented in the 2003 permit amendment application, did not include models of the non-landfill areas, and therefore was not used for the demonstration presented herein.

Areas of the EDA that discharge into Hurricane Creek (located west of the EDA) have also been incorporated into Analysis Scenario 3, as presented below.

## 1.3 Analysis Scenario 2 - Expanded West Disposal Area (EWDA)

The EWDA includes both the vertical expansion of the existing WDA, and a contiguous lateral expansion of the landfill onto property located immediately south and west of the WDA. The EWDA expansion incorporates construction of flood control levee systems that remove landfill footprint from the floodplain/floodway of the West Fork Trinity River and the construction of two large flood control detention basins. Levees and detention basins are design components developed as a result of the flood study performed in support of Conditional Letters of Map Revision (CLOMRs) obtained through the Federal Emergency Management Agency (FEMA) and the Corridor Development Certificate (CDC) obtained through the North Central Texas

Council of Governments (NCTCOG), in support of this permit amendment. A copy of the CDC authorization is provided in Parts I/II, Appendix C-6. Basins will also serve as wetlands mitigation areas in support of the 404 permit for the Facility, in support of expanding the landfill into jurisdictional waters of the United States.

Hydrologic models were developed for the majority of the EWDA, including both landfill and non-landfill areas of the Facility property, as well as upstream off-site properties that discharge surface water onto the Facility property. The only areas not analyzed by hydrological modeling are the areas located (approximately) between the south access road (parallels the West Fork Trinity River) and the river channel. Modeling was not performed for these areas as no changes are proposed for the post-development conditions, in addition to these areas representing areas of sheet flow or shallow concentrated flow from the Facility property directly into the channel of the river.

Surface water from the EWDA discharges into either Walker Branch (a small tributary of the West Fork Trinity River, located near the southwest corner of the Facility permit boundary), Hurricane Creek (which transects the EWDA and the EDA) at a location east of the EWDA, or the West Fork Trinity River, all of which are located within the floodplain or floodway of the West Fork Trinity River. Analysis Scenario 2 is limited to areas of the EWDA that discharge into Walker Branch or the West Fork Trinity River only. Areas that discharge into Hurricane Creek are incorporated into Analysis Scenario 3, below.

For Analysis Scenario 2, pre-development discharge rates were calculated for the point discharges into the West Fork Trinity River and Walker Branch (a small tributary of the West Fork Trinity River into which the Facility property discharges at a location approximately 1,200 feet upstream of the confluence of Walker Branch and West Fork Trinity River). For the pre-development conditions, the Walker Branch point discharge is a 5-foot diameter culvert, and a second discharge point into the West Fork Trinity River, a 3-foot diameter culvert, is located south of the previously mined property, at the location shown on Figure 2-7.

Offsite run-on includes surface water discharging onto the Facility property through a 2-foot by 6-foot box culvert, and a 3-foot diameter culvert, each of which drain properties north of the northern-most permit boundary. Both drainage features are installed through the embankment fill of the Trinity Railway Express Railroad embankment. The location of the discharge points are shown on Figure 2-7. Additionally, properties north of the north permit boundary, and south of the railroad, also discharge onto the Facility property as surface flow.

Pre-development discharge for Scenario 2 also includes surface discharge from portions of the closed West Disposal Area (WDA), as shown on Figure 2-7.

Post development discharge for Scenario 2 is limited to a single discharge structure that drains the West Detention Basin, at the location shown on Figure 2-8. The pre-development discharge

structure into Walker Branch was not used for the post-development condition, as the flow line elevations of the existing culvert and Walker Branch would not allow drainage of stormwater from the detention basin for the 25-year, 24-hour storm event. Additionally, continued use of the Walker Branch discharge would require extensive modification and erosion protection to both the culvert outlet and Walker Branch to facilitate drainage of flood events from the West Fork Trinity River in a manner that does not cause erosional damage at the outlet or within Walker Branch. The culvert will be abandoned and closed for the post-development conditions.

## 1.4 Analysis Scenario 3 - Discharge from EWDA Property into Hurricane Creek

As previously described, Hurricane Creek transects the EDA and EWDA at a location near the center of the Facility property, and discharges into the West Fork Trinity River along the Facility's southernmost boundary. For Analysis Scenario 3, a model was developed for discharge from Hurricane Creek onto the Facility property (at the north Facility property boundary), and then pre- and post-development surface water flows from the EWDA and EDA were imposed onto the Hurricane Creek hydrological model. A generalized model was developed for Hurricane Creek based on a typical cross section and channel slope for the channel obtained from aerial survey. Upstream contribution into Hurricane Creek at the Facility's north permit boundary was established using data derived from the FEMA Flood Insurance Study (2009) as presented in Appendix 2-A.

Pre-development discharge into Hurricane Creek is generally limited to the surface flow from the closed WDA, and from future proposed discharge from the currently permitted EDA landfill and lands located between the EDA landfill waste limits and the Hurricane Creek channel. Post-development discharge includes surface water discharge from the completed landfill surfaces and adjacent lands at both the EWDA and EDA, including discharge from the future East Detention Basin located south of the EWDA landfill mound.

Pre- and post-development points of discharge are shown on Figures 2-9 and 2-10 respectively.

## 1.5 Analysis Methodology

Surface water models were developed using the US Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) Hydrologic Modeling System (HMS), version 3.5, also referred to as HEC-HMS. HEC-HMS allows estimation of both peak and total discharge for the design storm event imposed on the study area. For both the EDA and EWDA analyses, a 25-year, 24-hour storm event was used for the demonstration. The Soil Conservation Service (SCS) method was used as the transform method within the model, with curve number (CN) values determined from published National Resources Conservation Service (NRCS) soil type maps, and from review of aerial photographs of the contributing areas in order to ascertain land usage. Time of concentration and lag time values were estimated based on an assumed maximum flow length within the individual drainage subbasins.

Further, the models were developed for stormwater contacting the Facility property and upstream properties only. Floodwaters within the floodplain or floodway of the West Fork Trinity River were not incorporated into the surface water analysis for the demonstration of compliance with §330.303 and §330.305), as river floodwaters inundate the floodplain and floodway areas of the Facility property during any significant flood event, thereby negating impacts (erosion or other detrimental impacts) associated with runoff from the Facility property. For a flood condition, major portions of the pre-development Facility property act as valley storage for the flood waters within the West Fork Trinity River. Further, impacts associated with the post-development land configuration were subject to analysis for the 100-year flood event and Standard Design Flood (SDF) of the West Fork Trinity River for the Conditional Letter of Map Revision (CLOMR) obtained for the project included in Parts I/II, Appendix I/II.C-3. The CLOMR studies demonstrate that the post-development land configuration does not significantly alter the flood profile within the West Fork Trinity River, nor is valley storage significantly reduced for the post-development conditions.

# 2.0 ANALYSIS SCENARIO 1 - EAST DISPOSAL AREA (EDA)

## 2.1 Vertical Expansion - EDA

The EDA expansion is limited to vertical expansion of the landfill over the Subtitle D portions of the currently permitted waste footprint. Specifically, Sectors 2 through 6 of the EDA will be expanded vertically. Sector 1, a pre-Subtitle D disposal cell, will not be expanded vertically (beyond the limits described in the 2003 permit amendment) for this permit amendment. Further a portion of the currently permitted EDA, located at the northeast corner of the landfill, has been removed from the waste footprint for this application. No waste fill activity has or will occur in this area.

The 2003 permit amendment included a site grading plan for the EDA, including hydrological analysis of the pre- and post-development surface drainage conditions for the 2003 permit amendment conditions. For this permit amendment, surface drainage models were developed for both landfill and non-landfill areas of the Facility property, including a model for upstream off-site properties utilizing the permitted final grades, and the Soil Liner Evaluation Reports for Sectors 2, 3 and 4 to identify areas of lined versus unlined existing disposal areas.

The location of discharge points from the EDA remain consistent between the 2003 permit amendment conditions (pre-development) and the conditions proposed in this permit amendment (post-development), allowing the analysis to consider the change in peak and total discharge at the various points of discharge from the Facility property as a means of demonstrating that no significant impact to surface drainage results from the proposed landfill vertical expansion as determined by comparing pre- and post-development discharge at the downstream Facility property boundaries.

## 2.2 Hydrologic Analysis Methodology - EDA

For this analysis, the 2003 post-development permitted conditions represent pre-development conditions, and the designs set forth in this permit amendment represent the post-development conditions. HEC-HMS models were developed for each contributing area. HEC-HMS was used for both the pre- and post-development modeling.

The EDA analysis methods and assumptions are described in Appendix 2-B.

### 2.2.1 Pre-development Conditions - EDA

The pre-development conditions for the hydrological analysis are represented by the permitted final grades and drainage features set forth in the 2003 permit amendment. For this demonstration, the points of discharge from the Facility property, as well as the drainage features remain consistent, as represented on Figure 2-5. New drainage subbasins were established for the hydrological modeling which includes both on and off-landfill areas, as well as the upstream off-site properties that discharge onto to the Facility property.

Points of Demonstration (POD's) were established for the pre-development conditions, which represent the points of discharge of surface water from the Facility property onto adjacent, downstream properties. These points are used for comparison with the post-development conditions for demonstration of no significant impact to downstream properties.

Additionally, Internal Points of Discharge (IPD's) were established for discharge from the EDA towards Hurricane Creek (west of the EDA). The IDP subbasins were subsequently imposed on the Hurricane Creek hydrological model for demonstration of impact to Hurricane Creek (and downstream West Fork Trinity River) in Analysis Scenario 3.

Pre-development conditions at the EDA incorporate the following features:

- Off-site areas contributing run-on onto the EDA property include only OS-1, as shown on Figure 2-2. OS-1 is located north of the Facility property, and includes portions of the Trinity Express Railway railroad and properties north of the railroad embankment. Surface water from OS-1 flows in a southerly direction, towards the railroad track embankment, to a location north of the railroad track that includes a 2-foot diameter culvert which allows surface water to flow under the railroad track embankment, towards the Facility property. A second, 3-foot diameter culvert is located immediately down stream of the 2-foot diameter culvert, at the location of a low-water crossing of Mosier Valley Road. For the hydrological modeling performed for this permit amendment, the presence of these culverts was not considered in the analysis, as the available ponding (storage) upstream of the 2-foot diameter culvert and railroad embankment is estimated at less than 0.5 acre-feet in volume (total), whereas the total flow of surface water from OS-1 for the 25-year, 24-hour design storm event exceeds 7 acre-feet, resulting in overtopping of the railroad track embankment during the peak of the design storm event and water flowing onto the Facility property at the location shown on the figure. Storage for the larger 3-foot diameter culvert is significantly less than the storage for the upstream 2-foot diameter culvert, resulting in overtopping and free-flow of surface water across the Mosier Valley Road low water crossing during storm events.
- On-site drainage includes the existing landfill areas (EDA-1 through EDA-4), an area south of the EDA (between the EDA and the West Fork Trinity River), and both flooded areas and upland areas within the Facility property. Upland areas north of the EDA landfill are used for landfill operations, equipment staging, offices, and other associated activities. Levees around the existing EDA disposal area remove this area from the floodplain of the West Fork Trinity River.
- The majority of surface water contacting the EDA discharges in a southerly or westerly direction into the West Fork Trinity River or Hurricane Creek (respectively), although there is some discharge from the east and northeast corners of the EDA landfill and adjacent Facility property to the east, into a drainage ditch that exists along the eastern boundary of the Facility property. Water in this ditch subsequently discharges to the east to the adjacent FM 157 property which includes a 10-foot by 5-foot box culvert

installed under FM 157. Discharge at the east Facility property boundary are represented by Downstream Evaluation Point 1 (DEP-1).

- The currently permitted (and proposed expanded) EDA is constructed with a series of sideslope surface water diversion berms and downchutes that divert surface runoff to several discharge points located at the EDA. Diversion berms, swales, and discharge points are shown on Figures 2-5 and 2-6. Discharge points analyzed along the western slope of the EDA are referred to, as previously described, IDP's, and are used for the Analysis Scenario 3 Hurricane Creek demonstration presented below.
- Stormwater contacting the historical fill area south of the EDA (as represented by subbasins 5 and 6 on Figure 2-5) discharges as surface flow in a generally south and southwest direction, discharging as surface flow into the West Fork Trinity River or Hurricane Creek.
- Stormwater runs on to the northeast portion of the site (drainage area EDA-9) from offsite area OS-1 and EDA-1. Runoff in EDA-9 is detained in low-lying areas ("NE basin") upstream of ~~3~~2-2' diameter culverts with flap gates. These culverts outlet into the east property owned by the City of Arlington, and an existing channel conveys runoff south to an existing 10'x5' box culvert under FM 157. Runoff through the ~~three~~ two 2-ft diameter culverts is identified as discharge point POD-A on figure 2-6 in Attachment 2.

### 2.2.2 Post-development Conditions – EDA

Vertical expansion of the EDA described in this permit amendment reduces the size and dimensions of the flatter top deck of the landfill, while increasing the area of steeper 4H:1V sideslope. Additionally, the vertical expansion does not include the area above Sector 1 (a pre-Subtitle D cell); therefore, the post-development sideslope drainage system in this area results in a small modification of the post-development drainage subbasin size for the landfill surface.

Non-landfill drainage conditions (i.e., areas of Facility not on the EDA landfill contours) previously described for the pre-development conditions at the EDA remain generally consistent for the post-development conditions.

## 2.3 Analysis Results – EDA

Pre- and post-development peak discharge rates and peak total discharge volumes calculated using the previously described methods, are summarized in the tables below.

**Analysis Scenario 1 – Description of PODs**

| POD | Description | Change from Pre- to Post-Development (Note 1) |
|---|---|---|
| A | North-East discharge point – EDA-1, 4A, 9 and OS-1 runoff | Change in peak flow from pre- to post-development at east discharge points evaluated at downstream evaluation point (DEP-1). Runoff from permitted disposal site at east discharge points is routed to DEP 1 through Channel 1, located in Arlington property described in the restrictive covenant in Appendix 2-O. |
| B | East discharge point – EDA-10 runoff | Change in peak flow from pre- to post-development at east discharge points evaluated at downstream elevation point (DEP-1). Runoff from permitted disposal site at east discharge points is routed to DEP 1 through Channel 1, located in Arlington property described in the restrictive covenant in Appendix 2-O. |

1. Refers to changes in discharge location, discharge structures, flow regime at discharge point.

## Analysis Scenario 1 – Description of PODs (Continued)

| | | |
|---|---|---|
| B-1 | East Discharge Point – EDA-10A runoff | Change in peak flow from pre- to post-development at east discharge points evaluated at downstream evaluation point (DEP-1). Runoff from permitted disposal site at east discharge points is routed to DEP 1 through Channel 1, located in Arlington property described in the restrictive covenant in Appendix 2-O. |
| B-2 | East Discharge Point – EDA-2A runoff | Change in peak flow from pre- to post-development at east discharge points evaluated at downstream evaluation point (DEP-1). Runoff from permitted disposal site at east discharge points is routed to DEP 1 through Channel 1, located in Arlington property described in the restrictive covenant in Appendix 2-O. |
| C | South discharge point – EDA-2 runoff | No Change |
| D | South West discharge point into West Fork Trinity River – EDA-5 runoff | No Change |
| DEP-1 | Downstream Evaluation Point – Downstream Discharge Point from Arlington Property includes EDA-1, 4A, 9, OS-1, 10, 10A, 2A, and AP-1 runoff. | ~~No Change~~ Overall decrease in peak flow rate. No change in total discharge volume. |

1. Refers to changes in discharge location, discharge structures, flow regime at discharge point.

## Analysis Scenario 1 – Comparison of Pre- versus Post-development Peak Discharge (cfs)

| Point of Demonstration | Pre-Development Conditions | Post-Development Conditions | Change (%) |
|---|---|---|---|
| A | 150.6 | 50.8 | -66.3* |
| B | 48.2 | 34.7 | -28.0* |
| B-1 | NA | 23.9 | NA* |
| B-2 | NA | 110.2 | NA* |
| C | 191.6 | 194.6 | 1.6 |
| D | 64.8 | 64.8 | 0.0 |
| DEP-1 | 153.6 | 142.7 | -7.10 |

*Change in peak flow from pre- to post-development is evaluated at downstream evaluation point (DEP-1). Runoff is routed to DEP 1 through Channel 1, located in Arlington property described in the restrictive covenant in Appendix 2-O.

## Analysis Scenario 1 – Comparison of Pre- versus Post-development Total Discharge (acre-feet)

| Point of Demonstration | Pre-Development Conditions | Post-Development Conditions | Change (acre-feet) | Change (%) |
|---|---|---|---|---|
| A | 45.1 | 33.1 | -12.0 | -26.6 |
| B | 2.5 | 1.7 | 0 -0.8 | -32.0 |
| B-1 | NA | 1.2 | NA | NA* |
| B-2 | NA | ~~7.3~~ 7.4 | NA | NA* |
| C | 27.9 | 29.8 | 1.9 | 6.8 |
| D | 3.7 | 3.7 | 0 | 0 |
| DEP-1 | 43.7 | 43.7 | 0 | 0.0 |

*Change in peak flow from pre- to post-development is evaluated at downstream evaluation point (DEP-1). Runoff is routed to DEP 1 through Channel 1, located in Arlington property described in the restrictive covenant in Appendix 2-O.
** Downstream evaluation point 1 represents off-site flow through the existing 10'x5' concrete box culvert from the adjacent City of Arlington property. Property downstream of DEP-1 is a master-planned community, designed to manage discharge from the 10'x5' culvert in excess of 700 cfs.

As presented in the above tables, changes in the combined peak discharge and the combined total discharge rates are not significant. The only positive change in pre- versus post-development conditions is at POD-C (associated with subbasin EDA-2), which has the greatest increase in both peak discharge rate and total discharge volume between the pre- and post-development conditions. However, as shown on Figure 2-6, EDA-2 surface water from the landfill surface discharges onto the approximately 67-acre floodplain/floodway located on the Facility property immediately south of the EDA. The Facility property onto which the landfill surface of EDA-2 discharges is relatively flat and protected by established vegetation. The 67-acre parcel provides dissipation of both the peak discharge rate and total discharge volume increase of EDA-2 prior to surface water discharging off of the Facility property into the West Fork Trinity River at a location

At the downstream evaluation point, there is ~~no increase~~ a slight decrease in peak flow rate ~~or~~ and no change to the flow volume relative to the permitted conditions. ~~At Discharge Points A, B, C, and D, flow rates and volumes either decrease or do not change.~~ The addition of Discharge Points B-1 and B-2 is mitigated by storage provided in Channel 1, and a detention pond in EDA-9 located within the City of Arlington property located east of and adjacent to the permit boundary. Use of this area for drainage purposes has been established through a restrictive covenant located in Appendix 2.0.

Note that this entire portion of the Facility property (i.e., south of the EDA) is inundated by floodwater from the West Fork Trinity River during river channel flood events.

Velocities at internal discharge points leading to Hurricane Creek (IDP-A through IDP-I) are generally non-erosive (less than 5 feet per second.) At two locations (IDP-B and IDP-C), velocities are slightly above 5 fps, and erosion potential will be addressed by installing turf reinforcement mat (TRM), gabions or riprap. Similarly, most perimeter discharge points have non-erosive velocities. Erosion control measures (TRM, gabions or riprap) will be installed within the drainage restrictive covenant area at discharge points POD-A and POD-B2.

As demonstrated above, the vertical expansion of the EDA does not negatively impact the surface water drainage patterns or management systems currently in place or previously permitted for the EDA.

# 3.0 ANALYSIS SCENARIO 2 - EXPANDED WEST DISPOSAL AREA (EWDA)

## 3.1 Vertical and Lateral Expansion - EWDA

The EWDA is comprised of both the vertical expansion of the existing WDA and the lateral expansion to property south and west of the WDA. Additionally, the expansion incorporates the construction of flood control levees and two large detention basins (referred to as the East Detention Basin and West Detention Basin) to be used for stormwater management, flood control, and wetlands mitigation for the project.

Portions of the property south and west of the WDA currently are designated as floodplain and floodway of the West Fork Trinity River. The area of the EWDA proposed for landfilling that currently is within the floodplain or floodway will be removed from the floodplain/floodway by construction of levees. Levees will be designed and constructed as set forth in the Code of Federal Regulations (CFR) Part 44, Chapter 1, Section 65.10. The conceptual designs for levee improvements were described in a Conditional Letter of Map Revision (CLOMR) application, which was approved by FEMA in December 2010. Copies of the CLOMR approval letters are included in Part I/II.

Additionally, the future EWDA development will impact areas previously designated as jurisdictional wetlands, as set forth in Section 404 of the Clean Water Act. The jurisdictional wetlands will be mitigated by construction of wetlands and uplands within the detention basins. The wetlands mitigation is described in the Wetlands Demonstration included in Part I/II.

## 3.2 Hydrologic Analysis Methodology - EWDA

New hydrologic models were developed for both the pre- and post-development conditions at the EWDA that incorporate both the existing site conditions at the WDA and the property west of the WDA, an area that was not previously within the landfill's permit boundary. The existing surface contours and drainage features of the WDA, a previously closed landfill, were incorporated into the pre-development modeling for the demonstration. HEC-HMS was used for both the pre- and post-development modeling.

The EWDA analysis methods and assumptions are described in Appendix 2-C.

### 3.2.1 Pre-Development Conditions - EWDA

Pre-development conditions at the EWDA incorporate the following features:

- Off-site areas contributing run-on onto the EWDA property include OS-4, OS-5, OS-6, and OS-7, as shown on Figure 2-2. All four off-site areas are located north of the Facility property. Discharge from OS-4 and OS-5 enters onto the Facility property through a 2-foot by 6-foot box culvert and a 3-foot diameter culvert, respectively. The culverts are installed through the embankment fill supporting the Trinity Railway Express railroad

or directly into the West Fork Trinity River, respectively), and compared to the discharge characteristics of the post-development POD-E2, a three-culvert discharge structure to be installed at the location shown on Figure 2-8.

- The POD-E2 discharge point is located at the same location as the pre-development POD-E discharge point, and will require removal and replacement of the existing 3-foot diameter culvert with the new discharge structure. The combining and relocation of the POD-F discharge point was necessitated by the flow line elevations of the existing culvert and Walker Branch which would not allow drainage of stormwater from the detention basin for the 25-year, 24-hour storm event. Additionally, continued use of the Walker Branch discharge feature would require extensive modification and erosion protection to both the culvert outlet and Walker Branch to facilitate drainage of flood events from the West Fork Trinity River in a manner that does not cause erosional damage at the outlet or within Walker Branch (as currently exists).
- Discharge points into Hurricane Creek are represented by IDP's shown on Figure 2-8. Additionally, a discharge structure from the East Detention Basin into Hurricane Creek is designated as an IDP for the Scenario 3 demonstration.
- A channel is located along the northern permit boundary (referred to as the North Channel), that diverts off-site run-on from subbasins OS-5 and OS-7 to the West Detention Basin.
- The constructed EWDA landfill, with sideslope swales and downchutes in place, as shown on Figure 2-8.

Several of the above features are described in additional detail below.

### 3.2.3 East and West Detention Basins

Detention basins and outlet structures perform multiple roles of providing surface water management, flood control, and wetlands mitigation for the EWDA landfill. Basins have been designed to comply with FEMA flood control requirements for the 100-year and Standard Project Flood (SPF) events in the West Fork Trinity River. Basins also have been designed to meet the no net loss of valley storage requirements for the Corridor Development Certificate (CDC) program, as administered by the NCTCOG. CDC approval is included in Parts I/II, Appendix I/II.C-6. After completion of basin construction, and upon issuance by FEMA of the Letter of Map Revision (LOMR) for the completed basins, the EWDA will be designated as being located outside of the floodplain or floodway of the West Fork Trinity River on the revised Flood Insurance Rate Map (FIRM).

With a 100-year peak flood elevation of approximately 479 feet msl, and a basin invert elevation ranging from 446 to 448 feet msl, the detention basins are designed to be inundated with as much as 33 feet of floodwater during a 100-year flood event in the West Fork Trinity River basin. At the 100-year flood elevation, areas to the east, south, west, and portions north of the EWDA levees are inundated by floodwater.

By comparison, the stormwater detention and routing characteristics of basins have been designed and analyzed to address the 25-year, 24-hour storm event, assuming that the design storm event contacts upstream properties and the Facility property only. Stormwater detention characteristics (for the 25-year, 24-hour storm event) of the basins have been analyzed incorporating the assumption that discharge structures are not subject to backwater conditions from the West Fork Trinity River, thereby facilitating calculation of the rate of discharge from the basins into the West Fork Trinity River or into Hurricane Creek resulting from stormwater contacting the upstream and permit properties. Backwater conditions within the West Fork Trinity River would result in eventual inundation of the Facility property, and subsequent discharge back into the West Fork Trinity River channel controlled by the eventual drawdown of the flood event, versus controlled by the storm intensity or duration.

By comparison with the previously described flood event, a 25-year, 24-hour storm event contacting upgradient and Facility properties will result in maximum impoundment depths of approximately 1.6 and 1.8 feet within the East and West Detention Basins, respectively, compared to the 33 feet (mol) of water depth over the basin floor invert associated with the 100-year flood for the West Fork Trinity River.

### 3.2.4 Detention Basin Discharge Structures

The East and West Detention Basins have been designed to include outlet structures that incorporate either two or three 5-foot diameter culverts, respectively. The culverts provide discharge control for the 25-year, 24-hour storm event, as well as provide an outlet for draining of impounded water entering the basins during a flood event within the West Fork Trinity River basin. The outlet structures have been designed to facilitate lowering of flood waters within the basins concurrent with receding flood waters within the river channel. Analysis of the discharge structures is presented in Appendix 2-F.

### 3.2.5 North Channel Improvements

The existing drainage channel located along the northern permit boundary of the EWDA (between the future EWDA landfill and north permit boundary) will be extended and improved for the post-development conditions. The post-development channel was designed with 3H:1V sideslopes (mol) on the north side of the channel, and a 4H:1V sideslope on the south side of the channel (formed by the outer sideslope of the perimeter levee). Drainage designs were developed to assure surface drainage within the Facility boundary remains within the boundary, and that regrading does not conflict with the existing natural gas line or adjacent property features.

The North Channel also extends eastward to the area north of the existing WDA. However, this section of channel does not receive large volumes of runoff, and will be minimally improved (surface grading and vegetation) only for the post-development conditions.

Supporting calculations for the North Channel improvements are presented in Appendix 2-H.

### 3.2.6 Stormwater Conveyance Structures

Stormwater conveyance features on the landfill include sideslope surface water diversion berms, downchutes, and toe ditches. Conveyance features were designed for the 25-year, 24-hour storm event.

Sideslope surface water diversion berm channels are sloped at 1.5 percent with 4H:1V (landfill side of channel) and 3H:1V sideslopes, and a vertical height of 2.5 feet (from the channel invert to the top of the berm). A minimum 0.5 feet of freeboard is provided for the design storm event. A channel invert slope of 1.5 percent was selected to maintain flow velocities below 5 feet per second for the design storm event, while maintaining sufficient slope to convey runoff to the downchutes. Detailed calculations are included in Appendix 2-E. Diversion berm details are presented on Figure 2-20.

Downchutes convey water from the sideslope surface water diversion berms to the toe of the landfill. Downchutes are designed of stoned-filled Reno mattresses (gabions) armoring. Downchutes are sized to provide a maximum flow velocity of 21 feet per second, based on supplier recommendations. A minimum 0.5 feet of freeboard is provided for the design storm event. Downchute calculations are provided in Appendix 2-F. Details for the downchutes are provided on Figure 2-20.

Suitable alternatives to Reno mattresses may be used, provided that the design is verified by a professional engineer prior to installation. Such alternatives include riprap, concrete, turf reinforcing mat, geomembrane or other conveyance structures.

Toe ditches are designed on the landfill side of the perimeter roads installed on the top of the levee, and around the perimeter of filling at the EWDA. Stormwater collected in the toe ditches is discharged down the sideslope of the levees in culverts, and discharged into one of the two detention basins, or into Hurricane Creek. The toe ditches are grassed lined, and are designed with peak flow velocities of less than 5 feet per second. The channels are trapezoidal in shape with variable bed slopes, eight-foot bottom widths, variable depths, and 2H:1V sideslopes. Toe ditch details are shown on Figure 2-20. Toe ditch calculations are presented in Appendix 2-H.

## 3.3 Analysis Results – EWDA

As previously described, Analysis Scenario 2 is the pre- and post-development comparison of discharge from the EWDA property directly into the West Fork Trinity River, or into Walker Branch at a location immediately upstream of the confluence of Walker Branch and the West Fork Trinity River. Pre-development conditions are represented by POD-E and POD-F, and post-development conditions are represented by the single discharge point POD-E2, as shown on Figures 2-7 and 2-8, respectively. As previously noted, the areas south of the south perimeter road remain unchanged for the pre- and post-development conditions, and therefore were not incorporated into the demonstration

**Analysis Scenario 2 - Comparison of Pre- Versus Post-development Peak Discharge (cfs)**

| Discharge Points | Pre-development Conditions | Post-development Peak Conditions | Percent Change (%) |
|---|---|---|---|
| POD-E | 7.4 | NA | |
| POD-F | 143.1 | NA | |
| POD-E + POD-F | 150.5 | | |
| POD-E2 | NA | 67.1 | -55.4 |

**Analysis Scenario 2 - Comparison of Pre- Versus Post-development Total Discharge (acre-feet)**

| Discharge Points | Pre-development Conditions | Post-development Peak Conditions | Percent Change (%) |
|---|---|---|---|
| POD-E | 61.6 | NA | |
| POD-F | 20.8 | NA | |
| POD-E + POD-F | 82.4 | | |
| POD-E2 | NA | 138.6 | 68.2 |

As shown in the above tables, the peak discharge rate into the West Fork Trinity River is reduced by approximately 55 percent for the post-development condition (at POD-E2) when compared to the pre-development conditions for the combined POD-E and POD-F. Total discharge volumes into the West Fork Trinity River increase for the post-development condition, due in part to the pre-development modeling incorporating evaporation (due to the extended discharge period at POD-E).

Evaporation was not incorporated into the post-development modeling of the West Detention Basin. As shown in the table above, the pre-development condition had a majority of the total drainage (61.6 acre-feet from POD-E) draining through a single 36-inch culvert, resulting in a total discharge period of over 23 days (as derived from the HEC modeling results included in Appendix 2-C, Exhibit 2-C.7), when compared to a discharge period of approximately 9 days for the post-development conditions at POD-E2. Based on the extended discharge period for POD-E, evaporation was incorporated into the pre-development POD-E subbasin. Incorporating evaporation into the POD-E pre-development subbasin and not into the POD-E2 post-development subbasin is a conservative assumption, as it results in greater total discharge for the post-development condition at POD-E2.

Note that for the above comparison, the total discharge from the EWDA increases from 82.4 acre-feet to 138.6 acre-feet, an increase of 56 acre-feet, or approximately 68.2 percent. However, by comparison the 100-year flood valley storage of the West Fork Trinity River along the reach bordering the Facility property exceeds 7,000 acre feet. Based on this comparison,

the minor increase in total discharge is insignificant when compared to the storage and routing capacity of the West Fork Trinity River basin.

## 4.0 ANALYSIS SCENARIO 3 – HURRICANE CREEK

As previously described, Analysis Scenario 3 is the evaluation of pre- versus post-development discharge into Hurricane Creek, and how that discharge impacts the downstream discharge of channelized surface water into the West Fork Trinity River. Previously described IDP's were established for both the pre- and post development conditions at the EDA and the EWDA, and flows from the IDP's were imposed on the flow model developed for Hurricane Creek.

### 4.1 Hydrologic Analysis Methodology

A hydrologic model in HEC-HMS was developed for Hurricane Creek, using an estimated typical channel cross section and channel slope, as derived from aerial survey of the property. Hydrologic parameters for the adjacent on-site drainage subbasins that discharge into Hurricane Creek also were input into the model for both the pre- and post-development conditions.

The 25-year peak flow rate of 6,390 cfs representing discharge from Hurricane Creek onto the Facility property (along the north permit boundary) was derived from the 2009 FEMA Flood Insurance Study (FIS) (Appendix 2-A). As shown in the appendix, discharge values (for the 10, 50, 100, and 500 year storm events) were plotted, and a value for the 25-year (4 percent) storm event was interpolated. Note also from the 2009 FIS that a contributing area of 5.5 square miles is reported for the point immediately upstream of the Facility property.

The HEC-HMS input parameters (contributing area, Curve Number (CN), storm event, and lag time) were obtained as follows:

- The contributing area of 5.5 square miles was obtained from the FIS study.
- The 25-year storm event was obtained from published data included in Exhibit 2B-1.
- A representative CN value of 80 was selected for the 5.5 square mile contributing area, based on an assumed mixed ground cover of developed urban, paved areas, open areas, and commercial.
- The above assumptions were input into the HEC-HMS calibration model, and the lag time within the model was adjusted until the peak discharge from the subbasin upstream of the Facility property approximated the FIS-reported value of 6,390 cfs. A lag time of 68 minutes was obtained for a peak discharge of 6,356 cfs.
- The HEC-HMS values derived from the calibration model were then used for subsequent models of Hurricane Creek pre- and post-development conditions.

**Hurricane Creek Calibration Model Summary**

| Source | Contributing Area (sq. miles) | CN | Lag Time (minutes) | Peak Discharge (cfs) | Total Discharge (acre-feet) |
|---|---|---|---|---|---|
| 2009 Flood Insurance Study | 5.5 sq. miles | Not Provided | Not Provided | 6,390 cfs | Not Provided |
| HEC-HMS Calibration Model | 5.5 sq. miles | 80 (Note 1) | 68 (Note 2) | 6,356 cfs | 1,486 ac-ft (Note 3) |

1. Estimated from review of aerial photographs, based on an assumed mixed ground cover of developed urban, paved areas, open areas, and commercial.
2. As calculated by HEC-HMS calibration model adjusted to obtain peak discharge rate consistent with 2009 FIS published value.
3. From HEC-HMS calibration model.

Discharge from the contributing subbasins for the EDA and EWDA were obtained by methods previously described.

**Analysis Scenario 3 - Summary of Peak Discharge for Interior Discharge Points (IDP's) Along Hurricane Creek (cfs)**

| Interior Discharge Point | Pre-development Peak Discharge Rate (cfs) | Post-development Peak Discharge Rate (cfs) |
|---|---|---|
| IDP-A | 32.6 | 50.3 |
| IDP-B | 149.8 | 252 |
| IDP-C | 56.6 | 70.2 |
| IDP-D | 126.7 | 160.6 |
| IDP-E | 49.1 | 49.6 |
| IDP-F (combined IDP-F1 and IDP-F2) | 20.4 | 253.3 |
| IDP-F1 | NA | 5.9 |
| IDP-F2 | NA | 247.4 |
| IDP-G | 278.3 | 161.1 |
| IDP-H | 243.4 | 38.7 |
| IDP-I | 89.9 | 38.2 |
| Total | 1,046.8 | 1,074 |

**Analysis Scenario 3 - Summary of Total Discharge for Interior Discharge Points (IDP's) Along Hurricane Creek (acre-feet)**

| Interior Discharge Point | Pre-development Total Discharge (acre-feet) | Post-development Total Discharge (acre-feet) |
|---|---|---|
| IDP-A | 2.1 | 3.2 |
| IDP-B | 20.2 | 20.6 |
| IDP-C | 2.9 | 3.6 |
| IDP-D | 13.9 | 12.6 |
| IDP-E | 2.9 | 2.8 |
| IDP-F (combined IDP-F1 and IDP-F2) | 1.4 | 14.3 |
| IDP-F1 | NA | 0.5 |
| IDP-F2 | NA | 13.8 |
| IDP-G | 23.2 | 8.7 |
| IDP-H | 28.9 | 2.4 |
| IDP-I | 11.8 | 44.5 |
| Total | 107.3 | 112.7 |

**Analysis Scenario 3 - Summary Results for Peak Discharge within Hurricane Creek (cfs)**

| Hurricane Creek | Pre-development Conditions | Post-development Conditions | Change (%) |
|---|---|---|---|
| Upstream | 6356 | 6356 | 0 |
| Downstream | 5,704 | 5,625 | -1.4 |

**Analysis Scenario 3 - Summary Results for Total Discharge within Hurricane Creek (acre-feet)**

| Hurricane Creek | Pre-development Conditions | Post-development Conditions | Change (%) |
|---|---|---|---|
| Upstream | 1486 | 1486 | 0 |
| Downstream | 1,579 | 1,585 | 0.4 |

Above results for HEC-HMS modeling presented in Appendix 2-D.

Review of the HEC-HMS Hurricane Creek input parameters and output results indicates the following:

- The combined peak discharge rates for the IDP's into Hurricane Creek are reduced for the post-development conditions when compared to the pre-development conditions.
- The combined total discharge rates for the IDP's into Hurricane Creek are reduced for the post-development conditions when compared to the pre-development conditions.

- Pre-development time of concentration (Tc) values for discharge entering Hurricane Creek from the EDA and EWDA range from 4.5 to 52 minutes, with the majority of flow into Hurricane Creek having a Tc value of 25 minutes or less.
- Post-development time of concentration (Tc) values for discharge entering Hurricane Creek from the EDA and EWDA range from 4.3 to 42.4 minutes, with the majority of flow into Hurricane Creek having a Tc value of 20 minutes or less.
- With a back-calculated Tc value for Hurricane Creek of 113 minutes (based on a lag time of 68 minutes (from the calibration model), and based on the relationship of T(lag) = 0.6Tc), and based on the Tc information summarized above, it can be concluded that the timeframe for development of the peak discharge onto the Facility property from upstream Hurricane Creek (Tc = 113 minutes) is greater than the time of concentration for flow from the individual IDP's into Hurricane Creek by 70 minutes or more, resulting in the peak flow into Hurricane Creek from the upstream basin entering the on-site creek channel after peak flows from the IDP's have discharged to the downstream West Fork Trinity River.

The above analyses results demonstrate that the proposed post-development improvements do not negatively impact existing surface water drainage patterns both upstream and downstream of the Facility property.

# 5.0 WEST FORK TRINITY RIVER FLOODPLAIN AND FLOODWAY DEMONSTRATION

## 5.1 East Disposal Area (EDA)

Portions of the Facility property adjacent to the EDA are located within the 100-year floodplain, as identified on the existing Federal Emergency Management Agency ("FEMA") Flood Insurance Rate Maps ("FIRMs") (Map No. 48439C0240K, Effective Date: September 25, 2009). A Letter of Map Amendment was submitted to FEMA on behalf of the City of Arlington, and was approved by FEMA on September 23, 2008, which removed the future area of landfilling within the EDA from the 100-year floodplain. A copy of the approved LOMA, including the revised FIRM, is included as Appendix I/II.C-2. Areas remaining within the floodplain (on the LOMA-revised FIRM) are not subject to future landfilling.

Solid waste disposal operations at the EDA will not occur within the 100-year floodway, as defined by FEMA. Filling shall not be conducted within the 100-year floodplain, and Facility operations shall not result in a reduction of temporary water storage capacity within the floodplain, or restriction of the 100-year flood.

## 5.2 Expanded West Disposal Area (EWDA)

The EWDA is proposed to be constructed within areas currently shown on the FEMA FIRM as being within the 100-year floodplain and floodway of the West Fork Trinity River. Two Conditional Letter of Map Revisions (CLOMRs) were submitted to FEMA to remove the area of future landfilling from within the floodway/floodplain by the construction of levees. Copies of the CLOMR applications, correspondence, and approval letters will be maintained at the Facility within the site operating record. Copies of the CLOMR approval letters are included in Appendix I/II.C-3.

As set forth in the CLOMRs, the EWDA levee system will be constructed in two phases, which will remove the interior property from the 100-year floodplain/floodway. As set forth in the CLOMRs, the levee and supporting facilities (e.g., adjacent flood and stormwater detention basins) will be constructed and approved by FEMA by Letter of Map Revision (LOMR) prior to landfilling within the levee interior.

Solid waste disposal operations at the EWDA will not occur within the 100-year floodway, as defined by FEMA. Waste disposal shall not be conducted within the 100-year floodplain, and Facility operations shall not result in a reduction of temporary water storage capacity within the floodplain, or restriction of the 100-year flood, as demonstrated within the current CLOMR supporting calculations.

### 5.2.1 Levee Design Features

The following features have been incorporated into the levee designs set forth in the approved CLOMR:

- Designed such that no off-site stormwater or floodwaters are routed into or through the interior of the levee.
- 4H:1V exterior (flood side) slopes, and 3H:1V (landfill side) slopes.
- Minimum 3 foot freeboard for the 100-year (1 percent chance) flood.
- Grass slope protection for the levee exterior to address overbank velocities ranging from 0.97 to 3.51 feet per second.

Design and construction features are described in the report titled "Geotechnical Report and Operation Plans for Sequence 1 and Sequence 2 Conditional Letter of Map Revision", dated July 2010. This report was submitted to FEMA in response to comments received from review of the CLOMR application, and is a component of the approved CLOMR.

### 5.2.2 Basin Design Features

The following features will be incorporated into the East and West Basins, as described in the 404 permit application:

- Designed with 3H:1V and 4H:1V sideslopes.
- Vegetated with recreated native wetlands and uplands plantings.
- Generally flat bottoms to promote localized shallow ponding and habitat development.
- Outlet structures that facilitate controlled discharge from the basins into the West Fork Trinity River. Outlet structures are described in previous sections of this attachment.

The East Basin will be constructed in an area of historic waste filling. The limits of previous waste filling are generally assumed to be limited to the area immediately south of the WDA, between the WDA and the south perimeter road. The depth of historic fill also is unknown, although it is assumed that waste is generally less than 15 feet in depth in this area. The historic fill area presently is covered with soil and vegetated.

Prior to excavation and relocation, the waste will be characterized (by field investigations) to demonstrate its suitability for disposal into the landfill. Additionally, visual observations of waste during removal will confirm the suitability of the waste for disposal into the landfill. Soil and other inert materials will be separated during excavations, and used for on-site earth construction, or used for daily or intermediate cover soils.

All work will be performed in accordance with the Erosion and Sedimentation Control Plan presented in this attachment. Additionally, the site-specific SWPPP shall be modified prior to waste excavation and relocation to address erosion protection measures to be incorporated

during the construction. A copy of the revised SWPPP shall be maintained within the site operating record.

# 6.0 EROSION AND SEDIMENTATION CONTROL PLAN

## 6.1 Introduction

This Erosion and Sedimentation Control Plan (Plan) was prepared in compliance with the requirements of 30 TAC §330, Subchapter G (effective March 27, 2006). The Plan sets forth the methods used to reduce the transport of solids off site. This Plan previously was submitted to the TCEQ for the City of Arlington Landfill and approved as a "no notice" permit modification as specified in §330.301 and in accordance with 30 TAC §305.70(d) and §305.70(l). The Plan has been updated for this permit amendment, including modification of the previous erosion calculations to incorporate the longer slope lengths associated with the permit amendment.

Specifically, this Plan is designed to comply with the requirements of §330.305(d) to provide effective erosional stability to top deck surfaces and external embankment and landfill sideslopes during applicable interim phases of landfill construction.

The draft document titled "Guidance For Addressing Erosional Stability During All Phases of Landfill Operation" as provided by TCEQ (February 14, 2007), provides the following clarification for compliance with §330.305(d):

- Phases of landfill operation include daily cover, intermediate cover, and final cover.
- Top deck and external embankment sideslopes include slopes meeting all of the following conditions:
  - above grade,
  - drain directly to the roadway toe ditch, site perimeter discharge points, or detention basins,
  - have received intermediate or final cover, and
  - have either reached permitted elevation or will subsequently remain inactive for longer than 180 days.

This Plan addresses erosion control structures for intermediate cover on top deck and external sideslopes that meet the above criteria. The erosion controls will fall in one (or more) of three categories:

1. Class 1 controls include surface vegetation and any other controls that will be needed over the life of the intermediate cover and will be maintained until construction of final cover in that area commences.

2. Class 2 controls include temporary controls that will be installed as specified later in this Plan where required to protect the seed bed and control surface erosion until vegetation is established.

3. Class 3 controls are those controls that will be used in isolated areas until the Class 1 controls are proven to satisfactorily control erosion. These areas are difficult to predict until the Class 1 controls are in place, and their use will be based on the performance of the Class 1 controls. The landfill manager will select the appropriate Class 3 control(s) based on area, degree of erosion, and experience.

The plan addresses two distinct areas of landfilling:

- The currently active East Disposal Area (EDA), and
- The Expanded West Disposal Area (EWDA), which is comprised of the vertical and lateral expansion of the previously closed West Disposal Area.

Fill sequencing plans for both the EDA and EWDA are presented in Parts I/II of this permit amendment.

This Plan does not address landfill slopes with daily cover or soil stockpiles. The Best Management Practices (BMPs) included within the landfill's Storm Water Pollution Prevention Plan (SWPPP) will apply to these temporary slopes. Erosion protection for final cover with completed drainage structures is also not within the scope of this Plan. The final landfill condition (including final cover, installation of structural drainage controls, and establishment of surface vegetation) is addressed in Attachment 7 of this permit amendment.

Consistent with the BMPs set forth in the SWPPP, run-off entering the excavations for cell construction will be contained and allowed to evaporate or used for dust control. Therefore, run-off from interior interim waste slopes or excavation sideslopes does not present a potential for transport of solids off site. Stormwater contacting the exterior slopes of the landfill travels in grass-lined swales and by sheet flow to one of several discharge points existing at the Facility. Discharge points include Hurricane Creek (which separates the EDA and the previously closed WDA), the West Fork Trinity River, or one of several discharge points along the Facility's eastern property boundary.

## 6.2 Site Conditions

### 6.2.1 Top Deck Surfaces without Final Cover

Top deck surfaces will be relative flat (ranging from 4 to 5 percent) and therefore not subject to significant erosion. The maximum top slope flow length typically will not exceed 800 feet for interim conditions. A maximum slope length value of 800 feet was used for the demonstration of interim erosion control.

### 6.2.2 Exterior Waste Fill Slopes without Final Cover

Exterior waste fill slopes will be constructed to approximately 4H:1V grades or flatter, and will vary in length as the individual sector cells are developed. The maximum sideslope height will

be approximately 350 feet and incorporate interim sideslope surface water diversion berms, as described in Appendix 2-I.

### 6.2.3 Drainage Outlets and Discharge Points

The Facility has been designed with drainage features that collect and convey stormwater run-off away from the property. Sideslope diversion channels, perimeter channels, detention basins, and surface features are generally grass-lined or vegetated, and will periodically be cleaned of accumulated silt and soil, and maintained to further reduce transport of solids off-property. Overland surface flow generally drains towards Hurricane Creek, towards the eastern Facility property boundary of the Facility, or towards the floodplain/floodway areas located between the landfill and the West Fork Trinity River.

### 6.2.4 Weather Conditions

The City of Arlington Landfill is located in North Central Texas and experiences an average annual rainfall of approximately 32 inches. The peak 2-year and 5-year, 24 hour storm events are 3.9 and 5.3 inches of precipitation, respectively.

### 6.2.5 Soil Conditions

The soils at the site consist of Silawa fine sandy loams and Pulexas fine sandy loams with some Trinity clay, silty clay loams, sandy clay, and clay. Additionally, imported soil from excavations in the Arlington area is also stockpiled on site for use in cell construction and cover soil. The imported soils could range from Woodbine sandy soil to fat clay of the Eagle Ford Shale Formation. Therefore, the intermediate cover may range in texture from sandy or silty clay loams to sandy clay to clay.

## 6.3 Erosional Stability Analysis

### 6.3.1 Methodology

The external sideslopes and spacing of the sideslope surface water diversion berms varies in length from the EDA to the EWDA. Therefore, worst case conditions for top slope and sideslope were identified for each area. The analysis and subsequent control designs will be based on worst case conditions for each area. The following analysis procedures were utilized:

- Select combination of longest/steepest sideslope and top slope drainage length.
- Calculate overland flow quantity for the top slope and sideslope segments for a unit slope width.
- Calculate flow depth and flow velocity for each segment.
- Compare the calculated flow velocity with the maximum acceptable flow velocity for the appropriate condition. Soils will be assumed to be clayey or have a clay component. Surface vegetation (i.e., grass) is required for intermediate cover; therefore, the

acceptable velocity will be based on a vegetated slope. For this plan an allowable overland flow velocity of 5 fps (clayey soils with vegetation) will be used.

- If the overland flow velocity for slopes with a minimum of 60% vegetation exceeds 3.5 fps for sands or 5 fps for clays, select controls that will effectively reduce the slope length and flow velocity.
- Calculate soil loss and compare the calculated loss with the maximum allowable value of 50 tons/acre/year.
- If soil loss exceeds the allowable value, provide better ground cover or add controls to reduce the effective slope length until the calculated loss is less than the maximum allowable loss of 50 tons/acre/year.
- Design controls if applicable.

### 6.3.2 Erosional Soil Loss Results

The erosional soil loss calculations for interim conditions are presented in Appendix 2-I. As demonstrated in the calculations, the interim cover conditions are below the erosion loss criteria described in the respective appendices.

## 6.4 Erosional Stability Controls

### 6.4.1 General

The following controls are considered appropriate for protecting the intermediate cover on exterior slopes against erosion:

Class 1 Controls are controls that are required to protect the cover from erosion until the final cover construction commences.

- Surface Vegetation

Class 2 Controls are controls that are required to protect the seed bed and control surface erosion until vegetation is established and include one or a combination of the following:

- Mulch
- Erosion Control Bales
- Erosion Control Blanket

Class 3 Controls are controls that will be used where needed to control erosion in isolated or difficult areas where vegetation proves to be insufficient, and may include one or a combination of the following:

- Mulch
- Erosion Control Bales
- Erosion Control Blankets

- Silt Fences
- Compost socks or similar products
- Interim diversion swales or berms
- Interim let-down structures, lined with polyethylene or chlorosulfanated polyethylene
- Alternate ground cover materials comprised of stone, recycled concrete, or other non-degradable construction demolition debris (brick, concrete, masonry)

Typical BMP products for erosion control are presented in Appendix 2-K

### 6.4.2 Soil Surface Protection

Class 1 protection of soil surfaces from erosion by wind and surface water run-off will be provided by seeding to establish surface vegetation. A vegetative cover of at least 60 percent will be established within 180 days of completion of intermediate cover for the area. Class 2 controls will be provided to protect the soil/seed bed until a minimum of 60 percent coverage of surface vegetation is established for the area. Maintain surface vegetation in an area until the surface is stripped for final cover construction.

The types of seed used will be dependent on the planting season and local experience. Seed mixtures in pounds of pure live seed per acre (pls) taken from the TxDOT Standard Specifications for Construction of Highways, Streets, and Bridges and the USDA Soil Conservation Publication in pounds of commercial seed per acre are provided for reference. Other seed types or mixtures and application rates may be used, depending on planting season and local experience.

Warm season planting, February 1 – May 1:

- Green Sprangletop – 1.1 pounds/acre pure live seed (pls)
- K-R Bluestem – 1.3 pounds/acre (pls)
- Bermuda grass – 0.9 pounds/acre (pls) or 8 pounds/acre commercial seed
- Switch grass – 1.4 pounds/acre (pls) or 7 pounds/acre commercial seed
- Buffalo grass – 32 pounds/acre commercial seed

Cool season planting, August 15 – November 30

- Tall Fescue – 4.0 pounds/acre (pls)
- Western Wheatgrass – 5.0 pounds/acre (pls)
- Wheat (Red, Winter) – 30 pounds/acre (pls)
- Rye grass – 30 pounds/acre commercial seed

## 6.5 Mulch, Erosion Control Bales, and Erosion Control Blankets

Class 2 protection of the soil/seed bed until vegetation is established will be provided as needed by mulch, erosion control bales, or erosion control blankets. The Class 2 controls will be

installed within 7 days after the seed has been applied. After an area has established vegetation of at least 60 percent surface coverage, the Class 2 control(s) will no longer be required but they may be left in place until the material degrades or until final cover construction commences. As noted above, the Class 2 controls are also an option for use as Class 3 protection.

### 6.5.1 Mulch

Mulch will generally consist of dry straw, ground wood chips, or other approved mulching materials. Mulch will protect the seed bed and soil from rainfall and erosion due to wind and run-off. Additionally, mulch will assist in maintaining soil moisture and promote seed germination. The mulch will be applied at a rate of approximately 1 ton per acre for wood chips to 2 tons per acre for straw after seed bed preparation and seed application. Mulch should be evenly spread over the intermediate cover area by mechanical or blower-type spreading equipment leaving approximately 25 percent of the ground surface visible. Typically wood chips will not need anchoring, but straw and most other types of mulch will need some type of anchoring. Anchoring will be provided by disking (disk weighted and set nearly straight), mulch netting, peg and twine, or other approved procedures consistent with the type of mulch used, location (top slope or sideslope), and duration mulch will be needed.

### 6.5.2 Erosion Control Bales

Erosion control bales will consist of local grasses or straw that has been baled. The bales will be positioned end to end on top of the intermediate cover and oriented perpendicular to the slope direction (cross slope). Erosion control bales have proven to be effective in controlling erosion by filtering out solids and protecting the seed bed by reducing flow velocity. The bales may vary in size due to the equipment used to make the bales; however, the minimum height and width will be at least one foot.

### 6.5.3 Erosion Control Blankets

A degradable erosion control blanket may also be used for soil/seed bed protection. Products used for seed bed protection until vegetation is established should be rated not to degrade for at least 6 to 9 months and contain a minimum of 0.5 pounds per square yard of straw fiber or other suitable material. The erosion control blankets will be installed and anchored consistent with the manufacturer's recommendations. Typically the blankets will be rolled out in the down slope direction and anchored by staples or staked and seams will be stitched.

### 6.5.4 Silt Fences

Silt fences or fabric filter fences are a Class 3 control and may be used on slopes for localized erosion control and at the toe of slopes to reduce transport of solids away from the slope and at the inlet to outfalls or channels to reduce solids transport off site. The fences will be installed consistent with the manufacturer's recommendations but, where installed on intermediate cover slopes, the spacing will be not greater than 0.5 acre per 100 feet of fence.

### 6.5.5 Sediment Filters

Sediment filters are an option as a Class 3 control in localized areas of persistent erosion. Typically sediment filters are provided by the installation of straw, compost, or mulch encapsulated by a netting or permeable fabric (e.g., compost socks) and designed to allow run-off to pass through the roll but retain or trap sediment. The sediment trap should be a minimum of 9 inches in diameter. The rolls will be installed perpendicular to the slope direction (cross slope) in a trench approximately 3 inches deep. Installation shall be as recommended by the manufacturer, but typically the traps will be stapled or staked at approximately 1-foot intervals.

### 6.5.6 Swales/Berms

Calculations presented in Appendix 2-I incorporated the use of interim sideslope diversion berms at approximate 350-foot spacing for interim conditions. Interim berms will be constructed with 4H:1V slopes on the landfill side, and 3H:1V slopes on the berm side of the swale. Berm depths shall be estimated at the time of installation based on contributing area, assuming a freeboard depth of 1 foot and a maximum velocity of 5 feet per second for vegetated conditions. Site/location specific designs may be used to support greater slope length/swale lengths. When no longer required to control erosion, swales may be removed or bladed off or left in place until construction of final cover commences.

### 6.5.7 Temporary Downchutes or Let-down Structures

Temporary downchutes or let-down structures will be required to move water from the interim sideslope swales to the toe of the landfill. Temporary downchutes or let-down structures may consist of:

- Corrugated PE pipes installed on the intermediate cover and anchored with hold-down stakes at approximate 10-foot spacing or additional cover soil. An 18-inch pipe will accommodate approximately 600 lineal feet of swale.
- Open channels (downchutes) lined with suitable permanent turf reinforcement mat with sod or topsoil and seeding, installed on the intermediate cover in accordance with the manufacturer's recommendations. Open channels (downchutes) lined with geomembrane, stone, recycled concrete, or other non-degradable construction demolition debris (e.g., brick, concrete, masonry)

Let-down structures are considered Class 3 controls (as are the swales) since they are not designed as part of the Class 1 required controls for the intermediate cover. Thus, the let-down structures may be removed or otherwise taken out of service if the swales are no longer being used. Energy dissipation, such as riprap, concrete rubble, or other non-degradable construction demolition debris (e.g., brick, concrete, masonry) may be required at the toe of the downchutes.

## 6.6 Summary of Erosion Stability Controls

Based on the results of this analysis and the landfill operator's site experience, the following controls have been selected:

- Erosion control schedule
  - Seed as soon as practicable after cover placement in an area.
  - Install Class 2 controls within 7 days after seed application (weather permitting).
  - Establish a minimum of 60 percent vegetation coverage within 180 days of completion of intermediate cover.
  - Maintain surface vegetation until construction of final cover commences when the surface is stripped and prepared for infiltration layer construction.
  - Maintain Class 2 controls until the minimum required surface vegetation is established.

- Class 1 controls will be maintained until construction of final cover commences in the area. Applying seed to the intermediate cover with a goal of establishing at least 60 percent ground cover within 180 days of intermediate cover completion is the required Class 1 control.
- Class 2 controls are required to protect the exposed soil and seed bed and will be installed within 7 days of seed application in an area. Erosion control bales, mulch, or degradable erosion control blankets will be used as Class 2 controls to enhance the establishment of grass and for temporary soil erosion protection. The Class 2 controls are not required after at least 60 percent vegetation is established in an area and can either be removed or remain in place until they deteriorate and degrade or until the final cover is constructed.
- Class 3 controls are used on an interim basis for isolated areas of persistent erosion and shall remain in use as long as needed to control erosion or protect the soil surface in an area or until construction of final cover commences in that area.
- Silt fences, erosion control bales, mulch, erosion control blankets, or compost filter socks may be used in isolated areas of persistent erosion or at the toe of slopes as needed to control transport of solids from the slopes (Class 3 controls).
- Primary erosion control is on the slopes. However, silt fences, erosion control bales, or other suitable Class 3 controls will be installed at the inlets to channels or site outfalls for further control of transport of solids off site.

## 6.7 INSPECTION AND MAINTENANCE

### 6.7.1 General

In order to maintain an effective system of erosion control, periodic inspection and maintenance will be required.

### 6.7.2 Inspections

- The intermediate cover and controls will be inspected monthly consistent with the requirements established in the SOP.
- Channels will be observed for silting or blockage that will interfere with water flow.
- Verify erosion control bales, silt fences, or other selected controls are positioned and functioning as intended at the channel inlets or site outfalls.
- Cover inspections (including the intermediate cover and interim controls addressed in this plan), conditions noted, and any corrective action will be documented in the cover inspection record.

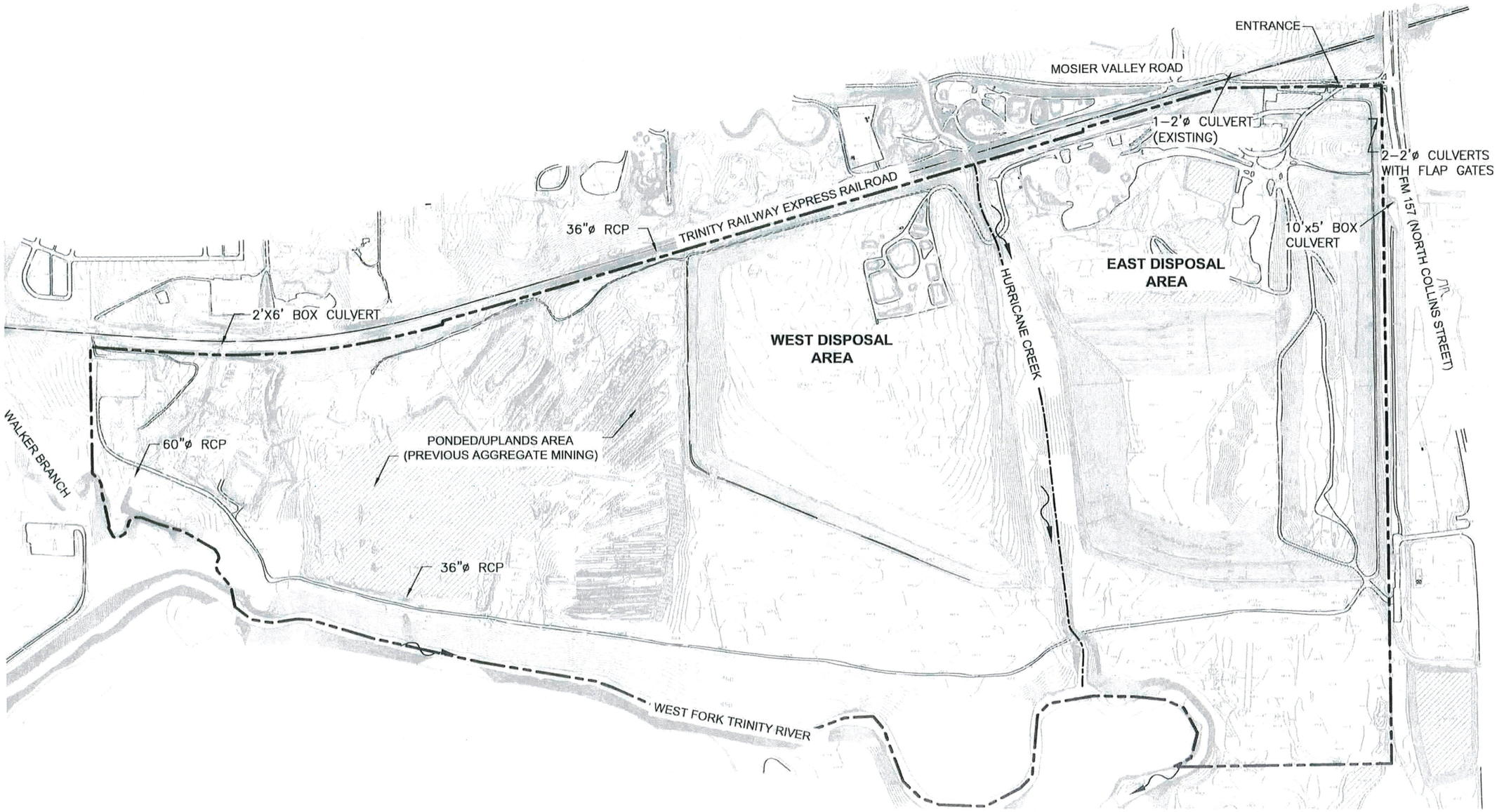
### 6.7.3 Maintenance and Repairs

- If erosion rills or gullies deeper than approximately 4 inches develop, additional cover soil will be placed and the area, reseeded, and covered with mulch or protected by erosion control bales (or other Class 2 controls) as soon as practicable but not later than five days after detection.
- Replace or reposition damaged or shifted erosion control bales, washed out mulch, or other damaged Class 2 controls as needed to protect the soil/seed bed until vegetation coverage is achieved.
- Silt fences, compost socks, mulch, erosion control blankets, or other best management practices will be utilized for localized areas of persistent erosion until vegetation is established.

  - Silt fences serve the predominant function of filtering solids and reducing the transport of solids off site.
  - Compost socks will filter out solids and effectively reduce the flow velocity.
  - Mulch will protect the soil surface from wind and rain and assist in soil moisture retention promoting seed growth.

- Replace or reconstruct berms and swales that are damaged by run-off and still required for erosion control.
- Replace soil apron and where needed compact soil around the inlet to let-down structures that are damaged by run-off and are still required to drain active swales.
- Reinstall damaged silt fences, bales, or compost socks that have been installed at site outfalls or channel inlets.
- Clean accumulated soils from swales, downchutes, and channels on an as-necessary basis to maintain flow in the feature.

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## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

## LEGEND

PERMIT BOUNDARY

FLOW DIRECTION

800 0 800
SCALE FEET

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F–2578

PERMIT ISSUED



| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
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Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490–8770
Texas Registration Number: F–2578

CITY OF ARLINGTON, TEXAS

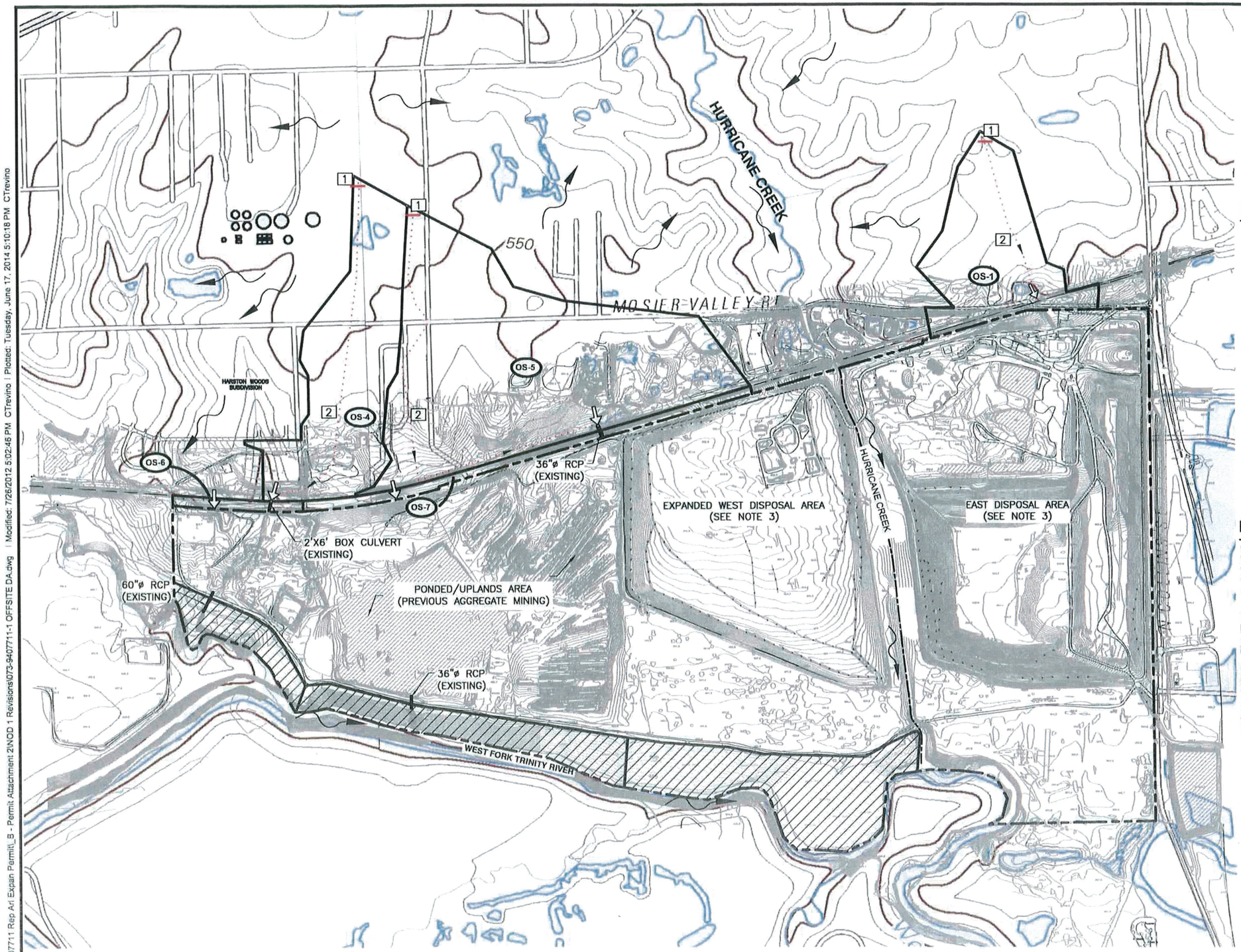
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: EXISTING CONDITIONS PLAN

| | |
|---|---|
| DRAWN TWM | REVIEWED DEP |
| CHECKED DJH/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711 EXIST.dwg |
| FIGURE NUMBER | PART III, ATT. 2 |
| | 2-1 |

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SCALE FEET

## LEGEND

- PERMIT BOUNDARY
- SUBBASIN BOUNDARY
- FLOW LINE FOR $T_C$ CALCULATION
- DRAINAGE PATH
- FLOW DIRECTION
- OS-4 — OFF-SITE DRAINAGE AREA DESIGNATION
- LOCATION OF SURFACE WATER ENTRY FROM OFF-SITE DRAINAGE AREAS
- [1] FLOW SEGMENT
- SUBBASIN AREA DISCHARGE UNCHANGED FROM PRE- TO POST-DEVELOPMENT CONDITIONS- NOT ANALYZED

## NOTES

1. USGS SOURCE: http://USGS.GOV -CONFORMS WITH VERSION 0.5.10 OF THE DRAFT USGS STANDARDS FOR 7.5 MINUTE QUADRANGLE MAPS : HURST QUADRANGLE, TARRANT COUNTY TEXAS, 2010, EULESS QUADRANGLE, TARRANT COUNTY TEXAS, 2010.

2. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

3. PRE AND POST DEVELOPMENT SURFACE DRAINAGE AREAS FOR EAST DISPOSAL AREA SHOWN ON FIGURES 2-5 AND 2-6, RESPECTIVELY. PRE AND POST DEVELOPMENT SURFACE DRAINAGE AREAS FOR EXPANDED WEST DISPOSAL AREA SHOWN ON FIGURES 2-7 AND 2-8, RESPECTIVELY.

PERMIT ISSUED

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-23-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

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Texas Registration Number: F-2578

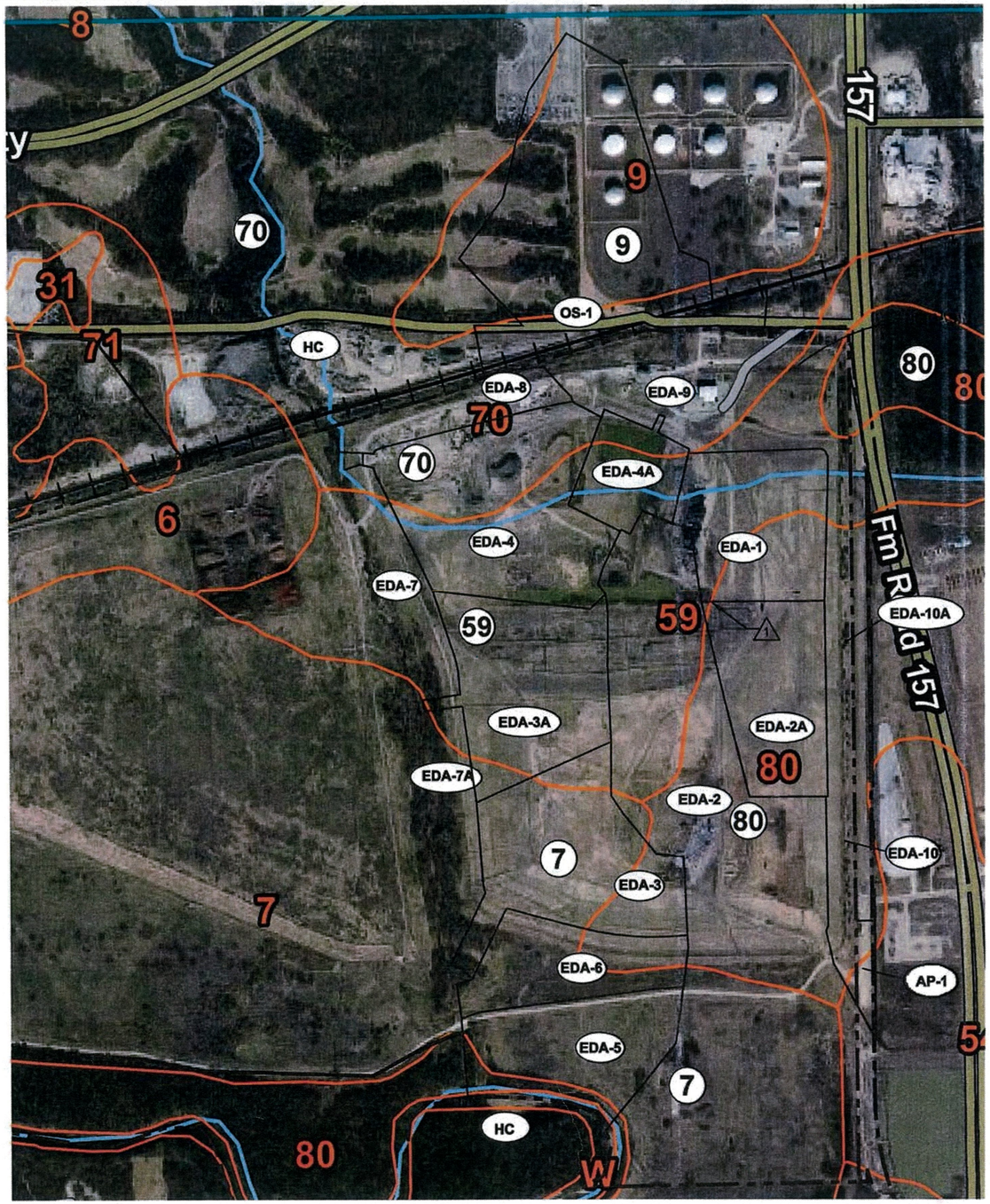
CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: OFF-SITE DRAINAGE AREAS

| | |
|---|---|
| DRAWN | TWM |
| CHECKED | DML/CMT |
| REVIEWED | DEP |
| APPROVED | DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-1 OFFSITE 0 |
| FIGURE NUMBER | |

PART III, ATT. 2
2-2




## SOIL SURFACE DESCRIPTION

- 6 — AQUILLA LOAMY FINE SAND, SOIL TYPE A
- 7 — ARENTS, FREQUENT FLOOD, SOIL TYPE A
- 9 — BASTSIL FINE SANY LOAM, SOIL TYPE B
- 59 — PULEXAS FINE SANDY LOAM, FREQUENT FLOOD, SOIL TYPE A
- 70 — SILAWA FINE SANDY LOAM, SOIL TYPE B
- 71 — SILSTID LOAMY FINE SAND, SOIL TYPE B
- 80 — TRINITY CLAY, FREQUENT FLOOD, SOIL TYPE D

N

0 400 800
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- POST-DEVELOPMENT SUBBASIN BOUNDARY
- OS-2 — POST-DEVELOPMENT DRAINAGE AREA DESIGNATION OFF-SITE
- EDA-2 — POST-DEVELOPMENT DRAINAGE AREA DESIGNATION ON-SITE
- △1 — INDICATES REVISION (SEE LIST OF REVISIONS BELOW)

LIST OF REVISIONS:

1. REVISED DRAINAGE AREAS.

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED PROFESSIONAL ENGINEER
12-18-19

NOTES:

1. ALL AREAS ASSUMED FAIR SOIL HYDROLOGICAL CONDITION.
2. SOIL MAP DOWNLOADED FROM ttp://websoilsurvey.nrcs.usda.gov. WEB SOIL SURVEY 2.0, NATIONAL COOPERATIVE SOIL SURVEY.

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 06/2014
FILE: 0023-404-11
CAD: 2-3 SOILS.DWG
DRAWN BY: RDM
DESIGN BY: RJS
REVIEWED BY: JAE

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| 1 | 03/2017 | PERMIT MODIFICATION |
| 2 | 12/2018 | SEE LIST OF REVISIONS |
| | | |

MAJOR PERMIT AMENDMENT
SOILS MAP-EDA

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE 2-3

0:\0023\404\LSMPA (2017)\ATT 2\2-3 SOIL E1.dwg, jwilson, 1:1




## SOIL SURFACE DESCRIPTION

| | |
|---|---|
| 6 | AQUILLA LOAMY FINE SAND<br>SOIL TYPE A |
| 7 | ARENTS, FREQUENTLY FLOODED<br>SOIL TYPE A |
| 8 | ARENTS, LOAMY<br>SOIL TYPE B |
| 9 | BASTSIL FINE SANDY LOAM<br>SOIL TYPE B |
| 31 | GASIL SANDY CLAY LOAM, GRADED<br>SOIL TYPE B |
| 59 | PULEXAS FINE SANDY LOAM,<br>FREQUENTLY FLOODED<br>SOIL TYPE A |
| 70 | SILAWA FINE SANDY LOAM<br>SOIL TYPE B |
| 71 | SILSTID LOAMY FINE SAND<br>SOIL TYPE B |

* EXISTING HISTORIC FILL AREA. SOIL TYPE B USED IN CALCULATIONS.

** EXISTING CLOSED LANDFILL AREA WITH CLAY FINAL COVER. SOIL TYPE C USED IN CALCULATIONS.

800 0 800
SCALE FEET

## NOTES

1. ALL AREAS ASSUMED FAIR SOIL HYDROLOGICAL CONDITION.
2. SOIL MAP DOWNLOADED FROM ttp://websoilsurvey.nrcs.usda.gov. WEB SOIL SURVEY 2.0, NATIONAL COOPERATIVE SOIL SURVEY.

## LEGEND

- PERMIT BOUNDARY
- PRE-DEVELOPMENT SUBBASIN BOUNDARY (WHITE)
- SOIL TYPE BOUNDARY (ORANGE)
- OS-2 — PRE-DEVELOPMENT DRAINAGE AREA DESIGNATION OFF-SITE
- PRE-2 — PRE-DEVELOPMENT DRAINAGE AREA DESIGNATION ON-SITE
- 6 — SOIL DESCRIPTION (WHITE)



PERMIT ISSUED

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS

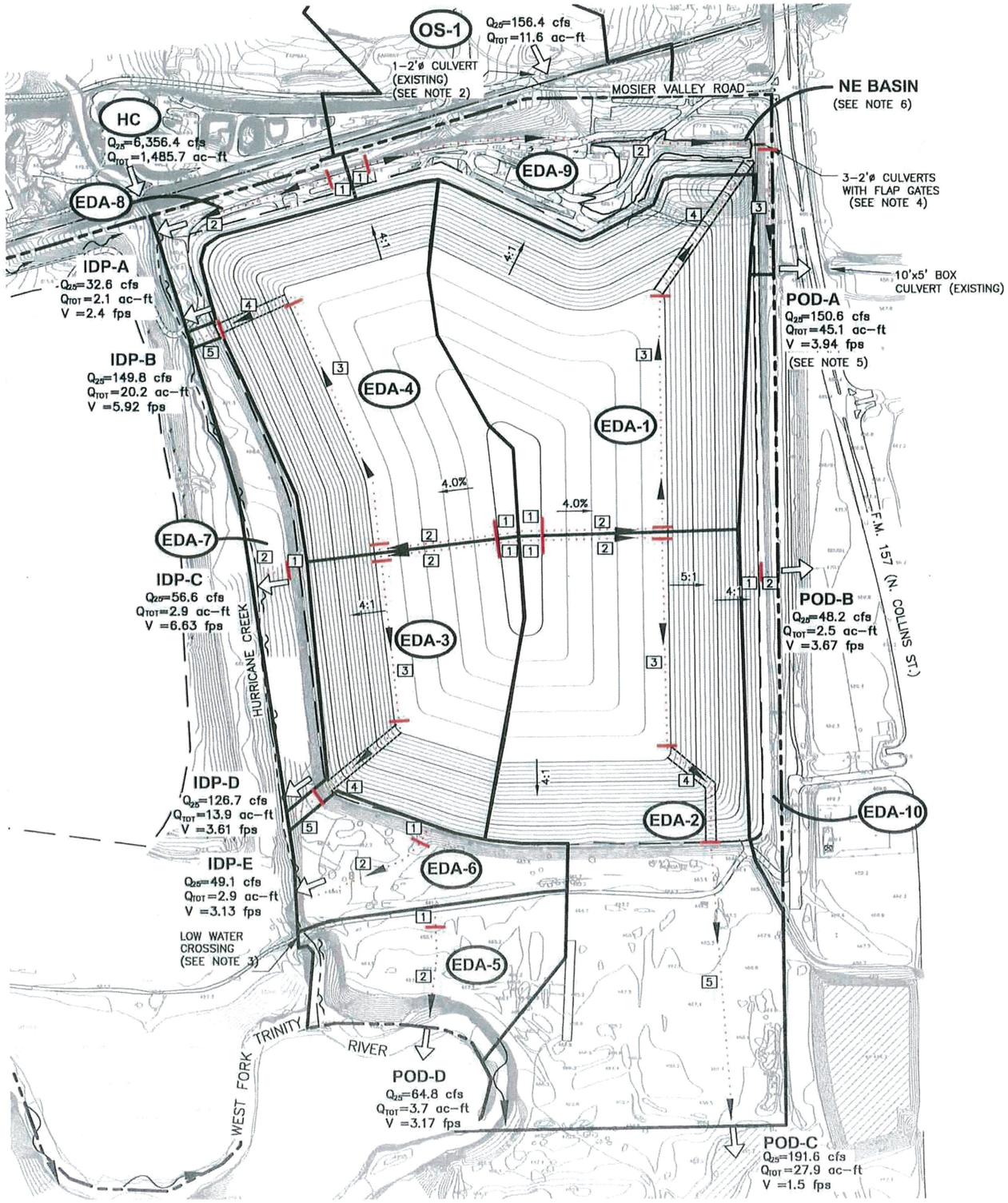
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: SOILS MAP - EWDA

| | |
|---|---|
| DRAWN | TWM |
| CHECKED | DML/CMT |
| REVISED | DEP |
| APPROVED | DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-16 SOIL W.dwg |
| FIGURE NUMBER | PART III, ATT. 2 |
| | 2-4 |

Drawing File: J:_2007\073-9407711 Rep Arl Expan Permit_B - Permit Attachment 2\073-9407711-16 SOIL W.dwg | Modified: 1/13/2012 3:15:10 PM CTrevino | Plotted: Tuesday, June 17, 2014 5:15:16 PM CTrevino




## LEGEND

- PERMIT BOUNDARY
- SUBBASIN BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- EDA-2 — PRE-DEVELOPMENT DRAINAGE AREA DESIGNATION
- LOCATION OF SURFACE WATER ENTRY OR EXIT FROM SITE
- POD-XX — POINT OF DEMONSTRATION
- $Q_{25}$=XX — 25-YEAR, 24-HOUR PEAK DISCHARGE (cfs)
- $Q_{TOT}$=XX — 25-YEAR, 24-HOUR TOTAL DISCHARGE (ac-ft)
- FLOW DIRECTION
- FLOW LINE FOR Tc CALCULATIONS
- HURRICANE CREEK
- PERIMETER ACCESS ROAD/LEVEE
- [1] FLOW SEGMENT

## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

2. THE EXISTING 2-FOOT DIAMETER CULVERT ALLOWS SURFACE WATER TO DRAIN BENEATH THE TRINITY RAILROAD EXPRESS RAILROAD EMBANKMENT. THE ESTIMATED UPSTREAM ROUTING CAPACITY OF THE CULVERT IS LESS THAN 0.5 ACRE-FEET, AFTER WHICH SURFACE WATER FLOWS (IN A DESIGN STORM EVENT) OVER THE TOP OF THE EMBANKMENT, AND ACROSS MOSIER VALLEY ROAD. AS THE TOTAL DISCHARGE FOR THE CONTRIBUTING AREA OF THE CULVERT IS GREATER THAN 7 ACRE-FEET, IT HAS BEEN ASSUMED FOR THE ANALYSIS THAT THE CULVERT ROUTING CAPACITY IS EXCEEDED FOR THE PEAK FLOW EVENT, AND SURFACE WATERS FLOW UNIMPEDED OVER THE TOP OF THE RAILROAD EMBANKMENT. THIS ASSUMPTION IS INCORPORATED INTO BOTH THE PRE- AND POST-DEVELOPMENT ANALYSES.

3. THE LOW-WATER CROSSING OVER HURRICANE CREEK PROVIDES RESTRICTED FLOW OF WATER DURING LOW WATER EVENTS. IT HAS BEEN CONSERVATIVELY ASSUMED THAT FOR A DESIGN STORM EVENT, THE VOLUME OF FLOW AT THE LOW WATER CROSSING WILL RESULT IN OVERTOPPING OF THE CROSSING, AND UNIMPEDED FLOW OF THE PEAK FLOW. THIS ASSUMPTION IS INCORPORATED INTO BOTH THE PRE- AND POST-DEVELOPMENT ANALYSES.

4. THE THREE 2-FOOT DIAMETER CULVERTS WERE ASSUMED TO BE UNDER INLET CONTROL FOR THE ANALYSIS, DUE TO THE SHORT (LESS THAN 60 MINUTES) TIME OF CONCENTRATION CALCULATED FOR THE CONTRIBUTING AREAS WHEN COMPARED TO THE TIME OF FLOOD DEVELOPMENT WITHIN THE WEST FORK TRINITY RIVER.

5. POD-A REPRESENTS THE LOCATION OF WATER FROM PROPERTY DISCHARGING INTO OFFSITE PERIMETER DITCH AND OFFISITE DOWNSTREAM 10'X5' BOX CULVERT.

6. DRAINAGE FEATURE "NE BASIN" IS NOT A DEFINED SURFACE WATER DETENTION BASIN, BUT INSTEAD REPRESENTS STORAGE IN THE LARGE DRAINAGE SWALE AND UPSTREAM OVERLAND PROPERTIES UNDER A PEAK STORM EVENT.

7. DISCHARGE VELOCITY VALUES OBTAINED FROM TIME OF CONCENTRATION CALCULATIONS PRESENTED IN EXHIBIT 2B-4

600 0 600
SCALE FEET

PERMIT ISSUED

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
2-24-14
DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|

Golder Associates
213 N. Oak St. 76262
Roanoke, Texas
Tel: (817) 490-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

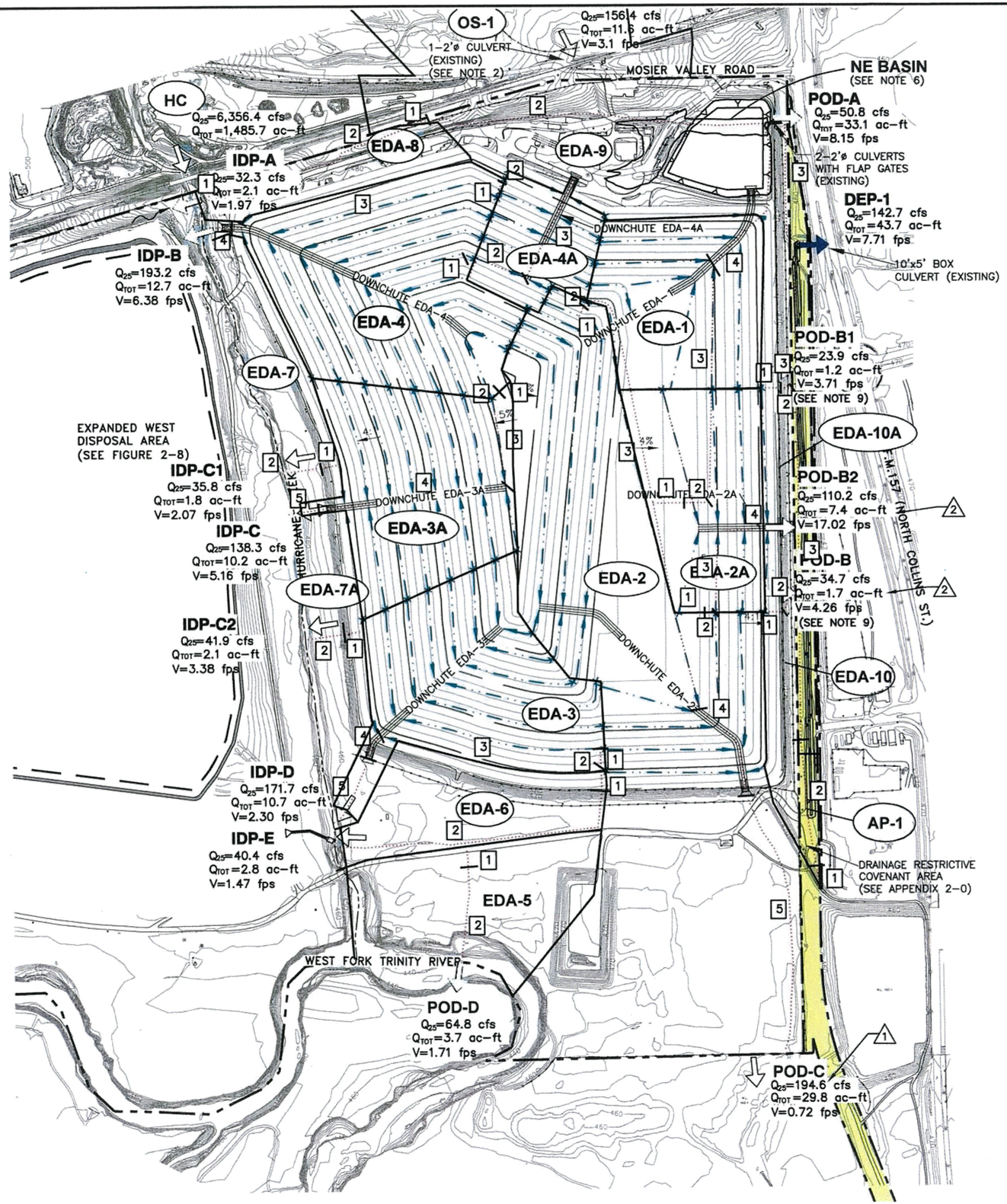
TITLE: PRE-DEVELOPMENT DRAINAGE PLAN - EDA

| | |
|---|---|
| DRAWN TWM | REVIEWED DEP |
| CHECKED DML/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-2A PRE Er1.dwg |
| FIGURE NUMBER | |

PART III, ATT. 2
2-5



Drawing File: J:_20071073-9407711 Rep Art Expan Permit_B - Permit Attachment 2\NOD 1 Revisions\073-9407711-2A PRE Er1.dwg | Modified: 8/10/2012 9:15:32 AM CTrevino | Plotted: Tuesday, June 17, 2014 5:28:28 PM CTrevino




NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-15-2016.

2. THE EXISTING 2-FOOT DIAMETER CULVERT ALLOWS SURFACE WATER TO DRAIN BENEATH THE TRINITY RAILROAD EXPRESS RAILROAD EMBANKMENT. THE ESTIMATED UPSTREAM ROUTING CAPACITY OF THE CULVERT IS LESS THAN 0.5 ACRE-FEET, AFTER WHICH SURFACE WATER FLOWS (IN A DESIGN STORM EVENT) OVER THE TOP OF THE EMBANKMENT, AND ACROSS MOSIER VALLEY ROAD. AS THE TOTAL DISCHARGE FOR THE CONTRIBUTING AREA OF THE CULVERT IS GREATER THAN 7 ACRE-FEET, IT HAS BEEN ASSUMED FOR THE ANALYSIS THAT THE CULVERT ROUTING CAPACITY IS EXCEEDED FOR THE PEAK FLOW EVENT, AND SURFACE WATERS FLOW UNIMPEDED OVER THE TOP OF THE RAILROAD EMBANKMENT. THIS ASSUMPTION IS INCORPORATED INTO BOTH THE PRE- AND POST-DEVELOPMENT ANALYSES.

3. THE LOW-WATER CROSSING OVER HURRICANE CREEK PROVIDES RESTRICTED FLOW OF WATER DURING LOW WATER EVENTS. IT HAS BEEN CONSERVATIVELY ASSUMED THAT FOR A DESIGN STORM EVENT, THE VOLUME OF FLOW AT THE LOW WATER CROSSING WILL RESULT IN OVERTOPPING OF THE CROSSING, AND UNIMPEDED FLOW OF THE PEAK FLOW. THIS ASSUMPTION IS INCORPORATED INTO BOTH THE PRE- AND POST-DEVELOPMENT ANALYSES.

4. THE THREE 2-FOOT DIAMETER CULVERTS WERE ASSUMED TO BE UNDER INLET CONTROL FOR THE ANALYSIS, DUE TO THE SHORT (LESS THAN 60 MINUTES) TIME OF CONCENTRATION CALCULATED FOR THE CONTRIBUTING AREAS WHEN COMPARED TO THE TIME OF FLOOD DEVELOPMENT WITHIN THE WEST FORK TRINITY RIVER.

5. DEP-1 REPRESENTS DISCHARGE OFFSITE FROM THE CITY OF ARLINGTON PROPERTY THROUGH THE 10'X5' BOX CULVERT, WHICH DRAINS TO EAST, UNDER FM 157.

6. DRAINAGE FEATURE "NE BASIN" IS NOT A DEFINED SURFACE WATER DETENTION BASIN, BUT INSTEAD REPRESENTS STORAGE IN THE LARGE DRAINAGE SWALE AND UPSTREAM OVERLAND PROPERTIES UNDER A PEAK STORM EVENT.

7. FLOW LINES SHOWN PARALLEL TO DOWNCHUTES FOR CLARITY ONLY.

8. DISCHARGE VELOCITY VALUES OBTAINED FROM TIME OF CONCENTRATION CALCULATIONS PRESENTED IN EXHIBIT 2B-4.

9. VELOCITY OF 4.92 AND 5.0 FPS AT POD-B AND POD-B1 REPRESENTS WATER FLOWING DOWN A SHORT SLOPE SEGMENT INTO AN OFF-SITE DRAINAGE FEATURE. ALTHOUGH REPRESENTED AS A POINT FLOW FOR THE ANALYSIS, THE ACTUAL FLOW IS DISTRIBUTED ACROSS A WIDE DRAINAGE SUBBASIN. THE LENGTH OF FLOW IS REDUCED FOR THE FINAL DESIGN BY THE INSTALLATION OF SIDESLOPE DIVERSION BERMS ON THE LANDFILL SIDESLOPE, UPSTREAM OF POD-B AND POD-B1. THE EARTHEN SLOPE AT POD-B AND POD-B1 IS EXISTING, AND HAS DEMONSTRATED ACCEPTABLE EROSION PROTECTION FROM ESTABLISHED AND MAINTAINED VEGETATION.

10. CHANNEL 1 IS AND EXISTING CHANNEL WITH AN APPROXIMATE BOTTOM WIDTH OF 100 FEET AND A SLOPE OF APPROXIMATELY 0.2% FROM SOUTH TO NORTH. DETAILS OF THE CHANNEL ARE INCLUDED ON FIGURES 2-19A AND 2-19B.

11. EROSION CONTROL DEVICES (e.g. TURF REINFORCEMENT MAT, GABIONS, OR RIPRAP WILL BE INSTALLED IN AREAS WHERE VELOCITIES ARE GREATER THAN 5 fps.

N

0 300 600
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- SUBBASIN BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- EDA-2 — POST-DEVELOPMENT DRAINAGE AREA DESIGNATION
- LOCATION OF SURFACE WATER ENTRY OR EXIT FROM SITE
- LOCATION OF SURFACE WATER EXIT FROM ARLINGTON PROPERTY AT DOWNSTREAM EVALUATION POINT.
- POD-XX — POINT OF DEMONSTRATION
- DEP-XX — DOWNSTREAM EVALUATION POINT
- $Q_{25}$=XX — 25-YEAR, 24-HOUR PEAK DISCHARGE (cfs)
- $Q_{TOT}$=XX — 25-YEAR, 24-HOUR TOTAL DISCHARGE (ac-ft)
- FLOW DIRECTION
- FLOW LINE FOR Tc CALCULATIONS
- HURRICANE CREEK
- PERIMETER ACCESS ROAD/LEVEE
- 1 — FLOW SEGMENT
- CHANNEL 1
- DRAINAGE RESTRICTIVE COVENANT AREA
- 1 — INDICATES REVISION (SEE LIST OF REVISIONS BELOW)

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED PROFESSIONAL ENGINEER
5.22.19

LIST OF REVISIONS:

1. UPDATED 25-YEAR FLOOD RATE.
2. UPDATED 25-YEAR DRAINAGE VOLUME.

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 06/2014
FILE: 0023-404-11
CAD: 2-6.DWG
DRAWN BY: JDW
DESIGN BY: RJS
REVIEWED BY: JAE

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| 1 | 03/2017 | PERMIT MODIFICATION |
| 2 | 05/2019 | SEE LIST OF REVISIONS |

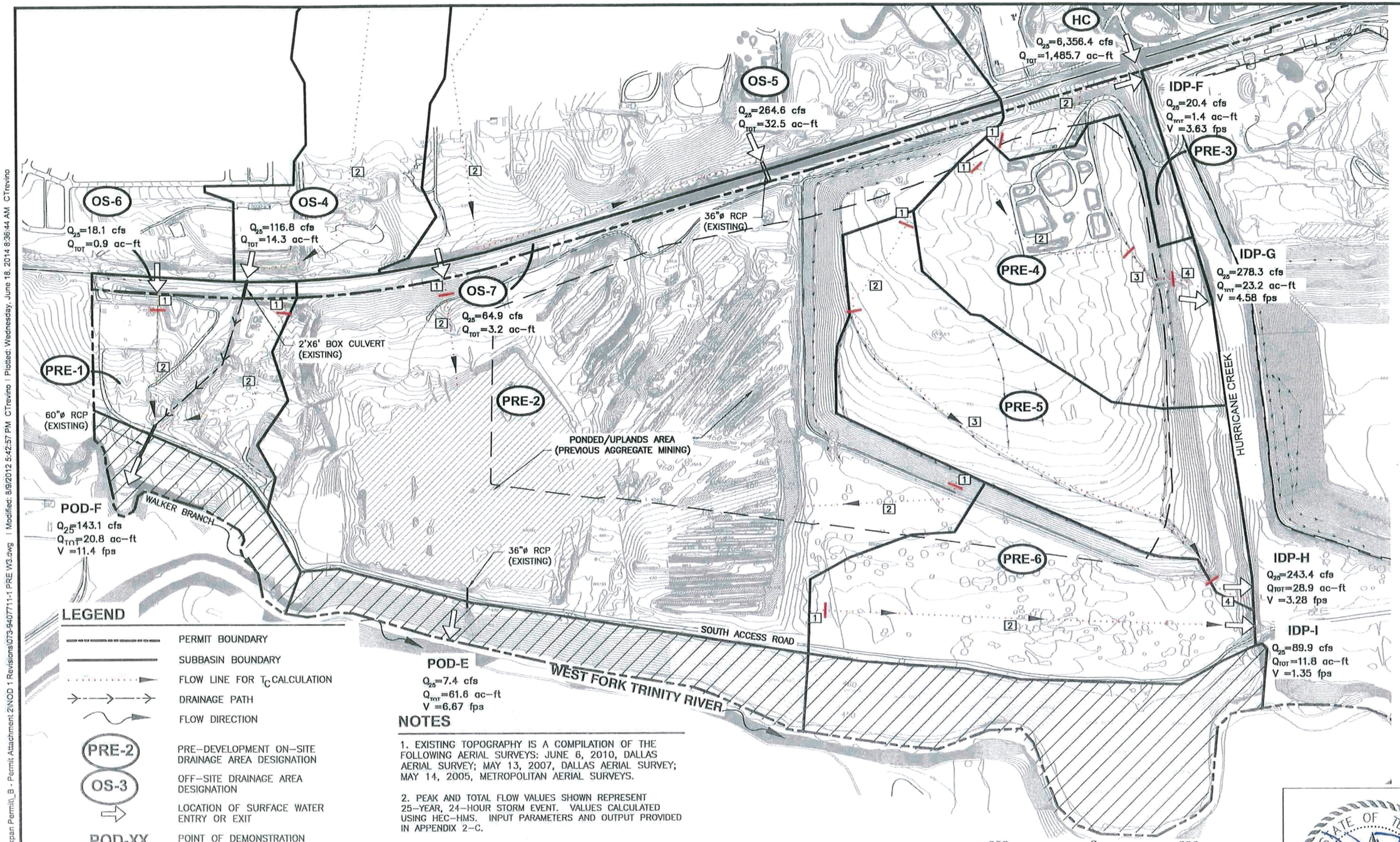
# MAJOR PERMIT AMENDMENT POST-DEVELOPMENT DRAINAGE PLAN-EDA

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE 2-6

O:\0023\404\LSMPA (2017)\ATT 2\2-6.dwg, sford, 1:2




## LEGEND

- PERMIT BOUNDARY
- SUBBASIN BOUNDARY
- FLOW LINE FOR $T_C$ CALCULATION
- DRAINAGE PATH
- FLOW DIRECTION
- PRE-2 — PRE-DEVELOPMENT ON-SITE DRAINAGE AREA DESIGNATION
- OS-3 — OFF-SITE DRAINAGE AREA DESIGNATION
- LOCATION OF SURFACE WATER ENTRY OR EXIT
- POD-XX — POINT OF DEMONSTRATION
- $Q_{25}$=XX — 25-YEAR, 24-HOUR PEAK DISCHARGE (cfs)
- $Q_{TOT}$=XX — 25-YEAR, 24-HOUR TOTAL DISCHARGE (ac-ft)
- IDP-XX — INTERNAL DISCHARGE POINT
- [1] — FLOW SEGMENT
- SUBBASIN AREA DISCHARGE UNCHANGED FROM PRE- TO POST-DEVELOPMENT CONDITIONS

## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

2. PEAK AND TOTAL FLOW VALUES SHOWN REPRESENT 25-YEAR, 24-HOUR STORM EVENT. VALUES CALCULATED USING HEC-HMS. INPUT PARAMETERS AND OUTPUT PROVIDED IN APPENDIX 2-C.

3. POD-F, A 60-INCH DIAMETER CULVERT, DISCHARGES INTO WALKER BRANCH, A SMALL TRIBUTARY OF THE WEST FORK TRINITY RIVER AT A LOCATION APPROXIMATELY 1,200 FEET UPSTREAM OF THE CONFLUENCE OF WALKER BRANCH AND THE WEST FORK TRINITY RIVER. POD-F IS ABANDONED FOR THE POST-DEVELOPMENT CONDITIONS.

4. INTERNAL DISCHARGE POINTS (IDP) REPRESENT SURFACE WATER DISCHARGE POINTS INTERNAL TO THE PERMIT BOUNDARY USED FOR DEMONSTRATION OF IMPACT FOR THE PROPOSED SITE IMPROVEMENTS, SPECIFICALLY FOR SURFACE WATER DISCHARGED FROM THE EWDA INTO THE FLOODPLAIN/FLOODWAY OF HURRICANE CREEK.

5. DISCHARGE VELOCITY VALUES OBTAINED FROM TIME OF CONCENTRATION CALCULATIONS PRESENTED IN EXHIBIT 2C-4.

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |


Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578


CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: PRE-DEVELOPMENT DRAINAGE PLAN - EWDA

| | | | |
|---|---|---|---|
| DRAWN | TWM | REVIEWED | DEP |
| CHECKED | DML/CMT | APPROVED | DEP |
| DATE | | FEBRUARY 2014 | |
| SCALE | | AS SHOWN | |
| JOB NO. | | 073-9407711 | |
| DWG. NO. | | 073-9407711-1 PRE W3.dwg | |

FIGURE NUMBER

PART III, ATT. 2

2-7

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

PERMIT ISSUED



Drawing File: J:_2007\073-9407711 Rep Art Expan Permit_B - Permit Attachment 2\NOD 1 Revisions\073-9407711-1 PRE W3.dwg | Modified: 8/9/2012 5:42:57 PM CTrevino | Plotted: Wednesday, June 18, 2014 8:36:44 AM CTrevino

Drawing File: J:_2007\073-9407711 Rep Art Expan Permit_B - Permit Attachment 2\NOD 1 Revisions\073-9407711-3 POST W1.dwg | Modified: 8/10/2012 11:27:14 AM CTrevino | Plotted: Wednesday, June 18, 2014 8:49:52 AM CTrevino

DA-10
HC
$Q_{25}$=6,356.4 cfs
$Q_{TOT}$=1,485.7 ac-ft
IDP-F1
$Q_{25}$=5.9 cfs
$Q_{TOT}$=0.5 ac-ft
V =1.14 fps
DA-11
OS-5
$Q_{25}$=264.6 cfs
$Q_{TOT}$=32.5 ac-ft
36" RCP (EXISTING)
IDP-F2
$Q_{25}$=247.8 cfs
$Q_{TOT}$=13.8 ac-ft
V =5.83 fps
NORTH CHANNEL
DA-12
OS-7
$Q_{25}$=64.9 cfs
$Q_{TOT}$=3.2 ac-ft
EAST DISPOSAL AREA
POST-DEVELOPMENT DRAINAGE
(SEE FIGURE 2-6)
OS-6
$Q_{25}$=18.1 cfs
$Q_{TOT}$=0.9 ac-ft
OS-4
$Q_{25}$=116.8 cfs
$Q_{TOT}$=14.3 ac-ft
2'X6' BOX CULVERT (EXISTING)
DA-7
DA-5
DA-1
DA-3
DOWNCHUTE 1
DOWNCHUTE 3
DOWNCHUTE 5
DOWNCHUTE 7
DA-8
IDP-G
$Q_{25}$=161.1 cfs
$Q_{TOT}$=8.7 ac-ft
V =3.89 fps
DOWNCHUTE 8
759
483
446
3:1
WEST BASIN INLET DOWNCHUTE
WEST BASIN
4:1
DA-2
DA-4
DA-6
DA-9
DOWNCHUTE 2
DOWNCHUTE 4
DOWNCHUTE 6
DOWNCHUTE 9
HURRICANE CREEK
TOE-DITCH CULVERT
DA-13
IDP-H
$Q_{25}$=38.7 cfs
$Q_{TOT}$=2.4 ac-ft
V =1.6 fps
WALKER BRANCH
WEST BASIN OUTLET STRUCTURE
EAST BASIN OUTLET STRUCTURE
DA-14
EAST BASIN
IDP-I
$Q_{25}$=38.2 cfs
$Q_{TOT}$=44.5 ac-ft
V =1.89 fps
SOUTH ACCESS ROAD
POD-E2
$Q_{25}$=67.1 cfs
$Q_{TOT}$=138.6 ac-ft
V =2.94 fps
WEST FORK TRINITY RIVER
466
448
470

## LEGEND

- PERMIT BOUNDARY
- SUBBASIN BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- DA-2 — POST-DEVELOPMENT DRAINAGE AREA DESIGNATION
- LOCATION OF SURFACE WATER ENTRY OR EXIT FROM SITE
- POD-XX — POINT OF DEMONSTRATION
- $Q_{25}$=XX — 25-YEAR, 24-HOUR PEAK DISCHARGE (cfs)
- $Q_{TOT}$=XX — 25-YEAR, 24-HOUR TOTAL DISCHARGE (ac-ft)
- FLOW DIRECTION
- IDP-XX — INTERNAL DISCHARGE POINT SEE NOTE X
- FLOW LINE FOR Tc CALCULATIONS
- PERIMETER ACCESS ROAD/LEVEE
- [1] FLOW SEGMENT
- SUB-BASIN AREA DISCHARGE UNCHANGED FROM PRE- TO POST-DEVELOPMENT CONDITIONS

## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

2. PEAK AND TOTAL FLOW VALUES SHOWN REPRESENT 25-YEAR, 24-HOUR STORM EVENT. VALUES CALCULATED USING HEC-HMS. INPUT PARAMETERS AND OUTPUT PROVIDED IN APPENDIX 2-C.

3. POD-F, A 60-INCH DIAMETER CULVERT, DISCHARGES INTO WALKER BRANCH, A SMALL TRIBUTARY OF THE WEST FORK TRINITY RIVER AT A LOCATION APPROXIMATELY 1,200 FEET UPSTREAM OF THE CONFLUENCE OF WALKER BRANCH AND THE WEST FORK TRINITY RIVER. POD-F IS ABANDONED FOR THE POST-DEVELOPMENT CONDITIONS.

4. INTERNAL DISCHARGE POINTS (IDP) REPRESENT SURFACE WATER DISCHARGE POINTS INTERNAL TO THE PERMIT BOUNDARY USED FOR DEMONSTRATION OF IMPACT FOR THE PROPOSED SITE IMPROVEMENTS, SPECIFICALLY FOR SURFACE WATER DISCHARGED FROM THE EWDA INTO THE FLOODPLAIN/FLOODWAY OF HURRICANE CREEK.

5. DRAINAGE FEATURE DETAILS SHOWN ON SUBSEQUENT FIGURES.

5. DISCHARGE VELOCITY VALUES OBTAINED FROM TIME OF CONCENTRATION CALCULATIONS PRESENTED IN EXHIBIT 2C-4.

600 0 600
SCALE FEET

PERMIT ISSUED

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-2014

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

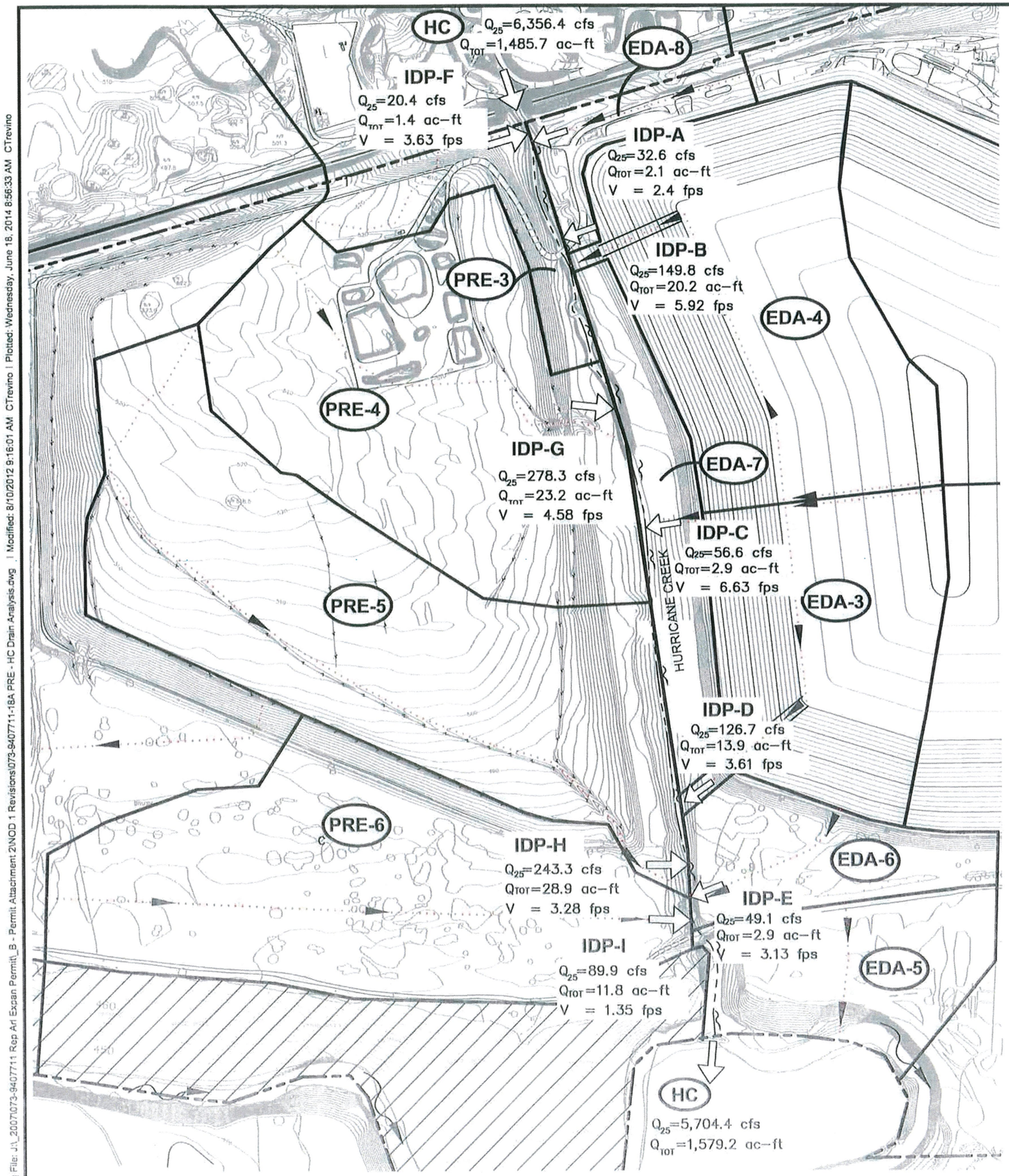
CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: POST-DEVELOPMENT DRAINAGE PLAN - EWDA

| | |
|---|---|
| DRAWN TWH | REVIEWED DEP |
| CHECKED DMR/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-3 POST W1.dwg |
| FIGURE NUMBER | |

PART III, ATT. 2
2-8




## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

2. PEAK AND TOTAL FLOW VALUES SHOWN REPRESENT 25-YEAR, 24-HOUR STORM EVENT. VALUES CALCULATED USING HEC-HMS. INPUT PARAMETERS AND OUTPUT PROVIDED IN APPENDIX 2-C.

4. INTERNAL DISCHARGE POINTS (IDP) REPRESENT SURFACE WATER DISCHARGE POINTS INTERNAL TO THE PERMIT BOUNDARY USED FOR DEMONSTRATION OF IMPACT FOR THE PROPOSED SITE IMPROVEMENTS, SPECIFICALLY FOR SURFACE WATER DISCHARGED FROM THE EWDA INTO THE FLOODPLAIN/FLOODWAY OF HURRICANE CREEK.

5. DISCHARGE VELOCITY VALUES OBTAINED FROM TIME OF CONCENTRATION CALCULATIONS PRESENTED IN EXHIBITS 2B-4 AND 2C-4.

## LEGEND

- PERMIT BOUNDARY
- SUBBASIN BOUNDARY
- FLOW LINE FOR T CALCULATION
- DRAINAGE PATH
- FLOW DIRECTION
- PRE-2 — PRE-DEVELOPMENT ON-SITE DRAINAGE AREA DESIGNATION
- OS-3 — OFF-SITE DRAINAGE AREA DESIGNATION
- LOCATION OF SURFACE WATER ENTRY OR EXIT
- POD-XX — POINT OF DEMONSTRATION
- $Q_{25}$=XX — 25-YEAR, 24-HOUR PEAK DISCHARGE (cfs)
- $Q_{TOT}$=XX — 25-YEAR, 24-HOUR TOTAL DISCHARGE (ac-ft)
- IDP-XX — INTERNAL DISCHARGE POINT
- SUBBASIN AREA DISCHARGE UNCHANGED FROM PRE- TO POST-DEVELOPMENT CONDITIONS
- HURRICANE CREEK

500 0 500
SCALE FEET

PERMIT ISSUED

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 491-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

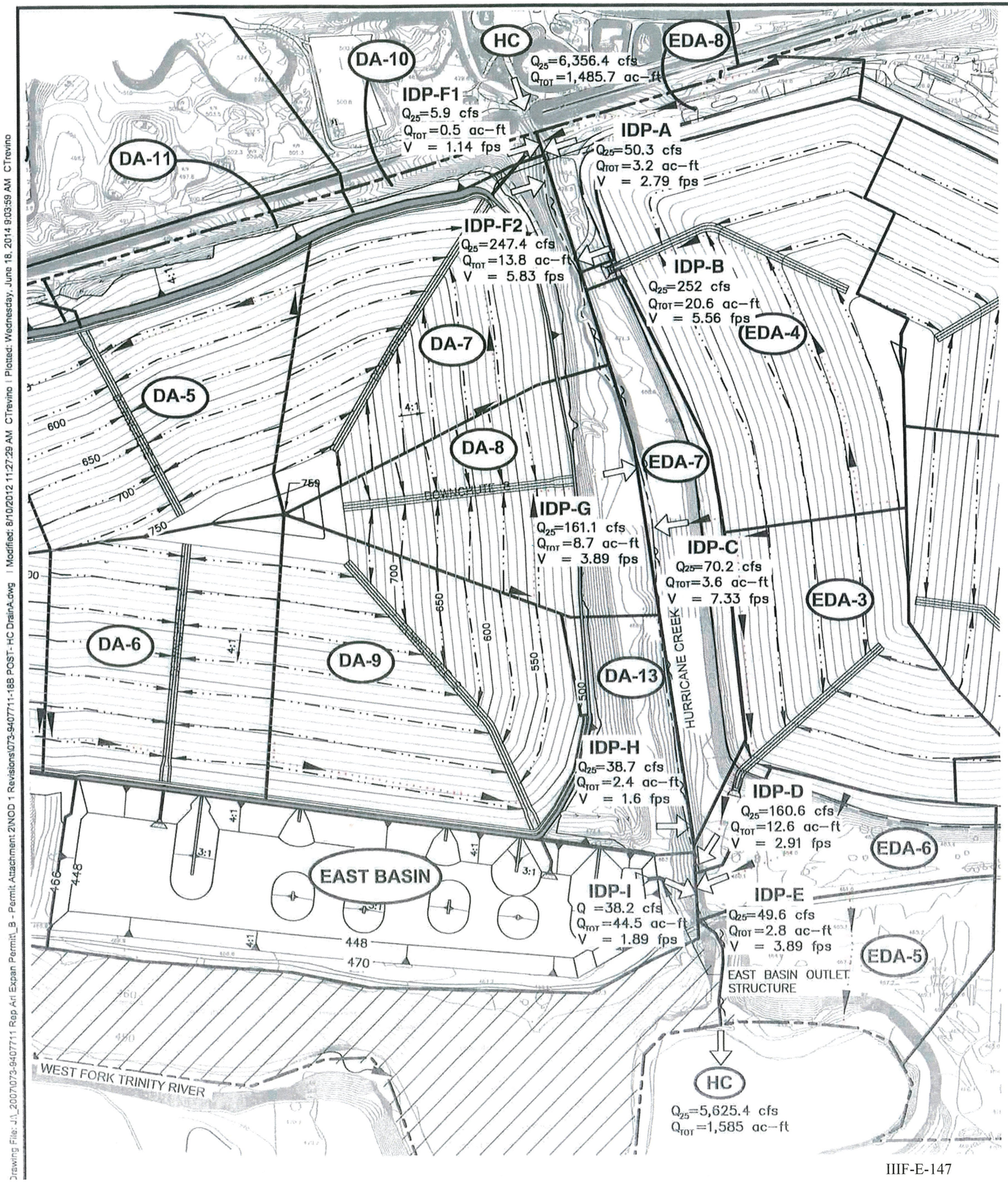
TITLE: PRE-DEVELOPMENT DRAINAGE PLAN - HURRICANE CREEK

| | | | |
|---|---|---|---|
| DRAWN | TWM | REVIEWED | DEP |
| CHECKED | DHL/CMT | APPROVED | DEP |
| DATE | FEBRUARY 2014 | | |
| SCALE | AS SHOWN | | |
| JOB NO. | 073-9407711 | | |
| DWG. NO. | | | |

FIGURE NUMBER
PART III, ATT. 2
2-9



Drawing File: J:_2007\073-9407711 Rep Art Expan Permit_B - Permit Attachment 2\NOD 1 Revisions\073-9407711-18A PRE - HC Drain Analysis.dwg | Modified: 8/10/2012 9:16:01 AM CTrevino | Plotted: Wednesday, June 18, 2014 8:56:33 AM CTrevino




## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

2. PEAK AND TOTAL FLOW VALUES SHOWN REPRESENT 25-YEAR, 24-HOUR STORM EVENT. VALUES CALCULATED USING HEC-HMS. INPUT PARAMETERS AND OUTPUT PROVIDED IN APPENDIX 2-C.

4. INTERNAL DISCHARGE POINTS (IDP) REPRESENT SURFACE WATER DISCHARGE POINTS INTERNAL TO THE PERMIT BOUNDARY USED FOR DEMONSTRATION OF IMPACT FOR THE PROPOSED SITE IMPROVEMENTS, SPECIFICALLY FOR SURFACE WATER DISCHARGED FROM THE EWDA INTO THE FLOODPLAIN/FLOODWAY OF HURRICANE CREEK.

5. DISCHARGE VELOCITY VALUES OBTAINED FROM TIME OF CONCENTRATION CALCULATIONS PRESENTED IN EXHIBIT 2B-4 AND 2C-4.

## LEGEND

- PERMIT BOUNDARY
- SUBBASIN BOUNDARY
- FLOW LINE FOR T CALCULATION
- DRAINAGE PATH
- FLOW DIRECTION
- **PRE-2** PRE-DEVELOPMENT ON-SITE DRAINAGE AREA DESIGNATION
- **OS-3** OFF-SITE DRAINAGE AREA DESIGNATION
- LOCATION OF SURFACE WATER ENTRY OR EXIT
- **POD-XX** POINT OF DEMONSTRATION
- $Q_{25}$=XX 25-YEAR, 24-HOUR PEAK DISCHARGE (cfs)
- $Q_{TOT}$=XX 25-YEAR, 24-HOUR TOTAL DISCHARGE (ac-ft)
- **IDP-XX** INTERNAL DISCHARGE POINT
- SUBBASIN AREA DISCHARGE UNCHANGED FROM PRE- TO POST-DEVELOPMENT CONDITIONS
- HURRICANE CREEK

500 0 500
SCALE FEET

PERMIT ISSUED

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|

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Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: POST-DEVELOPMENT DRAINAGE PLAN - HURRICANE CREEK

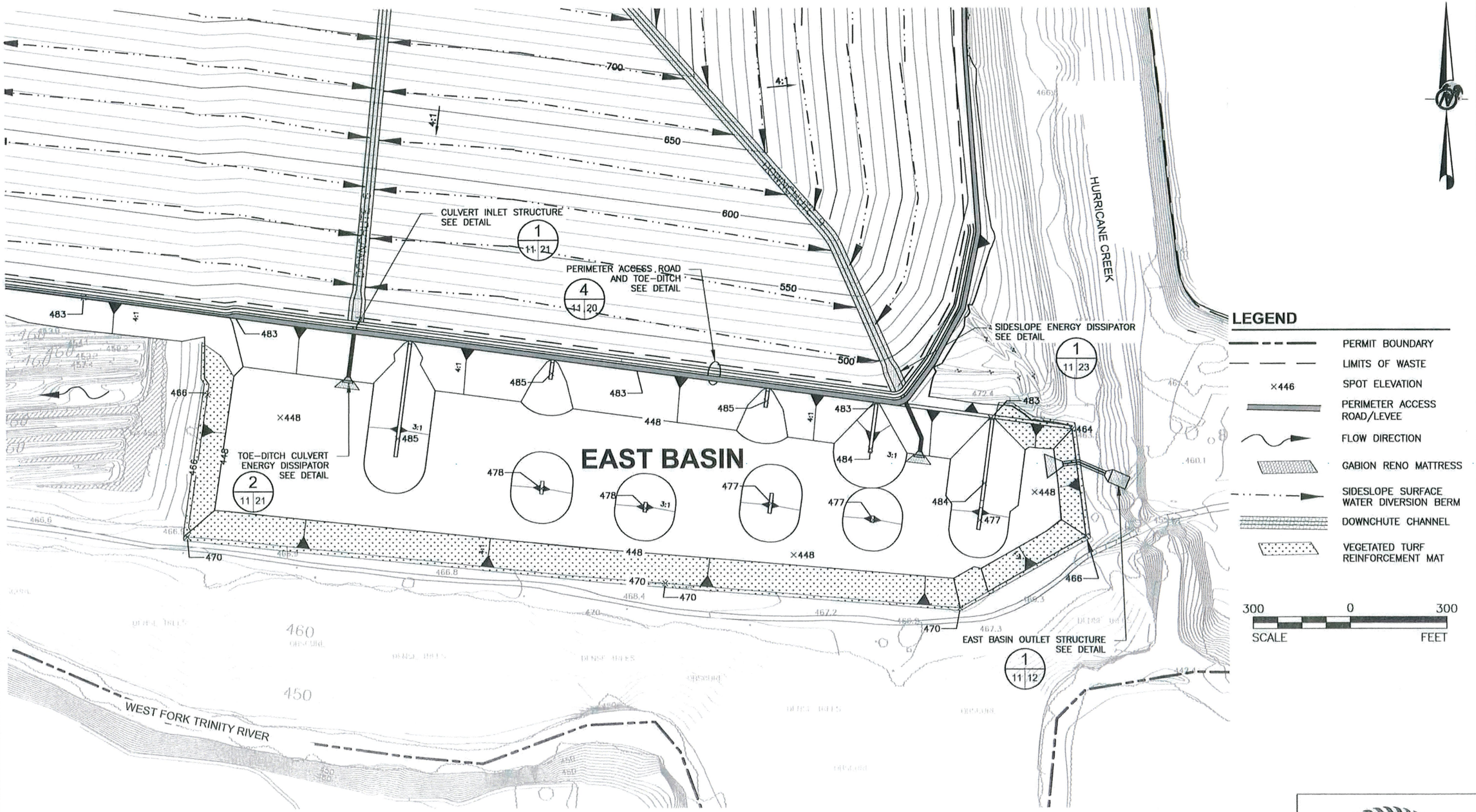
| | |
|---|---|
| DRAWN | REVIEWED DEP |
| CHECKED DJE/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-18B POST- HC Drai |
| FIGURE NUMBER | |

PART III, ATT. 2
2-10

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14



Drawing File: J:_2007\073-9407711 Rep Ari Expan Permit_B - Permit Attachment 2\NOD 1 Revisions\073-9407711-18B POST- HC DrainA.dwg | Modified: 8/10/2012 11:27:29 AM CTrevino | Plotted: Wednesday, June 18, 2014 9:03:59 AM CTrevino




## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

STATE OF TEXAS
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PROFESSIONAL ENGINEER
6-20-14

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GOLDER ASSOCIATES INC.
F-2578

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| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

Golder Associates
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Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

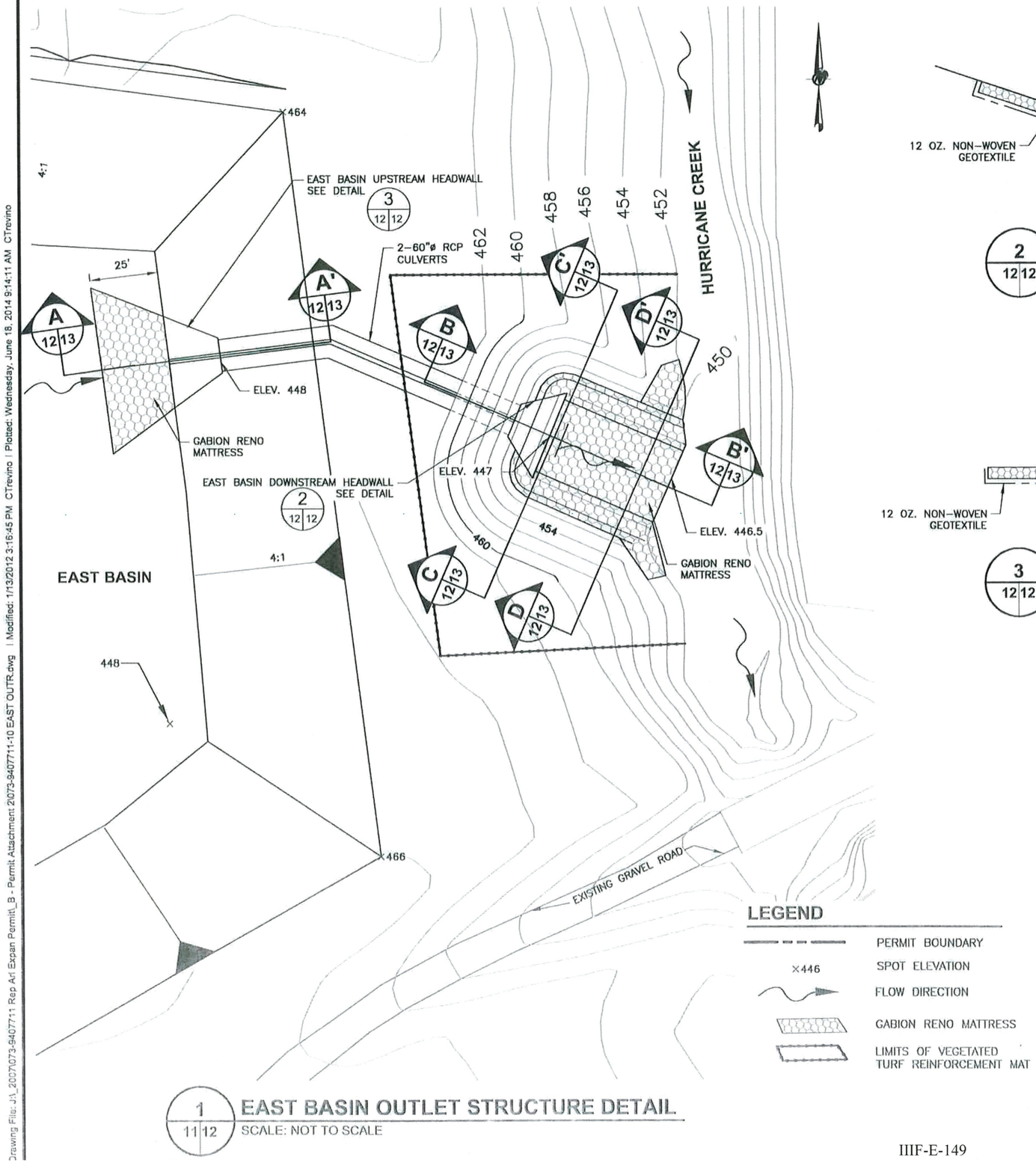
PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: EAST DETENTION BASIN PLAN - EWDA

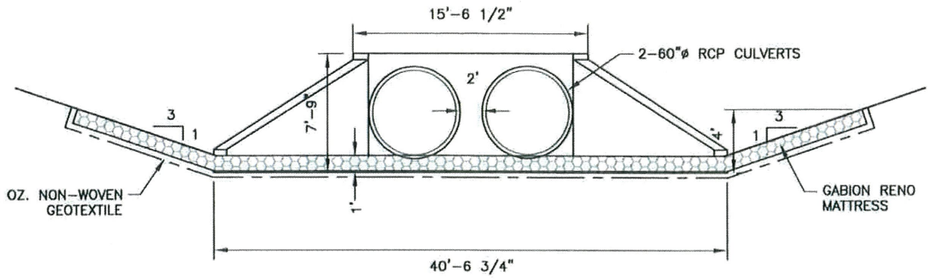
| | |
|---|---|
| DRAWN TWM | REVIEWED DEP |
| CHECKED BML/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-9 EAST B.dwg |
| FIGURE NUMBER | PART III, ATT. 2 2-11 |



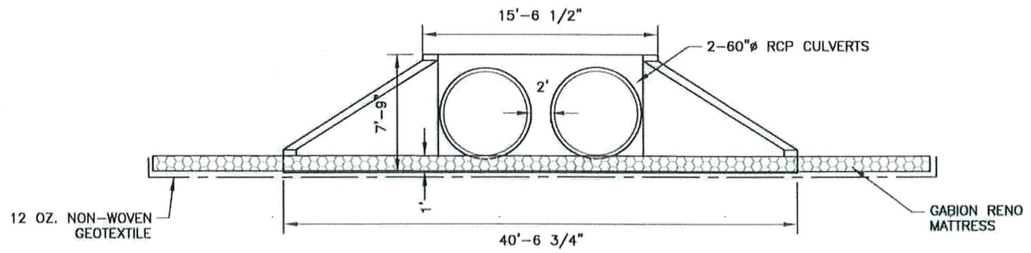
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1 / 11 12 **EAST BASIN OUTLET STRUCTURE DETAIL**
SCALE: NOT TO SCALE




2 / 12 12 **EAST BASIN DOWNSTREAM HEADWALL DETAIL**
SCALE: NOT TO SCALE




3 / 12 12 **EAST BASIN UPSTREAM HEADWALL DETAIL**
SCALE: NOT TO SCALE

## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

2. DISCHARGE CHARACTERISTICS FOR EAST BASIN OUTFALL STRUCTURE PRESENTED IN APPENDIX 2–F.

STATE OF TEXAS
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PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F–2578

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|---|---|---|---|---|
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Golder Associates
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Texas Registration Number: F–2578

CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

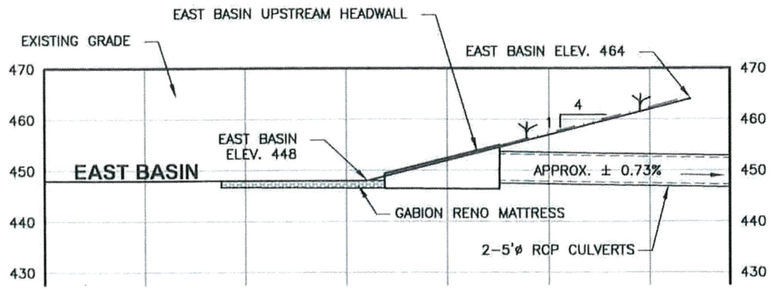
TITLE: EAST BASIN OUTFALL
STRUCTURE DETAILS - EWDA

| | | | |
|---|---|---|---|
| DRAWN | TWM | REVIEWED | DEP |
| CHECKED | DM/CMT | APPROVED | DEP |
| DATE | FEBRUARY 2014 | | |
| SCALE | AS SHOWN | | |
| JOB NO. | 073-9407711 | | |
| DWG. NO. | 073-9407711-10 EAST OUTR.dwg | | |

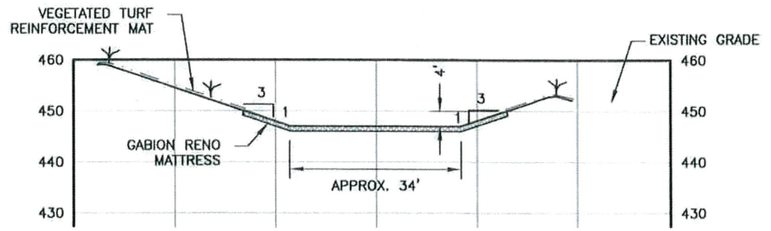
FIGURE NUMBER
PART III, ATT. 2
2-12



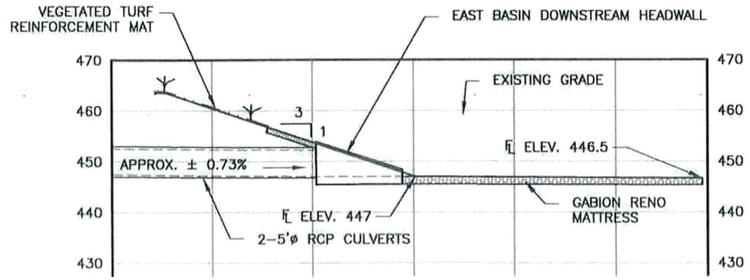
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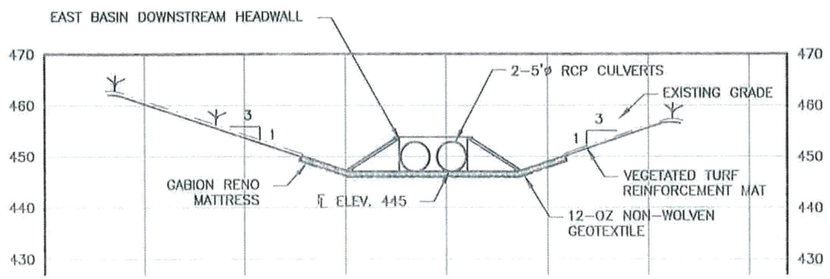

A-A' 12|13 **SECTION A-A'**
SCALE: 1"=30'




D-D' 12|13 **SECTION D-D'**
SCALE: 1"=30'




B-B' 12|13 **SECTION B-B'**
SCALE: 1"=30'




C-C' 12|13 **SECTION C-C'**
SCALE: 1"=30'

## LEGEND

| | |
|---|---|
| ℄ ELEV. XXX | FLOWLINE ELEVATION (MSL) |
| | GABION RENO MATTRESS |
| | VEGETATED TURF REINFORCEMENT MAT |

## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

2. DISCHARGE CHARACTERISTICS FOR EAST BASIN OUTFALL STRUCTURE PRESENTED IN APPENDIX 2–F.

STATE OF TEXAS
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PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F–2578

PERMIT ISSUED

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|

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Texas Registration Number: F–2578

CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

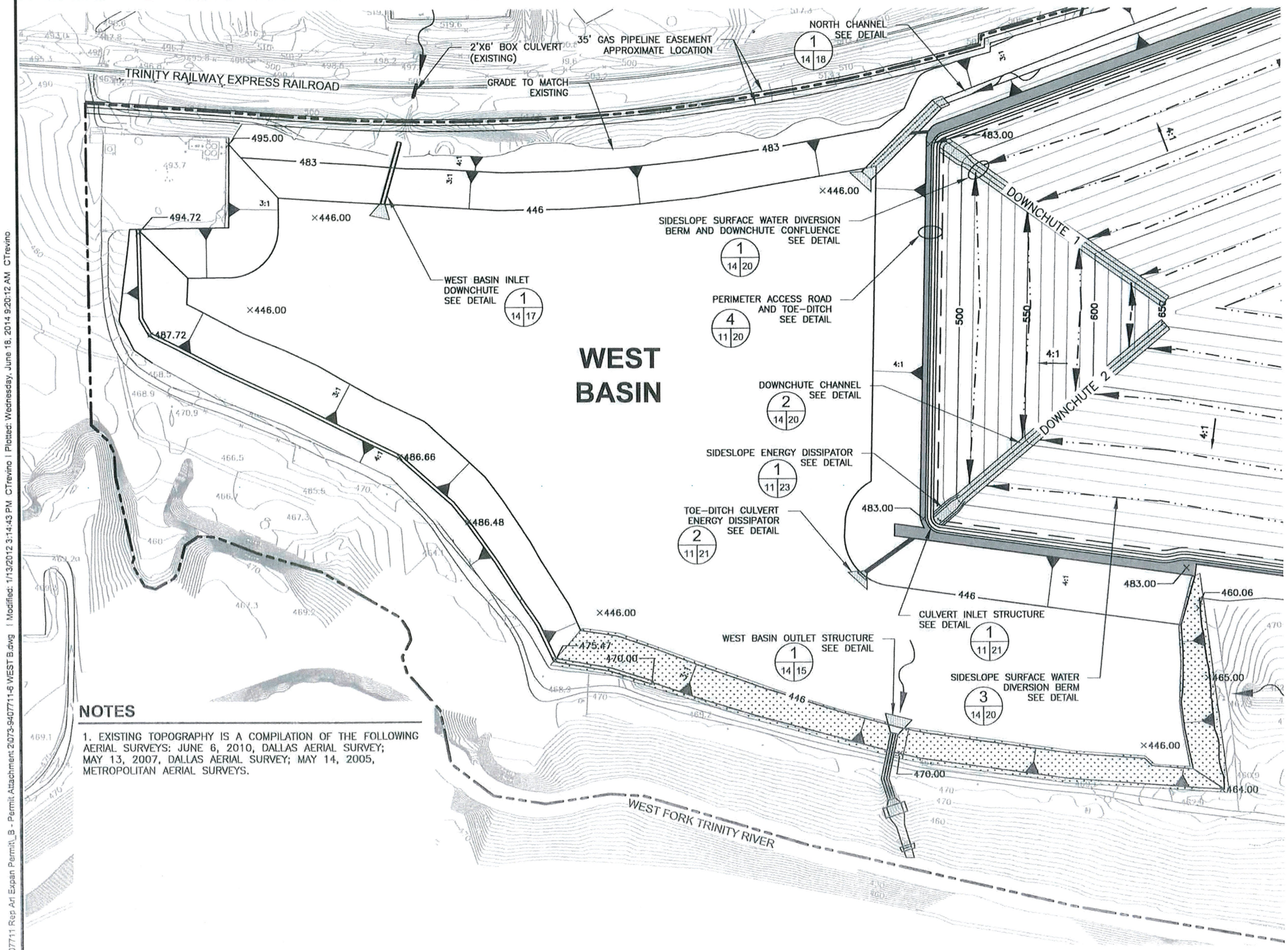
TITLE: EAST BASIN OUTFALL STRUCTURE SECTIONS

| | | | |
|---|---|---|---|
| DRAWN | TWM | REVIEWED | DEP |
| CHECKED | DML/CMT | APPROVED | DEP |
| DATE | FEBRUARY 2014 | | |
| SCALE | AS SHOWN | | |
| JOB NO. | 073-9407711 | | |
| DWG. NO. | 073-9407711-10 EAST OUTFALL | | |

FIGURE NUMBER
PART III, ATT. 2
2-13



Drawing File: J:_2007\073-9407711 Rep Art Expan Permit__FINAL PERMIT ISSUED DRAWINGS\DWG\Attachment 2\073-9407711-10 EAST OUTR.dwg | Modified: 6/18/2014 9:14:56 AM CTrevino | Plotted: Wednesday, June 18, 2014 9:16:07 AM CTrevino




## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- SIDESLOPE SURFACE WATER DIVERSION BERM
- ×446.00 SPOT ELEVATION
- PERIMETER ACCESS ROAD/LEVEE
- FLOW DIRECTION
- GABION RENO MATTRESS
- POD-XX POINT OF DEMONSTRATION
- VEGETATED TURF REINFORCEMENT MAT

300 0 300
SCALE FEET

STATE OF TEXAS
DAVID E. POE
81734
LICENSED PROFESSIONAL ENGINEER
2-20-14
DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

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213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 491-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

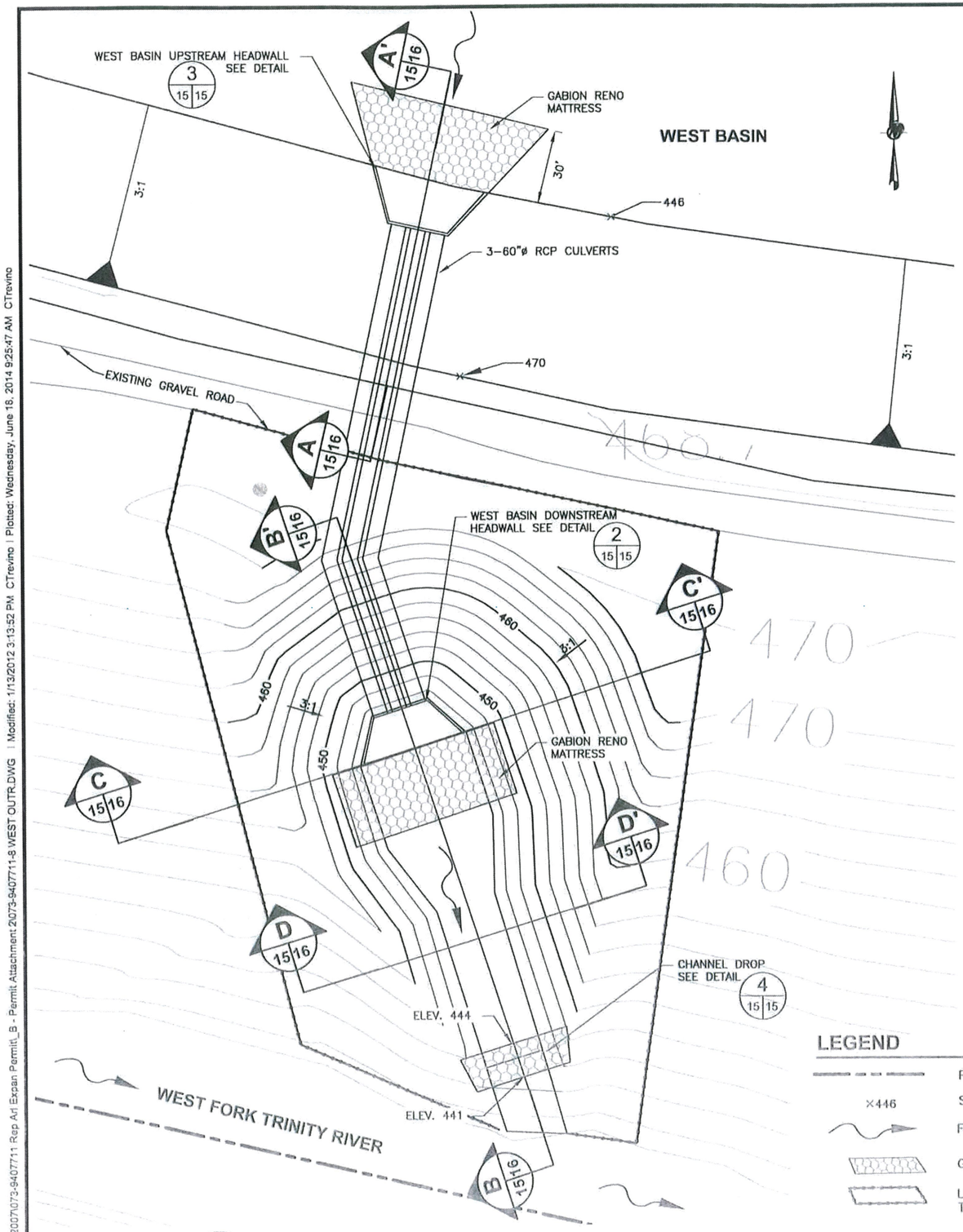
PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: WEST DETENTION BASIN PLAN - EWDA

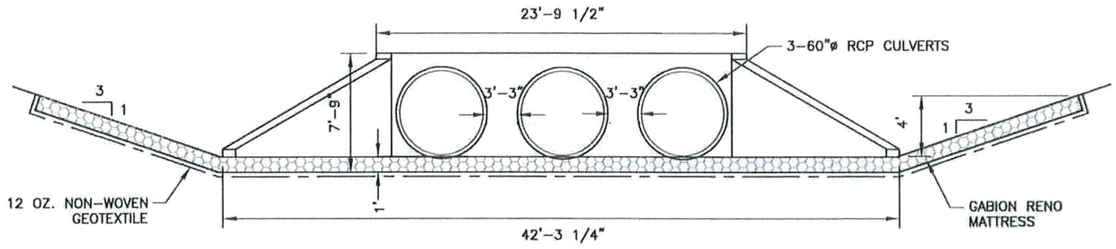
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| DRAWN | TWJ | REVIEWED | DEP |
| CHECKED | BML/CMT | APPROVED | DEP |
| DATE | FEBRUARY 2014 | | |
| SCALE | AS SHOWN | | |
| JOB No. | 073-9407711 | | |
| DWG. No. | 073-9407711-6 WEST B.dwg | | |

FIGURE NUMBER
PART III, ATT. 2
2-14

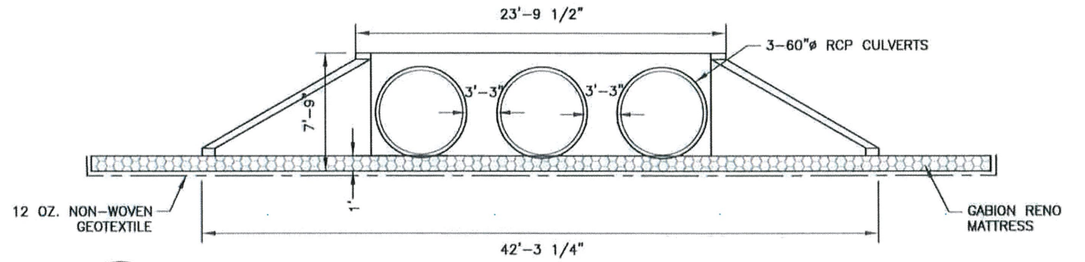
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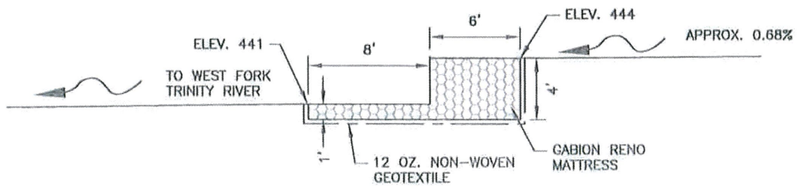

1 / 14 15 **WEST BASIN OUTLET STRUCTURE DETAIL**
SCALE: 1"=50'




2 / 15 15 **WEST BASIN DOWNSTREAM HEADWALL DETAIL**
SCALE: NOT TO SCALE




3 / 15 15 **WEST BASIN UPSTREAM HEADWALL DETAIL**
SCALE: NOT TO SCALE




4 / 15 15 **CHANNEL DROP DETAIL**
SCALE: NOT TO SCALE

**LEGEND**

- PERMIT BOUNDARY
- ×446 SPOT ELEVATION
- FLOW DIRECTION
- GABION RENO MATTRESS
- LIMITS OF VEGETATED TURF REINFORCEMENT MAT

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

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|---|---|---|---|---|

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Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

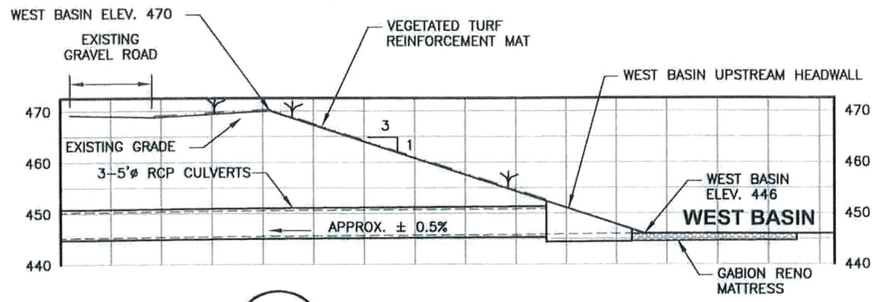
PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: WEST BASIN OUTFALL
STRUCTURE DETAILS - EWDA

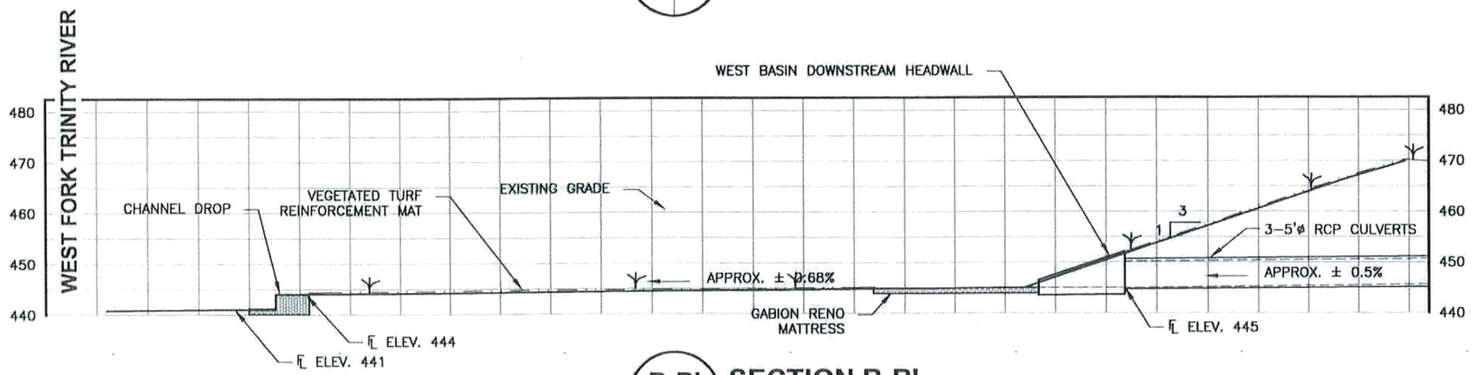
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|---|---|---|---|
| DRAWN | TWM | REVIEWED | DEP |
| CHECKED | DM/CMT | APPROVED | DEP |
| DATE | FEBRUARY 2014 | | |
| SCALE | AS SHOWN | | |
| JOB NO. | 073-9107711 | | |
| DWG. NO. | 073-9107711-8 WEST OUTL.DWG | | |

FIGURE NUMBER
PART III, ATT. 2
2-15

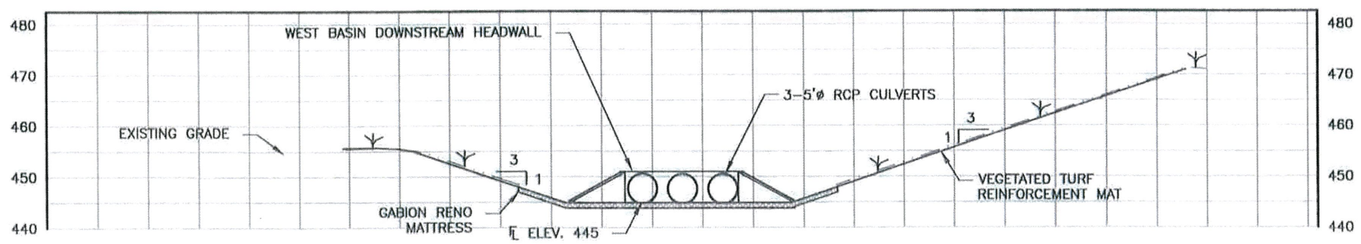
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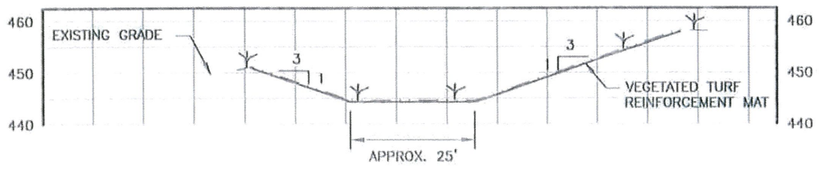

A-A' 15|16 **SECTION A-A'**
SCALE: 1"=30'




B-B' 15|16 **SECTION B-B'**
SCALE: 1"=30'




C-C' 15|16 **SECTION C-C'**
SCALE: 1"=30'




D-D' 15|16 **SECTION D-D'**
SCALE: 1"=30'

## LEGEND

| | |
|---|---|
| ℄ ELEV. XXX | FLOWLINE ELEVATION (MSL) |
| | GABION RENO MATTRESS |
| | VEGETATED TURF REINFORCEMENT MAT |

## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

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CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: WEST BASIN OUTFALL
STRUCTURE DETAIL AND SECTION

| | | | |
|---|---|---|---|
| DRAWN | TWM | REVIEWED | DEP |
| CHECKED | DJL/CMT | APPROVED | DEP |
| DATE | FEBRUARY 2014 | | |
| SCALE | AS SHOWN | | |
| JOB NO. | 073-9407711 | | |
| DWG. NO. | 073-9407711-8 WEST OUTB.DWG | | |

FIGURE NUMBER
PART III, ATT. 2
2-16

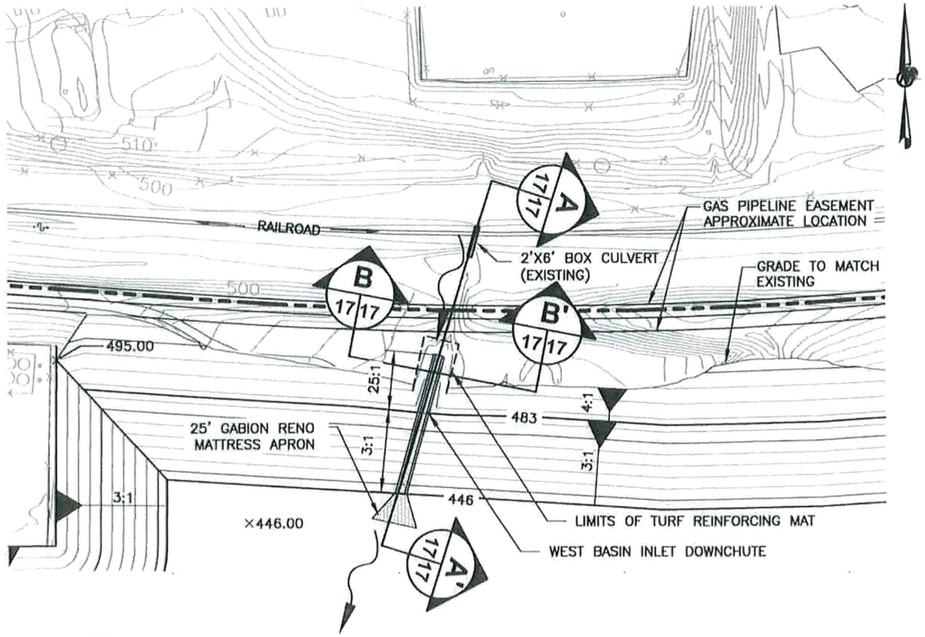
STATE OF TEXAS
DAVID E. POE
81734
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PROFESSIONAL ENGINEER
2-20-14

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GOLDER ASSOCIATES INC.
F-2578

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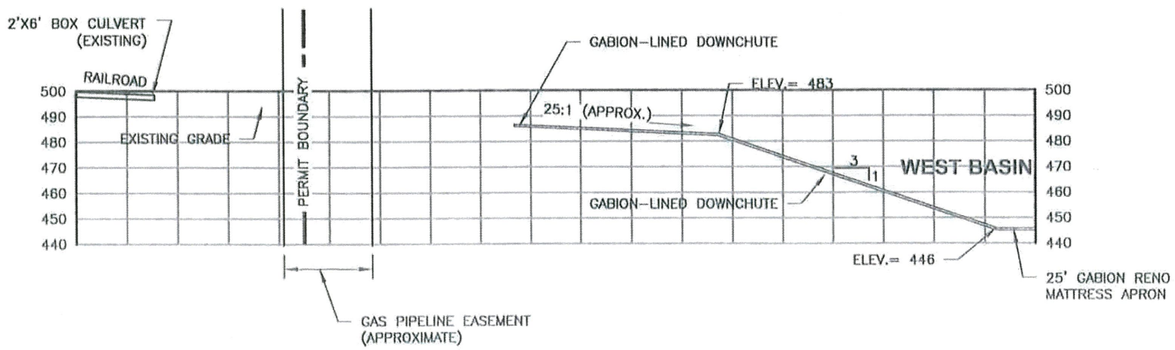


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1 / 14 | 17 **WEST BASIN INLET DOWNCHUTE DETAIL**

200 0 200
SCALE FEET

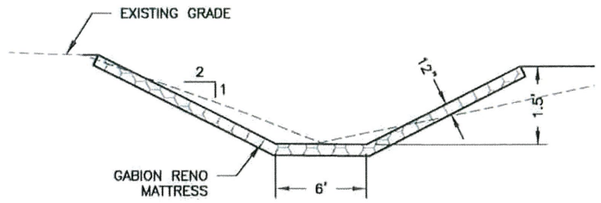



A-A' / 17|17 **SECTION A-A'**

60 0 60
HORIZ AND VERT FEET

## INLET DOWNCHUTE TABLE

| Q (cfs) | SLOPE (ft/ft) | MANNING | Vmax (ft) | Dmax (ft) | FREEBOARD (ft) |
|---|---|---|---|---|---|
| 98.8 | 25:1 | 0.0277 | 9.9 | 1.2 | 0.3 |
| 98.8 | 3:1 | 0.0277 | 20.5 | 0.66 | 0.84 |




B-B' / 17|17 **SECTION B-B'**
SCALE: NOT TO SCALE

## LEGEND

- PERMIT BOUNDARY
- ×446.00 SPOT ELEVATION
- FLOW DIRECTION
- GABION RENO MATTRESS

## NOTES:

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.
2. FLOW (Q) OBTAINS FROM HEC-HMS MODELING.
3. PLOW DEPTH (D) AND VELOCITY (V) VALUES OBTAINED FROM HYDRAULIC COMPUTER PROGRAM FOR FLOW AND SLOPE VALUES SHOWN IN TABLE

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REV. | DATE | DESCRIPTION | DR. BY | APP. BY

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

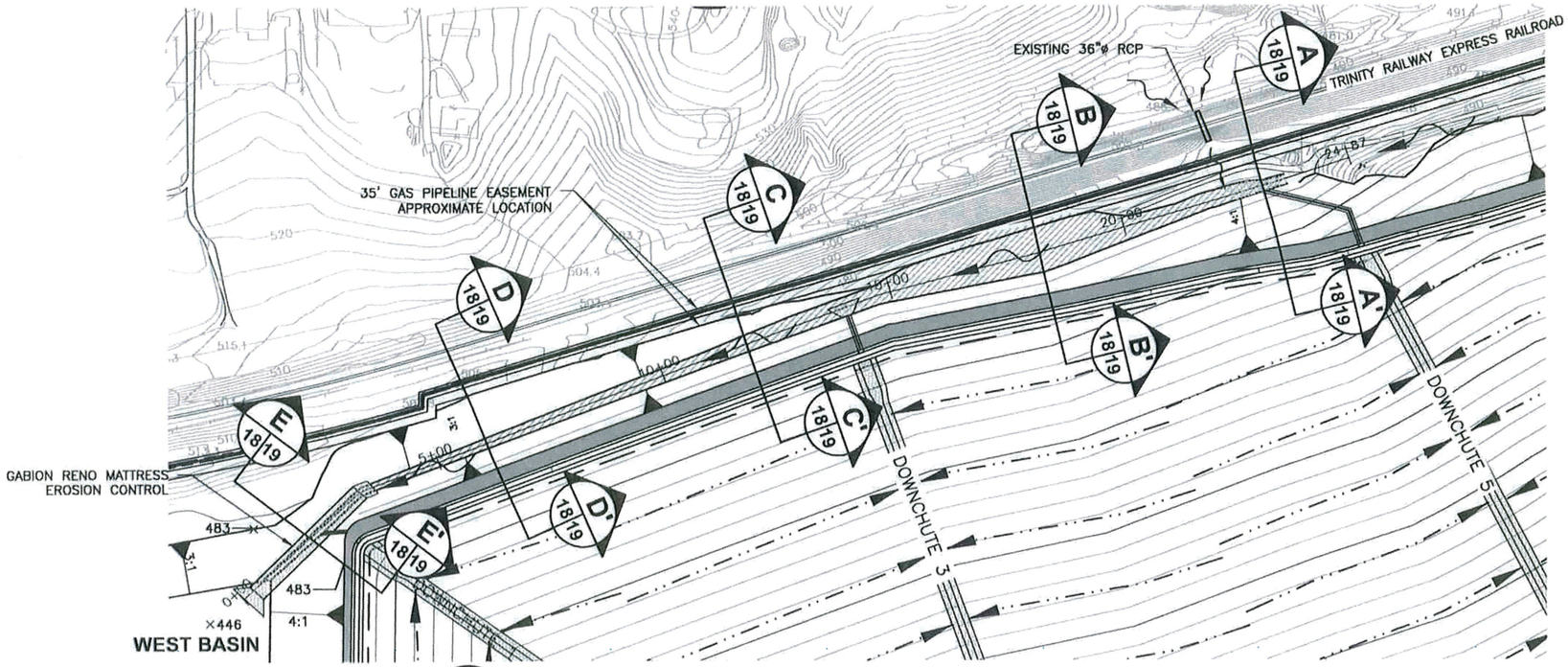
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| CHECKED DML/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
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| DWG. NO. | 073-9407711-7 WEST IN.dwg |
| FIGURE NUMBER | |

PART III, ATT. 2
2-17



Drawing File: J:_2007\073-9407711 Rep Arl Expan Permit_B - Permit Attachment 2073-9407711-7 WEST IN.dwg | Modified: 1/16/2012 6:18:39 PM CTrevino | Plotted: Wednesday, June 18, 2014 9:32:03 AM CTrevino




## LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- ×446.00 SPOT ELEVATION
- PERIMETER ACCESS ROAD/LEVEE
- FLOW DIRECTION
- GABION RENO MATTRESS
- NORTH CHANNEL BOTTOM

## NOTES

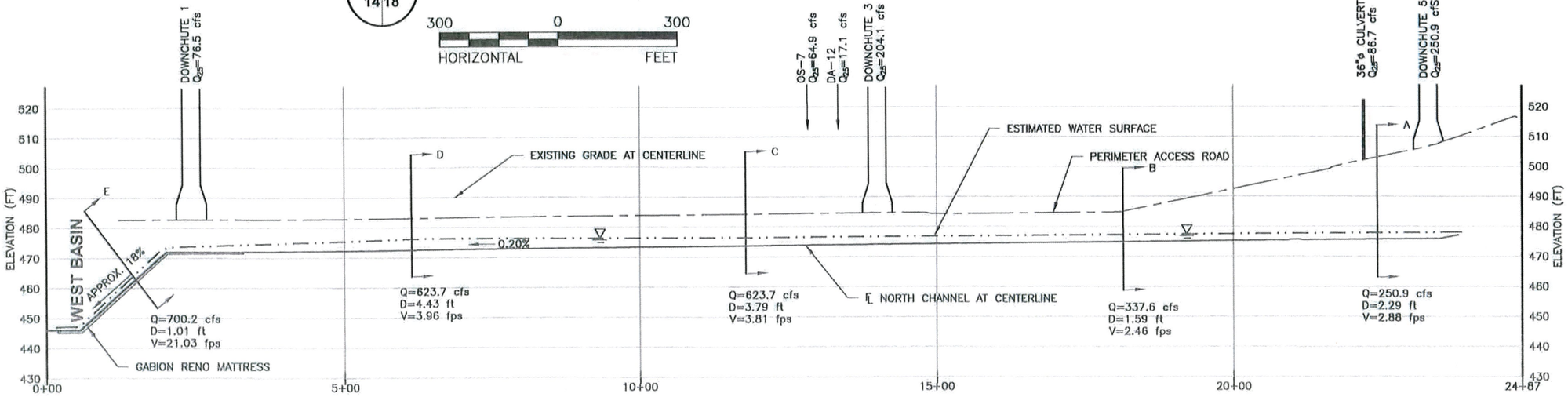
1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

2. FLOW (Q), FLOW DEPTH (D), AND VELOCITY (V) VALUES OBTAINED FROM HYDROCALC COMPUTER PROGRAM. SEE APPENDIX 2-H FOR HYDROCALC OUTPUT.

3. CALCULATIONS ASSUME CUMULATIVE FLOW, WITHOUT REGARD TO ROUTING EFFECTS, AND THEREFORE ARE CONSERVATIVE.

1
14|18
## NORTH CHANNEL DETAIL

300 0 300
HORIZONTAL FEET




200 0 200
HORIZONTAL FEET

40 0 40
VERTICAL FEET

## NORTH CHANNEL PROFILE



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6-26-14

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F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|

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Texas Registration Number: F-2578

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REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: NORTH CHANNEL PLAN AND PROFILE

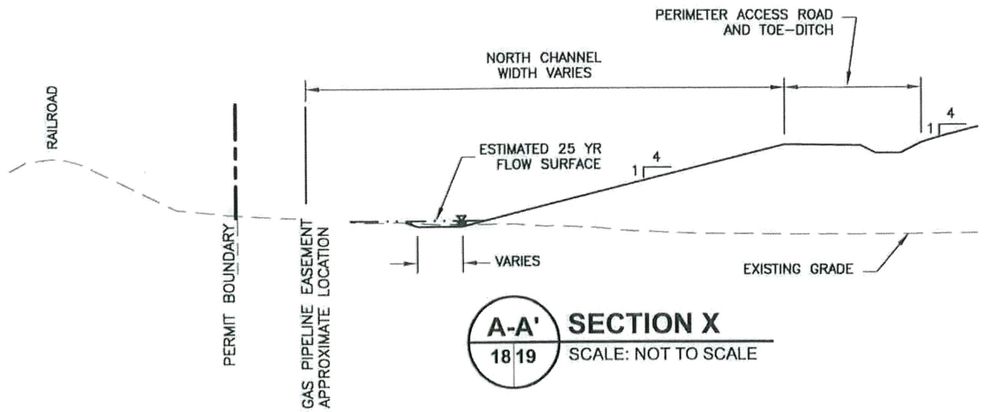
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|---|---|
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| CHECKED DML/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 73-9407711-5 NORTH CH.dwg |
| FIGURE NUMBER | |

PART III, ATT. 2

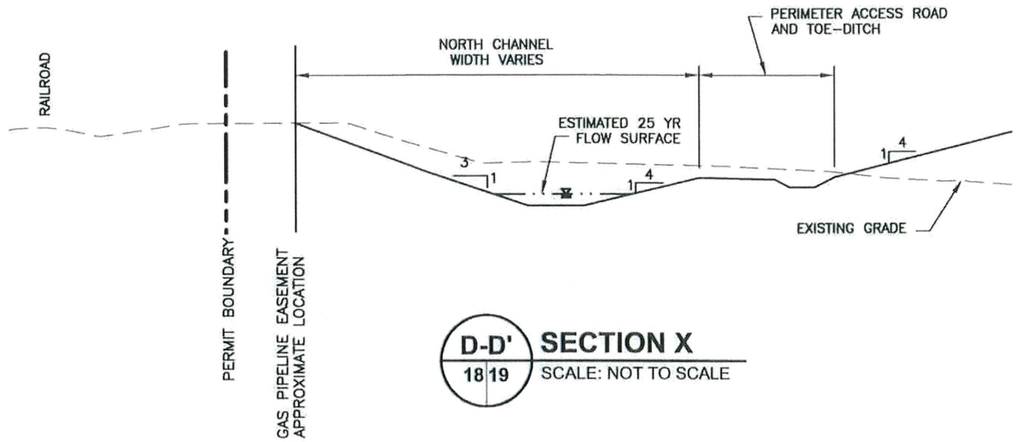
2-18

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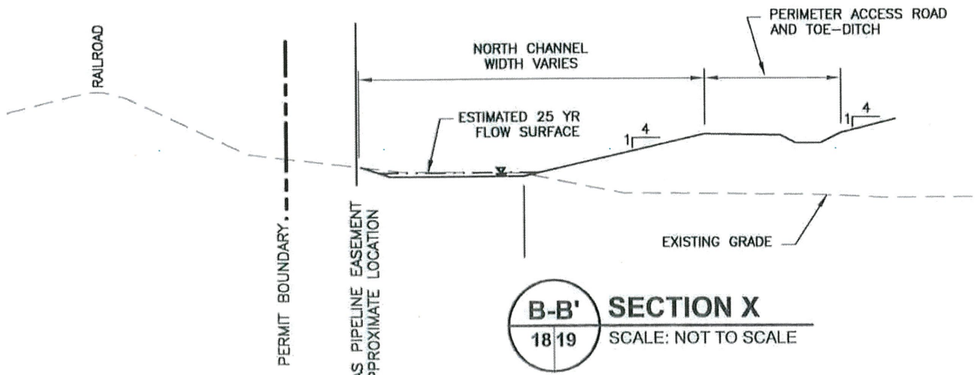
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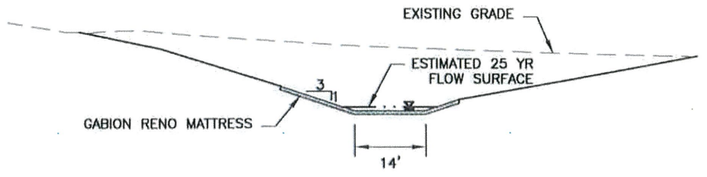

A-A' 18|19 **SECTION X**
SCALE: NOT TO SCALE



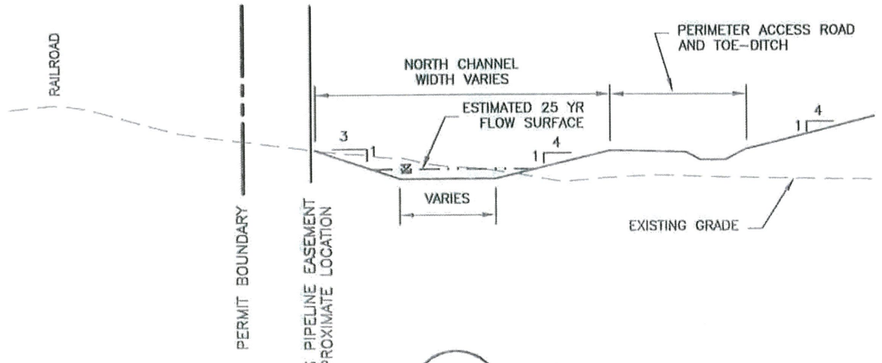

D-D' 18|19 **SECTION X**
SCALE: NOT TO SCALE




B-B' 18|19 **SECTION X**
SCALE: NOT TO SCALE




E-E' 18|19 **SECTION X**
SCALE: NOT TO SCALE




C-C' 18|19 **SECTION X**
SCALE: NOT TO SCALE

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
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| | | | | |

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TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: NORTH CHANNEL SECTIONS

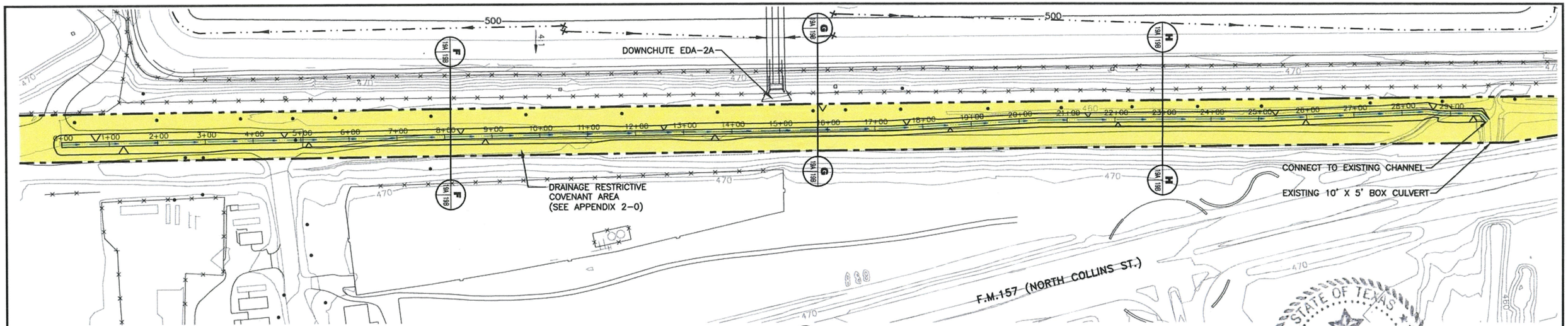
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| CHECKED | DML/CMT | APPROVED | DEP |
| DATE | FEBRUARY 2014 | | |
| SCALE | AS SHOWN | | |
| JOB NO. | 073-9407711 | | |
| DWG. NO. | 073-9407711-5 NORTH CH.dwg | | |

FIGURE NUMBER
PART III, ATT. 2
2-19

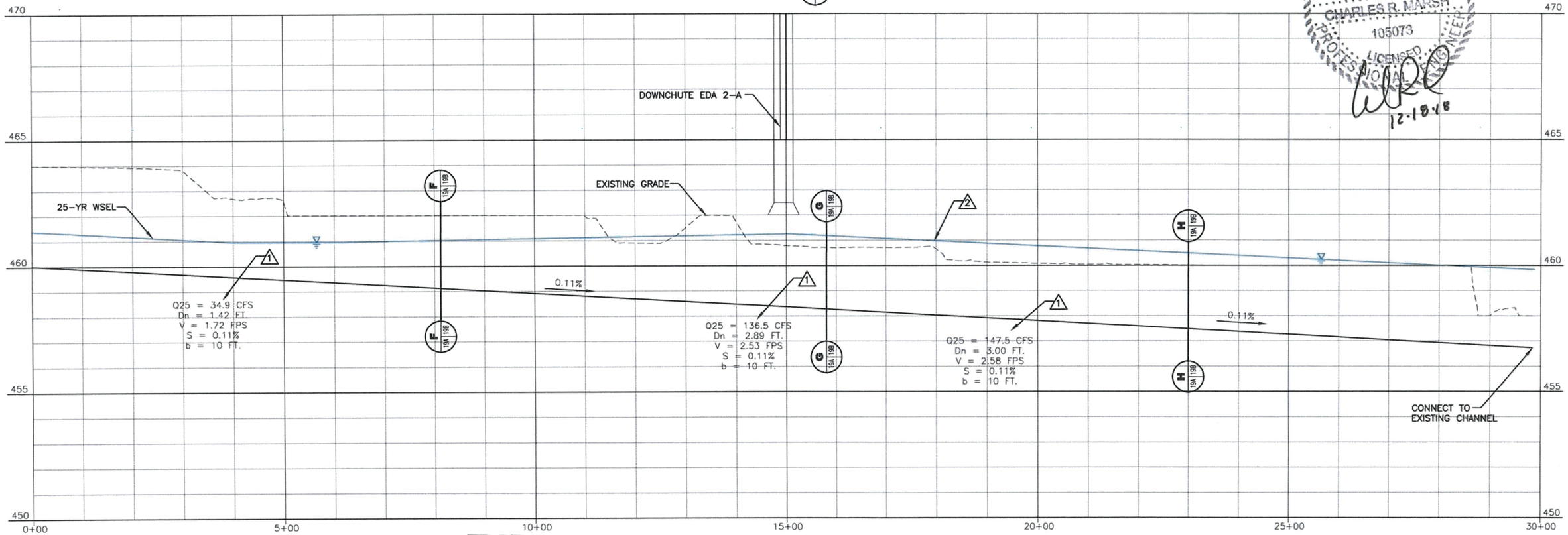
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CHANNEL 1 DETAIL (2 / 6 | 19A)




HORIZONTAL SCALE IN FEET: 0, 100, 200 — VERTICAL SCALE IN FEET: 0, 2, 4

CHANNEL 1 PROFILE

LEGEND

- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- SUBBASIN BOUNDARY
- PERIMETER ACCESS ROAD/LEVEE
- CHANNEL 1
- DRAINAGE RESTRICTIVE COVENANT AREA
- INDICATES REVISION (SEE LIST OF REVISIONS)

LIST OF REVISIONS:

1. UPDATED FLOW CALCULATIONS.
2. WATER SURFACE ELEVATION UPDATED.

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-15-2016.

2. REFER TO FIGURE 2-6 FOR FLOW RATE CALCULATIONS. HYDRAULIC CALCULATIONS WITHIN CHANNEL 1 WERE COMPLETED USING DODSON HYDROCALC HYDRAULICS FOR WINDOWS, VERSION 2.0.1, 1996-2010.

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CHARLES R. MARSH
105073
LICENSED PROFESSIONAL ENGINEER
12-18-18

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

DATE: 06/2014
FILE: 0023-404-11
CAD: 2-19A.DWG
DRAWN BY: JDW
DESIGN BY: RJS
REVIEWED BY: JAE

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

REVISIONS

| NO. | DATE | DESCRIPTION |
|---|---|---|
| 1 | 06/2017 | PERMIT MODIFICATION |
| 2 | 12/2018 | SEE LIST OF REVISIONS |

# MAJOR PERMIT AMENDMENT
# CHANNEL 1 PLAN AND PROFILE

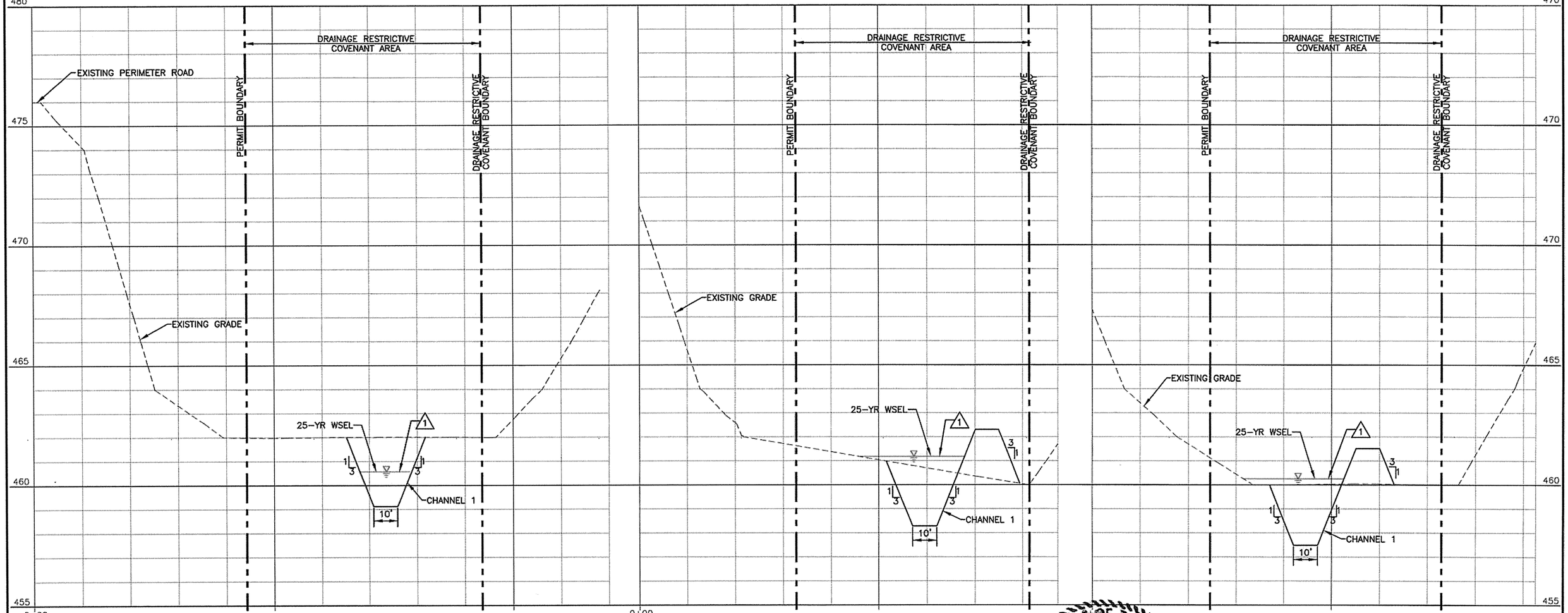
CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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FIGURE 2-19A



O:\0023\404\SMPA (2017)\ATT 2\2-19A PROFILE.dwg, jwilson, 1:2




SECTION F (F 19A | 19B)

0 20 40 HORIZONTAL SCALE IN FEET

0 2 4 VERTICAL SCALE IN FEET

SECTION G (G 19A | 19B)

0 20 40 HORIZONTAL SCALE IN FEET

0 2 4 VERTICAL SCALE IN FEET

SECTION H (H 19A | 19B)

0 20 40 HORIZONTAL SCALE IN FEET

0 2 4 VERTICAL SCALE IN FEET

STATE OF TEXAS
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LICENSED PROFESSIONAL ENGINEER
12-18-18

LIST OF REVISIONS:

1. UPDATED 25-YEAR WSEL.

LEGEND

PERMIT BOUNDARY

CITY OF ARLINGTON PROPERTY BOUNDARY

1 INDICATES REVISION (SEE LIST OF REVISIONS BELOW)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-15-2016.

2. REFER TO FIGURE 2-6 FOR FLOW RATE CALCULATIONS. HYDRAULIC CALCULATIONS WITHIN CHANNEL 1 WERE COMPLETED USING DODSON HYDROCALC HYDRAULICS FOR WINDOWS, VERSION 2.0.1, 1996-2010.

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DATE: 08/2017
FILE: 0023-404-11
CAD: 2-19B.DWG

DRAWN BY: JDW
DESIGN BY: RJS
REVIEWED BY: JAE

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REVISIONS

| NO. | DATE | DESCRIPTION |
|---|---|---|
| 1 | 09/2018 | PERMIT MODIFICATION |
| 2 | 12/2018 | SEE LIST OF REVISIONS |
| | | |

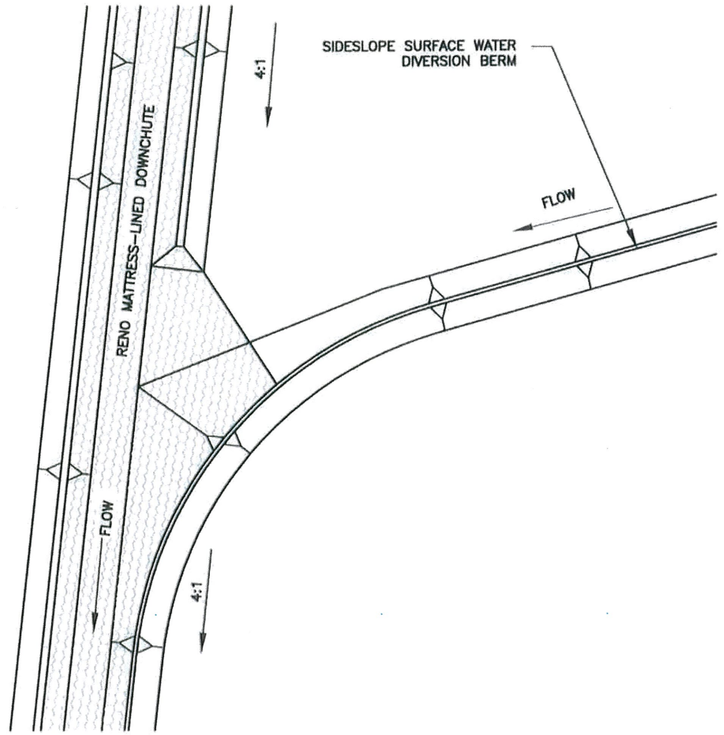
MAJOR PERMIT AMENDMENT
CHANNEL 1 SECTIONS

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

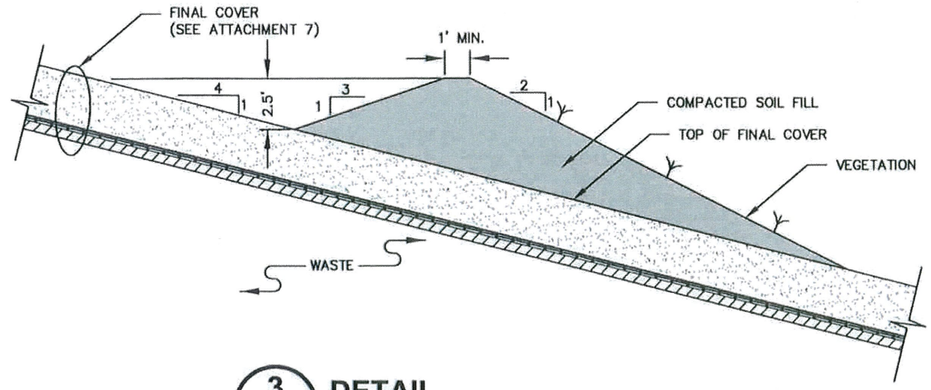
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FIGURE 2-19B

O:\0023\04\LSNPA (2017)\ATT 2\2-19B SECTIONS.dwg, jwilson, 1:2



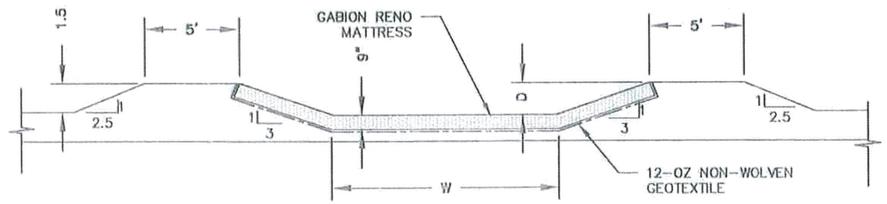

1 / 14 / 20 **DETAIL**
**SIDESLOPE SURFACE WATER DIVERSION BERM AND DOWNCHUTE CONFLUENCE**
SCALE: NOT TO SCALE




3 / 14 / 20 **DETAIL**
**SIDESLOPE SURFACE WATER DIVERSION BERM**
SCALE: NOT TO SCALE

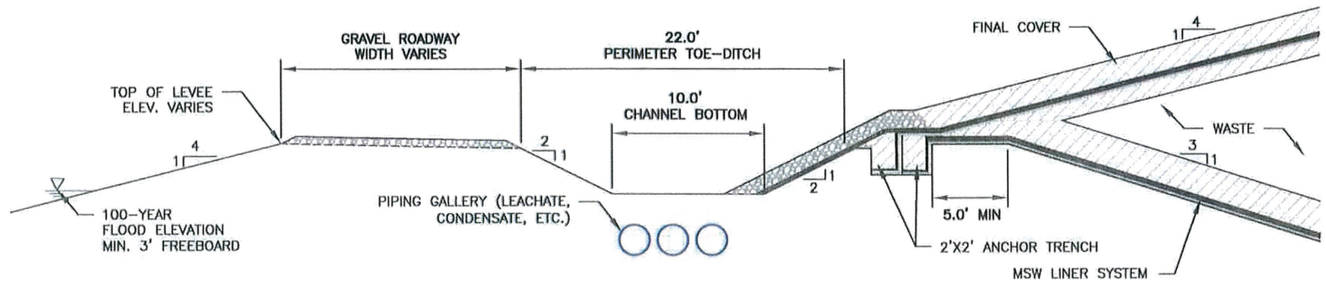
**NOTES**

1. ALL SIDE SLOPE SURFACE WATER DIVERSION BERMS ARE GRASS-LINED WITH A LONGITUDINAL SLOPE OF 1.5%.
2. PEAK VELOCITY LESS THAN 5.0 ft/s FOR 25-YEAR, 24-HOUR STORM EVENT.




**NOTE**
REFER TO TABLE ON FIGURE 2-16 FOR DOWNCHUTE WIDTHS AND DEPTHS.

2 / 14 / 20 **DETAIL**
**DOWNCHUTE CHANNEL**
SCALE: NOT TO SCALE




4 / 11 / 20 **PERIMETER ACCESS ROAD AND TOE-DITCH DETAIL (TYPICAL)**
SCALE: NOT TO SCALE

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PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

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|---|---|---|---|---|
| | | | | |

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Texas Registration Number: F-2578

CITY OF ARLINGTON
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: DRAINAGE CONTROL DETAILS
CHANNELS AND BERMS
EROSION AND SEDIMENT CONTROL

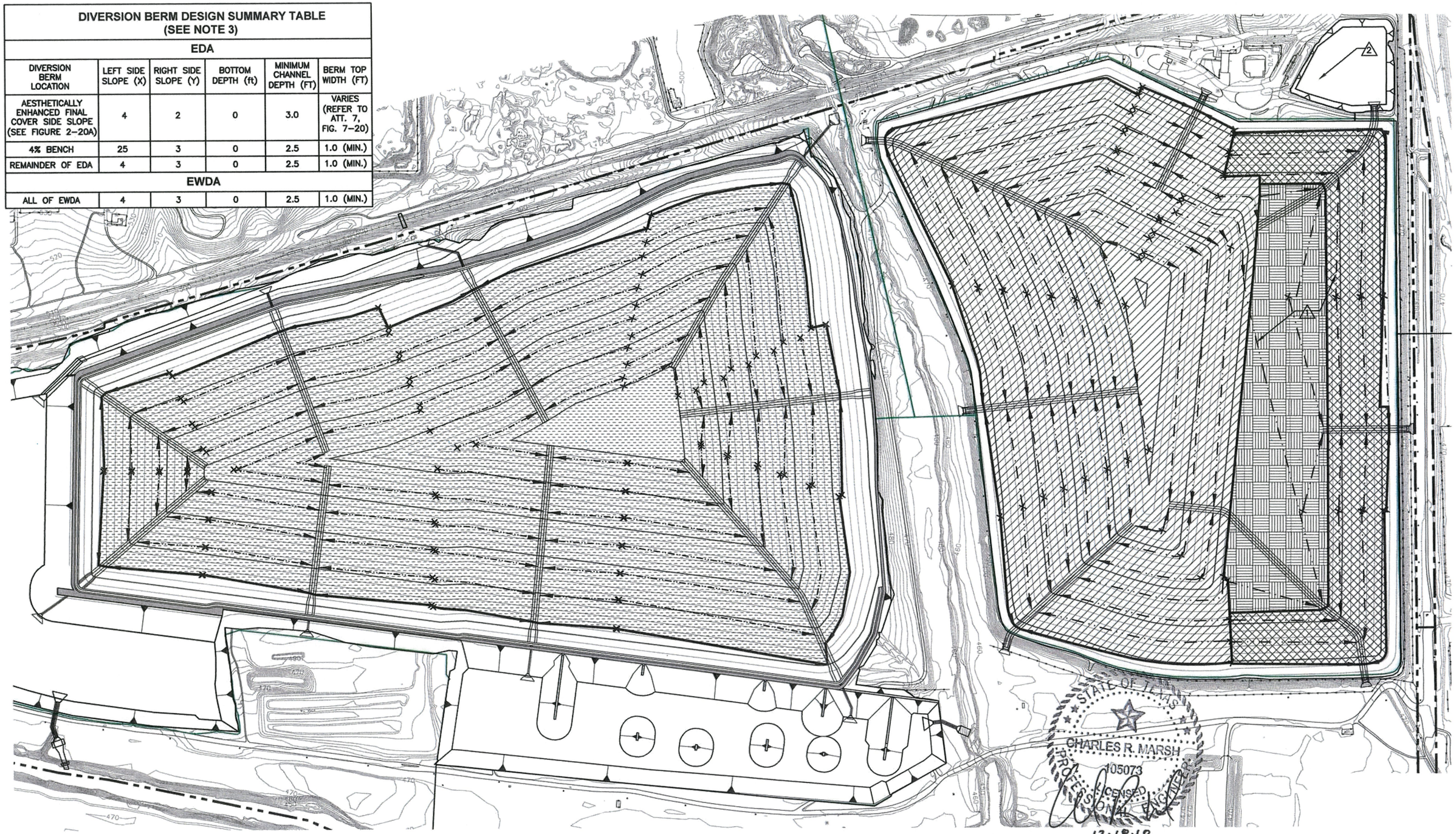
| | |
|---|---|
| DRAWN TWM | REVIEWED DEP |
| CHECKED DML/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-13 MISC DET.dwg |
| FIGURE NUMBER | |

PART III, ATT. 2
2-20



Drawing File: J:_20070073-9407711 Rep Arl Expan Permit_B - Permit Attachment 20\073-9407711-13 MISC DET.dwg | Modified: 1/13/2012 3:13:07 PM CTrevino | Plotted: Wednesday, June 18, 2014 9:43:08 AM CTrevino

| DIVERSION BERM DESIGN SUMMARY TABLE (SEE NOTE 3) | | | | | |
|---|---|---|---|---|---|
| **EDA** | | | | | |
| DIVERSION BERM LOCATION | LEFT SIDE SLOPE (X) | RIGHT SIDE SLOPE (Y) | BOTTOM DEPTH (ft) | MINIMUM CHANNEL DEPTH (FT) | BERM TOP WIDTH (FT) |
| AESTHETICALLY ENHANCED FINAL COVER SIDE SLOPE (SEE FIGURE 2-20A) | 4 | 2 | 0 | 3.0 | VARIES (REFER TO ATT. 7, FIG. 7-20) |
| 4% BENCH | 25 | 3 | 0 | 2.5 | 1.0 (MIN.) |
| REMAINDER OF EDA | 4 | 3 | 0 | 2.5 | 1.0 (MIN.) |
| **EWDA** | | | | | |
| ALL OF EWDA | 4 | 3 | 0 | 2.5 | 1.0 (MIN.) |




LIST OF REVISIONS:

1. UPDATED SWALE LAYOUT.
2. ADDED DETENTION POND.

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-15-2016.

N

0 250 500
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- DIVERSION BERM DESIGN AREA
- 1 INDICATES REVISION (SEE LIST OF REVISIONS)
- EDA DIVERSION BERMS
- AESTHETICALLY ENHANCED FINAL COVER SIDESLOPE DIVERSION BERMS
- EDA 4% DIVERSION BERMS
- EWDA DIVERSION BERMS

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DATE: 10/2014
FILE: 0023-404-11
CAD: 2-20A DIVERSION BERM DESIGN.DWG

DRAWN BY: RDM
DESIGN BY: RJS
REVIEWED BY: JAE

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| 1 | 10/2017 | PERMIT MODIFICATION |
| 2 | 12/2018 | SEE LIST OF REVISIONS |
| | | |

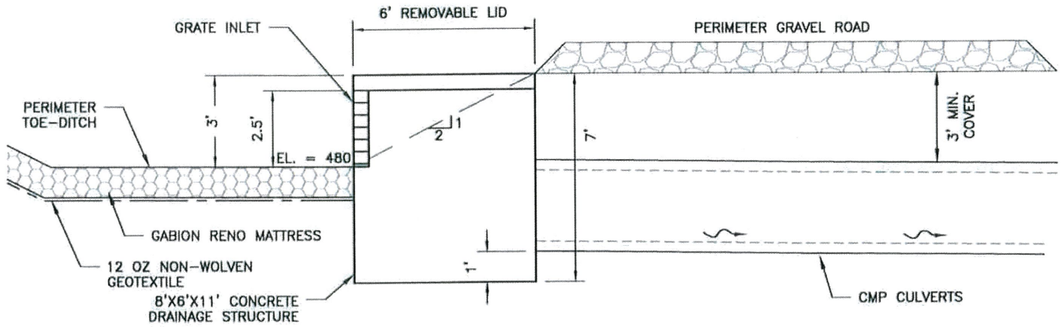
# MAJOR PERMIT AMENDMENT DIVERSION BERM DESIGN LOCATIONS

CITY OF ARLINGTON LANDFILL
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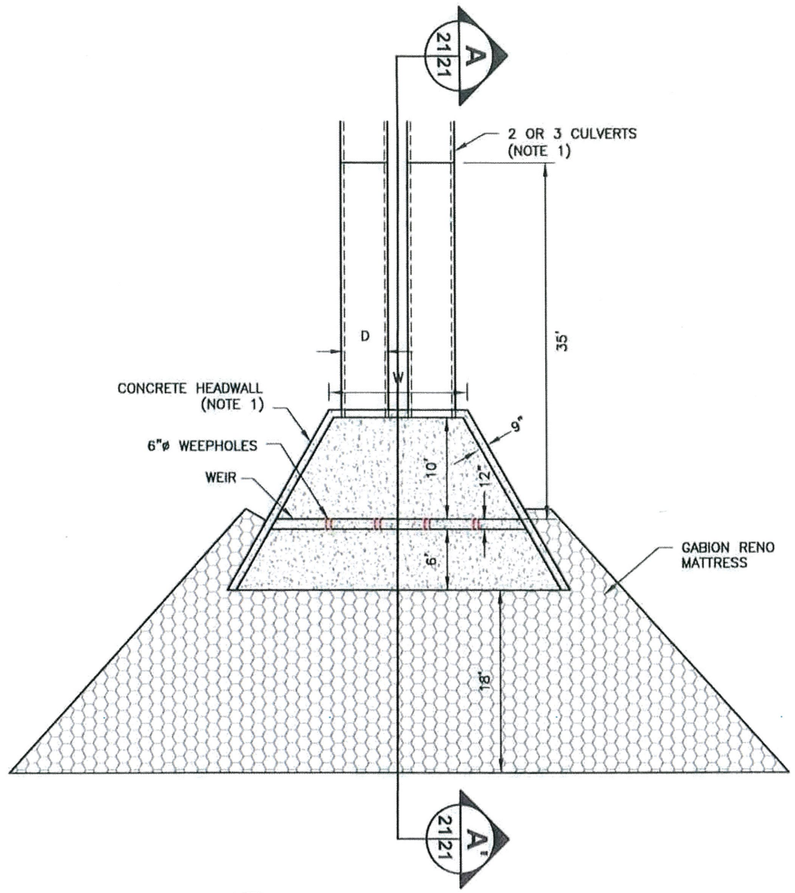
FIGURE 2-20A

O:\0023\404\LSMPA (2017)\ATT 2\2-20A DIVERSION BERM AREAS.dwg, jwilson, 1:2




1 / 11 21 **TYPICAL CULVERT INLET STRUCTURE DETAIL**

SCALE: NOT TO SCALE

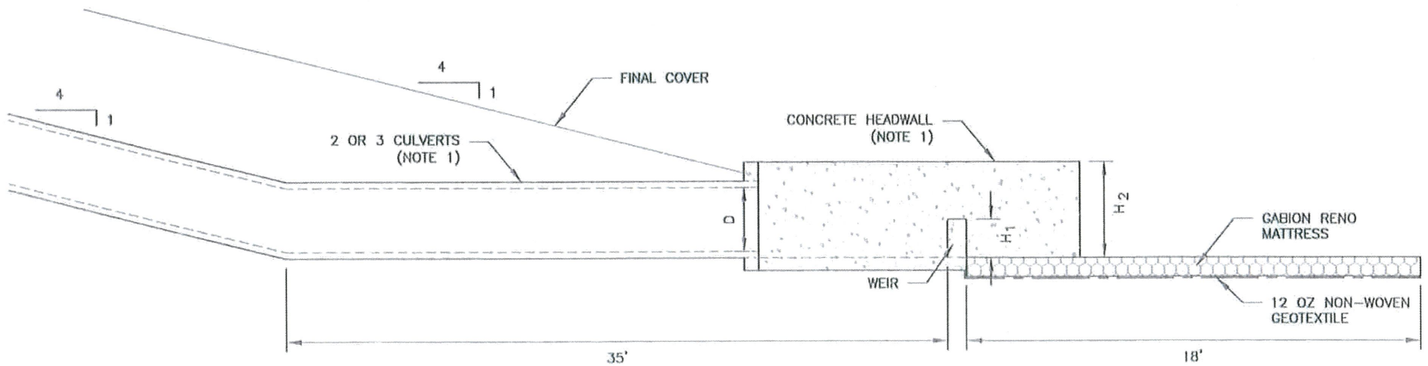



2 / 11 21 **TOE-DITCH CULVERT ENERGY DISSIPATOR DETAIL**

SCALE: NOT TO SCALE

## NOTES:

1. DIMENSIONS TO BE MODIFIED TO HEADWALL COINCIDE WITH NUMBER AND SIZE OF CULVERTS.
2. NUMBER AND SIZE OF CULVERTS PRESENTED IN APPENDIX 2-H.
3. DIAMETER (D) VARIES FROM 2 TO 4 FEET.




A-A' / 21 21 **SECTION A-A'**

SCALE: NOT TO SCALE



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GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: TOE-DITCH CULVERT DETAILS

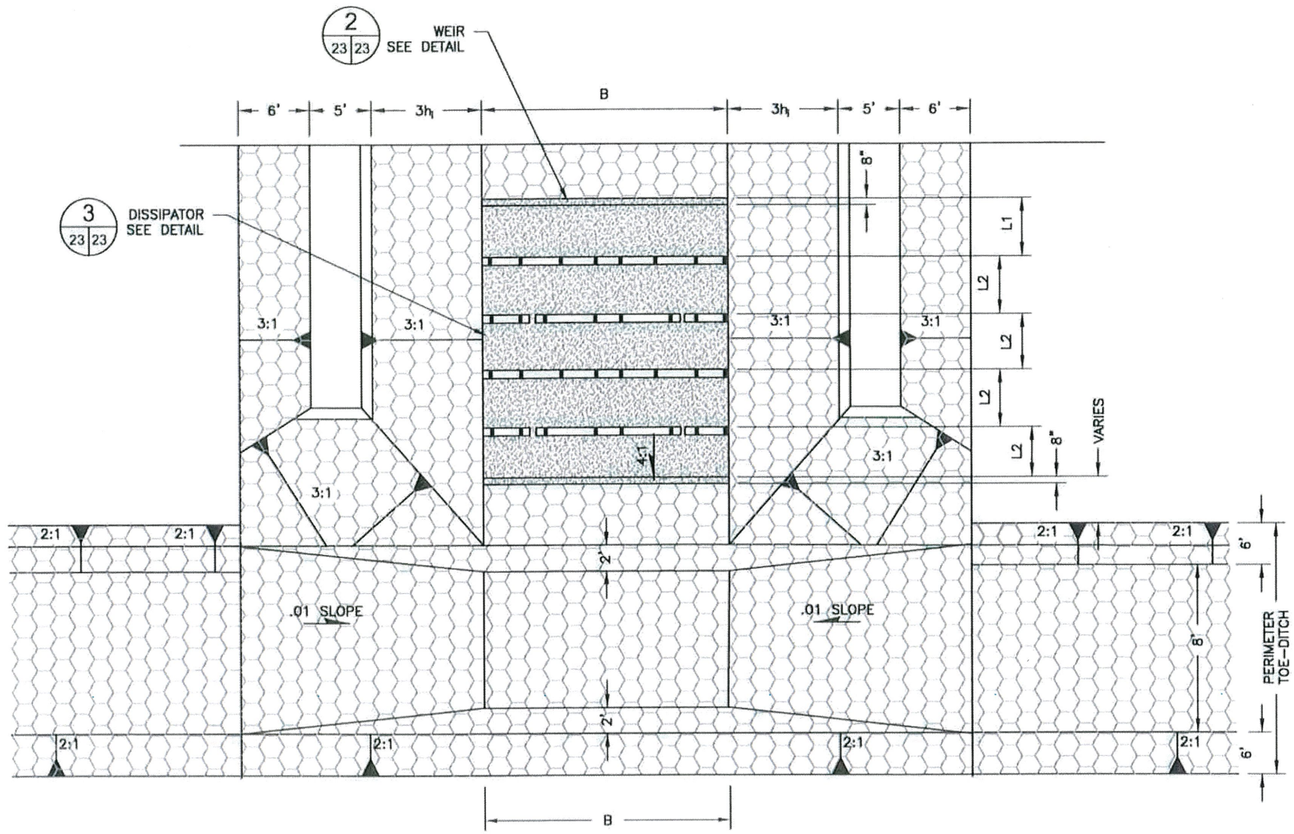
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| DRAWN TWM | REVIEWED DEP |
| CHECKED DML/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-12 TOE D DETR.dwg |

FIGURE NUMBER

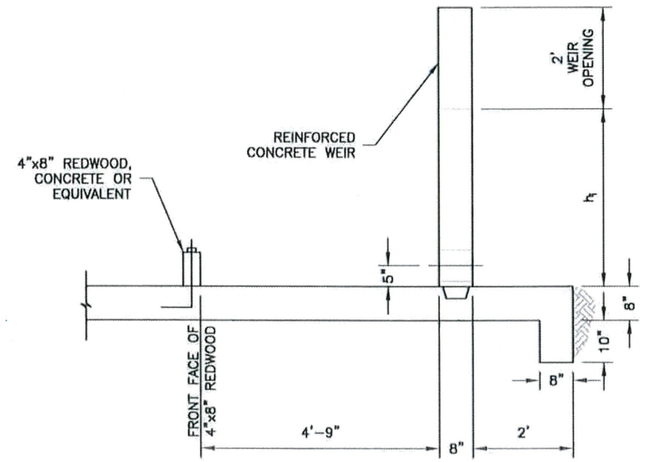
PART III, ATT. 2

2-21

Drawing File: J:_2007\073-9407711 Rep Ar Expan Permit_B - Permit Attachment 2\073-9407711-12 TOE D DETR.dwg | Modified: 3/6/2012 5:28:27 PM Mlaskowski | Plotted: Wednesday, June 18, 2014 9:45:10 AM Mlaskowski



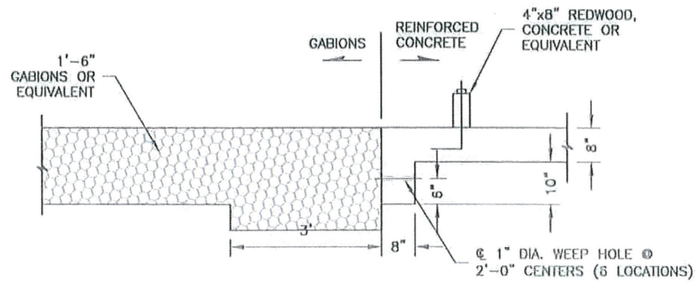

1 / 11 23 **SIDESLOPE ENERGY DISSIPATOR DETAIL**
SCALE: NOT TO SCALE




2 / 23 23 **WEIR DETAIL**
SCALE: NOT TO SCALE

| DOWNCHUTE WIDTH SUMMARY | | | |
|---|---|---|---|
| | CHUTE | CHUTE WIDTH BEFORE TRANSITION ZONE (B1) | CHUTE WIDTH AFTER TRANSITION ZONE (B2) |
| EWDA | 1 | 6 | 12 |
| | 2 | 6 | 12 |
| | 3 | 12 | 24 |
| | 4 | 12 | 24 |
| | 5 | 15 | 30 |
| | 6 | 12 | 24 |
| | 7 | 12 | 24 |
| | 8 | 12 | 24 |
| | 9 | 15 | 30 |
| EDA | 1 | 10 | 20 |
| | 2 | 10 | 20 |
| | 3 | 10 | 20 |
| | 4 | 10 | 20 |

NOTE REFER TO APPENDIX 2-F FOR SUPPORTING CALCULATIONS




3 / 23 23 **DISSIPATOR DETAIL**
SCALE: NOT TO SCALE



PERMIT ISSUED

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

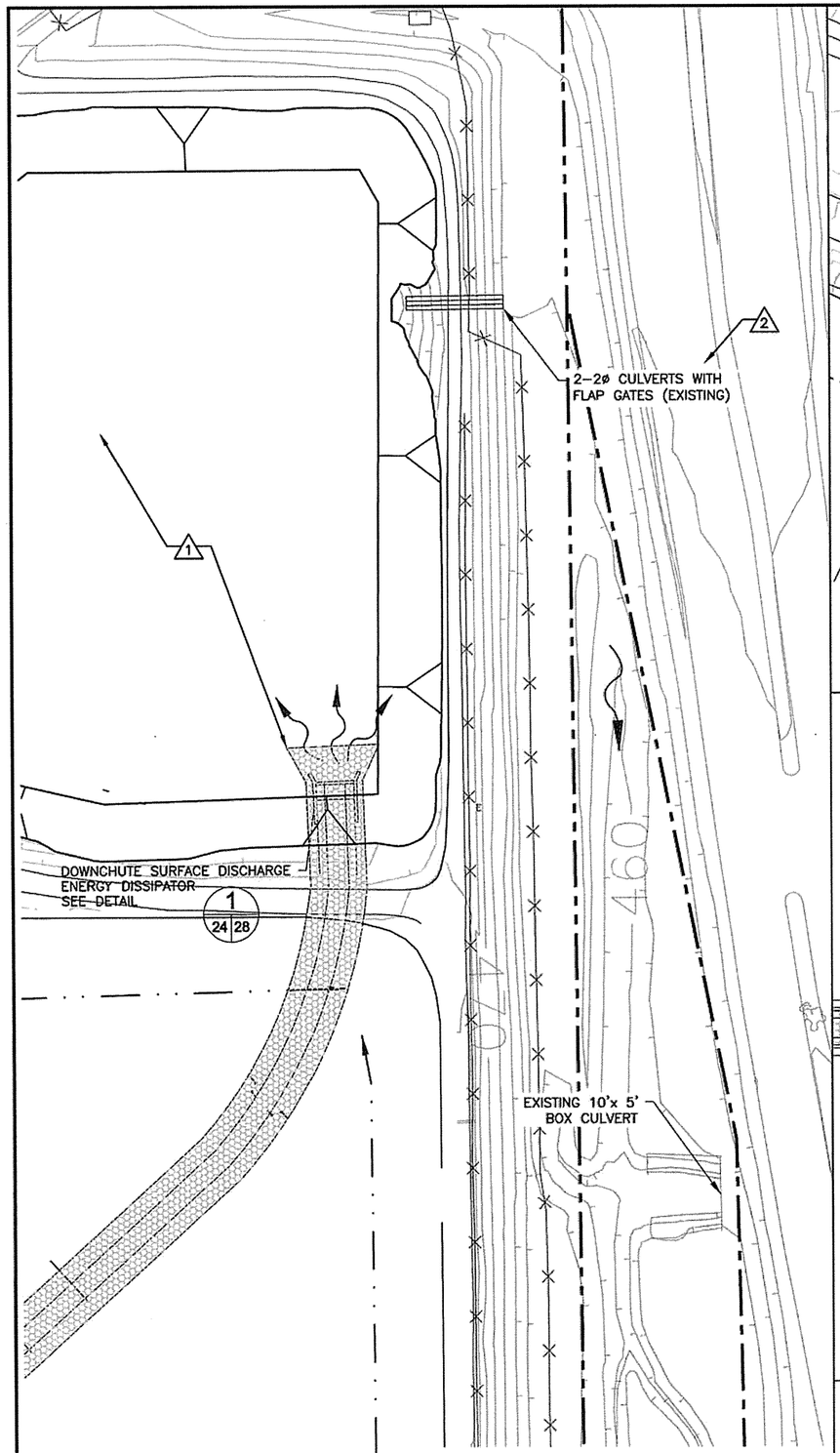
CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

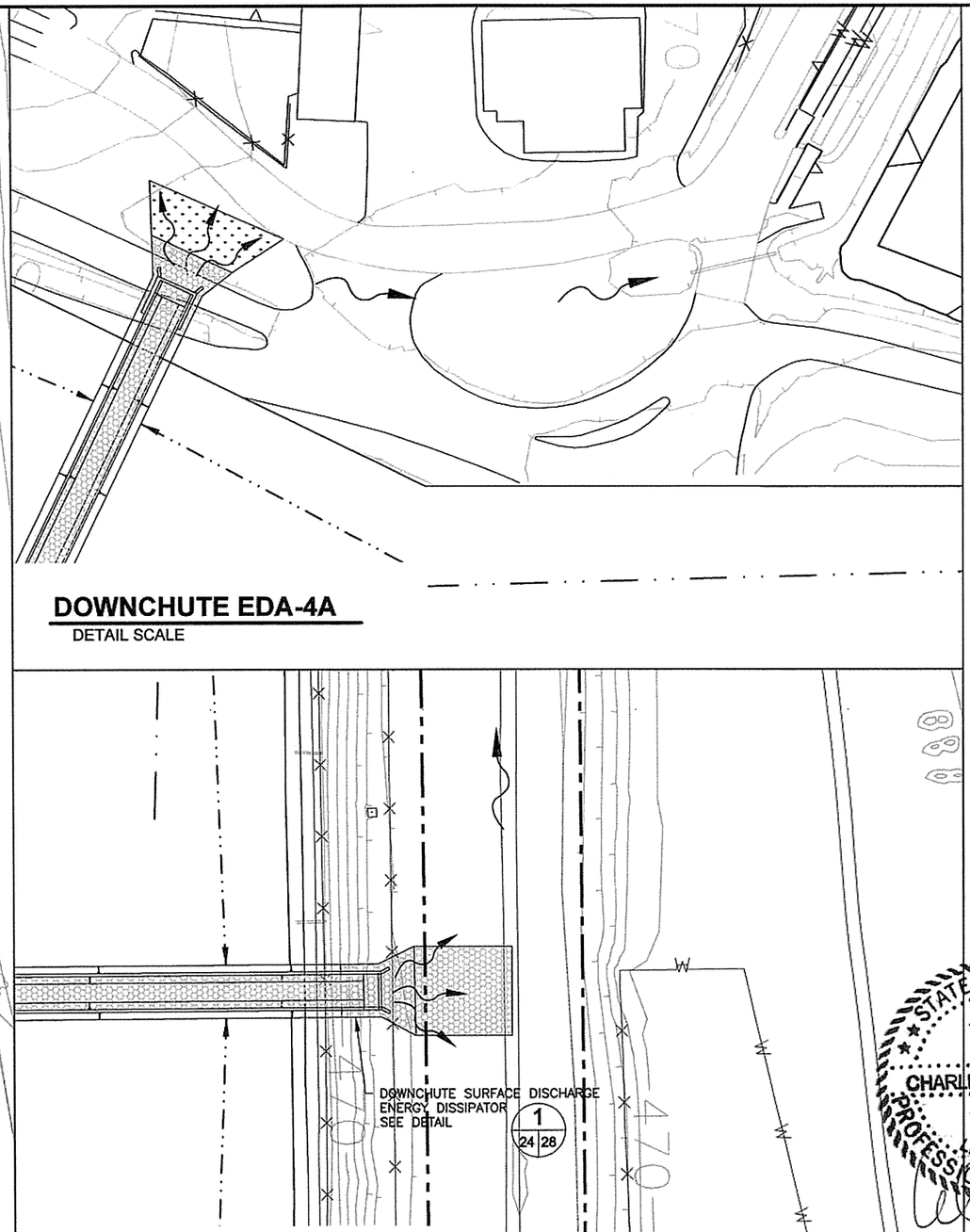
TITLE: ENERGY DISSIPATOR AND WEIR DETAILS

| | |
|---|---|
| DRAWN TWM | REVIEWED DEP |
| CHECKED DML/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-23 DISSDET |
| FIGURE NUMBER | |
| PART III, ATT. 2 | |
| 2 23 | |

Drawing File: J:_2007\073-9407711 Rap Art Expan Permit_B - Permit Attachment 2\073-9407711-23 DISSDET.dwg | Modified: 1/13/2012 3:13:00 PM CTrevino | Plotted: Wednesday, June 18, 2014 9:50:11 AM CTrevino



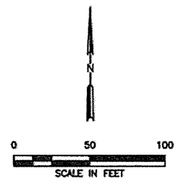

**DOWNCHUTE EDA-1**
DETAIL SCALE




**DOWNCHUTE EDA-2A**
DETAIL SCALE



**DOWNCHUTE EDA-4A**
DETAIL SCALE




LEGEND

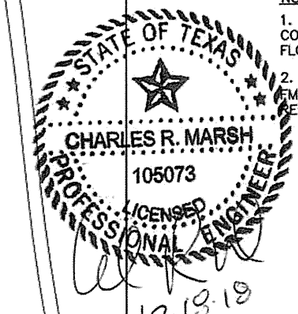
- PERMIT BOUNDARY
- CITY OF ARLINGTON PROPERTY BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- FLOW DIRECTION
- GABION RENO MATTRESS OR APPROVED ALTERNATIVE (SEE NOTE 2)
- VEGETATED TURF REINFORCEMENT MAT
- 1 INDICATES REVISION (SEE LIST OF REVISIONS BELOW)

LIST OF REVISIONS:

1. UPDATED CHUTE LAYOUT AND ADDED DETENTION POND.
2. REVISED OUTLET STRUCTURE.

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY FLOWN 1–11–2016.
2. APPROVED ALTERNATIVE LETDOWN OPTIONS INCLUDE FML/GROUTED RIPRAP AND FLEXAMAT/GROUTED RIPRAP. REFER TO FIGURES 2–23A THROUGH 2–23D.




☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 06/2014
FILE: 0023-404-11
CAD: 2-24 DEC DET EDA.DWG

DRAWN BY: RDM
DESIGN BY: RJS
REVIEWED BY: JAE

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| 1 | 09/2018 | PERMIT MODIFICATION |
| 2 | 12/2018 | SEE LIST OF REVISIONS |

MAJOR PERMIT AMENDMENT
EDA DOWNCHUTE DRAINAGE STRUCTURES

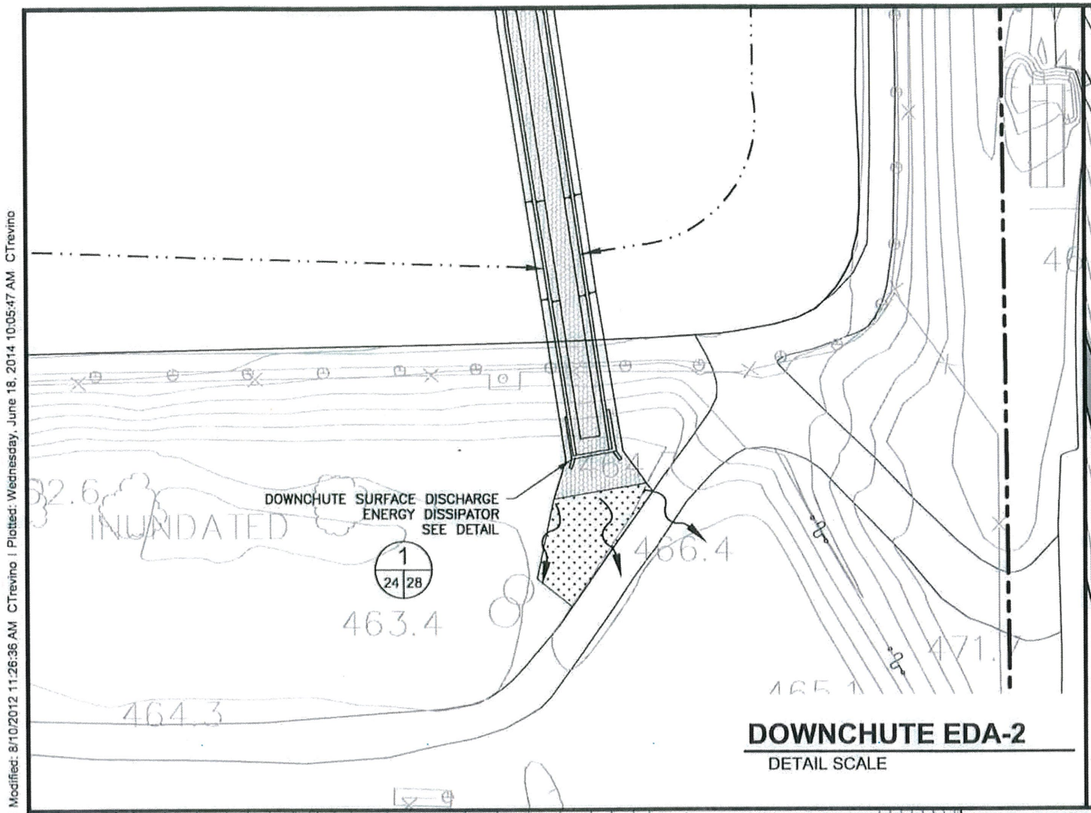
CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

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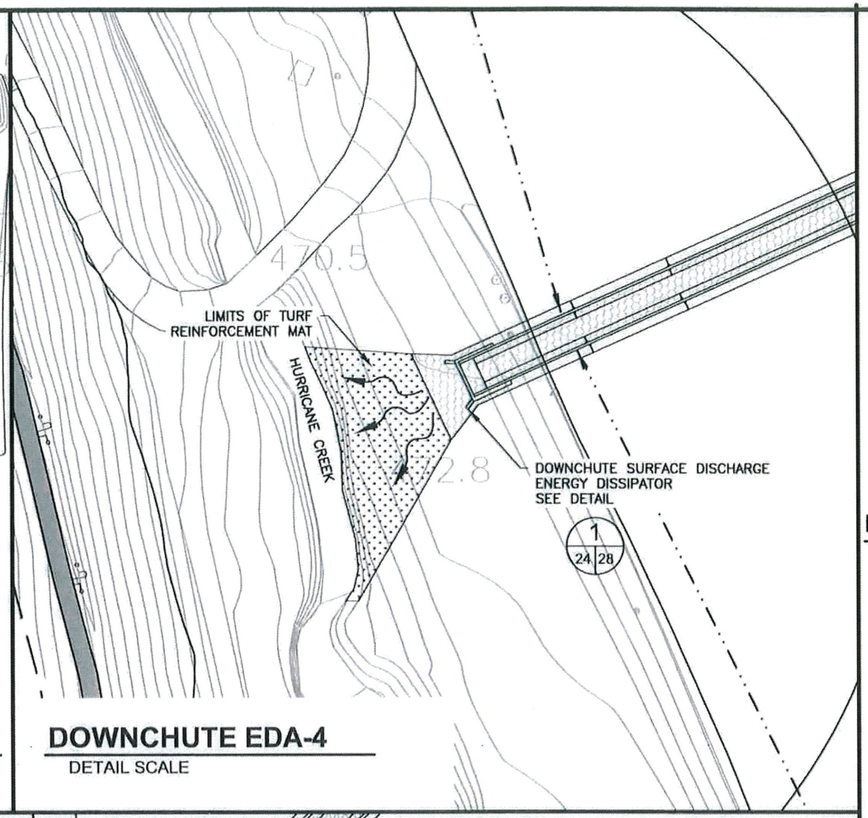
FIGURE 2–24

O:\0023\404\LSMPA (2017)\ATT 2\2-24 & 2-25 DC DET EDA.dwg, jwilson, 1:1

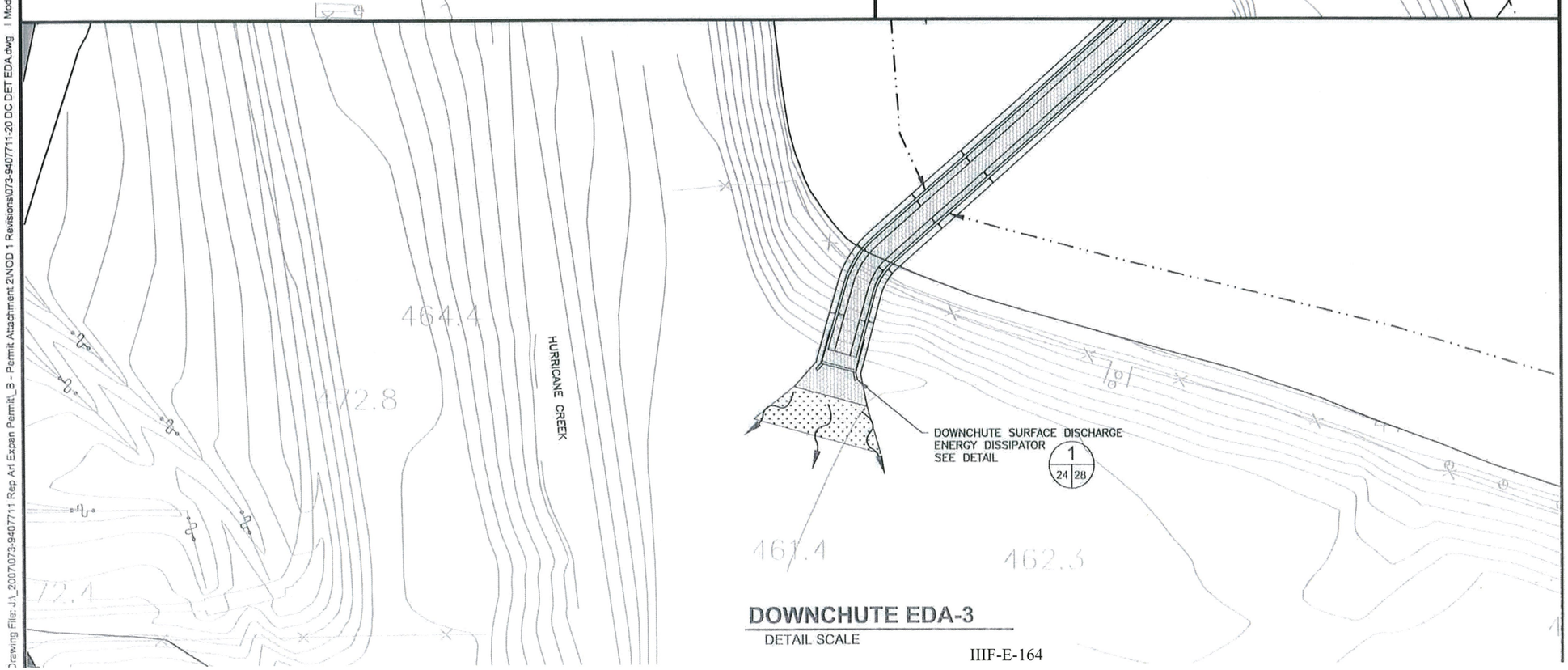
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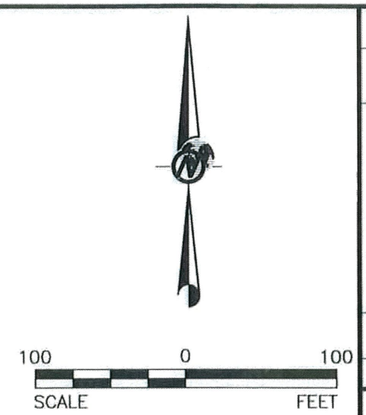

**DOWNCHUTE EDA-2**
DETAIL SCALE




**DOWNCHUTE EDA-4**
DETAIL SCALE




**DOWNCHUTE EDA-3**
DETAIL SCALE




## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

## LEGEND

- PERMIT BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- FLOW DIRECTION
- GABION RENO MATTRESS
- VEGETATED TURF REINFORCEMENT MAT

**PERMIT ISSUED**

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: EDA DOWNCHUTE DRAINAGE STRUCTURES

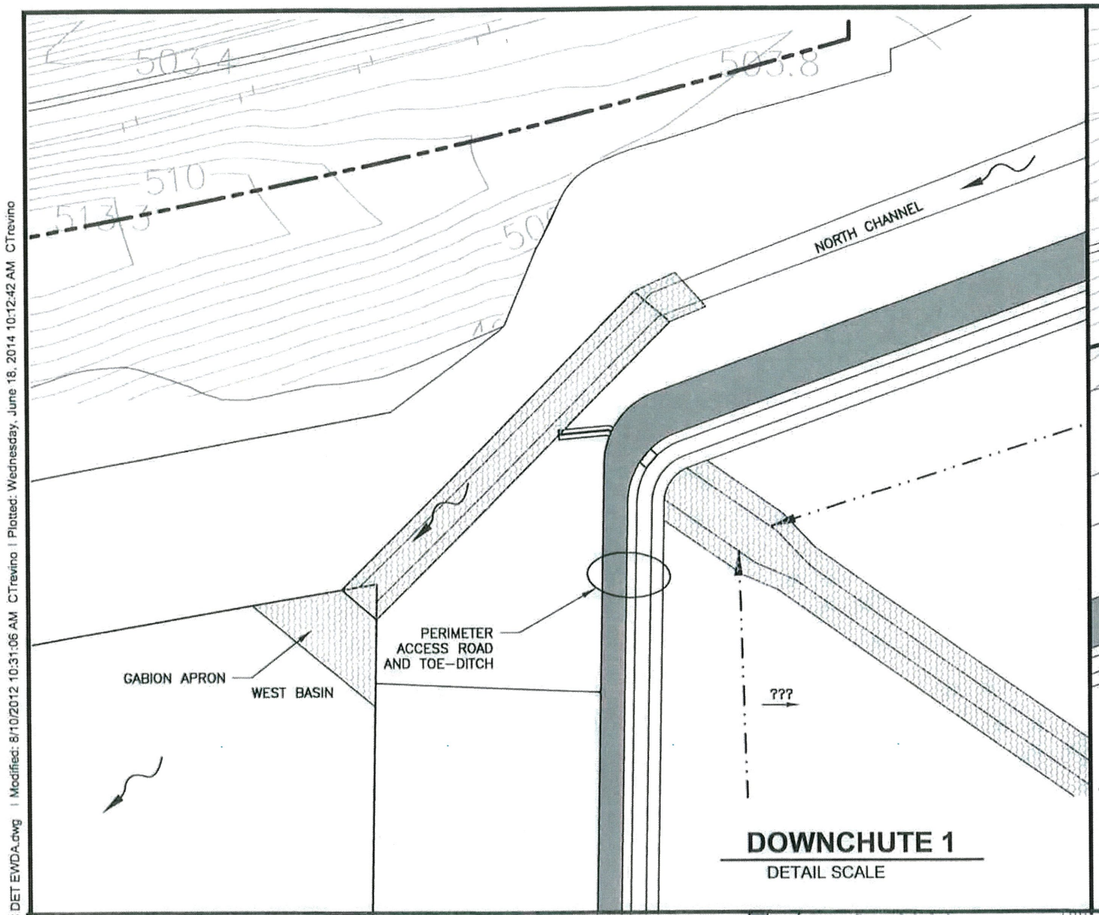
| | |
|---|---|
| DRAWN TWM | REVIEWED DEP |
| CHECKED DML/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-20 DC DET EDA.dwg |

FIGURE NUMBER

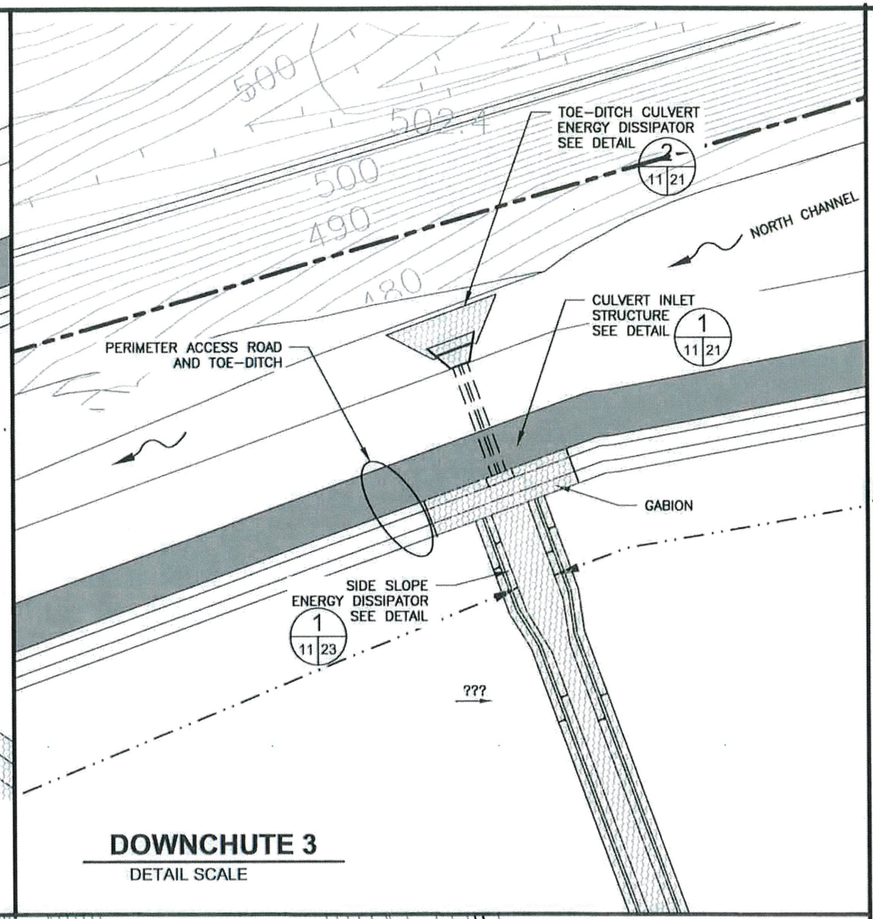
PART III, ATT. 2

2-25

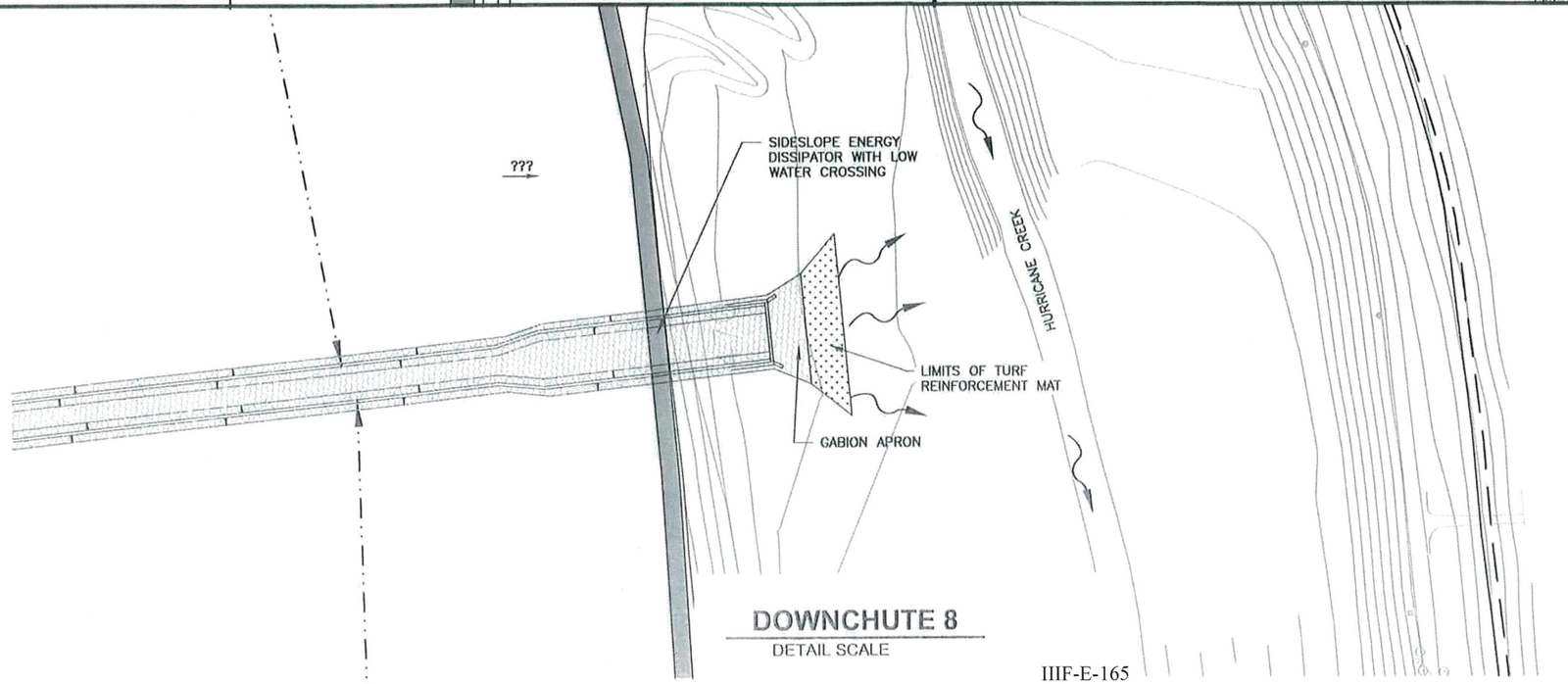
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**DOWNCHUTE 1**
DETAIL SCALE




**DOWNCHUTE 3**
DETAIL SCALE




**DOWNCHUTE 8**
DETAIL SCALE




## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

## LEGEND

- PERMIT BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- FLOW DIRECTION
- GABION RENO MATTRESS
- PERIMETER ACCESS ROAD

**PERMIT ISSUED**

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-8770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS

**REPUBLIC**
WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: EWDA DOWNCHUTE DRAINAGE STRUCTURES

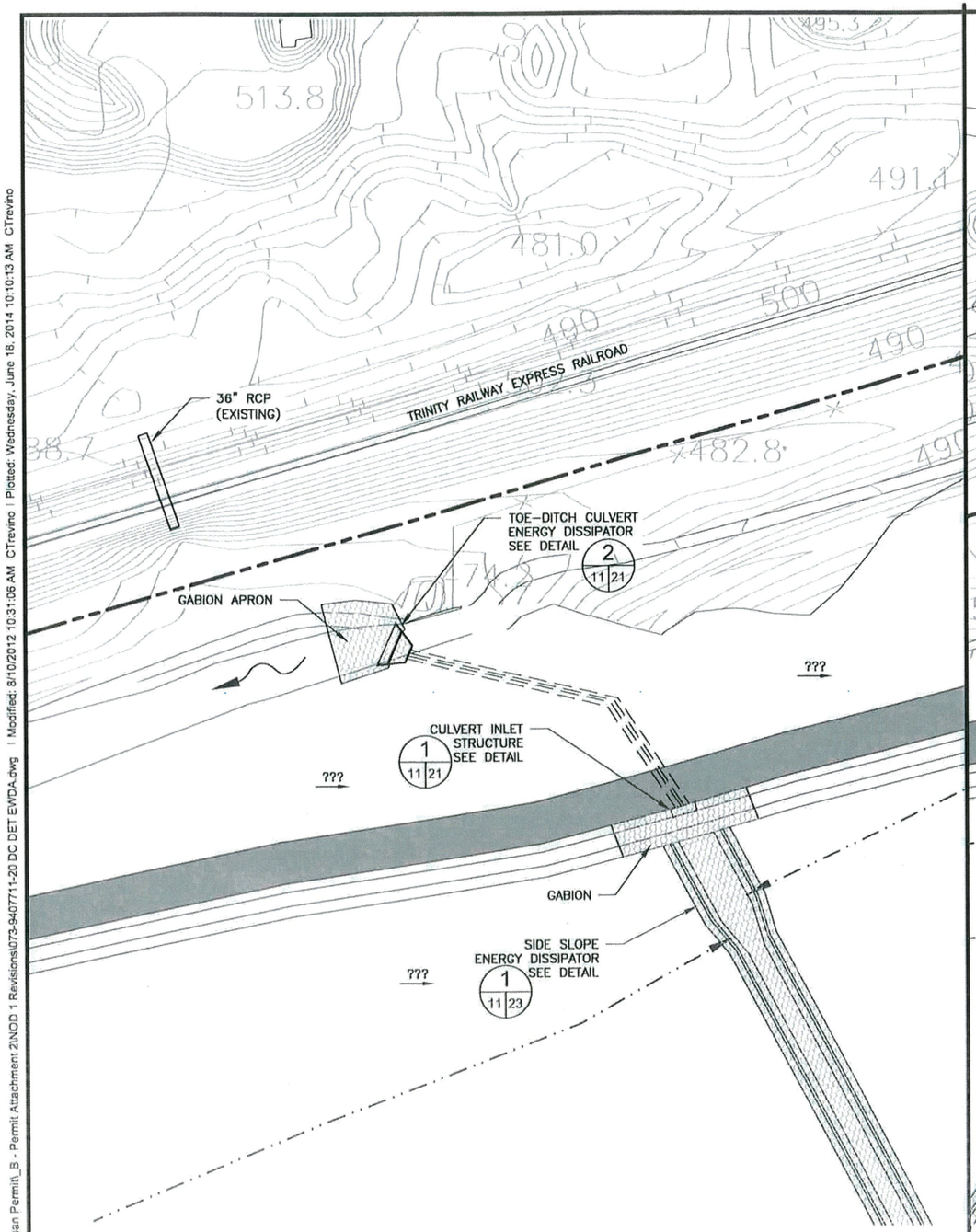
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|---|---|
| DRAWN | TWH |
| CHECKED | DML/CMT |
| REVIEWED | DEP |
| APPROVED | DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-20 DC DET EWDA.dwg |

FIGURE NUMBER

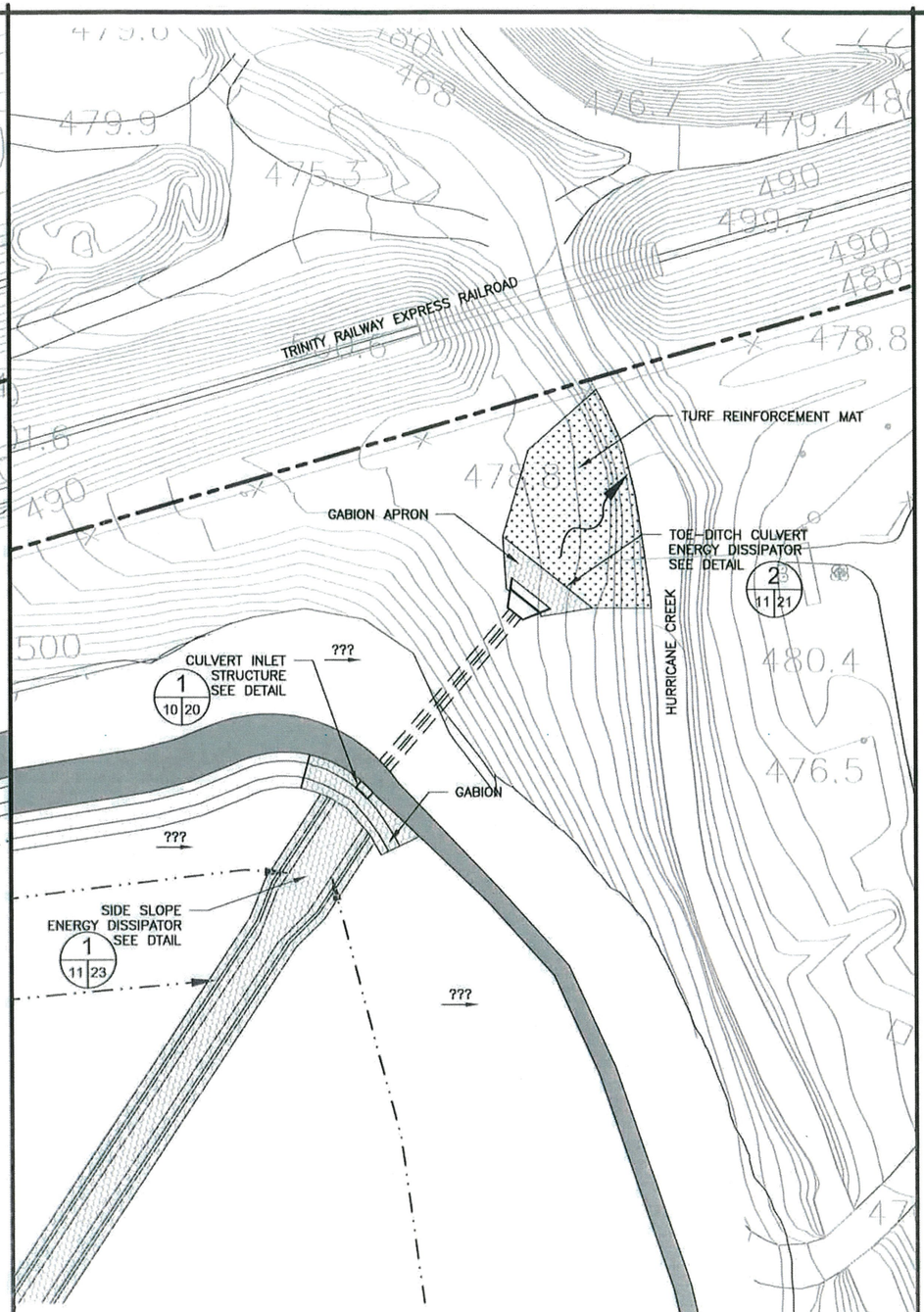
PART III, ATT. 2

2-26

Drawing File: J:_2007\073-9407711 Rep Art Expan Permit_B - Permit Attachment 2\NOD 1 Revisions\073-9407711-20 DC DET EWDA.dwg | Modified: 8/10/2012 10:31:06 AM CTrevino | Plotted: Wednesday, June 18, 2014 10:10:13 AM CTrevino




**DOWNCHUTE 5**
DETAIL SCALE




**DOWNCHUTE 7**
DETAIL SCALE

100 0 100
SCALE FEET

## LEGEND

- PERMIT BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- FLOW DIRECTION
- GABION RENO MATTRESS
- PERIMETER ACCESS ROAD
- VEGETATED TURF REINFORCEMENT MAT

**PERMIT ISSUED**

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 491-8770
Texas Registration Number: F-2578

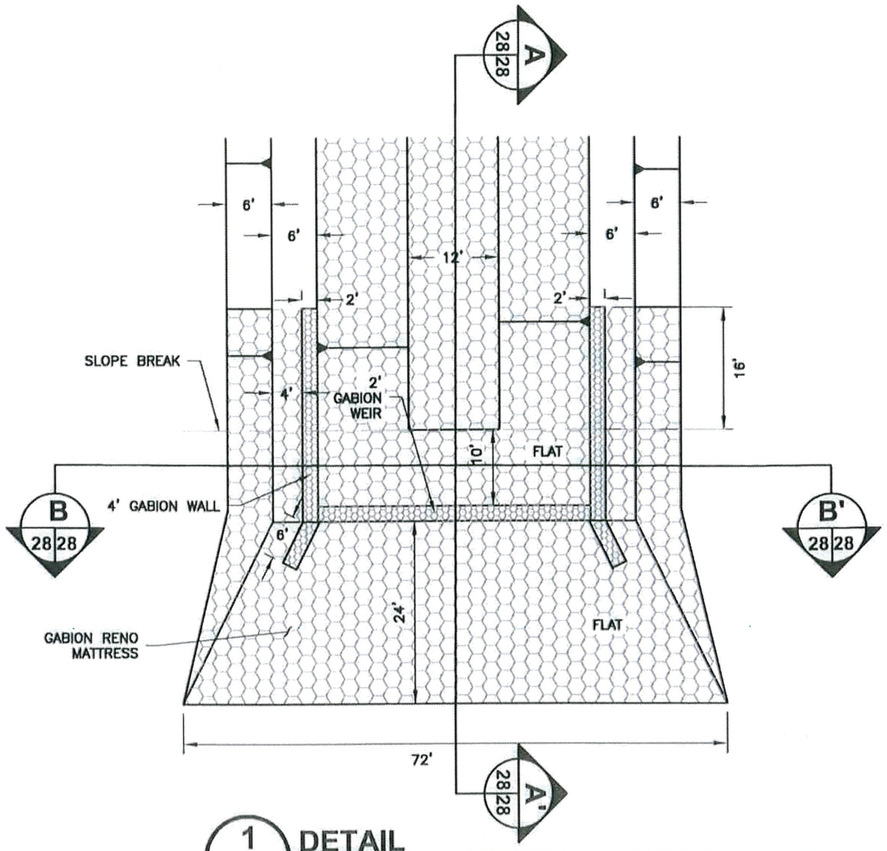
CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

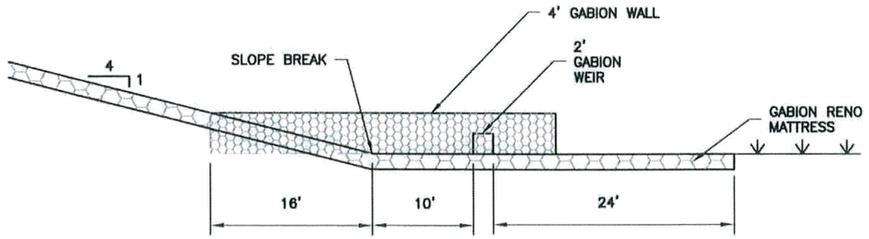
TITLE: EWDA DOWNCHUTE DRAINAGE STRUCTURES

| | |
|---|---|
| DRAWN | TWM |
| REVIEWED | DEP |
| CHECKED | DML/CMT |
| APPROVED | DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-20 DC DET EWDA.dwg |

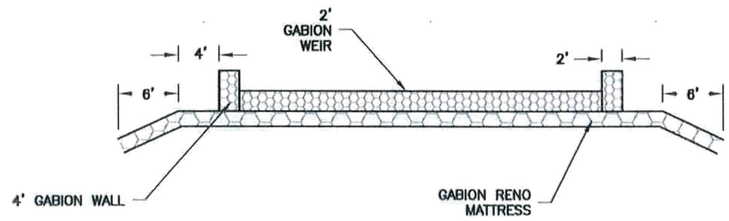
FIGURE NUMBER
PART III, ATT. 2
2-27




**1 / 24 28 DETAIL**
**DOWNCHUTE SURFACE DISCHARGE ENERGY DISSIPATOR**
SCALE: NOT TO SCALE




**A-A' / 28 28 SECTION A-A'**
SCALE: NOT TO SCALE




**B-B' / 28 28 SECTION B-B'**
SCALE: NOT TO SCALE

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
2-20-14
DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

PERMIT ISSUED

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
Tel: (817) 490-5770
Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

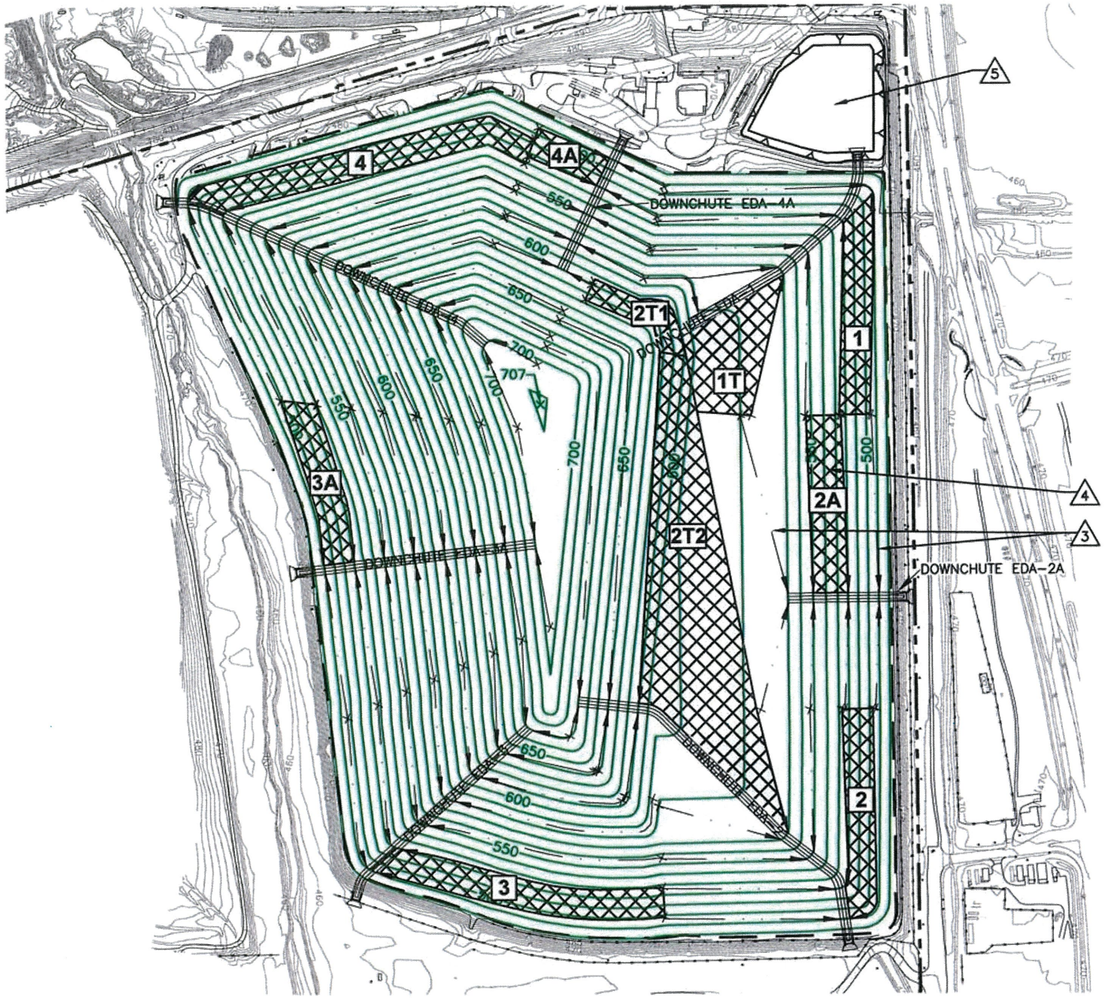
TITLE: DOWNCHUTE SURFACE DISCHARGE ENERGY DISSIPATOR

| | |
|---|---|
| DRAWN TWM | REVIEWED DEP |
| CHECKED DMR/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-24 DC STRU |
| FIGURE NUMBER | |

PART III, ATT. 2
2-28



Drawing File: J:_2007\073-9407711 Rep Art Expan Permit_B - Permit Attachment 2\073-9407711-24 DC STRU.dwg | Modified: 1/13/2012 4:38:11 PM CTrevino | Plotted: Wednesday, June 18, 2014 10:14:22 AM CTrevino




0 300 600
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- SUBBASIN BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- DOWNCHUTE
- SIDESLOPE DIVERSION BERM DRAINAGE AREA
- (1) INDICATES REVISION (SEE LIST OF REVISIONS BELOW)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY FLOWN 11-15-2016.

STATE OF TEXAS
CHARLES R. MARSH
105073
LICENSED
PROFESSIONAL ENGINEER

LIST OF REVISIONS:

1. UPDATED HYDRAULIC CALCULATIONS.
2. UPDATED ACREAGE.
3. UPDATED SWALE LAYOUT.
4. UPDATED DRAINAGE AREA 2A.
5. UPDATED DETENTION POND.

## DOWNCHUTE DESIGN

| DOWNCHUTE NO. (1) | PEAK FLOW (cfs) (1) | DESIGN WIDTH (ft) | DESIGN DEPTH (ft) | MAXIMUM VELOCITY (ft/s) (1) | NORMAL FLOW DEPTH (ft) (1) | FREEBOARD (ft) (1) |
|---|---|---|---|---|---|---|
| 1 | 113 | 10 | 2.0 | 15.92 | 0.60 | 1.40 |
| 2 | 195 | 10 | 2.0 | 20.09 | 0.78 | 1.22 |
| 2A | 110 | 10 | 2.0 | 15.77 | 0.59 | 1.41 |
| 3 | 172 | 10 | 2.0 | 19.28 | 0.73 | 1.27 |
| 3A | 138 | 10 | 2.0 | 17.96 | 0.65 | 1.35 |
| 4 | 193 | 10 | 2.0 | 20.04 | 0.78 | 1.22 |
| 4A | 65 | 10 | 2.0 | 13.86 | 0.42 | 1.58 |

## DIVERSION BERM DRAINAGE AREAS (MAX.)

| AREA NO. | AREA IN ACRES |
|---|---|
| 1 | 2.3 |
| 1T | 2.9 (2) |
| 2 | 2.1 |
| 2A | 2.2 (4) |
| 2T (SEGMENT 1) | 1.0 |
| 2T (SEGMENT 2) | 12.3 |
| 3 | 3.1 |
| 3A | 1.9 |
| 4 | 3.6 |
| 4A | 0.8 |

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☐ ISSUED FOR CONSTRUCTION

DATE: 06/2014
FILE: 0023-404-11
CAD: 2-29 POST DEV DRNG.DWG

DRAWN BY: RDM
DESIGN BY: RJS
REVIEWED BY: JAE

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

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

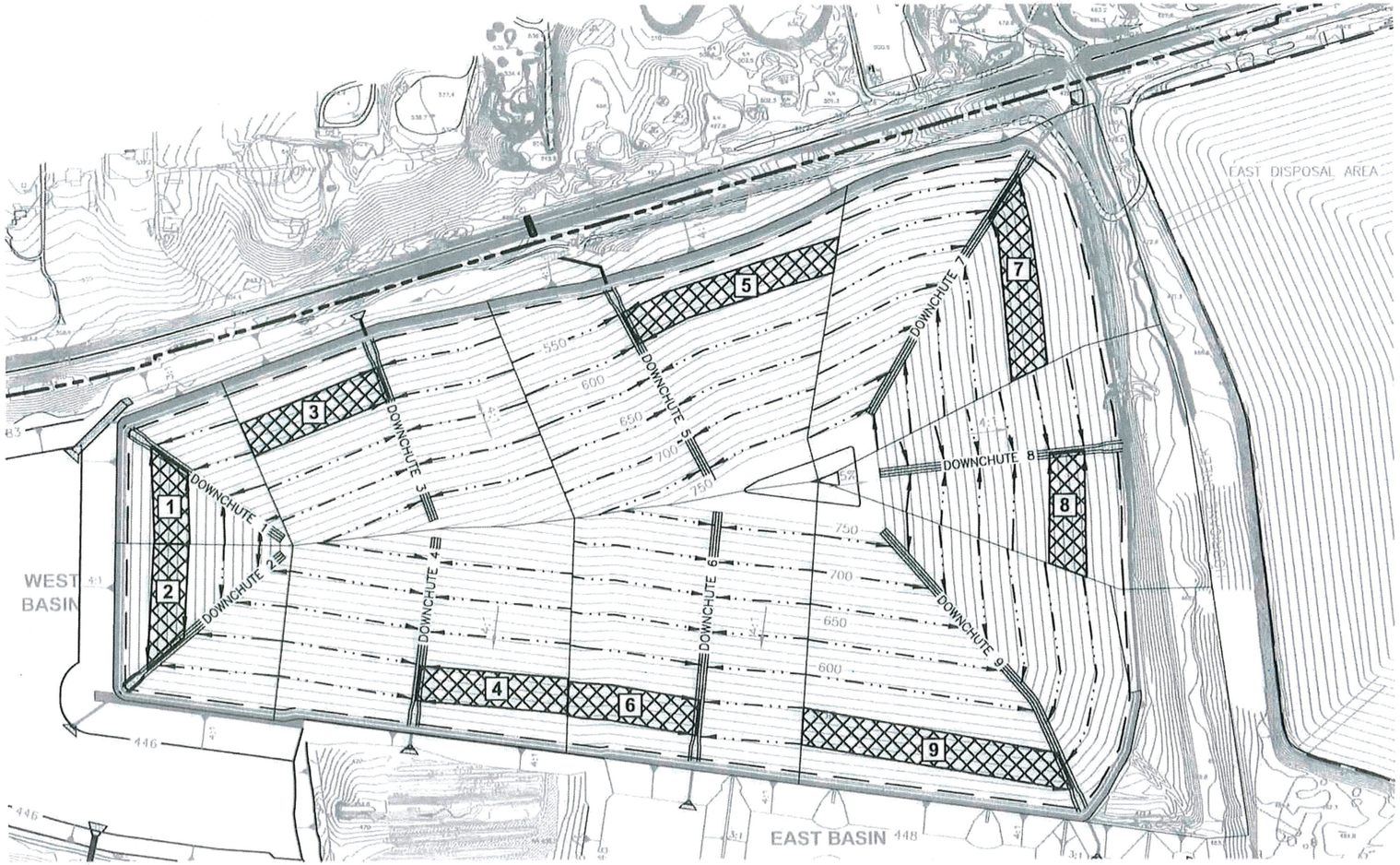
| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
| 1 | 06/2017 | PERMIT MODIFICATION |
| 2 | 12/2018 | SEE LIST OF REVISIONS |

MAJOR PERMIT AMENDMENT
SIDESLOPE DIVERSION BERM MAX. DRAINAGE AREAS AND DOWNCHUTE DIMENSIONS EDA
CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE 2-29

O:\0023\404\LSMPA (2017)\ATT 2\2-29 SWALE D E.dwg, jwilson, 1:1




600 0 600
SCALE FEET

## NOTES

1. EXISTING TOPOGRAPHY IS A COMPILATION OF THE FOLLOWING AERIAL SURVEYS: JUNE 6, 2010, DALLAS AERIAL SURVEY; MAY 13, 2007, DALLAS AERIAL SURVEY; MAY 14, 2005, METROPOLITAN AERIAL SURVEYS.

## DOWNCHUTE DESIGN

| DOWNCHUTE NO. | PEAK FLOW (cfs) | DESIGN WIDTH (ft) | DESIGN DEPTH (ft) | MAXIMUM VELOCITY (ft/s) | NORMAL FLOW DEPTH (ft) | FREEBOARD (ft) |
|---|---|---|---|---|---|---|
| 1 | 77 | 6 | 2 | 16.4 | 0.60 | 1.40 |
| 2 | 100 | 6 | 2 | 17.8 | 0.69 | 1.31 |
| 3 | 204 | 12 | 2 | 19.6 | 0.73 | 1.27 |
| 4 | 206 | 12 | 2 | 19.7 | 0.74 | 1.26 |
| 5 | 251 | 15 | 2 | 20.0 | 0.73 | 1.27 |
| 6 | 229 | 12 | 2 | 20.4 | 0.78 | 1.22 |
| 7 | 248 | 12 | 2 | 21.0 | 0.82 | 1.18 |
| 8 | 163 | 12 | 2 | 18.2 | 0.64 | 1.36 |
| 9 | 290 | 15 | 2 | 21.0 | 0.79 | 1.21 |

## SIDESLOPE DIVERSION BERM DRAINAGE AREAS (MAX.)

| AREA NO. | AREA IN ACRES |
|---|---|
| 1 | 1.3 |
| 2 | 1.6 |
| 3 | 2.2 |
| 4 | 2.2 |
| 5 | 3.0 |
| 6 | 1.9 |
| 7 | 2.7 |
| 8 | 1.8 |
| 9 | 4.0 |

## LEGEND

- PERMIT BOUNDARY
- SUBBASIN BOUNDARY
- SIDESLOPE SURFACE WATER DIVERSION BERM
- DOWNCHUTE
- SIDESLOPE BERM DRAINAGE AREA

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
6-20-14

DAVID E. POE, P.E.
GOLDER ASSOCIATES INC.
F-2578

PERMIT ISSUED

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

Golder Associates
213 N. Oak St.
Roanoke, Texas 76262
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Texas Registration Number: F-2578

CITY OF ARLINGTON, TEXAS
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: SIDESLOPE DIVERSION BERM MAX. DRAINAGE AREAS AND DOWNCHUTE DIMENSIONS - EWDA

| | |
|---|---|
| DRAWN | TWM |
| CHECKED | DML/CMT |
| REVIEWED | DEP |
| APPROVED | DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-14 SWALE D W.dwg |

FIGURE NUMBER
PART III, ATT. 2
2-30



Drawing File: J:_2007\073-9407711 Rep Art Expan Permit_B - Permit Attachment 2\073-9407711-14 SWALE D W.dwg | Modified: 1/16/2012 6:18:22 PM CTrevino | Plotted: Wednesday, June 18, 2014 10:31:53 AM CTrevino

Drawing File: J:\1_2007\073-9407711 Rep Arl Expan Permit_B - Permit Attachment 2\073-9407711-21 Lowwat.dwg | Modified: 2/29/2012 8:54:02 AM CTrevino | Plotted: Wednesday, June 18, 2014 10:34:31 AM CTrevino

## NOTES

1. LOCATION AND LIMITS OF GABION RENO MATTRESSES AND TURF REINFORCEMENT MAT (TRM) SHOWN ON DRAWINGS FOR REPRESENTATION PURPOSES ONLY. ACTUAL LIMITS, TIE-INS, AND GRADING WILL BE DETERMINED DURING CONSTRUCTION DRAWINGS PREPARATION.

2. GABION RENO MATTRESSES, STONE BACKFILL, CONNECTIONS, TIE-INS AND ANCHORING, AND NON-WOVEN GEOTEXTILE TO BE INSTALLED ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.

3. TURF REINFORCEMENT MAT (TRM) TO BE INSTALLED ON ALL CHANNEL SLOPES DISTURBED DURING CONSTRUCTION. INSTALLATION, SEEDING, AND VEGETATION DEVELOPMENT ACCORDING TO MANUFACTURER'S RECOMMENDATION.

4. TRM COMPOSITION SHALL PROVIDE PERMANENT VEGETATION REINFORCING, POSSESSING A MINIMUM 15 PSF SHEAR STRENGTH PER MANUFACTURER'S PUBLISHED LITERATURE. LOCATION OF TRM INSTALLATION SHOWN ON DRAWINGS MAY BE INCREASED DEPENDING ON SITE DISTURBANCE DURING CONSTRUCTION. AREAS WITHIN CHANNELS OR ON SIDESLOPES SUBJECT TO WATER FLOW (E.G., HURRICANE CREEK, WEST FORK TRINITY RIVER) DISTURBED DURING CONSTRUCTION SHALL RECEIVE TRM PRIOR TO RESTORING VEGETATION.

5. CONCRETE STRUCTURES MAY BE PRE-CAST OR CAST IN PLACE. STEEL REINFORCING WILL BE DETERMINED BASED ON PROPOSED BACKFILL SOILS AND FOUNDATION CONDITIONS, AS DETERMINED DURING CONSTRUCTION PLANS PREPARATION.

6. CONCRETE STRUCTURES, PIPING, CONNECTIONS, FILL, AND BACKFILL TO COMPLY WITH TXDOT STANDARD SPECIFICATIONS AS A MINIMUM DESIGN AND CONSTRUCTION CRITERION. MATERIALS HANDLING, INSTALLATION, PIPE, CONCRETE STRUCTURES, FILL AND BACKFILL SHALL BE INSTALLED TO TXDOT STANDARD SPECIFICATIONS AS A MINIMUM CONSTRUCTION CRITERION. PIPE BEDDING, FOUNDATION PREPARATION OR IMPROVEMENTS, AND FILL AND BACKFILL COMPACTION REQUIREMENTS SHALL BE DETERMINED BASED ON GEOTECHNICAL INVESTIGATIONS TO BE PERFORMED IN SUPPORT OF CONSTRUCTION PLANS PREPARATION.

7. ADDITIONAL FOUNDATION IMPROVEMENTS (ROCK BEDDING, OVEREXCAVATION AND REPLACEMENT, LIME OR CEMENT STABILIZATION, PILES) MAY BE REQUIRED BELOW PIPING OR STRUCTURES, AS DETERMINED BY GEOTECHNICAL INVESTIGATIONS TO BE PERFORMED IN SUPPORT OF CONSTRUCTION PLANS PREPARATION.

8. THE NEED FOR CONCRETE THRUST BLOCKS AT CULVERT PIPE BENDS OR TRANSITIONS SHALL BE DETERMINED BASED ON GEOTECHNICAL INVESTIGATIONS TO BE PERFORMED IN SUPPORT OF CONSTRUCTION PLANS PREPARATION.

9. RIPRAP MAY BE SUBSTITUTED FOR GABION MATTRESSES FOR INLET AND OUTLET APRONS FOR HORIZONTAL OR NEAR-HORIZONTAL APPLICATION. RIPRAP SHALL BE SIZED TO ADDRESS THE PEAK VELOCITY DESCRIBED HEREIN.

10. ALL WORK SHALL BE PERFORMED IN ACCORDANCE WITH THE STORM WATER POLLUTION PREVENTION PLAN MAINTAINED FOR THE FACILITY. SWPPP SHALL BE UPDATED PRIOR TO CONSTRUCTION, AND ALL RECOMMENDED BEST MANAGEMENT PRACTICES (BMP'S) IMPLEMENTED AND MAINTAINED DURING CONSTRUCTION.

11. VEGETATION AND PLANTING SCHEDULE WITHIN THE DETENTION BASINS SHALL COMPLY WITH THE WETLANDS MITIGATION PLAN INCLUDED IN PARTS I/II OF THIS APPLICATION. SMALL TREE ISLANDS, AS REQUIRED IN THE WEST DETENTION BASIN AS A COMPONENT OF THE CONDITIONAL LETTER OF MAP REVISION (CLOMR) RECEIVED FOR THE PROJECT, HAVE NOT BEEN SHOWN ON THIS DRAWING FOR CLARITY. THE TREE ISLANDS AND OTHER WETLANDS FEATURES SHALL BE INCORPORATED INTO THE WETLANDS MITIGATION DESIGNS INCORPORATED INTO THE BASIN CONSTRUCTION PLANS.

12. A 30 TAC 330, SUBCHAPTER T REGISTRATION (OR REGULATORY EQUIVALENT AT THE TIME OF CONSTRUCTION) SHALL BE OBTAINED PRIOR TO EXCAVATING OR DISTURBING HISTORIC WASTE LOCATED ON PROPERTY SOUTH OF EXISTING WEST DISPOSAL AREA (SITE OF FUTURE EAST DETENTION BASIN). WASTE AND SOIL SHALL BE REMOVED TO THE LIMITS SHOWN ON DRAWINGS. WASTE SHALL BE REMOVED AT LOCATION OF FINGER BERMS AND ISLANDS SHOWN ON DRAWINGS, PRIOR TO RECONSTRUCTING FINGER BERMS AND ISLANDS WITH COMPACTED FILL.

13. AREAS OF WASTE EXPOSED IN SIDEWALLS OF EXCAVATION THAT WILL REMAIN IN PLACE (PRIMARILY ALONG SOUTHERN SLOPE OF EAST BASIN) SHALL BE COVERED BY A MINIMUM 2-FOOT THICK LAYER OF COMPACTED CLAY SOIL PRIOR TO VEGETATING. CLAY SOILS SHALL HAVE A LABORATORY PERMEABILITY OF NOT GREATER THAN 1X10-7 CM/SEC. CLAY COVER SHALL BE PLACED IN MAXIMUM 6-INCH THICK COMPACTED LAYERS, AND SCARIFIED BETWEEN LIFTS TO PROVIDE BONDING BETWEEN LIFTS.

14. AREAS OF WASTE REMAINING IN THE EXCAVATION SIDEWALLS ABUTTING THE WEST DISPOSAL AREA SHALL BE EXPOSED AND EVALUATED BY A LICENSED GEOTECHNICAL ENGINEER TO CONFIRM THAT THE WASTE REMAINING IN PLACE DOES NOT AFFECT LOCAL OR GLOBAL STABILITY OF THE PROPOSED VERTICAL EXPANSION.

| REV. | DATE | DESCRIPTION | DR. BY | APP. BY |
|---|---|---|---|---|
| | | | | |

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CITY OF ARLINGTON, TEXAS

REPUBLIC WASTE SERVICES OF TEXAS, LTD.

PROJECT: CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TX
MSW PERMIT NO. 358B

TITLE: DRAINAGE NOTES

| | |
|---|---|
| DRAWN TWM | REVIEWED DEP |
| CHECKED DJR/CMT | APPROVED DEP |
| DATE | FEBRUARY 2014 |
| SCALE | AS SHOWN |
| JOB NO. | 073-9407711 |
| DWG. NO. | 073-9407711-21 lowwat.dwg |
| FIGURE NUMBER | |

PART III, ATT. 2

2-31

STATE OF TEXAS
DAVID E. POE
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PERMIT ISSUED

# APPENDIX IIIF-F

# EROSION CONTROL PLAN FOR ALL PHASES OF LANDFILL OPERATION

Includes pages IIIF-F-1 through IIIF-F-15



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**APPENDIX IIIF-F-1**
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# EROSION CONTROL PLAN FOR ALL PHASES OF LANDFILL OPERATION

## 1.0 Introduction

The purpose of this appendix is to provide an Erosion Control Plan (ECP) to meet the requirements of Title 30 Texas Administrative Code (TAC) Chapter §330.305(d), which are listed below.

> *"The landfill design must provide effective erosional stability to top dome surfaces and external embankment side slopes during all phases of landfill operation, closure, and post-closure care in accordance with the following.*
>
> *(1) Estimated peak velocities for top surfaces and external embankment slopes should be less than the permissible non-erodible velocities under similar conditions.*
>
> *(2) The top surfaces and external embankment slopes of municipal solid waste landfill units must be designed to minimize erosion and soil loss through the use of appropriate side slopes, vegetation, and other structural and nonstructural controls, as necessary. Soil erosion loss (tons/acre) for the top surfaces and external embankment slopes may be calculated using the Soil Conservation Service of the United States Department of Agriculture's Universal Soil Loss Equation, in which case the potential soil loss should not exceed the permissible soil loss for comparable soil-slope lengths and soil-cover conditions."*

This ECP has also been developed to meet the requirements of the Texas Commission on Environmental Quality (TCEQ) guidance document titled, "Guidance for Addressing Erosional Stability During All Phases of Landfill Operation." As noted in the above guidance document, landfill cover phases are defined as daily cover, intermediate cover, and final cover. Top dome surfaces and external embankment side slopes are:

- Those above grade slopes that directly drain to the site perimeter stormwater management system (i.e., areas where the stormwater directly flows to a perimeter channel or detention pond designed in accordance with Title 30 TAC §330.63(c), §330.303, and §330.305);
- Above grade slopes that have received intermediate or final cover; and

- Above grade slopes that have either reached their permitted elevation, or will subsequently remain inactive for longer than 180 days. For example, after an above grade slope has reached the permitted elevation and intermediate cover has been placed, the structural erosion control features (e.g., drainage swales, letdown structures, and/or sedimentation ponds) will be in-place 180 days after intermediate cover has been placed.

Slopes which drain to ongoing waste placement areas, pre-excavated areas, areas that have received only daily cover, and areas under construction which have not received waste are not considered external side slopes.

The ECP for daily cover areas and top dome surfaces and external side slopes that drain directly to the site perimeter stormwater management system, have received intermediate cover, and either reached their permitted configuration or will remain inactive for longer than 180 days are addressed in the following sections. Erosion control measures for final cover areas are addressed in the currently TCEQ-approved Site Development Plan (SDP).

Inspection, maintenance, and recordkeeping requirements are included in the Site Operating Plan (SOP) and discussed in Section 2.4. The word "temporary" is used throughout the ECP to describe any erosion control feature that is not a permanent erosion control feature that is included in the approved Site Development Plan. Additionally, "temporary" is defined as the time between construction of intermediate cover and the construction of final cover. Temporary erosion controls are those controls which are installed or constructed within 180 days from when the intermediate cover is constructed and in place until permanent controls are constructed for the final cover.

## 2.0 Erosion Control Plan for Top Dome Surfaces and External Side Slopes with Intermediate Cover

Erosion control for above grade top dome surfaces and external embankment side slopes that drain directly to the site perimeter stormwater management system, have received intermediate cover, and either reached their permitted configuration or will remain inactive for longer than 180 days will be managed using a system of nonstructural and structural erosion and sediment controls to meet rule requirements for the intermediate cover phase of landfill construction.

The structural controls will consist of a combination of vegetation, temporary add-on swales, and letdown structures. These structural controls will be configured in a manner that will result in a net soil loss of 50 tons/acre/year or less from the external slope area. As shown on Sheet IIIF-F-10, stormwater runoff will be collected in swales and conveyed to drainage letdown structures down the 25 percent slopes to the perimeter drainage system. The primary goal will be to

establish the vegetative cover percentage and swale spacing distance indicated in the swale design summary table on Sheet IIIF-F-11 on all external top dome surfaces and external embankment slopes. These criteria will result in a net soil loss of 50 tons/acres/year or less for each drainage swale and letdown combination specified on Sheets IIIF-F-10 and IIIF-F-11 (refer to Section 2.1 for additional information).

Mulch, woodchips, compost or straw/hay will be used as a layer placed over the intermediate cover to protect the exposed soil surface from erosive forces and conserve soil moisture until vegetation can be established. The mulch, woodchips, compost or straw/hay will be used to stabilize recently graded or seeded areas. If needed, the mulch, woodchips, compost or straw/hay will be spread evenly over a recently seeded area and tracked into the surface to protect the soil from erosion and moisture loss, and provide additional erosional stability to the intermediate cover surface during the establishment of vegetation. These materials are not required for the establishment of vegetation on the intermediate cover unless they are needed to provide additional erosional stability to the intermediate cover surface. These materials will vary in thickness but the mulch, woodchips, compost or straw/hay will be placed so as not to inhibit the growth of vegetation. In the event that the indicated vegetative ground cover required for a specific swale spacing distance is not obtained within 180 days after intermediate cover is placed on a top dome or external side slope, mulch, woodchips, compost or straw/hay will be used as a secondary measure to limit soil loss to 50 tons/acre/year or less until vegetation is established. Stormwater discharge from the site must comply with the current TPDES for the site. The discharge locations for the site are identified in Appendix IIIF as a part of the final drainage design and cannot be revised based on this ECP. Design and use of temporary erosion control measures can not result in offsite discharge exceeding the peak flow rates, volumes, or velocities listed in Table 4-1 of Appendix IIIF.

As an alternative to mulch, wood chips, compost, or straw/hay, a detention/ sedimentation pond may be used as a secondary measure to limit the discharge of eroded soil loss to 50 tons/acre/year or less (refer to Section 2.2 for additional information) if the required percent vegetation goal is not obtained within 180 days after intermediate cover is placed on the top dome or external side slopes. In this case, the detention/sedimentation pond will remain in place until the specified percent vegetation goal is met (e.g., 60 percent vegetation on the external embankment slopes and top dome surfaces).

## 2.1 Drainage Swale and Letdown Structure Requirements

Sheet IIIF-F-10 shows a typical layout for erosion control structures, including temporary add-on swales and drainage letdowns. Sheet IIIF-F-11 provides a swale design summary, which includes spacing and vegetative cover requirements for the swales. Supporting calculations for the specifications listed on Sheet IIIF-F-11 are provided in Appendix IIIF-F-1 – Temporary Add-on Swale Design. Appendix IIIF-F-1

also includes a demonstration to show that sheet flow velocities for the grass established surfaces for all swale spacings are less than 5 ft/sec and sheet flow velocity for "nearly bare ground" is less than 3.5 ft/sec (consistent with Title 30 TAC §330.305(d)(1)).

Letdown structures will be located and constructed in a manner that minimizes erosion loss. The letdowns are designed to convey runoff from the 25-year frequency storm event (refer to Appendix IIIF-F-2 – Temporary Letdown Design for more information). Sheet IIIF-F-12 shows letdown details and the letdown design summary. As shown on Sheet IIIF-F-12, the letdowns will consist of either a lined open channel structure or a pipe letdown. The type, size, and number of letdowns will be determined based on the size of the drainage area using the design information specified on Sheet IIIF-F-12. As noted on Sheet IIIF-F-12, the use of pipe letdowns will be limited to 1 inlet per letdown.

As noted on Sheet IIIF-F-10, the acceptable soil loss is determined for each acre on the top dome surfaces and external embankment side slopes. The soil loss for top dome surfaces and external embankment side slopes will vary depending on swale spacing and percent vegetative cover (refer to Sheet IIIF-F-11 for soil loss estimates). If certain percent vegetation cover is not achieved, a sediment control pond will be temporarily used for sediment capture to reduce the discharge of eroded soil from the external slopes to a rate that is equal to or less than 50 tons/acre/year. Sediment will be removed when necessary. The swale spacing as shown on Sheet IIIF-F-11 for top dome and side slope surfaces is based on the limiting soil loss of 50 tons/acres/year. If a vegetative coverage and swale spacing configuration results in a soil loss greater than 50 tons/acre/year, the following procedure will be used to verify that an acceptable intermediate cover thickness is maintained.

- Intermediate cover areas will be inspected to detect erosion gullies and vegetation loss.
- After identifying the areas requiring additional soil, these areas will be replenished with additional soil and graded to provide uniform surfaces prior to reseeding.
- Any damaged concentrated flow drainage structures such as swales will be repaired to eliminate uncontrolled concentrated flow.

Temporary open channel letdowns will be inspected for erosion/hollowing through and under the lining materials (e.g., gabions, grouted riprap, and turf reinforcement) and repaired as necessary to ensure the letdown is functioning as designed. As of October 2018, numerous erosion control structures have been installed at the site that conform to the requirements of this ECP, and these structures will remain in place and continue to serve as erosion control measures until they are decommissioned.

As stated previously, the primary goal is to obtain the required vegetation coverage percentage for each condition (e.g., swale spacing).

## 2.2 Sedimentation Pond Design

As noted on Sheets IIIF-F-10 and IIIF-F-11, if vegetative cover for any surface is maintained at or above the percentages given for swale spacing distances, the estimated soil loss is less than 50 tons/acre/year. In the event that certain percent ground cover that limits the soil loss to 50 tons/acre/year is not achieved and soil loss is temporarily greater than 50 tons/acre/year, a sedimentation pond will be used along with other structural and non-structural BMPs approved as part of this plan to limit the discharge of eroded soil. Sheet IIIF-F-13 provides a procedure for determining the required pond size. Supporting calculations for the procedure listed on Sheet IIIF-F-13 are included in Appendix IIIF-F-3 – Sediment Control Pond Design. If a sediment control pond is used to limit the off-site discharge of eroded soil to 50 tons/acre/year or less from the external slope area, a demonstration noting how the pond was sized will be documented and maintained in the Site Operating Record. This document will also include a statement that notes how the temporary sedimentation pond, the pond outlet, and any related perimeter channels were constructed consistent with the requirements of the Site Development Plan. Sheet IIIF-F-14 shows the different options for typical pond outlet structures.

The sedimentation pond option is a secondary erosion control option, similar to mulch, wood chips, compost, or straw/hay, and will only be used if the required percent vegetation specification is not met. If the sedimentation pond option is implemented, the swales and letdowns specified will remain in-place. The sedimentation pond option simply allows for the control of sediment while vegetation is being established.

For example, if intermediate cover is placed over a 20-acre external side slope area that is at the permitted elevation on December 31, then the operator will install swales and letdowns on the 20-acre slope consistent with the design and specifications listed in Section 2.1. The operator then has 180 days (which for this example would be June 29) to obtain the required vegetation coverage on the 20-acre area. If in early June it becomes apparent that the percent vegetation will be less than the required coverage on June 29, then the operator may install a sedimentation pond downstream of the 20-acre area, consistent with the requirements shown on Sheet IIIF-F-13. Consistent with Section II.D of the TCEQ guidance document titled, "Guidance for Addressing Erosional Stability During All Phases of Landfill Operation," the sedimentation pond will remain in-place so that the net annual soil loss from the 20-acre area that could leave the facility boundary is less than 50 tons/acre/year until the required percent vegetation specification is met.

If a sedimentation pond is used as a source to maintain a soil loss equal to or less than 50 tons/acre/year, the following procedure will be used to verify that an acceptable intermediate cover thickness is maintained.

- Intermediate cover areas will be inspected to detect erosion gullies and vegetation loss.
- After identifying the areas requiring additional soil, these areas will be replenished with additional soil and graded to provide uniform surfaces prior to reseeding.
- Any damaged concentrated flow drainage structures such as swales will be repaired to eliminate uncontrolled concentrated flow.

As stated previously, the primary goal is to obtain the specified vegetation coverage percentage on top dome surfaces and external embankments. The sedimentation pond will only be used until the specified vegetation coverage percentage is obtained. The sedimentation pond may only be used for a period of 12 months after the 180-day period has expired (e.g., 12 months after the June 29th date used in the above example). Once the required vegetation percentage is achieved, then the sedimentation pond will no longer be needed (but may remain in-place as an additional BMP until the site reaches the permitted final configuration). If the percent vegetation does not meet the required specification within the 12-month period, then additional erosion control measures will be implemented. These measures will include: (1) adjusting the swale spacing, (2) applying mulch, wood chips, compost, or straw/hay, or similar TCEQ approved materials, or (3) the submittal of a permit modification to revise this erosion control plan to provide additional erosion protection measures that will allow the site to meet the goals of this plan.

## 2.3 Other Erosion Control BMPs

Other best management practices (BMPs) used in conjunction with the above erosion control measures are listed below.

- Check Dams – These structures will be used in channels to slow down flow velocities and improve sediment capture.
- Silt Fences – These structures will be used in capturing sediment transported by sheet flow and for diversion of flow for controlling sediment discharge.
- Compost Filter Berms – These structures may be used in capturing sediment transported by sheet flow and for diversion of flow for controlling sediment discharge.
- Erosion Booms – These structures may be used in capturing sediment and for diversion of flow for controlling sediment discharge.

These erosion control measures will be used on slopes to help control erosion loss. Rock check dams will be used in the detention/sedimentation pond. Refer to Sheet IIIF-F-15 for details of typical BMPs.

Nonstructural controls that will be used at the site to minimize erosion loss include: plans and designs to minimize disruption of the natural features, drainage, topography, and vegetative cover features; phased development to minimize the area of bare soil exposed at any given time; plans to disturb only the smallest area necessary to perform current activities; scheduling of construction activities during the time of year with the least erosion potential; and specific plans for the stabilization of exposed surfaces in a timely manner.

## 2.4 Schedule and Recordkeeping Requirements

After an external side slope or top dome surface reaches the final permitted grade or will remain inactive for longer than 180 days, the structural erosion control features and letdown structures will be in place within 180 days from when intermediate cover is placed. During this 180 day period, the structural erosion control structures will be constructed and vegetation established. Structural erosion control measures consist of drainage swales, letdown structures, and detention ponds.

At the end of this 180-day period, the cover log will be updated to document the external side slope and top dome surface area, the structural controls that were installed, and a demonstration showing how the structural controls meet the 50 tons/acre/year or less soil loss requirement (e.g., percent vegetation coverage, swale spacing, and letdowns installed). Inspection requirements and schedules are listed in the SOP for all drainage features, including intermediate cover areas. If the required percent vegetation coverage is not achieved within the 180-day period, secondary erosion control measures such as mulch, wood chips or compost will be used to limit the soil loss to the 50 tons/acre/year or less. Other erosion protection measures will only be utilized upon prior written authorization (e.g., permit modification) by TCEQ. In addition, a detention/sedimentation pond may also be used until the required vegetation coverage is achieved. Any secondary measure used will be documented in the Site Operating Record at the end of the 180-day period to document compliance with this plan. In addition, the date the required vegetation cover is achieved and the date that the secondary measure is no longer needed will also be documented in the Site Operating Record. The dates and locations of installation of erosion and sediment control will also be documented in the Site Operating Record. Inspection requirements and schedules are listed in the SOP for all drainage features, including intermediate cover areas. Inspection and maintenance of the erosion and sediment control structures of the top dome surfaces and external embankment side slopes will follow the same schedule and methods as described in Section 4.24 of the facility's SOP.

For example, as stated in Section 4.18.3 of the current Site Operating Plan (SOP), intermediate cover areas are inspected weekly and within 72 hours of a rainfall event of 0.5 inches or more, or as soon as the areas are accessible, for proper placement, thickness, erosion, and compaction. Additionally, Section 4.23 of the SOP also requires inspections of perimeter channels and ponds to ensure they are functioning as designed (e.g., excess sediment removed, outlet structures intact, and erosion control measures intact, etc.) on a weekly basis and after a rainfall event of 0.5 inches or more, or as soon as the areas are accessible.

During the inspection of structural controls (e.g., vegetation over intermediate cover areas), if significant soil loss is identified in a given intermediate cover area, impacted areas will be replenished with additional soil. Prior to application of temporary erosion controls and seeding, the area will be graded to eliminate preferential path ways or any other uneven surface due to settlement to prevent concentrated flow over the intermediate cover areas. Soil for replenishment of cover areas will be borrowed from sedimentation ponds or any other soil source. If sediment collected from wet retention pond(s) (e.g., Pond NP or temporary sedimentation ponds) is used for erosion layer replenishment, it will be stockpiled outside the ponds to dry out prior to being used for intermediate cover layer replenishment. Soil borrowed from other soil sources may be used as intermediate cover layer and erosion layer replenishment soil.

## 2.5 Construction Activities on Top Dome Surfaces and External Side Slopes with Intermediate Cover

Occasionally, top dome surfaces and external side slopes that have been stabilized through the use of swales, letdown structures, and compliance with the minimum required vegetation cover specification will be disturbed due to various construction activities such as the installation or repair of a landfill gas system, regrading of an area due to ponded water caused by uneven waste settlement, the repair of erosion rills, or damage due to an extreme storm event or natural disaster. Each of these events will be documented in the Site Operating Record. Recorded information will include the date of construction, approximate area disturbed, and the date re-seeding of the disturbed area occurred. In accordance with Title 30 TAC §330.165(g), previously stabilized surfaces will be repaired within 5 days of detection of the disturbance of these surfaces.

# 3.0 Erosion Control Plan for Daily Cover Areas and Intermediate Cover Areas for Non-External Side Slopes

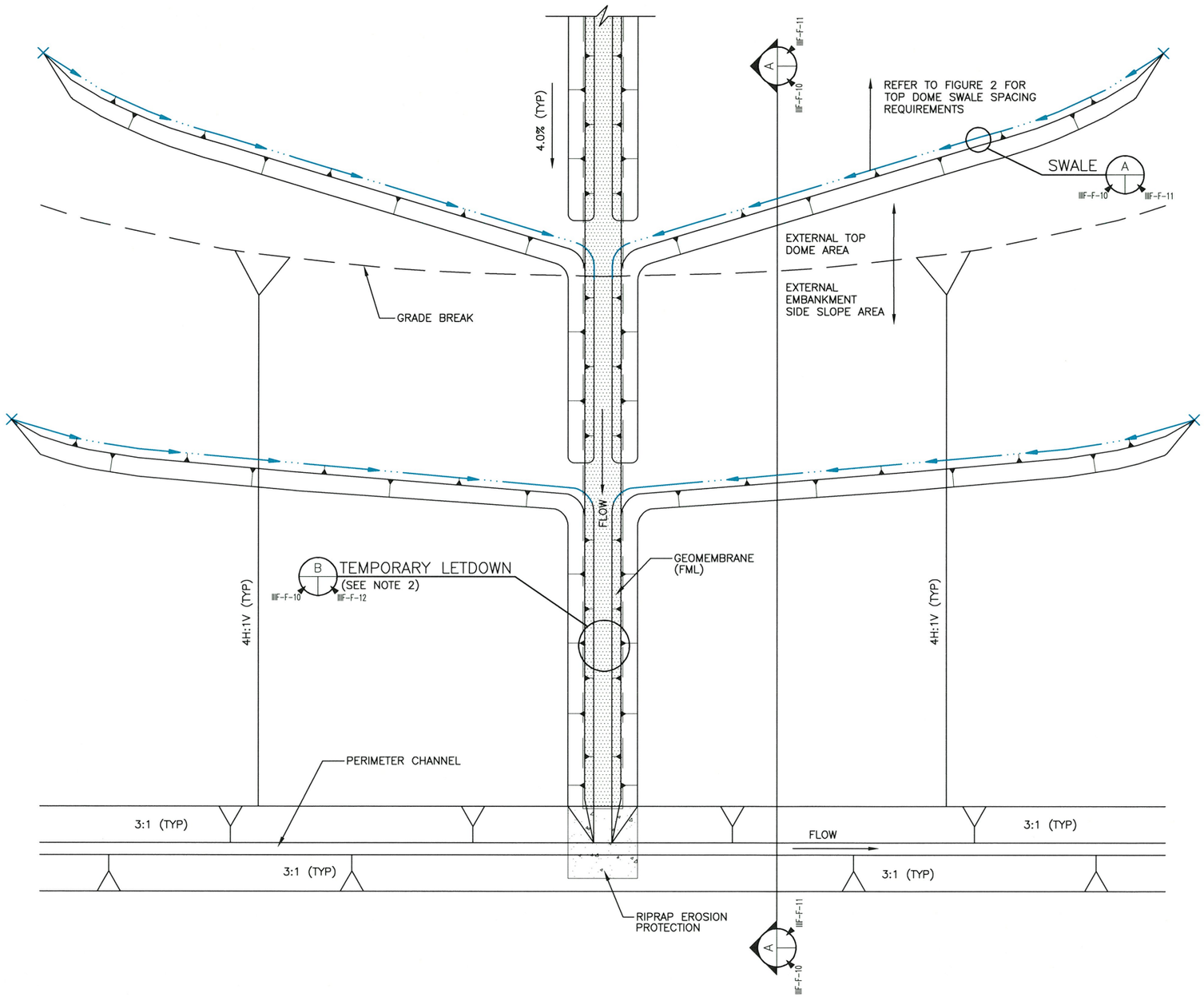
BMPs will be employed to control erosion. BMPs will include the use of temporary rock riprap, silt fences, straw bales, check dams, interceptor swales and berms,

temporary and permanent seeding and sodding, surface roughening, matting and mulching, sediment traps, and surface wetting for dust control.

Examples of erosion and sedimentation control features that will be used during the phased development of the site are shown in Appendix IIIA-A of the Site Development Plan. The following provides general guidelines of how the erosion control features will minimize sediment discharge from the site.

- As noted in the SOP, vegetation will be established on above-grade intermediate cover areas that remain inactive. The temporary vegetative cover will minimize erosion potential.
- Typically, uncontaminated stormwater runoff from the site will be channeled through the perimeter channel system to detention ponds before being discharged from the site. Sediment that collects in the channels and detention ponds will be removed consistent with the stormwater system maintenance plan presented in Section 2.3 of Appendix IIIF.
- Erosion will be controlled by vegetation in drainage structures with flow velocities less than or equal to 5 ft/sec. For drainage structures with flow velocities greater than 5 ft/sec, rock riprap or gabions will be used for surface reinforcement. Other erosion protection measures may be utilized if equivalent erosion protection is met.

Typical erosion control features are shown on Sheet IIIF-F-15. Inspection items and schedules are listed in the SOP for all drainage features, daily cover, and intermediate cover areas.




LEGEND

- DRAINAGE SWALE FLOWLINE
- LETDOWN
- GEOMEMBRANE LINING WITHIN LETDOWN (SEE NOTE 2)
- RIPRAP EROSION PROTECTION

NOTES:

1. THE ACCEPTABLE SOIL LOSS IS LESS THAN OR EQUAL TO 50 TONS/ACRE/YEAR. THE SOIL LOSS FOR TOP DOME SURFACES AND EXISTING EXTERNAL EMBANKMENT SIDE SLOPES WILL VARY DEPENDING ON SWALE SPACING AND PERCENT VEGETATIVE COVER (REFER TO SHEET IIIF-F-11 FOR SOIL LOSS ESTIMATES).
2. TEMPORARY LETDOWN IS SHOWN AS AN OPEN CHANNEL WITH A GEOMEMBRANE LINER. AS NOTED ON SHEET IIIF-F-12, OTHER CHANNEL LININGS MAY BE USED (e.g., GABIONS, GROUT, GROUTED CONCRETE RIPRAP, AND TURF REINFORCEMENT MAT). IN ADDITION, PIPE LETDOWNS MAY ALSO BE USED. HOWEVER, IF PIPE LETDOWNS ARE USED THEY WILL BE LIMITED TO 1-INLET AS SHOWN ON SHEET IIIF-F-12.

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# EROSION CONTROL PLAN
# TYPICAL EROSION CONTROL STRUCTURE LAYOUT

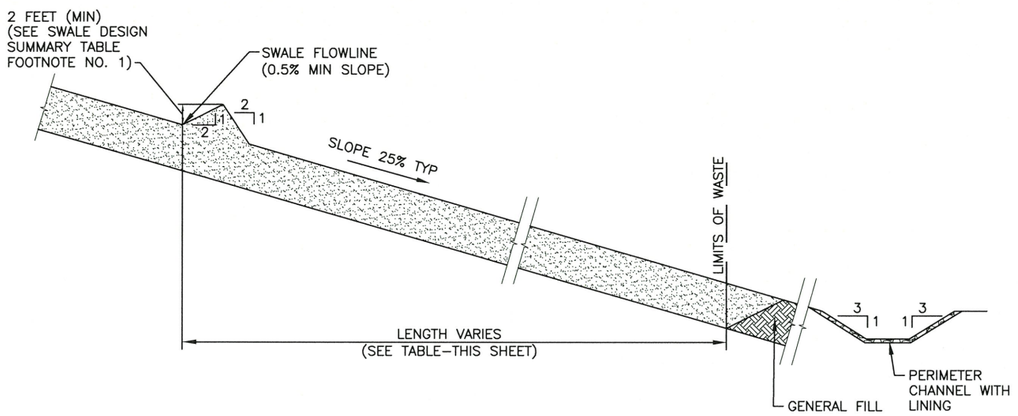
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A — SIDE SLOPE DRAINAGE SWALE

IIIF–F–10 IIIF–F–11

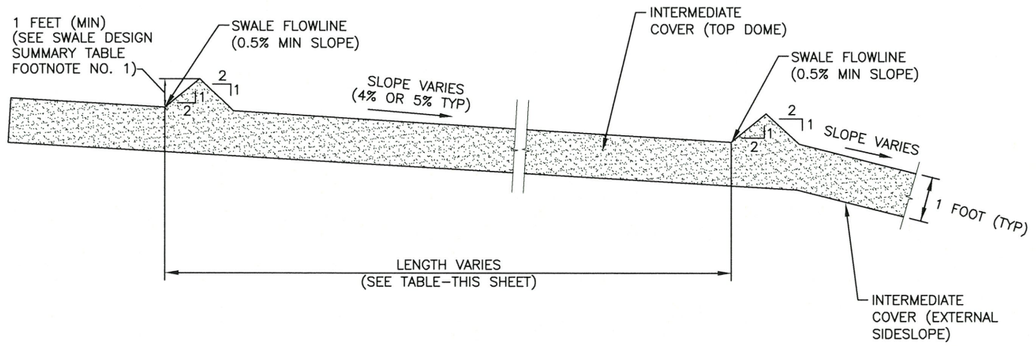
## SWALE DESIGN SUMMARY[1]

| SIDE SLOPE (25%) | | | | TOP SLOPE (5%) | | | |
|---|---|---|---|---|---|---|---|
| VEGETATIVE COVER PERCENTAGE | DISTANCE BETWEEN SWALES (FT) | ESTIMATED SOIL LOSS (TONS/ACRE/YEAR) | ADDITIONAL SEDIMENT CAPTURE REQUIRED[2] | VEGETATIVE COVER PERCENTAGE | DISTANCE BETWEEN SWALES[3](FT) | ESTIMATED SOIL LOSS (TONS/ACRE/YEAR) | ADDITIONAL SEDIMENT CAPTURE REQUIRED[2] |
| 60 | 100 | 15.8 | NO | 60 | 200 | 1.9 | NO |
| 70 | 100 | 6.6 | NO | 70 | 200 | 0.8 | NO |
| 80 | 100 | 4.9 | NO | 80 | 200 | 0.6 | NO |
| 90 | 100 | 3.1 | NO | 90 | 200 | 0.4 | NO |
| 60 | 500 | 28.0 | NO | 60 | 1000 | 4.6 | NO |
| 70 | 500 | 11.6 | NO | 70 | 1000 | 1.9 | NO |
| 80 | 500 | 8.7 | NO | 80 | 1000 | 1.4 | NO |
| 90 | 500 | 5.5 | NO | 90 | 1000 | 0.9 | NO |
| | | | | TOP SLOPE (4%) | | | |
| | | | | 60 | 200 | 1.3 | NO |
| | | | | 70 | 200 | 0.6 | NO |
| | | | | 80 | 200 | 0.4 | NO |
| | | | | 90 | 200 | 0.3 | NO |
| | | | | 60 | 400 | 1.8 | NO |
| | | | | 70 | 400 | 0.8 | NO |
| | | | | 80 | 400 | 0.6 | NO |
| | | | | 90 | 400 | 0.4 | NO |

[1] REFER TO APPENDIX IIIF–F–1 FOR SUPPORTING CALCULATIONS.

[2] IF SITE SPECIFIC CONDITIONS YIELD A MAXIMUM HORIZONTAL DISTANCE BETWEEN THE TOE OF THE SLOPE AND GRADE BREAK OF LESS THAN 300 FEET FOR SIDE SLOPES AND A DISTANCE OF 500 FEET FROM THE GRADE BREAK TO THE PEAK OF THE TOP SLOPES, ESTABLISHMENT OF 60% VEGETATION WILL BE SUFFICIENT MEANS OF EROSION CONTROL WITHOUT THE ADDITION OF TEMPORARY SWALES AND LETDOWNS GIVEN THAT THE TOTAL SOIL LOSS FOR THE SIDE SLOPE IS LESS THAN 50 TONS/ACRE/YEAR AND THE TOP SLOPE IS LESS THAN 50 TONS/ACRE/YEAR.

[3] NUMBERS INDICATE THE MAXIMUM SWALE SPACING FOR A GIVEN VEGETATIVE COVER PERCENTAGE.




A — TOP DOME SURFACE DRAINAGE SWALE

IIIF–F–10 IIIF–F–11

## SWALE DRAINAGE AREA SUMMARY

| CONDITION (SWALE HEIGHT) | MAXIMUM DRAINAGE AREA (ACRES) | MINIMUM SWALE SPACING[1] (FEET) | MAXIMUM SWALE LENGTH[2] (FEET) |
|---|---|---|---|
| TOP SLOPE (2 FT SWALE, 5%) | 27.8 | 200 | 6,405 |
| TOP SLOPE (1.5 FT SWALE, 5%) | 12.9 | 200 | 2,807 |
| TOP SLOPE (1 FT SWALE, 5%) | 4.4 | 200 | 953 |
| TOP SLOPE (2 FT SWALE, 4%) | 34.1 | 200 | 7,433 |
| TOP SLOPE (1.5 FT SWALE, 4%) | 15.8 | 200 | 3,451 |
| TOP SLOPE (1 FT SWALE, 4%) | 5.4 | 200 | 1,170 |
| SIDE SLOPE (2 FT SWALE, 25%) | 7.4 | 100 | 3,202 |

[1] THE MINIMUM SWALE SPACING IS USED TO DETAIN THE MAXIMUM SWALE LENGTH GIVEN THAT THE AREA IS FIXED. MINIMUM SWALE SPACING IS OBTAINED FROM THE CALCULATIONS PROVIDED ON PAGE IIIF–F–1–10.

[2] MAXIMUM SWALE LENGTH CALCULATED USING THE FOLLOWING EQUATION:

MAXIMUM DRAINAGE AREA x (43,560 SF/ACRE)/MINIMUM SWALE SPACING

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# EROSION CONTROL PLAN
# SWALE DESIGN SUMMARY

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## OPEN CHANNEL GEOMEMBRANE LETDOWN DESIGN SUMMARY

DESIGN IS APPLICABLE FOR A DRAINAGE AREA UP TO 30.0 ACRES (TOP DECK AND SIDE SLOPE).

25% SLOPE
MAXIMUM FLOW DEPTH = 0.46 FT.
BOTTOM WIDTH = 8 FT.

5% SLOPE
MAXIMUM FLOW DEPTH = 0.73 FT.
BOTTOM WIDTH = 8 FT.

4% SLOPE
MAXIMUM FLOW DEPTH = 0.78 FT.
BOTTOM WIDTH = 8 FT.

## OPEN CHANNEL GABION AND ROCK RIPRAP LETDOWN DESIGN SUMMARY

DESIGN IS APPLICABLE FOR A DRAINAGE AREA UP TO 30.0 ACRES (SIDE SLOPE AND TOP DECK).

25% SLOPE
MAXIMUM FLOW DEPTH = 1.02 FT.
BOTTOM WIDTH = 8 FT.

5% SLOPE
MAXIMUM FLOW DEPTH = 1.59 FT.
BOTTOM WIDTH = 8 FT.

4% SLOPE
MAXIMUM FLOW DEPTH = 1.69 FT.
BOTTOM WIDTH = 8 FT.

## OPEN CHANNEL GROUTED RIPRAP LETDOWN DESIGN SUMMARY

DESIGN IS APPLICABLE FOR A DRAINAGE AREA UP TO 30.0 ACRES (TOP DECK AND SIDE SLOPE).

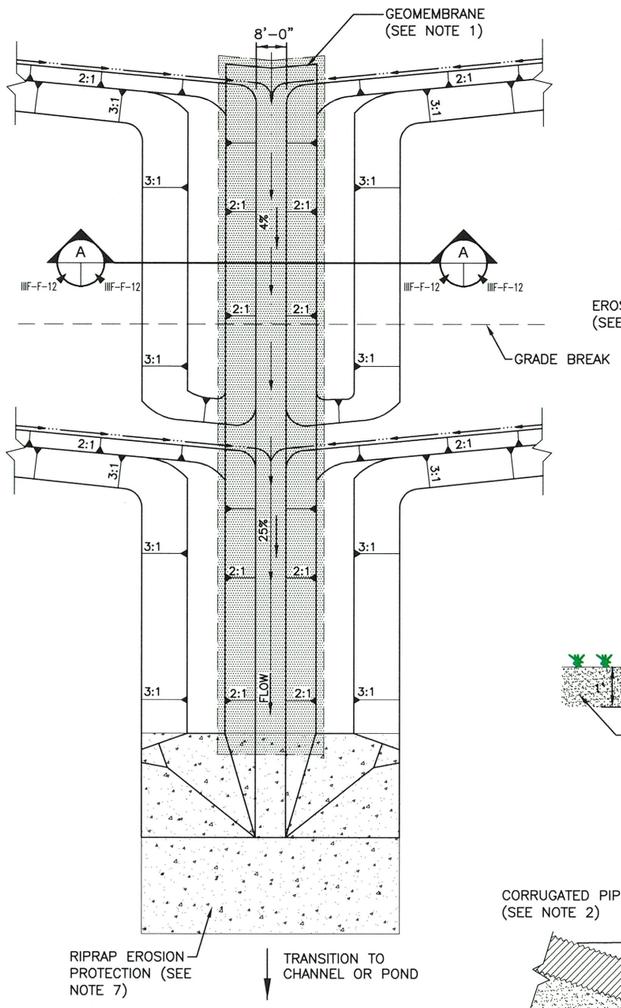
25% SLOPE
MAXIMUM FLOW DEPTH = 0.86 FT.
BOTTOM WIDTH = 8 FT.

5% SLOPE
MAXIMUM FLOW DEPTH = 1.36 FT.
BOTTOM WIDTH = 8 FT.

4% SLOPE
MAXIMUM FLOW DEPTH = 1.45 FT.
BOTTOM WIDTH = 8 FT.

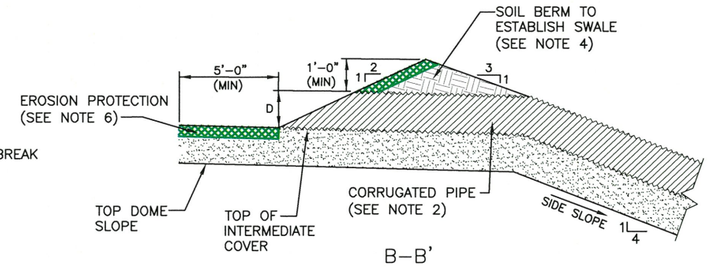
## OPEN CHANNEL TURF REINFORCEMENT LETDOWN DESIGN SUMMARY

SEE GROUTED RIPRAP LETDOWN DESIGN.




TEMPORARY OPEN CHANNEL LETDOWN

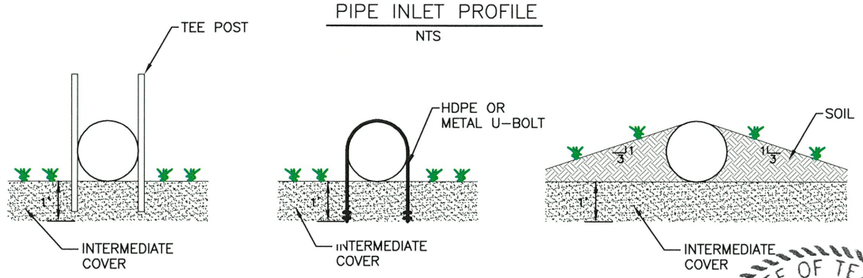
0 20 40
SCALE IN FEET




B–B'

PIPE INLET PROFILE

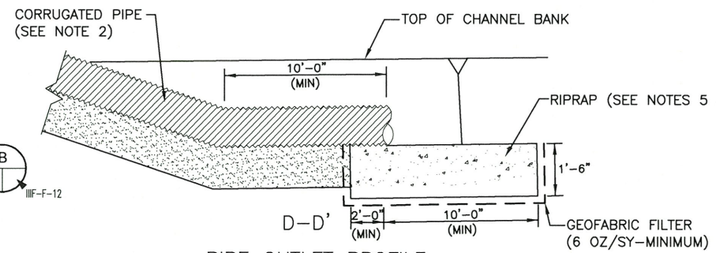
NTS




C–C'

ANCHORING DETAILS

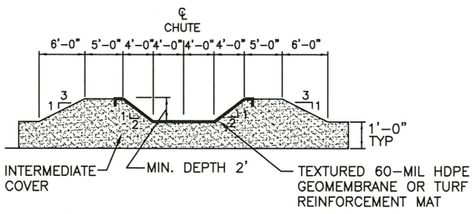
NTS




D–D'

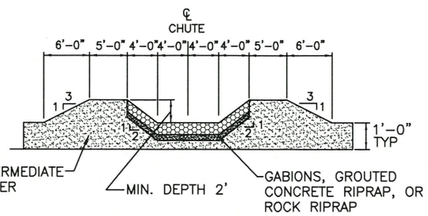
PIPE OUTLET PROFILE (SEE NOTE 3)

NTS




A1 TEMPORARY GEOMEMBRANE OR TURF REINFORCEMENT LETDOWN OPTION

0 10 20
SCALE IN FEET



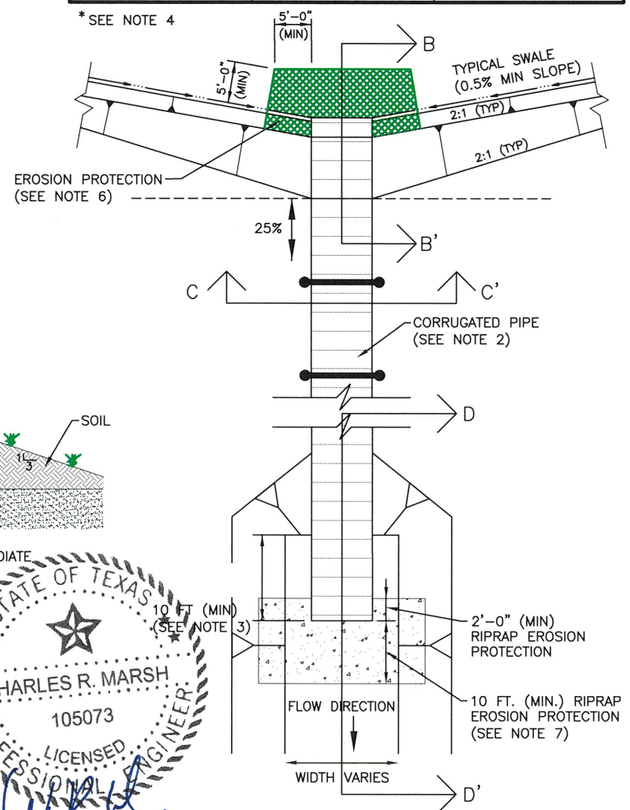

A2 TEMPORARY GABION LETDOWN OPTION

0 10 20
SCALE IN FEET

## 25% PIPE LETDOWN DESIGN SUMMARY* (USE OF PIPE LETDOWN IS LIMITED TO 1–INLET)

| DRAINAGE AREA (ACRE) | DESIGN FLOW RATE (CFS) | REQUIRED PIPE DIAMETER (FT) |
|---|---|---|
| 3.2 | 17.8 | 2 |
| 5.5 | 30.2 | 3 |

*SEE NOTE 4




TEMPORARY PIPE LETDOWN

NTS

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NOTES:

1. 60 MIL HDPE GEOMEMBRANE TEXTURED BOTH SIDES WILL BE USED FOR GEOMEMBRANE LETDOWN LINING. AS AN ALTERNATIVE, TEMPORARY LETDOWN CAN BE LINED WITH GABIONS, GROUTED CONCRETE RIPRAP, TURF REINFORCEMENT MAT, OR ROCK RIPRAP.
2. PIPE DRAINAGE LETDOWN WILL BE ANCHORED BY USING SOIL BERM AT THE INLET LOCATED WITHIN THE SWALE. ADDITIONAL ANCHORING ON THE SIDE SLOPE MAY BE PROVIDED USING SOIL, HDPE OR METAL U-BOLTS, T-POSTS OR EQUIVALENT MATERIALS.
3. PIPE WILL BE EXTENDED INTO THE CHANNEL TO MINIMIZE EROSION.
4. PIPE LETDOWNS WILL BE LIMITED TO 1 INLET PER LETDOWN. SOIL BERMS AROUND THE PIPE INLET WILL BE EXTENDED A MINIMUM 1-FOOT ABOVE THE LETDOWN PIPE INLET. REFER TO PAGE IIIF-F-2-22 FOR HYDRAULIC ANALYSIS.
5. RIPRAP APRON DESIGN IS PROVIDED ON PAGES IIIF-F-2-33 AND 34. $D_{50}$ FOR RIPRAP 8-INCHES IS MINIMUM.
6. RIPRAP, GROUT, GROUTED RIPRAP, GABIONS, GEOMEMBRANE, EXISTING VEGETATION OR TURF REINFORCEMENT MAY BE USED FOR EROSION PROTECTION.
7. OTHER EROSION PROTECTION (e.g., RIPRAP, GROUT, GROUTED RIPRAP, GABIONS OR TURF REINFORCEMENT) MAY BE USED AT TEMPORARY LETDOWN OUTFALLS.
8. REFER TO PAGE IIIF-F-2-35 FOR EROSION PROTECTION DESIGN. IF LETDOWN DISCHARGES TO A POND, 10 FEET OF RIPRAP WILL BE SUFFICIENT.

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# EROSION CONTROL PLAN LETDOWN DESIGN SUMMARY

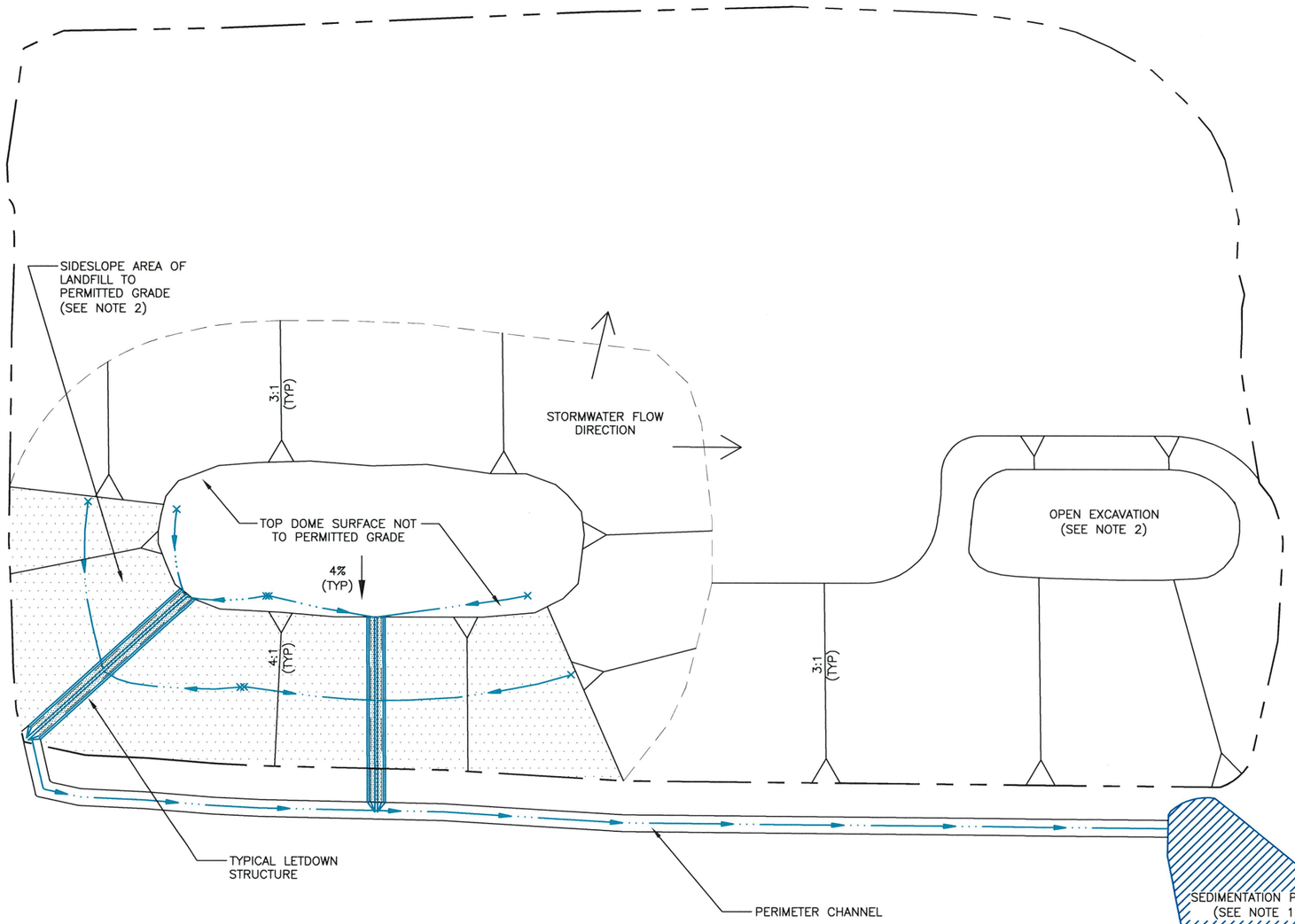
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LEGEND

EXTERNAL SIDE SLOPE TO PERMITTED GRADE

LETDOWN

DRAINAGE SWALE

STORMWATER FLOW DIRECTION

## EXAMPLE CALCULATION

REQUIRED POND SIZE = EXTERNAL EMBANKMENT AREA (ACRES) X POND AREA REQUIRED/ UNIT DRAINAGE AREA FACTOR

EXTERNAL EMBANKMENT AREA DRAINING TO POND = 50 ACRES

ADDITIONAL UPLAND AREA DRAINING TO POND = 0 ACRES (SEE NOTE 1)

REQUIRED SEDIMENT REMOVAL FROM EXTERNAL SIDE SLOPE AREA = 80 TONS/ACRE/YEAR TO 50 TONS/ACRE/YEAR

POND AREA REQUIRED/UNIT DRAINAGE AREA FACTOR = 0.060 (FROM TABLE BELOW)

REQUIRED POND SIZE = 50 ACRES X 0.060 = 3.00 ACRES

| SIZE OF POND REQUIRED[1] | | |
|---|---|---|
| REQUIRED SEDIMENT REMOVAL (TONS/ACRE/YEAR) | POND AREA REQUIRED/ UNIT DRAINAGE AREA FACTOR | EFFICIENCY OF POND (DYNAMIC AND QUIESCENT) |
| 60 TO 50 | 0.025 | 17.0% |
| 70 TO 50 | 0.040 | 29.3% |
| 80 TO 50 | 0.060 | 38.1% |
| 90 TO 50 | 0.075 | 45.5% |
| 100 TO 50 | 0.110 | 50.9% |
| 200 TO 50 | 0.300 | 75.9% |

[1] REFER TO APPENDIX IIIF-F-3 FOR MORE INFORMATION. THE POND DESIGN AND DEMONSTRATION ARE PROVIDED TO ENSURE THAT SEDIMENT DISCHARGE FROM THE SITE WILL BE PREVENTED DURING INITIAL ESTABLISHMENT OF VEGETATION OVER THE SIDE SLOPES AND TOP DOME SURFACES.

NOTES:

1. EXAMPLE POND CONFIGURATION IS SHOWN. A DEMONSTRATION WILL BE INCLUDED IN THE SITE OPERATING RECORD TO SHOW THAT THE POND HAS THE CAPABILITY TO CAPTURE SEDIMENT SUCH THAT DISCHARGE IS LESS THAN OR EQUAL TO 50 TONS/ACRE/YEAR FROM THE EXTERNAL SIDE SLOPE AND TOP DOME AREA. THE DEMONSTRATION WILL ACCOUNT FOR THE ADDITIONAL SEDIMENT CREATED BY THE UPLAND AREA THAT FLOWS TO THE POND. FOR DEMONSTRATION PURPOSES, THE POND DEPTH WILL BE AN AVERAGE OF 4 FEET. OVERALL SEDIMENT DISCHARGE FROM THE SITE MUST COMPLY WITH THE CURRENT TPDES PERMIT FOR THE SITE.
2. EXCAVATED FUTURE CELL AREAS OR SOIL BORROW AREAS CAN ALSO BE USED AS SEDIMENTATION PONDS. IF THESE AREAS ARE USED FOR PONDS, A DEMONSTRATION NOTING THAT THE EXCAVATED FUTURE CELL AREA OR SOIL BORROW AREA HAS MORE CAPACITY THAN THE VOLUME PRODUCED BY THE 25-YEAR, 24-HOUR STORM WILL BE DOCUMENTED AND MAINTAINED IN THE SITE OPERATING RECORD.
3. AS STATED IN SECTION 2.2, A STATEMENT WILL BE ADDED TO THE SITE OPERATING RECORD EACH TIME A SEDIMENTATION POND IS INSTALLED TO NOTE HOW THE TEMPORARY SEDIMENTATION POND AND THE POND OUTLET WERE CONSTRUCTED CONSISTENT WITH THE REQUIREMENTS OF THE SITE DEVELOPMENT PLAN.

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# EROSION CONTROL PLAN
# SEDIMENT CONTROL POND PLAN

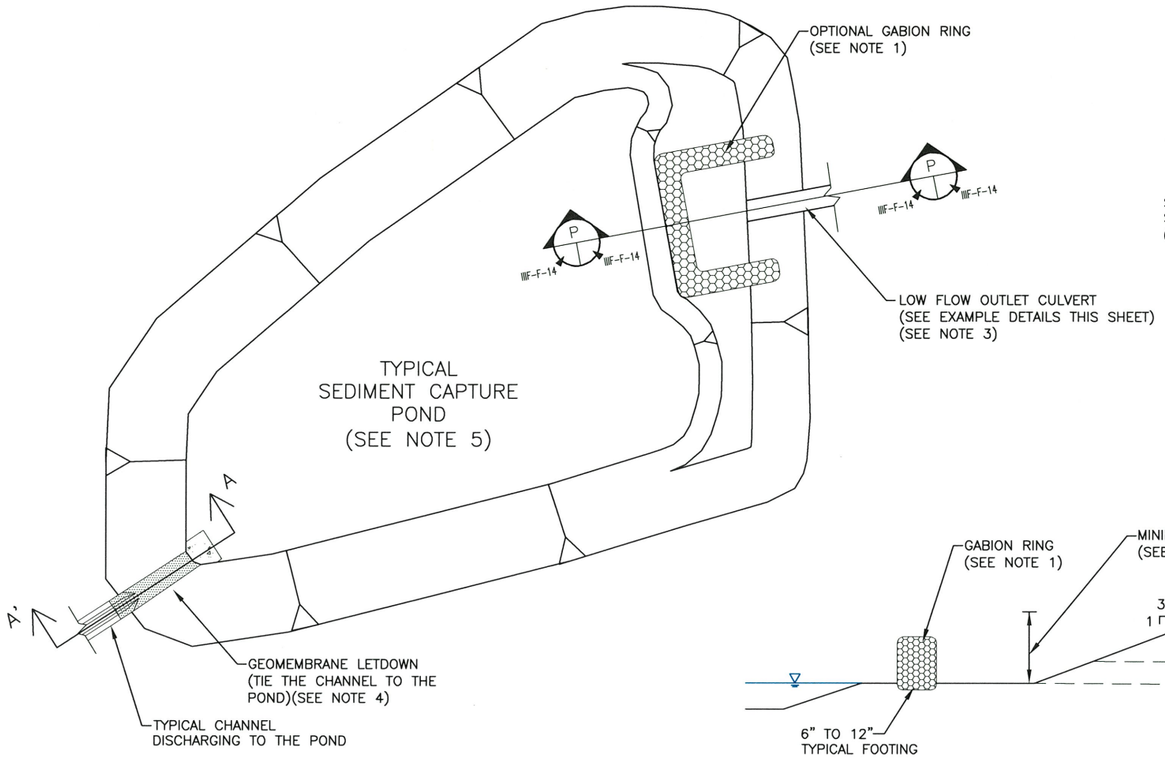
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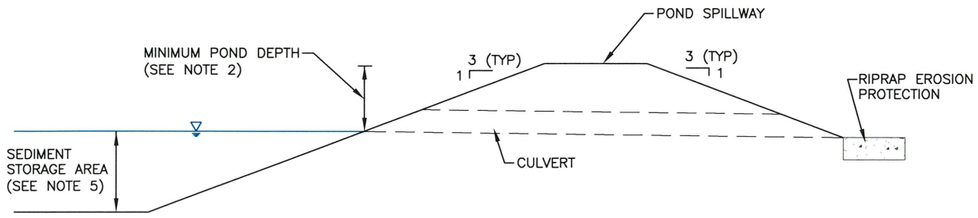
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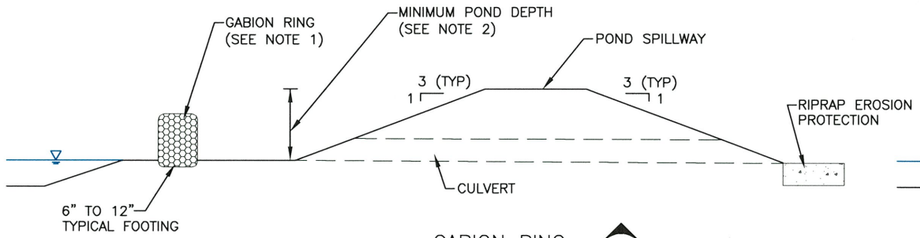
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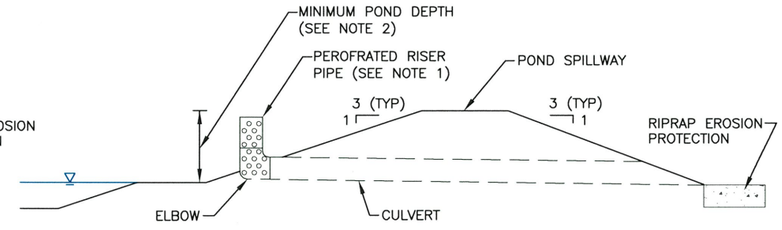



OUTLET STRUCTURE FOR PERMANENT POOL

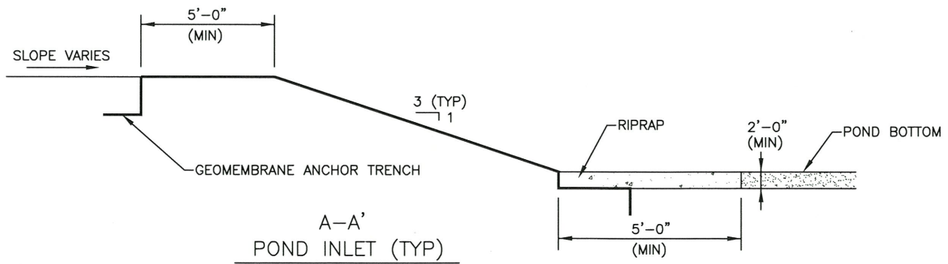



GABION RING




PERFORATED RISER PIPE

OPTIONS FOR DRY PONDS




A-A'
POND INLET (TYP)
NTS

NOTES:

1. AS AN OPTION TO THE GABION RING, A PERFORATED RISER PIPE (SHOWN ON THIS SHEET) MAY ALSO BE USED, AS WELL AS A ROCK CHECK DAM.
2. MINIMUM POND DEPTH IS 4 FEET BETWEEN THE LOW FLOW OUTLET FLOW LINE AND POND SPILLWAY ELEVATION.
3. IF THE POND IS INSTALLED WITHOUT A LOW FLOW OUTLET, THEN SEE NOTE 2 ON SHEET IIIF-F-13.
4. VEGETATIVE SURFACING, GROUTED RIPRAP, RIPRAP, GABIONS, OR TURF REINFORCEMENT MAY BE USED TO ENSURE THE STABILITY OF THE POND INLET.
5. POND BOTTOM AREAS WILL BE EXCAVATED BELOW THE LOW FLOW OUTLET FLOW LINE ELEVATION TO PROVIDE SEDIMENT STORAGE. SEDIMENT ACCUMULATED IN POND WILL BE REMOVED AS NEEDED TO ENSURE SEDIMENT STORAGE CAPACITY BELOW THE FLOWLINE ELEVATION OF LOW FLOW OUTLET (REFER TO SECTION 2.4 FOR ADDITIONAL INFORMATION REGARDING SEDIMENT REMOVAL).




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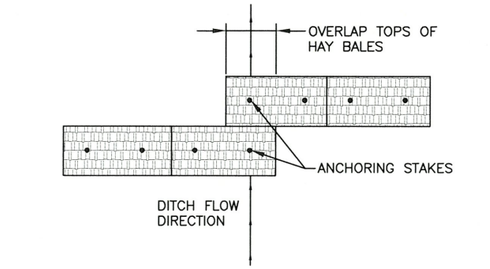
# EROSION CONTROL PLAN
# TYPICAL POND OUTLET STRUCTURES

CITY OF ARLINGTON LANDFILL
TARRANT COUNTY, TEXAS

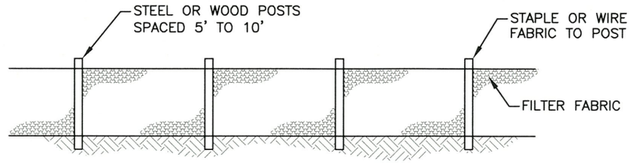
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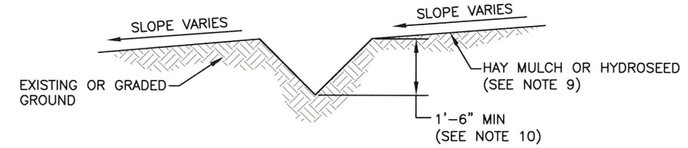
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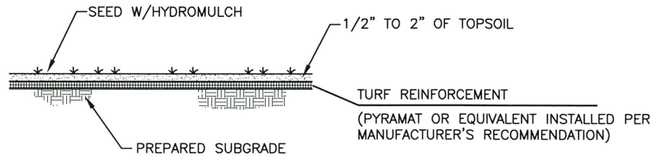

BALED HAY FOR EROSION CONTROL
NTS
(SEE NOTE 1)



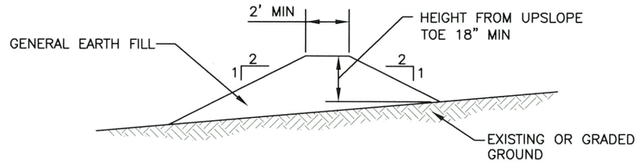

TEMPORARY SEDIMENT CONTROL FENCE
NTS
(SEE NOTE 3)




TEMPORARY DIVERSION CHANNEL
NTS
(SEE NOTE 6)

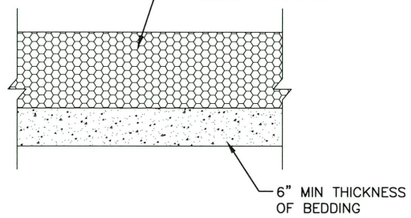



TURF REINFORCEMENT
NTS
(SEE NOTE 4)

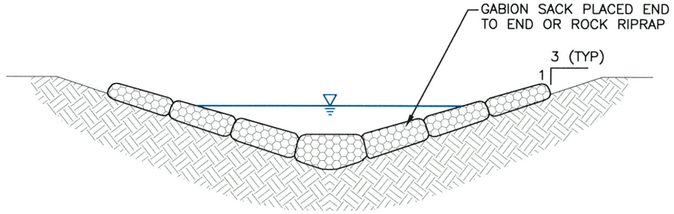



TEMPORARY DIVERSION BERM
NTS
(SEE NOTE 7)

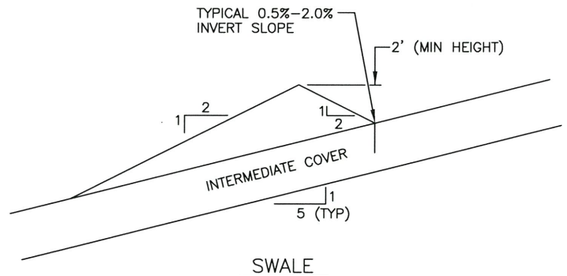
| 24" THICKNESS OF RIPRAP | |
|---|---|
| SIEVE SIZE SQUARE MESH | PERCENT PASSING |
| 30 INCH | 100 |
| 24 INCH | 65–100 |
| 18 INCH | 45–75 |
| 12 INCH | 25–50 |
| 8 INCH | 10–30 |
| 6 INCH | 0–15 |




ROCK RIPRAP
NTS
(SEE NOTE 2)




ROCK CHECK DAM
NTS
(SEE NOTE 5)




SWALE
NTS
(SEE NOTE 8)

NOTES:

1. BALED HAY MAY BE USED IN NEWLY ESTABLISHED COVER AREAS OR DISTURBED/REGRADED SURFACES TO MAINTAIN SHEET FLOW UNTIL VEGETATION IS ESTABLISHED.
2. ROCK RIPRAP MAY BE USED IN AREAS WHERE CONCENTRATED FLOW WITH HIGH VELOCITIES MAY OCCUR (e.g., CULVERT INLETS/OUTLETS).
3. A TEMPORARY SEDIMENT CONTROL FENCE MAY BE USED IN CAPTURING SEDIMENT TRANSPORTED BY SHEET FLOW AND FOR DIVERSION OF FLOW FOR CONTROLLING SEDIMENT DISCHARGE.
4. TURF REINFORCEMENT MAY BE USED ON NEWLY ESTABLISHED SURFACES SUCH AS INTERMEDIATE COVER AND IN CHANNELS WHERE MODERATELY HIGH FLOW VELOCITIES ARE EXPECTED.
5. A ROCK CHECK DAM MAY BE USED IN CHANNELS TO SLOW DOWN FLOW VELOCITIES AND IMPROVE SEDIMENT CAPTURE.
6. A TEMPORARY DIVERSION CHANNEL MAY BE USED FOR SHORTENING SHEET FLOW DISTANCES IN UNDEVELOPED AREAS OR IN LARGER CHANNELS TO PROVIDE MEANDERING AND SLOWER FLOW VELOCITIES TO PREVENT IN–CHANNEL EROSION.
7. A TEMPORARY DIVERSION BERM MAY BE USED IN AREAS TO DIVERT FLOW FROM ENTERING STEEP SLOPED AREAS (e.g., TOP OF EXCAVATION) AND TO REDUCE SHEET FLOW LENGTHS.
8. A SWALE MAY BE USED IN AREAS TO DIVERT FLOW FROM ENTERING STEEP SLOPED AREAS (e.g., TOP OF EXCAVATION) AND TO REDUCE SHEET FLOW LENGTHS.
9. HAY MULCH AND HYDROSEED MAY ALSO BE USED FOR NEWLY ESTABLISHED SURFACES TO PROMOTE VEGETATION ESTABLISHMENT AND PREVENT EROSION.
10. THE VALUE SHOWN IS AT THE TIME OF CHANNEL INSTALLATION; CHANNEL WIDTH AND DEPTH MAY VARY.

STATE OF TEXAS
CHARLES R. MARSH
105073
PROFESSIONAL ENGINEER
LICENSED
05.19.22

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 01/2019
FILE: 0023-406-14
CAD: IIIF-F-15-TYPICAL BMPS.DWG
DRAWN BY: JDW
DESIGN BY: RCE
REVIEWED BY: CRM

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
REPUBLIC WASTE SERVICES OF TEXAS, LTD.

| REVISIONS | | |
|---|---|---|
| NO. | DATE | DESCRIPTION |
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# EROSION CONTROL PLAN TYPICAL BMPs

MALOY LANDFILL
HUNT COUNTY, TEXAS

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SHEET IIIF-F-15

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# APPENDIX IIIF-F-1

# TEMPORARY ADD-ON SWALE DESIGN

Includes pages IIIF-F-1-1 through IIIF-F-1-12



# SWALE DESIGN

This appendix includes the expected soil loss calculations for various swale spacing intervals on the side slopes and top dome surfaces. An example calculation is provided on pages IIIF-F-1-2 through IIIF-F-1-4 for a vegetative cover of 60 percent. For the results of various percent vegetative covers and swale spacing intervals, refer to the table on page IIIF-F-1-5 and to Sheet IIIF-F-11 – Swale Design Summary. If the required percent vegetation coverage is not achieved within the 180-day period, secondary erosion control measures such as mulch, wood chips, compost or straw/hay will be used to limit the soil loss to 50 tons/acre/year or less. In addition, a detention/sedimentation pond may also be used until the required vegetation coverage is achieved. Any secondary measure used will be documented in the Site Operating Record at the end of the 180-day period to document compliance with this plan. In addition, the date the required percent vegetation coverage is achieved and the secondary measure is no longer needed will also be documented in the Site Operating Record.

Also included in this appendix are the sheet flow velocities for all swale spacing intervals on the side slopes and top dome surfaces. As noted in these calculations (pages IIIF-F-1-6 through IIIF-F-1-8), all velocities are acceptable.

Additionally, this appendix includes a calculation for the maximum drainage area that each swale can drain, as well as the maximum swale length. These calculations are included on pages IIIF-F-1-9 through IIIF-F-1-12.

CITY OF ARLINGTON LANDFILL
0023-404-11-102-07
TEMPORARY EROSION LAYER EVALUATION



**Required:** Determine the required spacing of the drainage swales for different percentages of vegetative cover for top dome surfaces and external embankment side slopes.

**Method:**
1. Estimate soil loss per acre based on percent ground cover and swale spacing for top dome surface and external side slope.
2. Summary.

**Notes:**
1. The following example calculation procedure has been developed for 60 percent ground cover.
2. The table on page IIIF-F-1-5 includes the results of the following procedure for 60, 70, 80, and 85 percent ground cover and various swale spacings. The results are also summarized on Figure 2 in Appendix IIIF-F.

**References:**
1. SCS National Engineering Handbook, Chapter 3 - Erosion.
2. TNRCC, *Use of the USLE in Final Cover/Configuration Design*, 1993.
3. United States Department of Agriculture, National Resource Conservation Service, Web Soil Survey for Tarrant County, Texas ( http://websoilsurvey.nrcs.usda.gov ).
4. United States Environmental Protection Agency, *Solid Waste Disposal Facility Criteria Technical Manual*, 1993.

**Solution:**

1. Estimate soil loss per acre based on percent ground cover and swale spacing for top dome surface and external side slope.

Soil Loss Equation: $A=RKL_SCP$

Where:
- A= Soil loss (tons/ac/yr)
- R= Rainfall factor
- K= Soil erodibility factor
- $L_S$= Slope length/slope gradient factor
- C= Plant cover or cropping management factor
- P= Erosion practice factor

The rainfall factor, R, represents the average intensity for the maximum intensity, 30 minute storms over a 22 year period of record compiled by the SCS. Using Figure 1 (Ref 2), Average Annual Values of the R Factor, the R factor for Tarrant County is:

R = 290

The soil erodibility factor, K, factor represents the resistance of a soil surface to erosion as a function of the soil's physical and chemical properties. Assume an organic matter content of 2% to determine the K factor. The intermediate soil will consist of soils comparable to sandy clay. Additionally, compost will be added to intermediate soil as necessary to protect against erosion. Therefore, the following is a conservative K value for the site (Table 1 on page 6, Ref. 2).

K = 0.20

The slope length/slope gradient factor, $L_s$, represents the erosion of the soil due to both slope length and degree of slope.

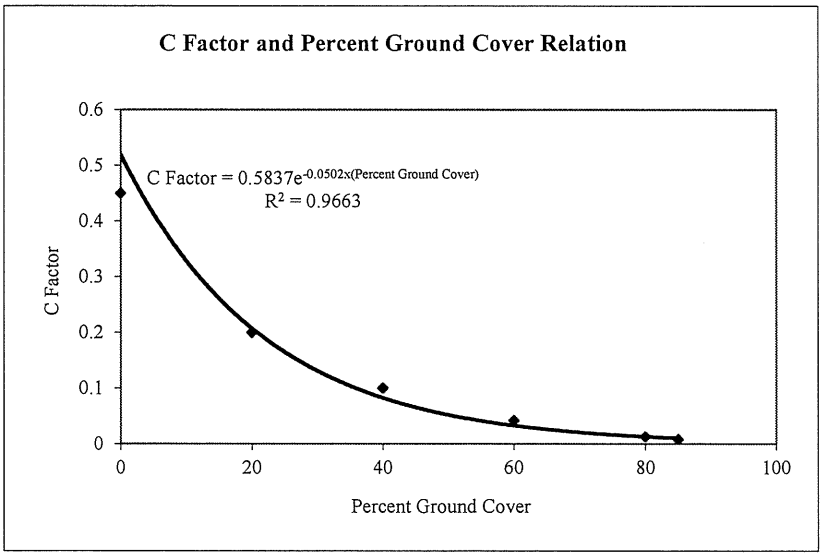
| | | | | | |
|---|---|---|---|---|---|
| Case 1. Top Slope | | | Case 2. Top Slope | | |
| slope = | 5 | % | slope = | 5 | % |
| length = | 200 | ft | length = | 1000 | ft |
| Case 3. Top Slope | | | Case 4. Top Slope | | |
| slope = | 4 | % | slope = | 4 | % |
| length = | 200 | ft | length = | 400 | ft |
| Case 5. Side Slope | | | Case 6. Side Slope | | |
| slope = | 25 | % | slope = | 25 | % |
| length = | 100 | ft | length = | 500 | ft |

Using the above information and Figure 2 (Ref 2, p.9), the $L_s$ factors are determined.

| Case | Slope (%) | Slope Length (ft) | $L_s$ |
|---|---|---|---|
| 1. Top Slope | 5 | 200 | 0.80 |
| 2. Top Slope | 5 | 1000 | 1.90 |
| 3.Top Slope | 4 | 200 | 0.55 |
| 4.Top Slope | 4 | 400 | 0.75 |
| 5.Side Slope | 25 | 100 | 6.50 |
| 6.Side Slope | 25 | 500 | 11.50 |

The plant cover or cropping management factor, C, represents the percentage of soil loss that would occur if the surface were partially protected by some combination of cover and management practices. C Factor for Permanent Pasture, Range, and Idle Land with No Appreciable Canopy has the following relation with percent ground cover (GC) (from Ref 2, p.7) .

| % GC | C Factor: |
|---|---|
| 0 | 0.45 |
| 20 | 0.20 |
| 40 | 0.10 |
| 60 | 0.042 |
| 80 | 0.013 |
| 85 | 0.0082 |




C Factor= $0.5837e^{(-0.0502x60)}$

C Factor= 0.0082 (for 85% ground cover)

The erosion control practice factor, P, measures the effect of control practices that reduce the erosion potential of the runoff by influencing drainage patterns, runoff concentration , and runoff velocity. Contouring for this site will be done only to establish vegetation.

P = 1.00

| Slope Condition | R | K | $L_s$ | C | P | A (tons/ac/yr) |
|---|---|---|---|---|---|---|
| 1. Top Slope<br>5% slope<br>200 ft length | 290 | 0.20 | 0.80 | 0.0082 | 1.0 | 0.38 |
| 2. Top Slope<br>5% slope<br>1000 ft length | 290 | 0.20 | 1.90 | 0.0082 | 1.0 | 0.90 |
| 3.Top Slope<br>4% slope<br>200 ft length | 290 | 0.20 | 0.55 | 0.0082 | 1.0 | 0.26 |
| 4.Top Slope<br>4% slope<br>400 ft length | 290 | 0.20 | 0.75 | 0.0082 | 1.0 | 0.36 |
| 5.Side Slope<br>25% slope<br>100 ft length | 290 | 0.20 | 6.50 | 0.0082 | 1.0 | 3.09 |
| 6.Side Slope<br>25% slope<br>500 ft length | 290 | 0.20 | 11.50 | 0.0082 | 1.0 | 5.46 |

2. Summary
   For a summary of soil loss rates for various percentages of ground cover, see Figure 2 in Appendix IIIF-F and page IIIF-F-1-5.

**SOIL LOSS ESTIMATE SUMMARY TABLE**

| Case | Slope (%) | Length (ft) | $L_s$ | Percent Ground Cover | C Factor | A (tons/ac/yr) |
|---|---|---|---|---|---|---|
| Top Slope | 5 | 200 | 0.80 | 60 | 0.042 | 1.9 |
| Top Slope | 5 | 200 | 0.80 | 70 | 0.017 | 0.8 |
| Top Slope | 5 | 200 | 0.80 | 80 | 0.013 | 0.6 |
| Top Slope | 5 | 200 | 0.80 | 85 | 0.0082 | 0.4 |
| Top Slope | 5 | 1000 | 1.90 | 60 | 0.042 | 4.6 |
| Top Slope | 5 | 1000 | 1.90 | 70 | 0.017 | 1.9 |
| Top Slope | 5 | 1000 | 1.90 | 80 | 0.013 | 1.4 |
| Top Slope | 5 | 1000 | 1.90 | 85 | 0.0082 | 0.9 |
| Top Slope | 4 | 200 | 0.55 | 60 | 0.042 | 1.3 |
| Top Slope | 4 | 200 | 0.55 | 70 | 0.017 | 0.6 |
| Top Slope | 4 | 200 | 0.55 | 80 | 0.013 | 0.4 |
| Top Slope | 4 | 200 | 0.55 | 85 | 0.0082 | 0.3 |
| Top Slope | 4 | 400 | 0.75 | 60 | 0.042 | 1.8 |
| Top Slope | 4 | 400 | 0.75 | 70 | 0.017 | 0.8 |
| Top Slope | 4 | 400 | 0.75 | 80 | 0.013 | 0.6 |
| Top Slope | 4 | 400 | 0.75 | 85 | 0.0082 | 0.4 |
| Side Slope | 25 | 100 | 6.50 | 60 | 0.042 | 15.8 |
| Side Slope | 25 | 100 | 6.50 | 70 | 0.017 | 6.6 |
| Side Slope | 25 | 100 | 6.50 | 80 | 0.013 | 4.9 |
| Side Slope | 25 | 100 | 6.50 | 85 | 0.0082 | 3.1 |
| Side Slope | 25 | 500 | 11.50 | 70 | 0.042 | 28.0 |
| Side Slope | 25 | 500 | 11.50 | 80 | 0.017 | 11.6 |
| Side Slope | 25 | 500 | 11.50 | 85 | 0.013 | 8.7 |
| Side Slope | 25 | 500 | 11.50 | 90 | 0.0082 | 5.5 |

**Required:** Determine the sheet flow velocity for the top dome surfaces and external embankment side slopes and compare to the permissible non-erodible flow velocity.

**Method:**
1. Determine the peak velocities for the cases listed on page IIIF-F-1-2.
2. Compare to permissible velocities.
3. Conclusion.

**References:**
1. Raudkivi, A.J., *Hydrology - An Advanced Introduction to Hydrological Processes and Modeling*, 1979.
2. Texas Department of Transportation, *Bridge Division Hydraulic Manual*, December 2019.
3. United States Soil Conservation Service, *TR-55 Hydrology for Small Watersheds*, December 1989.

**Solution:** Use the typical case scenarios from the USLE calculation to determine the expected peak sheet flow velocity.

| | | | | | |
|---|---|---|---|---|---|
| Case 1. Top Slope | | | Case 2. Top Slope | | |
| slope = | 5 | % | slope = | 5 | % |
| length = | 200 | ft | length = | 1000 | ft |
| Case 3. Top Slope | | | Case 4. Top Slope | | |
| slope = | 4 | % | slope = | 4 | % |
| length = | 200 | ft | length = | 400 | ft |
| Case 5. Side Slope | | | Case 6. Side Slope | | |
| slope = | 25 | % | slope = | 25 | % |
| length = | 100 | ft | length = | 500 | ft |

1. Determine the peak velocities for the cases listed on page IIIF-F-1-2.

Cultivated Straight Row (Overland Flow)

From Figure 15.2 (page 15-8 in Ref. 1), determine the velocities for all cases.

| | | | |
|---|---|---|---|
| Case 1. | V = | 2.0 | ft/s |
| Case 2. | V = | 2.0 | ft/s |
| Case 3. | V = | 1.7 | ft/s |
| Case 4. | V = | 1.7 | ft/s |
| Case 5. | V = | 4.5 | ft/s |
| Case 6. | V = | 4.5 | ft/s |

Note: Figure 15.2 is reproduced on page IIIF-F-1-8.

2. Compare to permissible velocities.

**Summary of Velocities**

| | Condition | Equivalent Percent Ground Coverage | Peak Velocity (ft/s) | Permissible Velocity[1] (ft/s) |
|---|---|---|---|---|
| Cultivated Straight Row | 5%, 200 ft | >60% | 2.0 | 5.0 |
| | 5%, 1000 ft | >60% | 2.0 | 5.0 |
| | 4%, 200 ft | >60% | 1.7 | 5.0 |
| | 4%, 400 ft | >60% | 1.7 | 5.0 |
| | 25%, 100 ft | >60% | 4.5 | 5.0 |
| | 25%, 500 ft | >60% | 4.5 | 5.0 |

[1] Permissible velocity information is from USACE EM 1110-0-1418, Chapter 5 - Evaluation of Stability.

3. Conclusion.
The peak velocities for each case are listed in the above summary table. As shown peak velocities are below permissible velocities for the conditions analyzed. After 180 days, at least 60 percent vegetation will be established in order to maintain permissible non-erodible velocities.

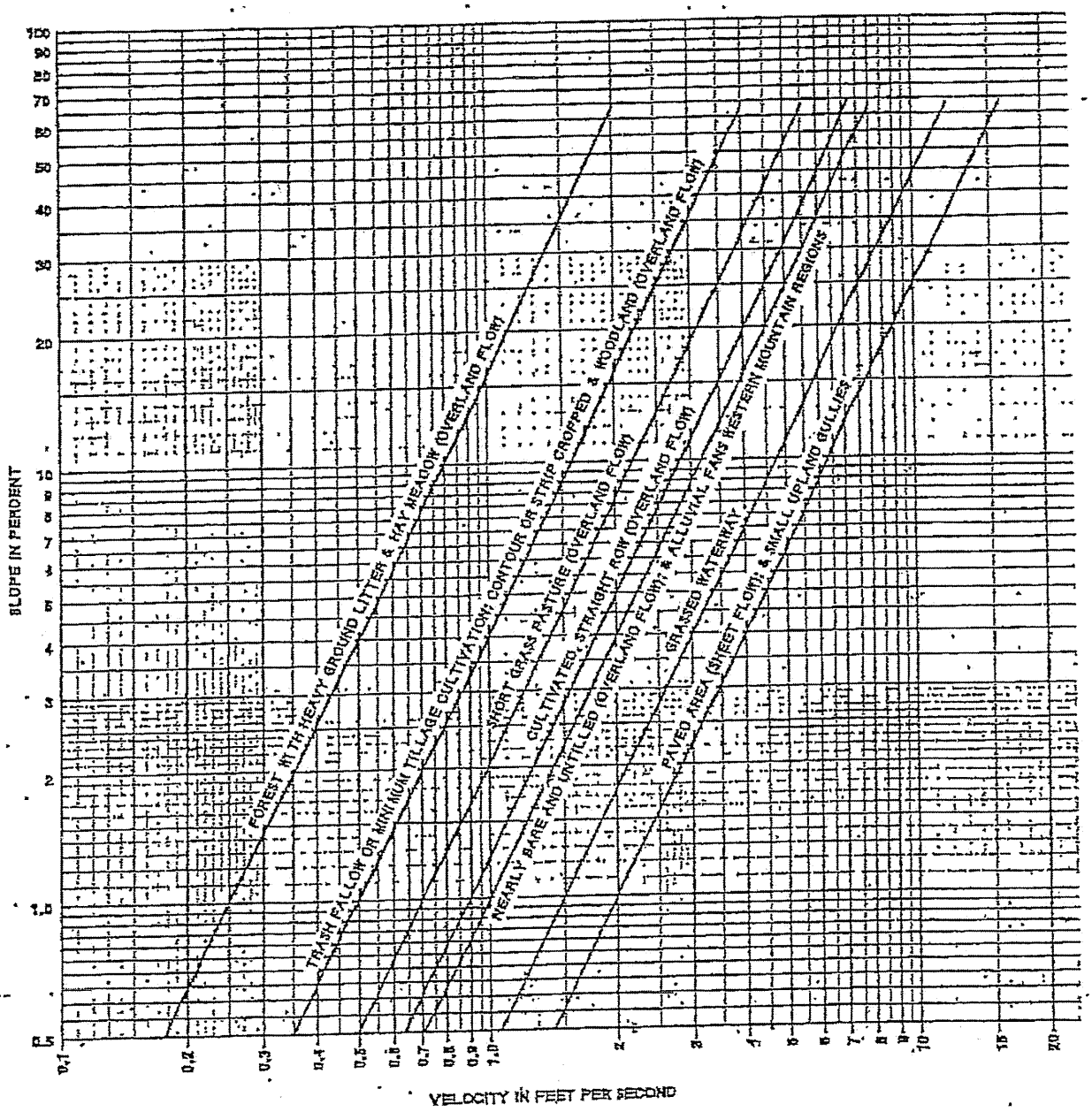



Figure 15.2.—Velocities for upland method of estimating $T_c$

**Required:** Analyze swales to determine the adequacy of the swale design.

**Method:**

1. Determine the 25-year, 24-hour flow rates for a maximum swale drainage area for top slopes and side slopes using the Rational Method.
2. Determine maximum swale length that corresponds to the maximum swale drainage area.

**Reference:**

1. State of Texas, Department of Transportation, Bridge Division, Hydraulic Manual, September 2019.
2. National Oceanic and Atmospheric Administration's Atlas 14 Point Precipitation Frequency Estimates.

**Solution:**

1. Determine the 25-year intensity flow rates.

$$Q = CIA$$

Where:
C= 0.7 (runoff coefficient, Ref 1.)
I = intensity in/hr
A= drainage area, ac

From Ref. 2, for
25-year storm event

$t_c$ is assumed to be 10 min.

I = 7.87 in/hr

For Top Slope (5%):

| | | |
|---|---|---|
| Maximum Drainage Area (2 ft swale) = | 27.8 | acres |
| Maximum Drainage Area (1.5 ft swale) = | 12.9 | acres |
| Maximum Drainage Area (1 ft swale) = | 4.4 | acres |

| | | |
|---|---|---|
| Flow Rate (2 ft swale) = | 152.9 | cfs |
| Flow Rate (1.5 ft swale) = | 71.0 | cfs |
| Flow Rate (1 ft swale) = | 24.1 | cfs |

For Top Slope (4%):

| | | |
|---|---|---|
| Maximum Drainage Area (2 ft swale) = | 34.1 | acres |
| Maximum Drainage Area (1.5 ft swale) = | 15.8 | acres |
| Maximum Drainage Area (1 ft swale) = | 5.4 | acres |

| | | |
|---|---|---|
| Flow Rate (2 ft swale) = | 188.0 | cfs |
| Flow Rate (1.5 ft swale) = | 87.3 | cfs |
| Flow Rate (1 ft swale) = | 29.6 | cfs |

For Side Slope (25 %):

| | | |
|---|---|---|
| Maximum Drainage Area = | 7.4 | acres |

| | | |
|---|---|---|
| Flow Rate (2 ft swale) = | 40.5 | cfs |

2. Determine maximum swale length that corresponds to the maximum swale drainage area.

| Condition (swale height) | Maximum Drainage Area (acres) | Minimum Swale Spacing[1] (ft) | Maximum Swale Length[2] (ft) |
|---|---|---|---|
| 5% Top Slope (2 ft swale) | 27.8 | 200 | 6,045 |
| 5% Top Slope (1.5 ft swale) | 12.9 | 200 | 2,807 |
| 5% Top Slope (1 ft swale) | 4.4 | 200 | 953 |
| 4% Top Slope (2 ft swale) | 34.1 | 200 | 7,433 |
| 4% Top Slope (1.5 ft swale) | 15.8 | 200 | 3,451 |
| 4% Top Slope (1 ft swale) | 5.4 | 200 | 1,170 |
| Side Slope (2 ft swale) | 7.4 | 100 | 3,202 |

[1] Minimum swale spacing is taken from calculations provided on page IIIF-F-1-2.

[2] Maximum swale length calculated using the following equation:

Maximum Drainage Area x (43,560 sf/acre) / Minimum Swale Spacing

CITY OF ARLINGTON LANDFILL
0023-404-11-102-07
SWALE ANALYSIS



| Flow Rate (cfs) | Bottom Slope (ft/ft) | n-value | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude No. | Velocity Head (ft) | Energy Head (ft) | Flow Area (sq. ft.) | Top Width of Flow (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 ft Top Slope (5%) Swale | | | | | | | | | | | | |
| 152.9 | 0.005 | 0.03 | 2 | 20 | 0 | 2.00 | 3.48 | 0.613 | 0.19 | 2.19 | 43.95 | 43.98 |
| 1.5 ft Top Slope (5%) Swale | | | | | | | | | | | | |
| 71.0 | 0.005 | 0.03 | 2 | 20 | 0 | 1.50 | 2.87 | 0.584 | 0.13 | 1.63 | 24.74 | 32.99 |
| 1 ft Top Slope (5%) Swale | | | | | | | | | | | | |
| 24.1 | 0.005 | 0.03 | 2 | 20 | 0 | 1.00 | 2.19 | 0.546 | 0.07 | 1.07 | 11.00 | 22.00 |
| 2 ft Top Slope (4%) Swale | | | | | | | | | | | | |
| 188.0 | 0.005 | 0.03 | 2 | 20 | 0 | 2.00 | 3.48 | 0.614 | 0.19 | 2.19 | 53.96 | 53.98 |
| 1.5 ft Top Slope (4%) Swale | | | | | | | | | | | | |
| 87.3 | 0.005 | 0.03 | 2 | 20 | 0 | 1.50 | 2.88 | 0.585 | 0.13 | 1.63 | 30.36 | 40.49 |
| 1 ft Top Slope (4%) Swale | | | | | | | | | | | | |
| 29.6 | 0.005 | 0.03 | 2 | 20 | 0 | 1.00 | 2.20 | 0.547 | 0.07 | 1.07 | 13.48 | 26.98 |
| 2 ft Side Slope (25%) Swale | | | | | | | | | | | | |
| 40.5 | 0.005 | 0.03 | 2 | 4 | 0 | 2.00 | 3.37 | 0.595 | 0.18 | 2.18 | 12.00 | 12.00 |

Note: Calculations were performed using the HYDROCALC HYDRAULICS program developed by Dodson and Associates (Version 2.01, 1996-2010).

Maximum flow depth is 2.0 ft (swale height).

Design is acceptable.

**Example Calculation:** Calculate the normal depth for the swale for the maximum size 5% top slope drainage area.

List of Symbols

$Q_d$ = design flow rate for channel, cfs
R = hydraulic radius, ft
n = Manning's roughness coefficient
S = channel slope, ft/ft
b = bottom width of channel, ft
$z_r$ = z-ratio (ratio of run to rise for channel sideslope) for right side slope of swale
$z_l$ = z-ratio (ratio of run to rise for channel sideslope) for left side slope of swale
$A_f$ = flow area, sf
g = gravitational acceleration = 32.2 $ft/s^2$
T = top width of flow, ft
d = normal depth of swale, ft

The program uses an iterative process to calculate the normal depth of the swale to satisfy Manning's Equation

$$Q = \frac{1.486}{n} A R^{0.67} S^{0.5}$$

Design Inputs:

| | | |
|---|---|---|
| $Q_d$ = | 152.9 | cfs |
| S = | 0.005 | ft/ft |
| b = | 0 | ft |
| $z_r$ = | 20 | (H) : 1 (V) |
| $z_l$ = | 2 | (H) : 1 (V) |
| n = | 0.03 | |

Step 1 - Based on the geometry of the swale cross-section, solve for R and $A_f$

$$R = \frac{bd + 1/2d^2(z_r + z_l)}{b + d((z_l^2 + 1)^{0.5} + (z_r^2 + 1))}$$

$$A_f = bd + 1/2d^2(z_r + z_l)$$

assume: d = 2.00 ft

R = 0.988 ft

$A_f$ = 43.95 sf

solve for Q: $Q = 152.9$

if Q is not equal to $Q_d$, select a new d and repeat calculations

Step 2 - solve for velocity, T, Froude number, velocity head, and energy head

$Q = VA \Rightarrow \quad V = Q/A$

$V = 3.48$ ft/s

$T = b + d(z_l + z_r)$

$T = 43.98$ ft

$$F_r = \frac{V}{(gA/T)^{0.5}}$$

$F_r = 0.613$

$$\text{Velocity Head} = \frac{V^2}{2g}$$

Velocity Head = 0.19 ft

Energy Head = water elevation + velocity head

Energy Head = 2.19 ft

# APPENDIX IIIF-F-2

# TEMPORARY LETDOWN DESIGN

Includes pages IIIF-F-2-1 through IIIF-F-2-35



# LETDOWN (OR CHUTE) DESIGN

The temporary letdown structure options include open channel flow letdowns and pipe letdowns. Open channel flow letdowns will be lined with either geomembrane, turf reinforcement mat, gabions, grouted concrete riprap, or rock riprap. The pipe letdowns are typically corrugated plastic pipe. Both types of letdowns may have an energy dissipator structure at the bottom of the letdown. Typical letdown details are shown on Sheet IIIF-F-12 – Letdown Design Summary.

This appendix includes a demonstration to show that the letdown structure sizes shown on Sheet IIIF-F-12 will contain the peak flow rate produced by the 25-year storm event. The geomembrane-lined and gabion-lined chutes (as well as turf reinforcement, rock riprap, and grouted riprap-lined chutes) were analyzed for peak flow rates generated from drainage areas ranging from 5 acres to 30 acres. This analysis (pages IIIF-F-2-2 through IIIF-F-2-5) is summarized on Sheet IIIF-F-12 and shows the maximum drainage areas that the 2-foot-deep chutes (8 feet minimum bottom width) are adequate to handle (i.e., the maximum flow depth calculated is less than 2.00 feet).

Also included in this appendix is an analysis for the 18-inch-, 24-inch-, and 36-inch-diameter temporary pipe letdowns for 25 percent slopes. The maximum flow that these pipes were capable of conveying was determined, and from this design flow rate a maximum drainage area size was calculated. The drainage area corresponds to the area that could drain to the pipe at each inlet. As noted on Sheet IIIF-F-12, the use of pipe letdowns will be limited to 1 inlet per letdown. The design summary for geomembrane-lined letdowns and pipe letdowns is provided on Sheet IIIF-F-12.

CITY OF ARLINGTON LANDFILL
0023-404-11-102
CHUTE ANALYSIS



**Required:** Analyze chutes to determine chute sizes for drainage areas that range from 1.81 acres to 32.4 acres.

**Method:**

1. Determine the 25-year, 24-hour flow rates for various sizes of chute drainage areas using the Rational Method.

**Reference:**

1. State of Texas, Department of Transportation, Bridge Division, Hydraulic Manual, September 2019.
2. National Oceanic and Atmospheric Administration's Atlas 14 Point Precipitation Frequency Estimates.

**Solution:**

1. Determine the 25-year intensity flow rates.

$$Q = CIA$$

Where:
C= 0.7 (runoff coefficient, Ref 1.)
I = intensity in/hr
A= drainage area, ac

From Ref. 2, for
25-year storm event

$t_c$ is assumed to be 10 min.

I = 7.87 in/hr

| Area (ac) | Flow (cfs) |
|---|---|
| 5.00 | 27.5 |
| 10.0 | 55.1 |
| 15.0 | 82.6 |
| 20.0 | 110.2 |
| 25.0 | 137.7 |
| 30.0 | 165.3 |

2. Demonstrate that the normal depth of flow for the maximum 25-year flow rate will be contained within the chute.

Please refer to Page IIIF-F-2-3 for chute hydraulic analysis output.

CITY OF ARLINGTON LANDFILL
0023-404-11-102
EROSION CONTROL STRUCTURE DESIGN
GEOMEMBRANE-LINED CHUTE



**Uniform flow design for the geomembrane-lined chutes on 5% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.05 | 0.01 | 2 | 2 | 8 | 0.25 | 12.72 | 4.580 | 2.52 | 2.77 | 2.16 | 9.02 |
| 55.1 | 0.05 | 0.01 | 2 | 2 | 8 | 0.38 | 16.42 | 4.879 | 4.19 | 4.57 | 3.36 | 9.53 |
| 82.6 | 0.05 | 0.01 | 2 | 2 | 8 | 0.49 | 18.94 | 5.041 | 5.57 | 6.06 | 4.36 | 9.94 |
| 110.2 | 0.05 | 0.01 | 2 | 2 | 8 | 0.58 | 20.92 | 5.157 | 6.80 | 7.38 | 5.27 | 10.30 |
| 137.7 | 0.05 | 0.01 | 2 | 2 | 8 | 0.66 | 22.56 | 5.246 | 7.91 | 8.56 | 6.10 | 10.62 |
| 165.3 | 0.05 | 0.01 | 2 | 2 | 8 | 0.73 | 23.98 | 5.319 | 8.94 | 9.66 | 6.89 | 10.92 |

**Uniform flow design for the geomembrane-lined chutes on 4% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.04 | 0.01 | 2 | 2 | 8 | 0.27 | 11.86 | 4.137 | 2.18 | 2.46 | 2.32 | 9.09 |
| 55.1 | 0.04 | 0.01 | 2 | 2 | 8 | 0.41 | 15.28 | 4.404 | 3.63 | 4.04 | 3.61 | 9.64 |
| 82.6 | 0.04 | 0.01 | 2 | 2 | 8 | 0.52 | 17.61 | 4.549 | 4.82 | 5.34 | 4.69 | 10.08 |
| 110.2 | 0.04 | 0.01 | 2 | 2 | 8 | 0.61 | 19.43 | 4.653 | 5.87 | 6.48 | 5.67 | 10.46 |
| 137.7 | 0.04 | 0.01 | 2 | 2 | 8 | 0.70 | 20.95 | 4.732 | 6.82 | 7.52 | 6.57 | 10.80 |
| 165.3 | 0.04 | 0.01 | 2 | 2 | 8 | 0.78 | 22.25 | 4.798 | 7.69 | 8.47 | 7.43 | 11.11 |

**Uniform flow design for the geomembrane-lined chutes on 25% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.25 | 0.01 | 2 | 2 | 8 | 0.16 | 21.12 | 9.581 | 6.93 | 7.09 | 1.30 | 8.63 |
| 55.1 | 0.25 | 0.01 | 2 | 2 | 8 | 0.24 | 27.31 | 10.143 | 11.59 | 11.83 | 2.02 | 8.95 |
| 82.6 | 0.25 | 0.01 | 2 | 2 | 8 | 0.30 | 31.71 | 10.511 | 15.62 | 15.93 | 2.61 | 9.21 |
| 110.2 | 0.25 | 0.01 | 2 | 2 | 8 | 0.36 | 35.20 | 10.776 | 19.26 | 149.62 | 3.13 | 9.44 |
| 137.7 | 0.25 | 0.01 | 2 | 2 | 8 | 0.41 | 38.20 | 11.009 | 22.67 | 23.08 | 3.61 | 9.64 |
| 165.3 | 0.25 | 0.01 | 2 | 2 | 8 | 0.46 | 40.74 | 11.173 | 25.79 | 26.24 | 4.06 | 9.82 |

Conclusions: Maximum normal depth is 0.78 feet. Chute design depth is 2.0 feet; therefore, design is acceptable.

1. Calculations were performed using the HYDROCALC Hydraulics for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010).

**Chute flow design for the gabion and rock riprap-lined chutes on 5% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.05 | 0.04 | 2 | 2 | 8 | 0.58 | 5.23 | 1.289 | 0.42 | 1.00 | 5.26 | 10.30 |
| 55.1 | 0.05 | 0.04 | 2 | 2 | 8 | 0.86 | 6.59 | 1.358 | 0.67 | 1.53 | 8.36 | 11.44 |
| 82.6 | 0.05 | 0.04 | 2 | 2 | 8 | 1.08 | 7.50 | 1.398 | 0.87 | 1.96 | 11.02 | 12.33 |
| 110.2 | 0.05 | 0.04 | 2 | 2 | 8 | 1.27 | 8.20 | 1.427 | 1.04 | 2.32 | 13.44 | 13.10 |
| 137.7 | 0.05 | 0.04 | 2 | 2 | 8 | 1.44 | 8.77 | 1.449 | 1.20 | 2.64 | 15.70 | 13.77 |
| 165.3 | 0.05 | 0.04 | 2 | 2 | 8 | 1.59 | 9.27 | 1.466 | 1.33 | 2.93 | 17.84 | 14.38 |

**Chute flow design for the gabion and rock riprap-lined chutes on 4% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.04 | 0.04 | 2 | 2 | 8 | 0.61 | 4.86 | 1.163 | 0.37 | 0.98 | 5.66 | 10.46 |
| 55.1 | 0.04 | 0.04 | 2 | 2 | 8 | 0.92 | 6.11 | 1.225 | 0.58 | 1.50 | 9.02 | 11.67 |
| 82.6 | 0.04 | 0.04 | 2 | 2 | 8 | 1.15 | 6.94 | 1.261 | 0.75 | 1.90 | 11.90 | 12.62 |
| 110.2 | 0.04 | 0.04 | 2 | 2 | 8 | 1.36 | 7.59 | 1.286 | 0.89 | 2.25 | 14.52 | 13.42 |
| 137.7 | 0.04 | 0.04 | 2 | 2 | 8 | 1.53 | 8.11 | 1.305 | 1.02 | 2.56 | 16.97 | 14.13 |
| 165.3 | 0.04 | 0.04 | 2 | 2 | 8 | 1.69 | 8.57 | 1.321 | 1.14 | 2.83 | 19.30 | 14.78 |

**Chute flow design for the gabion and rock riprap-lined chutes on 25% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.25 | 0.04 | 2 | 2 | 8 | 0.36 | 8.80 | 2.693 | 1.20 | 1.56 | 3.13 | 9.43 |
| 55.1 | 0.25 | 0.04 | 2 | 2 | 8 | 0.54 | 11.25 | 2.858 | 1.97 | 2.51 | 4.90 | 10.16 |
| 82.6 | 0.25 | 0.04 | 2 | 2 | 8 | 0.68 | 12.91 | 2.949 | 2.59 | 3.27 | 6.40 | 10.73 |
| 110.2 | 0.25 | 0.04 | 2 | 2 | 8 | 0.81 | 14.21 | 3.013 | 3.14 | 3.94 | 7.76 | 11.23 |
| 137.7 | 0.25 | 0.04 | 2 | 2 | 8 | 0.92 | 15.27 | 3.062 | 3.62 | 4.54 | 9.02 | 11.67 |
| 165.3 | 0.25 | 0.04 | 2 | 2 | 8 | 1.02 | 16.18 | 3.102 | 4.07 | 5.09 | 10.21 | 12.07 |

Conclusions: Maximum calculated normal depth is 1.69 feet, resulting from a peak flow from 30 acres. Chute design depth is 2.0 feet; therefore, 30.0 acres is the maximum allowable drainage area for a gabion or rock rip-rap lined chute.
Maximum velocity is 16.18 fps. As noted in footnote No. 2 below, the lining material will be selected so that the permissible velocity is not exceeded for erosion control.

1. Calculations were performed using the HYDROCALC Hydraulics for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010).
2. Permissible velocities are listed below, and lining material will be selected so that these are not exceeded.

| Description | Permissible Velocity (fps) |
|---|---|
| Turf Reinforcement Mat (based on Pyramat or equivalent. Refer to Sheet IIIF-F-2-19.) | 25 |
| Rock Riprap (based on Sheet IIIF-F-2-20 and a $D_{50}$ of 12 inches. If other riprap is used, it will meet the $D_{50}$ requirements listed on Sheet IIIF-F-2-21.) | 9 |
| Gabion/Concrete Grouted Riprap (based on Sheet IIIF-F-2-21 and a $D_{50}$ of 1 ft. If other gabion is used, it will meet the $D_{50}$ requirements listed on Sheet IIIF-F-2-21. (The permissible velocity for concrete grouted riprap will actually be greater than 21 fps because it is classified as a rigid channel lining material.) | 21 |

**Chute flow design for the concrete grouted riprap and turf reinforcement-lined chutes on 5% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.05 | 0.03 | 2 | 2 | 8 | 0.49 | 6.31 | 1.680 | 0.62 | 1.10 | 4.36 | 9.94 |
| 55.1 | 0.05 | 0.03 | 2 | 2 | 8 | 0.73 | 7.99 | 1.773 | 0.99 | 1.72 | 6.89 | 10.92 |
| 82.6 | 0.05 | 0.03 | 2 | 2 | 8 | 0.92 | 9.12 | 1.827 | 1.29 | 2.21 | 9.05 | 11.68 |
| 110.2 | 0.05 | 0.03 | 2 | 2 | 8 | 1.08 | 10.00 | 1.865 | 1.55 | 2.64 | 11.02 | 12.34 |
| 137.7 | 0.05 | 0.03 | 2 | 2 | 8 | 1.23 | 10.72 | 1.894 | 1.78 | 3.01 | 12.85 | 12.92 |
| 165.3 | 0.05 | 0.03 | 2 | 2 | 8 | 1.36 | 11.33 | 1.918 | 2.00 | 3.36 | 14.59 | 13.44 |

**Chute flow design for the concrete grouted riprap and turf reinforcement-lined chutes on 4% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.05 | 0.03 | 2 | 2 | 8 | 0.52 | 5.87 | 1.516 | 0.53 | 1.05 | 4.69 | 10.07 |
| 55.1 | 0.05 | 0.03 | 2 | 2 | 8 | 0.78 | 7.42 | 1.559 | 0.85 | 1.63 | 7.43 | 11.11 |
| 82.6 | 0.05 | 0.03 | 2 | 2 | 8 | 0.98 | 8.46 | 1.648 | 1.11 | 2.09 | 9.77 | 11.92 |
| 110.2 | 0.05 | 0.03 | 2 | 2 | 8 | 1.15 | 9.26 | 1.681 | 1.33 | 2.49 | 11.90 | 12.62 |
| 137.7 | 0.05 | 0.03 | 2 | 2 | 8 | 1.31 | 9.92 | 1.707 | 1.53 | 2.84 | 13.88 | 13.23 |
| 165.3 | 0.05 | 0.03 | 2 | 2 | 8 | 1.45 | 10.48 | 1.728 | 1.71 | 3.16 | 15.77 | 13.79 |

**Chute flow design for the concrete grouted riprap and turf reinforcement-lined chutes on 25% slope.**

| Flow Rate (cfs) | Bottom Slope (ft/ft) | Manning's n | Side Slope (left) | Side Slope (right) | Bottom Width (ft) | Normal Depth (ft) | Flow Vel. (fps) | Froude Number | Velocity Head (ft) | Energy Head (ft) | Flow Area (sf) | Flow Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.5 | 0.25 | 0.03 | 2 | 2 | 8 | 0.30 | 10.56 | 3.503 | 1.73 | 2.04 | 2.60 | 9.21 |
| 55.1 | 0.25 | 0.03 | 2 | 2 | 8 | 0.46 | 13.58 | 3.724 | 2.87 | 3.32 | 4.06 | 9.82 |
| 82.6 | 0.25 | 0.03 | 2 | 2 | 8 | 0.58 | 15.62 | 3.846 | 3.79 | 4.37 | 5.29 | 10.31 |
| 110.2 | 0.25 | 0.03 | 2 | 2 | 8 | 0.68 | 17.22 | 3.932 | 4.61 | 5.29 | 6.40 | 10.73 |
| 137.7 | 0.25 | 0.03 | 2 | 2 | 8 | 0.78 | 18.54 | 3.998 | 5.34 | 6.12 | 7.43 | 11.11 |
| 165.3 | 0.25 | 0.03 | 2 | 2 | 8 | 0.86 | 19.68 | 4.052 | 6.02 | 6.88 | 8.40 | 11.45 |

Conclusions: Maximum calculated normal depth is 1.45 feet, resulting from a peak flow from 30 acres. Chute design depth is 2.0 feet; therefore, 30.0 acres is the maximum allowable drainage area for a grouted riprap or turf reinforcement mat-lined chute.
Maximum velocity is 19.68 fps. As noted in footnote No. 2 below, the lining material will be selected so that the permissible velocity is not exceeded for erosion control.

1. Calculations were performed using the HYDROCALC Hydraulics for Windows program developed by Dodson and Associates (Version 2.01, 1996-2010).
2. Permissible velocities are listed below, and lining material will be selected so that these are not exceeded.

| Description | Permissible Velocity (fps) |
|---|---|
| Turf Reinforcement Mat (based on Pyramat or equivalent. Refer to Sheet IIIF-F-2-19.) | 25 |
| Rock Riprap (based on Sheet IIIF-F-2-20 and a $D_{50}$ of 12 inches. If other riprap is used, it will meet the $D_{50}$ requirements listed on Sheet IIIF-F-2-21.) | 9 |
| Gabion/Concrete Grouted Riprap (based on Sheet IIIF-F-2-21 and a $D_{50}$ of 1 ft. If other gabion is used, it will meet the $D_{50}$ requirements listed on Sheet IIIF-F-2-21. (The permissible velocity for concrete grouted riprap will actually be greater than 21 fps because it is classified as a rigid channel lining material.) | 21 |

CITY OF ARLINGTON LANDFILL
0023-404-11-102
OPEN CHANNEL LETDOWN
RIPRAP EROSION PROTECTION DESIGN



**Required:** Design the riprap erosion protection at the downstream end of the open channel letdown.

**Method:** Use HEC-RAS to model the open channel geomembrane-lined letdown to determine the hydraulic characteristics of the hydraulic jump that will occur at the downstream end of the letdown. Based on the results, design the riprap erosion protection area.

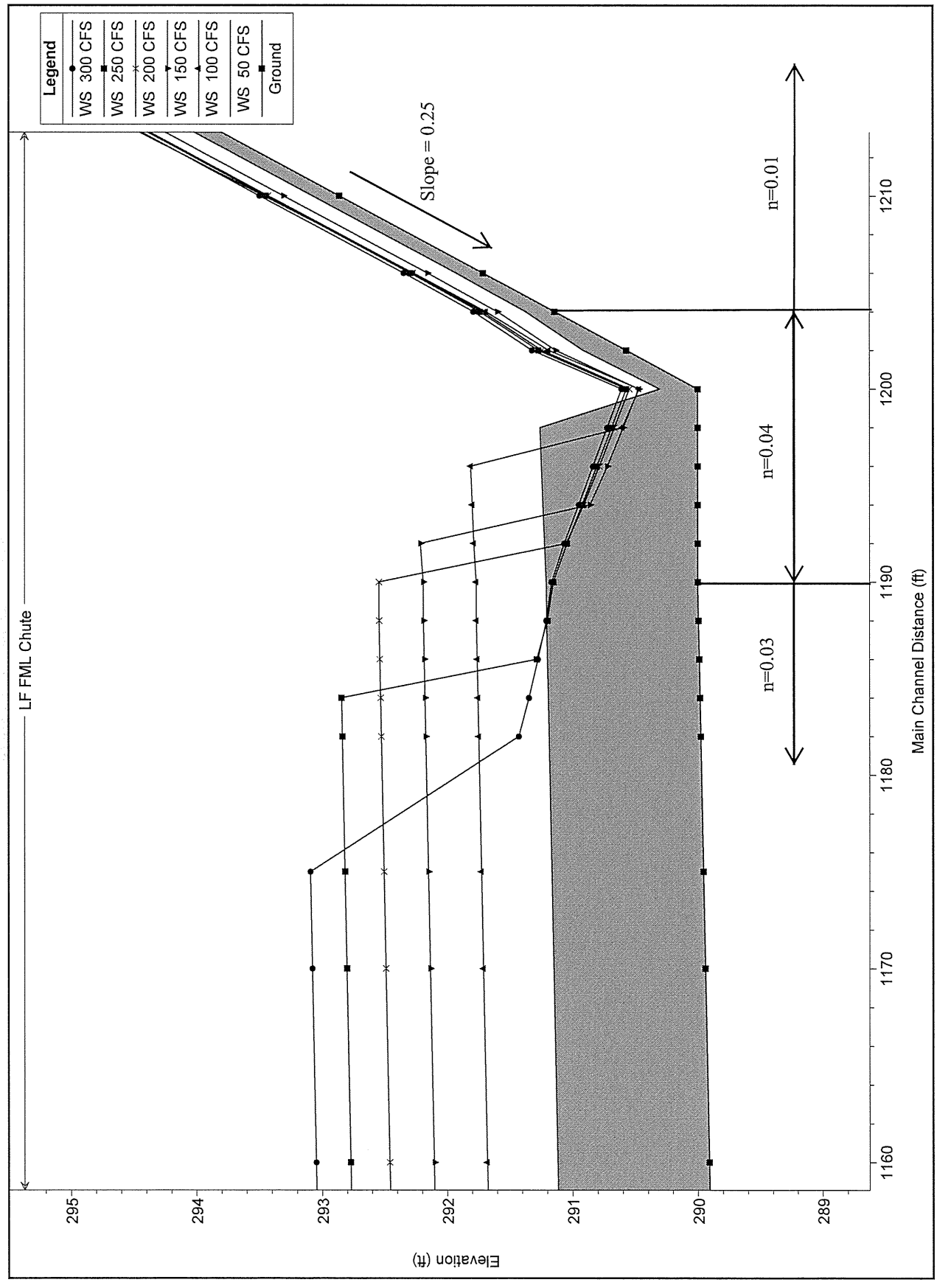
**Note:** This example calculation is shown for geomembrane-lined letdowns to conservatively estimate the length of riprap needed. As seen on pages IIIF-F-2-3 through IIIF-F-2-5, the geomembrane-lined letdowns have the highest velocities and represent the worst-case scenario. Therefore, this riprap design is applicable to all lined letdowns.

**Solution:** Page IIIF-F-2-7 shows the water surface profile for incremental flows up to 300 cfs for the geomembrane letdown into a channel, as modeled in HEC-RAS. The modeling output is presented on pages IIIF-F-2-8 through IIIF-F-2-18. The following table summarizes the erosion protection design for the various flows.

| Flow (cfs) | Drainage Area* (ac) | Length of Hydraulic Jump (ft) | Specified Runout of Riprap (ft) |
|---|---|---|---|
| 50 | 9 | 2 | 10 |
| 100 | 18 | 6 | 10 |
| 150 | 27 | 8 | 10 |
| 200 | 36 | 10 | 10 |
| 250 | 45 | 16 | 16 |
| 300 | 54 | 25 | 25 |

* Drainage areas are approximated based on corresponding flows/drainage areas listed on page IIIF-F-2-2.

The values listed in the above table are specified riprap lengths for letdowns terminating into a perimeter channel. If the letdown terminates into a pond, 10 feet of riprap erosion control will be sufficient because the water in the pond will provide additional energy dissipation.


Legend
WS 300 CFS
WS 250 CFS
WS 200 CFS
WS 150 CFS
WS 100 CFS
WS 50 CFS
Ground
LF FML Chute
Slope = 0.25
n=0.01
n=0.04
n=0.03
Elevation (ft)
Main Channel Distance (ft)
295
294
293
292
291
290
289
1160
1170
1180
1190
1200
1210

HEC-RAS Version 4.0.0 March 2008
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: Hydraulic Jump
Project File : HydraulicJump.prj
Run Date and Time: 2/2/2010 9:51:19 AM

Project in English units

PLAN DATA

Plan Title: RUNUP 0.3%
Plan File : s:\Chuck\HEC-RAS\HydraulicJump.p07

Geometry Title: FML CHUTE with 4' RUNUP .003
Geometry File : s:\Chuck\HEC-RAS\HydraulicJump.g07

Flow Title : FML CHUTE 0.3%
Flow File : s:\Chuck\HEC-RAS\HydraulicJump.f03

Plan Summary Information:
Number of: Cross Sections = 36 Multiple Openings = 0
Culverts = 0 Inline Structures = 0
Bridges = 0 Lateral Structures = 0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Mixed Flow

FLOW DATA

Flow Title: FML CHUTE 0.3%
Flow File : s:\Chuck\HEC-RAS\HydraulicJump.f03

Flow Data (cfs)

| River | Reach | RS | 50 CFS | 100 CFS | 150 CFS | 200 CFS | 250 CFS | 300 CFS |
|---|---|---|---|---|---|---|---|---|
| LF | FML Chute | 5000 | 50 | 100 | 150 | 200 | 250 | 300 |

Boundary Conditions

| River | Reach | Profile | Upstream | Downstream |
|---|---|---|---|---|
| LF | FML Chute | 50 CFS | Normal S = 0.25 | Normal S = 0.003 |
| LF | FML Chute | 100 CFS | Normal S = 0.25 | Normal S = 0.003 |
| LF | FML Chute | 150 CFS | Normal S = 0.25 | Normal S = 0.003 |
| LF | FML Chute | 200 CFS | Normal S = 0.25 | Normal S = 0.003 |
| LF | FML Chute | 250 CFS | Normal S = 0.25 | Normal S = 0.003 |
| LF | FML Chute | 300 CFS | Normal S = 0.25 | Normal S = 0.003 |

GEOMETRY DATA

Geometry Title: FML CHUTE with 4' RUNUP .003
Geometry File : s:\Chuck\HEC-RAS\HydraulicJump.g07

CROSS SECTION

RIVER: LF
REACH: FML Chute RS: 5000

INPUT
Description:
Station Elevation Data num= 4

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|
| 0 | 500 | 20 | 490 | 28 | 490 | 48 | 500 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 0 | .01 | 0 | .01 | 48 | .01 |

| Bank Sta: Left | Right | Lengths: Left Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|
| 0 | 48 | 100 | 100 | .1 | .5 |

CROSS SECTION

RIVER: LF

```
REACH: FML Chute          RS: 4900

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     475      20     465      28     465      48     475

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .01       0    .01      48    .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48             100     100     100             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4800

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     450      20     440      28     440      48     450

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .01       0    .01      48    .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48             100     100     100             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4700

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     425      20     415      28     415      48     425

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .01       0    .01      48    .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48             100     100     100             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4600

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     400      20     390      28     390      48     400

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .01       0    .01      48    .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48             100     100     100             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4500

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     375      20     365      28     365      48     375

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .01       0    .01      48    .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48             100     100     100             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4400

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     350      20     340      28     340      48     350

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .01       0    .01      48    .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48             100     100     100             .1       .5

CROSS SECTION
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RIVER: LF
REACH: FML Chute          RS: 4300

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     325      20     315      28     315      48     325

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .01       0     .01      48     .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48              75      75      75             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4225

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  306.25      20  296.25      28  296.25      48  306.25

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .01       0     .01      48     .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48               5       5       5             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4220

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     305      20     295      28     295      48     305

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .01       0     .01      48     .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48               5       5       5             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4215

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  303.75      20  293.75      28  293.75      48  303.75

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .01       0     .01      48     .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48               5       5       5             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4210

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0   302.5      20   292.5      28   292.5      48   302.5

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .01       0     .01      48     .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48               4       4       4             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4206

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0   301.5      20   291.5      28   291.5      48   301.5

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .01       0     .01      48     .01

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48               2       2       2             .1      .5

CROSS SECTION
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RIVER: LF
REACH: FML Chute          RS: 4204

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     301      20     291      28     291      48     301

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .04       0    .04      48    .04

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48               2       2       2            .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4202

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0   300.5      20   290.5      28   290.5      48   300.5

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .04       0    .04      48    .04

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      48               2       2       2            .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4200

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     300      30     290      42     290      72     300

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .04       0    .04      72    .04

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      72               2       2       2            .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4198

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     300      30     290      42     290      72     300

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .04       0    .04      72    .04

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      72               2       2       2            .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4196

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     300      30     290      42     290      72     300

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .04       0    .04      72    .04

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      72               2       2       2            .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4194

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     300      30     290      42     290      72     300

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .04       0    .04      72    .04

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      72               2       2       2            .1      .5

CROSS SECTION
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RIVER: LF
REACH: FML Chute          RS: 4192

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     300      30     290      42     290      72     300

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .04       0     .04      72     .04

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      72               2       2       2             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4190

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     310      60     290      72     290     132     310

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .03       0     .03      72     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      72               2       2       2             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4188

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 309.994      60 289.994      72 289.994     132 309.994

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .03       0     .03     132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132               2       2       2             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4186

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 309.988      60 289.988      72 289.988     132 309.988

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .03       0     .03     132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132               2       2       2             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4184

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 309.982      60 289.982      72 289.982     132 309.982

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .03       0     .03     132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132               2       2       2             .1       .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4182

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 309.976      60 289.976      72 289.976     132 309.976

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .03       0     .03     132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132               7       7       7             .1       .5
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CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4175

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 309.955      60 289.955      72 289.955     132 309.955

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0     .03        0     .03      132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132               5       5       5             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4170

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  309.94      60  289.94      72  289.94     132  309.94

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0     .03        0     .03      132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132              10      10      10             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4160

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  309.91      60  289.91      72  289.91     132  309.91

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0     .03        0     .03      132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132              10      10      10             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4150

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  309.88      60  289.88      72  289.88     132  309.88

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0     .03        0     .03      132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132              10      10      10             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4140

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  309.85      60  289.85      72  289.85     132  309.85

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0     .03        0     .03      132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132              10      10      10             .1      .5

CROSS SECTION


RIVER: LF
REACH: FML Chute          RS: 4130

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  309.82      60  289.82      72  289.82     132  309.82

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0     .03        0     .03      132     .03

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     132              10      10      10             .1      .5
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CROSS SECTION

RIVER: LF
REACH: FML Chute RS: 4120

INPUT
Description:
Station Elevation Data num= 4

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|
| 0 | 309.79 | 60 | 289.79 | 72 | 289.79 | 132 | 309.79 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 0 | .03 | 0 | .03 | 132 | .03 |

| Bank Sta: Left | Right | Lengths: Left Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|
| 0 | 132 | 10 | 10 | 10 | .1 | .5 |

CROSS SECTION

RIVER: LF
REACH: FML Chute RS: 4110

INPUT
Description:
Station Elevation Data num= 4

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|
| 0 | 309.76 | 60 | 289.76 | 72 | 289.76 | 132 | 309.76 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 0 | .03 | 0 | .03 | 132 | .03 |

| Bank Sta: Left | Right | Lengths: Left Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|
| 0 | 132 | 10 | 10 | 10 | .1 | .5 |

CROSS SECTION

RIVER: LF
REACH: FML Chute RS: 4100

INPUT
Description:
Station Elevation Data num= 4

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|
| 0 | 309.73 | 60 | 289.73 | 72 | 289.73 | 132 | 309.73 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 0 | .03 | 0 | .03 | 132 | .03 |

| Bank Sta: Left | Right | Lengths: Left Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|
| 0 | 132 | 100 | 100 | 100 | .1 | .5 |

CROSS SECTION

RIVER: LF
REACH: FML Chute RS: 4000

INPUT
Description:
Station Elevation Data num= 4

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|
| 0 | 309.43 | 60 | 289.43 | 72 | 289.43 | 132 | 309.43 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 0 | .03 | 0 | .03 | 132 | .03 |

| Bank Sta: Left | Right | Lengths: Left Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|
| 0 | 132 | 1000 | 1000 | 1000 | .1 | .5 |

CROSS SECTION

RIVER: LF
REACH: FML Chute RS: 3000

INPUT
Description:
Station Elevation Data num= 4

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|
| 0 | 306.43 | 60 | 286.43 | 72 | 286.43 | 132 | 306.43 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 0 | .03 | 0 | .03 | 132 | .03 |

| Bank Sta: Left | Right | Coeff Contr. | Expan. |
|---|---|---|---|
| 0 | 132 | .1 | .5 |

Profile Output Table - Standard Table 1

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| FML Chute | 5000 | 50 CFS | 50.00 | 490.00 | 490.22 | 490.98 | 500.99 | 0.250200 | 26.33 | 1.90 | 8.90 | 10.05 |
| FML Chute | 5000 | 100 CFS | 100.00 | 490.00 | 490.34 | 491.48 | 508.27 | 0.250152 | 33.98 | 2.94 | 9.36 | 10.68 |
| FML Chute | 5000 | 150 CFS | 150.00 | 490.00 | 490.43 | 491.87 | 514.41 | 0.250103 | 39.30 | 3.82 | 9.72 | 11.05 |
| FML Chute | 5000 | 200 CFS | 200.00 | 490.00 | 490.51 | 492.21 | 519.86 | 0.250072 | 43.47 | 4.60 | 10.04 | 11.32 |
| FML Chute | 5000 | 250 CFS | 250.00 | 490.00 | 490.58 | 492.50 | 524.82 | 0.250092 | 46.96 | 5.32 | 10.32 | 11.52 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FML Chute | 4900 | 50 CFS | 50.00 | 465.00 | 465.98 | 465.98 | 466.39 | 0.001647 | 5.14 | 9.73 | 11.91 |
| 1.00 | | | | | | | | | | | |
| FML Chute | 4900 | 100 CFS | 100.00 | 465.00 | 465.34 | 466.48 | 483.26 | 0.249924 | 33.97 | 2.94 | 9.36 |
| 10.67 | | | | | | | | | | | |
| FML Chute | 4900 | 150 CFS | 150.00 | 465.00 | 465.43 | 466.87 | 489.40 | 0.249922 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4900 | 200 CFS | 200.00 | 465.00 | 465.51 | 467.21 | 494.84 | 0.249919 | 43.46 | 4.60 | 10.04 |
| 11.31 | | | | | | | | | | | |
| FML Chute | 4900 | 250 CFS | 250.00 | 465.00 | 465.58 | 467.50 | 499.80 | 0.249911 | 46.95 | 5.33 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4800 | 50 CFS | 50.00 | 440.00 | 440.16 | 440.98 | 463.50 | 0.867039 | 38.77 | 1.29 | 8.62 |
| 17.67 | | | | | | | | | | | |
| FML Chute | 4800 | 100 CFS | 100.00 | 440.00 | 440.34 | 441.48 | 458.26 | 0.249924 | 33.97 | 2.94 | 9.36 |
| 10.67 | | | | | | | | | | | |
| FML Chute | 4800 | 150 CFS | 150.00 | 440.00 | 440.43 | 441.87 | 464.40 | 0.249922 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4800 | 200 CFS | 200.00 | 440.00 | 440.51 | 442.21 | 469.85 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4800 | 250 CFS | 250.00 | 440.00 | 440.58 | 442.50 | 474.80 | 0.249911 | 46.95 | 5.33 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4700 | 50 CFS | 50.00 | 415.00 | 415.25 | 415.98 | 423.63 | 0.167904 | 23.23 | 2.15 | 9.01 |
| 8.38 | | | | | | | | | | | |
| FML Chute | 4700 | 100 CFS | 100.00 | 415.00 | 415.34 | 416.48 | 433.27 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4700 | 150 CFS | 150.00 | 415.00 | 415.43 | 416.87 | 439.41 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4700 | 200 CFS | 200.00 | 415.00 | 415.51 | 417.21 | 444.85 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4700 | 250 CFS | 250.00 | 415.00 | 415.58 | 417.50 | 449.81 | 0.249956 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4600 | 50 CFS | 50.00 | 390.00 | 390.22 | 390.98 | 401.86 | 0.283536 | 27.38 | 1.83 | 8.87 |
| 10.63 | | | | | | | | | | | |
| FML Chute | 4600 | 100 CFS | 100.00 | 390.00 | 390.34 | 391.48 | 408.27 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4600 | 150 CFS | 150.00 | 390.00 | 390.43 | 391.87 | 414.41 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4600 | 200 CFS | 200.00 | 390.00 | 390.51 | 392.21 | 419.85 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4600 | 250 CFS | 250.00 | 390.00 | 390.58 | 392.50 | 424.82 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4500 | 50 CFS | 50.00 | 365.00 | 365.23 | 365.98 | 375.54 | 0.233381 | 25.76 | 1.94 | 8.92 |
| 9.73 | | | | | | | | | | | |
| FML Chute | 4500 | 100 CFS | 100.00 | 365.00 | 365.34 | 366.48 | 383.27 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4500 | 150 CFS | 150.00 | 365.00 | 365.43 | 366.87 | 389.41 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4500 | 200 CFS | 200.00 | 365.00 | 365.51 | 367.21 | 394.85 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4500 | 250 CFS | 250.00 | 365.00 | 365.58 | 367.50 | 399.82 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4400 | 50 CFS | 50.00 | 340.00 | 340.22 | 340.98 | 351.11 | 0.254706 | 26.48 | 1.89 | 8.89 |
| 10.13 | | | | | | | | | | | |
| FML Chute | 4400 | 100 CFS | 100.00 | 340.00 | 340.34 | 341.48 | 358.27 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4400 | 150 CFS | 150.00 | 340.00 | 340.43 | 341.87 | 364.41 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4400 | 200 CFS | 200.00 | 340.00 | 340.51 | 342.21 | 369.85 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4400 | 250 CFS | 250.00 | 340.00 | 340.58 | 342.50 | 374.82 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4300 | 50 CFS | 50.00 | 315.00 | 315.23 | 315.98 | 325.92 | 0.247365 | 26.24 | 1.91 | 8.90 |
| 9.99 | | | | | | | | | | | |
| FML Chute | 4300 | 100 CFS | 100.00 | 315.00 | 315.34 | 316.48 | 333.27 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4300 | 150 CFS | 150.00 | 315.00 | 315.43 | 316.87 | 339.41 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4300 | 200 CFS | 200.00 | 315.00 | 315.51 | 317.21 | 344.85 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4300 | 250 CFS | 250.00 | 315.00 | 315.58 | 317.50 | 349.82 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4225 | 50 CFS | 50.00 | 296.25 | 296.47 | 297.23 | 307.24 | 0.250314 | 26.34 | 1.90 | 8.90 |
| 10.05 | | | | | | | | | | | |
| FML Chute | 4225 | 100 CFS | 100.00 | 296.25 | 296.59 | 297.73 | 314.52 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4225 | 150 CFS | 150.00 | 296.25 | 296.68 | 298.12 | 320.66 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4225 | 200 CFS | 200.00 | 296.25 | 296.76 | 298.46 | 326.10 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4225 | 250 CFS | 250.00 | 296.25 | 296.83 | 298.75 | 331.07 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4220 | 50 CFS | 50.00 | 295.00 | 295.22 | 295.98 | 305.99 | 0.250314 | 26.34 | 1.90 | 8.90 |
| 10.05 | | | | | | | | | | | |
| FML Chute | 4220 | 100 CFS | 100.00 | 295.00 | 295.34 | 296.48 | 313.27 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4220 | 150 CFS | 150.00 | 295.00 | 295.43 | 296.87 | 319.41 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4220 | 200 CFS | 200.00 | 295.00 | 295.51 | 297.21 | 324.85 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4220 | 250 CFS | 250.00 | 295.00 | 295.58 | 297.50 | 329.82 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4215 | 50 CFS | 50.00 | 293.75 | 293.97 | 294.73 | 304.74 | 0.250314 | 26.34 | 1.90 | 8.90 |
| 10.05 | | | | | | | | | | | |
| FML Chute | 4215 | 100 CFS | 100.00 | 293.75 | 294.09 | 295.23 | 312.02 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4215 | 150 CFS | 150.00 | 293.75 | 294.18 | 295.62 | 318.16 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4215 | 200 CFS | 200.00 | 293.75 | 294.26 | 295.96 | 323.60 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4215 | 250 CFS | 250.00 | 293.75 | 294.33 | 296.25 | 328.57 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4210 | 50 CFS | 50.00 | 292.50 | 292.72 | 293.48 | 303.49 | 0.250314 | 26.34 | 1.90 | 8.90 |
| 10.05 | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| FML Chute | 4210 | 100 CFS | 100.00 | 292.50 | 292.84 | 293.98 | 310.77 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4210 | 150 CFS | 150.00 | 292.50 | 292.93 | 294.37 | 316.91 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4210 | 200 CFS | 200.00 | 292.50 | 293.01 | 294.71 | 322.35 | 0.249970 | 43.47 | 4.60 | 10.04 |
| 11.32 | | | | | | | | | | | |
| FML Chute | 4210 | 250 CFS | 250.00 | 292.50 | 293.08 | 295.00 | 327.32 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4206 | 50 CFS | 50.00 | 291.50 | 291.72 | 292.48 | 302.49 | 0.250314 | 26.34 | 1.90 | 8.90 |
| 10.05 | | | | | | | | | | | |
| FML Chute | 4206 | 100 CFS | 100.00 | 291.50 | 291.84 | 292.98 | 309.77 | 0.250000 | 33.98 | 2.94 | 9.36 |
| 10.68 | | | | | | | | | | | |
| FML Chute | 4206 | 150 CFS | 150.00 | 291.50 | 291.93 | 293.37 | 315.91 | 0.250043 | 39.29 | 3.82 | 9.72 |
| 11.05 | | | | | | | | | | | |
| FML Chute | 4206 | 200 CFS | 200.00 | 291.50 | 292.01 | 293.71 | 321.33 | 0.249766 | 43.46 | 4.60 | 10.04 |
| 11.31 | | | | | | | | | | | |
| FML Chute | 4206 | 250 CFS | 250.00 | 291.50 | 292.08 | 294.00 | 326.32 | 0.250046 | 46.95 | 5.32 | 10.32 |
| 11.52 | | | | | | | | | | | |
| FML Chute | 4204 | 50 CFS | 50.00 | 291.00 | 291.24 | 291.98 | 300.54 | 3.168813 | 24.47 | 2.04 | 8.96 |
| 9.03 | | | | | | | | | | | |
| FML Chute | 4204 | 100 CFS | 100.00 | 291.00 | 291.35 | 292.48 | 307.76 | 3.483119 | 32.51 | 3.08 | 9.41 |
| 10.02 | | | | | | | | | | | |
| FML Chute | 4204 | 150 CFS | 150.00 | 291.00 | 291.44 | 292.87 | 313.89 | 3.611811 | 38.02 | 3.95 | 9.78 |
| 10.55 | | | | | | | | | | | |
| FML Chute | 4204 | 200 CFS | 200.00 | 291.00 | 291.52 | 293.21 | 319.31 | 3.680328 | 42.30 | 4.73 | 10.09 |
| 10.89 | | | | | | | | | | | |
| FML Chute | 4204 | 250 CFS | 250.00 | 291.00 | 291.59 | 293.50 | 324.29 | 3.729970 | 45.88 | 5.45 | 10.37 |
| 11.16 | | | | | | | | | | | |
| FML Chute | 4202 | 50 CFS | 50.00 | 290.50 | 290.85 | 291.48 | 294.95 | 0.867986 | 16.24 | 3.08 | 9.41 |
| 5.00 | | | | | | | | | | | |
| FML Chute | 4202 | 100 CFS | 100.00 | 290.50 | 290.97 | 291.98 | 299.92 | 1.358543 | 24.01 | 4.16 | 9.86 |
| 6.51 | | | | | | | | | | | |
| FML Chute | 4202 | 150 CFS | 150.00 | 290.50 | 291.05 | 292.37 | 304.74 | 1.689934 | 29.69 | 5.05 | 10.22 |
| 7.44 | | | | | | | | | | | |
| FML Chute | 4202 | 200 CFS | 200.00 | 290.50 | 291.13 | 292.71 | 309.32 | 1.929858 | 34.22 | 5.84 | 10.52 |
| 8.09 | | | | | | | | | | | |
| FML Chute | 4202 | 250 CFS | 250.00 | 290.50 | 291.20 | 293.00 | 313.67 | 2.115861 | 38.04 | 6.57 | 10.80 |
| 8.59 | | | | | | | | | | | |
| FML Chute | 4200 | 50 CFS | 50.00 | 290.00 | 290.31 | 290.76 | 292.68 | 0.577996 | 12.36 | 4.05 | 13.88 |
| 4.03 | | | | | | | | | | | |
| FML Chute | 4200 | 100 CFS | 100.00 | 290.00 | 290.40 | 291.17 | 295.89 | 0.980102 | 18.80 | 5.32 | 14.42 |
| 5.46 | | | | | | | | | | | |
| FML Chute | 4200 | 150 CFS | 150.00 | 290.00 | 290.47 | 291.48 | 299.36 | 1.322610 | 23.93 | 6.27 | 14.81 |
| 6.48 | | | | | | | | | | | |
| FML Chute | 4200 | 200 CFS | 200.00 | 290.00 | 290.52 | 291.75 | 302.89 | 1.610460 | 28.22 | 7.09 | 15.13 |
| 7.27 | | | | | | | | | | | |
| FML Chute | 4200 | 250 CFS | 250.00 | 290.00 | 290.57 | 291.99 | 306.39 | 1.851131 | 31.91 | 7.83 | 15.43 |
| 7.89 | | | | | | | | | | | |
| FML Chute | 4198 | 50 CFS | 50.00 | 290.00 | 291.26 | 290.76 | 291.36 | 0.004652 | 2.52 | 19.82 | 19.54 |
| 0.44 | | | | | | | | | | | |
| FML Chute | 4198 | 100 CFS | 100.00 | 290.00 | 290.53 | 291.17 | 293.48 | 0.373613 | 13.77 | 7.26 | 15.20 |
| 3.51 | | | | | | | | | | | |
| FML Chute | 4198 | 150 CFS | 150.00 | 290.00 | 290.59 | 291.48 | 295.84 | 0.589034 | 18.39 | 8.16 | 15.55 |
| 4.48 | | | | | | | | | | | |
| FML Chute | 4198 | 200 CFS | 200.00 | 290.00 | 290.64 | 291.75 | 298.40 | 0.789548 | 22.35 | 8.95 | 15.86 |
| 5.24 | | | | | | | | | | | |
| FML Chute | 4198 | 250 CFS | 250.00 | 290.00 | 290.69 | 291.99 | 301.04 | 0.971954 | 25.82 | 9.68 | 16.13 |
| 5.87 | | | | | | | | | | | |
| FML Chute | 4196 | 50 CFS | 50.00 | 290.00 | 291.25 | | 291.35 | 0.004810 | 2.55 | 19.59 | 19.47 |
| 0.45 | | | | | | | | | | | |
| FML Chute | 4196 | 100 CFS | 100.00 | 290.00 | 290.68 | 291.17 | 292.39 | 0.163054 | 10.49 | 9.53 | 16.07 |
| 2.40 | | | | | | | | | | | |
| FML Chute | 4196 | 150 CFS | 150.00 | 290.00 | 290.72 | 291.48 | 294.10 | 0.301701 | 14.75 | 10.17 | 16.31 |
| 3.29 | | | | | | | | | | | |
| FML Chute | 4196 | 200 CFS | 200.00 | 290.00 | 290.76 | 291.75 | 296.00 | 0.436547 | 18.37 | 10.89 | 16.57 |
| 3.99 | | | | | | | | | | | |
| FML Chute | 4196 | 250 CFS | 250.00 | 290.00 | 290.80 | 291.99 | 298.02 | 0.564262 | 21.55 | 11.60 | 16.83 |
| 4.57 | | | | | | | | | | | |
| FML Chute | 4194 | 50 CFS | 50.00 | 290.00 | 291.23 | | 291.34 | 0.004982 | 2.58 | 19.36 | 19.40 |
| 0.46 | | | | | | | | | | | |
| FML Chute | 4194 | 100 CFS | 100.00 | 290.00 | 291.80 | 291.17 | 291.96 | 0.005042 | 3.20 | 31.24 | 22.78 |
| 0.48 | | | | | | | | | | | |
| FML Chute | 4194 | 150 CFS | 150.00 | 290.00 | 290.86 | 291.48 | 293.10 | 0.163928 | 12.04 | 12.46 | 17.13 |
| 2.49 | | | | | | | | | | | |
| FML Chute | 4194 | 200 CFS | 200.00 | 290.00 | 290.89 | 291.75 | 294.57 | 0.257977 | 15.40 | 12.98 | 17.32 |
| 3.13 | | | | | | | | | | | |
| FML Chute | 4194 | 250 CFS | 250.00 | 290.00 | 290.92 | 291.99 | 296.16 | 0.350291 | 18.37 | 13.61 | 17.53 |
| 3.67 | | | | | | | | | | | |
| FML Chute | 4192 | 50 CFS | 50.00 | 290.00 | 291.22 | | 291.33 | 0.005160 | 2.61 | 19.13 | 19.33 |
| 0.46 | | | | | | | | | | | |
| FML Chute | 4192 | 100 CFS | 100.00 | 290.00 | 291.78 | | 291.95 | 0.005172 | 3.23 | 30.96 | 22.70 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4192 | 150 CFS | 150.00 | 290.00 | 292.21 | 291.48 | 292.42 | 0.005182 | 3.64 | 41.24 | 25.28 |
| 0.50 | | | | | | | | | | | |
| FML Chute | 4192 | 200 CFS | 200.00 | 290.00 | 291.02 | 291.75 | 293.65 | 0.157016 | 13.02 | 15.36 | 18.12 |
| 2.49 | | | | | | | | | | | |
| FML Chute | 4192 | 250 CFS | 250.00 | 290.00 | 291.04 | 291.99 | 294.93 | 0.225868 | 15.83 | 15.79 | 18.26 |
| 3.00 | | | | | | | | | | | |
| FML Chute | 4190 | 50 CFS | 50.00 | 290.00 | 291.21 | | 291.32 | 0.002884 | 2.76 | 18.87 | 19.25 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4190 | 100 CFS | 100.00 | 290.00 | 291.77 | | 291.94 | 0.002881 | 3.44 | 30.54 | 22.60 |
| 0.50 | | | | | | | | | | | |
| FML Chute | 4190 | 150 CFS | 150.00 | 290.00 | 292.19 | | 292.41 | 0.002883 | 3.89 | 40.70 | 25.15 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4190 | 200 CFS | 200.00 | 290.00 | 292.55 | 291.77 | 292.81 | 0.002884 | 4.24 | 50.02 | 27.28 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4190 | 250 CFS | 250.00 | 290.00 | 291.15 | 292.01 | 294.31 | 0.085151 | 14.57 | 17.83 | 18.92 |
| 2.54 | | | | | | | | | | | |
| FML Chute | 4188 | 50 CFS | 50.00 | 289.99 | 291.20 | | 291.31 | 0.002999 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4188 | 100 CFS | 100.00 | 289.99 | 291.76 | | 291.93 | 0.003001 | 3.27 | 30.62 | 22.62 |
| 0.49 | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| FML Chute | 4188 | 150 CFS | 150.00 | 289.99 | 292.19 | | 292.40 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4188 | 200 CFS | 200.00 | 289.99 | 292.55 | | 292.79 | 0.002998 | 3.99 | 50.16 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4188 | 250 CFS | 250.00 | 289.99 | 291.20 | 291.99 | 293.94 | 0.075880 | 13.27 | 18.83 | 19.24 |
| 2.36 | | | | | | | | | | | |
| FML Chute | 4186 | 50 CFS | 50.00 | 289.99 | 291.20 | | 291.31 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4186 | 100 CFS | 100.00 | 289.99 | 291.76 | | 291.92 | 0.003001 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4186 | 150 CFS | 150.00 | 289.99 | 292.18 | | 292.39 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4186 | 200 CFS | 200.00 | 289.99 | 292.54 | | 292.79 | 0.002998 | 3.99 | 50.16 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4186 | 250 CFS | 250.00 | 289.99 | 291.29 | 291.98 | 293.57 | 0.058292 | 12.12 | 20.62 | 19.79 |
| 2.09 | | | | | | | | | | | |
| FML Chute | 4184 | 50 CFS | 50.00 | 289.98 | 291.19 | | 291.30 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4184 | 100 CFS | 100.00 | 289.98 | 291.75 | | 291.92 | 0.003001 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4184 | 150 CFS | 150.00 | 289.98 | 292.18 | | 292.39 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4184 | 200 CFS | 200.00 | 289.98 | 292.53 | | 292.78 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4184 | 250 CFS | 250.00 | 289.98 | 292.84 | 291.98 | 293.12 | 0.002997 | 4.24 | 58.92 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4182 | 50 CFS | 50.00 | 289.98 | 291.19 | | 291.29 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4182 | 100 CFS | 100.00 | 289.98 | 291.75 | | 291.91 | 0.003001 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4182 | 150 CFS | 150.00 | 289.98 | 292.17 | | 292.38 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4182 | 200 CFS | 200.00 | 289.98 | 292.53 | | 292.77 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4182 | 250 CFS | 250.00 | 289.98 | 292.84 | | 293.12 | 0.002997 | 4.24 | 58.92 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4175 | 50 CFS | 50.00 | 289.96 | 291.16 | | 291.27 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4175 | 100 CFS | 100.00 | 289.96 | 291.72 | | 291.89 | 0.003001 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4175 | 150 CFS | 150.00 | 289.96 | 292.15 | | 292.36 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4175 | 200 CFS | 200.00 | 289.96 | 292.51 | | 292.75 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4175 | 250 CFS | 250.00 | 289.96 | 292.82 | | 293.10 | 0.002997 | 4.24 | 58.92 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4170 | 50 CFS | 50.00 | 289.94 | 291.15 | | 291.26 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4170 | 100 CFS | 100.00 | 289.94 | 291.71 | | 291.87 | 0.003001 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4170 | 150 CFS | 150.00 | 289.94 | 292.14 | | 292.35 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4170 | 200 CFS | 200.00 | 289.94 | 292.49 | | 292.74 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4170 | 250 CFS | 250.00 | 289.94 | 292.80 | | 293.08 | 0.002997 | 4.24 | 58.92 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4160 | 50 CFS | 50.00 | 289.91 | 291.12 | | 291.23 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4160 | 100 CFS | 100.00 | 289.91 | 291.68 | | 291.84 | 0.003002 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4160 | 150 CFS | 150.00 | 289.91 | 292.11 | | 292.32 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4160 | 200 CFS | 200.00 | 289.91 | 292.46 | | 292.71 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4160 | 250 CFS | 250.00 | 289.91 | 292.77 | | 293.05 | 0.002997 | 4.24 | 58.92 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4150 | 50 CFS | 50.00 | 289.88 | 291.09 | | 291.20 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4150 | 100 CFS | 100.00 | 289.88 | 291.65 | | 291.81 | 0.003002 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4150 | 150 CFS | 150.00 | 289.88 | 292.08 | | 292.29 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4150 | 200 CFS | 200.00 | 289.88 | 292.43 | | 292.68 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4150 | 250 CFS | 250.00 | 289.88 | 292.74 | | 293.02 | 0.002996 | 4.24 | 58.93 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4140 | 50 CFS | 50.00 | 289.85 | 291.06 | | 291.17 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4140 | 100 CFS | 100.00 | 289.85 | 291.62 | | 291.78 | 0.003002 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4140 | 150 CFS | 150.00 | 289.85 | 292.05 | | 292.26 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4140 | 200 CFS | 200.00 | 289.85 | 292.40 | | 292.65 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4140 | 250 CFS | 250.00 | 289.85 | 292.71 | | 292.99 | 0.002996 | 4.24 | 58.93 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4130 | 50 CFS | 50.00 | 289.82 | 291.03 | | 291.14 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4130 | 100 CFS | 100.00 | 289.82 | 291.59 | | 291.75 | 0.003002 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4130 | 150 CFS | 150.00 | 289.82 | 292.02 | | 292.23 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4130 | 200 CFS | 200.00 | 289.82 | 292.37 | | 292.62 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4130 | 250 CFS | 250.00 | 289.82 | 292.68 | | 292.96 | 0.002996 | 4.24 | 58.93 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4120 | 50 CFS | 50.00 | 289.79 | 291.00 | | 291.11 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4120 | 100 CFS | 100.00 | 289.79 | 291.56 | | 291.72 | 0.003002 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4120 | 150 CFS | 150.00 | 289.79 | 291.99 | | 292.20 | 0.003001 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FML Chute | 4120 | 200 CFS | 200.00 | 289.79 | 292.34 | | 292.59 | 0.002997 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4120 | 250 CFS | 250.00 | 289.79 | 292.65 | | 292.93 | 0.002996 | 4.24 | 58.93 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4110 | 50 CFS | 50.00 | 289.76 | 290.97 | | 291.08 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4110 | 100 CFS | 100.00 | 289.76 | 291.53 | | 291.69 | 0.003003 | 3.27 | 30.61 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4110 | 150 CFS | 150.00 | 289.76 | 291.96 | | 292.17 | 0.003002 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4110 | 200 CFS | 200.00 | 289.76 | 292.31 | | 292.56 | 0.002996 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4110 | 250 CFS | 250.00 | 289.76 | 292.62 | | 292.90 | 0.002996 | 4.24 | 58.93 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4100 | 50 CFS | 50.00 | 289.73 | 290.94 | | 291.05 | 0.003000 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4100 | 100 CFS | 100.00 | 289.73 | 291.50 | | 291.66 | 0.003003 | 3.27 | 30.61 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 4100 | 150 CFS | 150.00 | 289.73 | 291.93 | | 292.14 | 0.003002 | 3.68 | 40.81 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4100 | 200 CFS | 200.00 | 289.73 | 292.28 | | 292.53 | 0.002996 | 3.99 | 50.17 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4100 | 250 CFS | 250.00 | 289.73 | 292.59 | | 292.87 | 0.002996 | 4.24 | 58.93 | 29.17 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 4000 | 50 CFS | 50.00 | 289.43 | 290.64 | | 290.75 | 0.002994 | 2.64 | 18.92 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 4000 | 100 CFS | 100.00 | 289.43 | 291.20 | 290.60 | 291.36 | 0.003007 | 3.27 | 30.60 | 22.61 |
| 0.50 | | | | | | | | | | | |
| FML Chute | 4000 | 150 CFS | 150.00 | 289.43 | 291.63 | 290.91 | 291.84 | 0.003003 | 3.68 | 40.80 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 4000 | 200 CFS | 200.00 | 289.43 | 291.98 | 291.18 | 292.23 | 0.002993 | 3.98 | 50.19 | 27.32 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 4000 | 250 CFS | 250.00 | 289.43 | 292.29 | | 292.57 | 0.002993 | 4.24 | 58.95 | 29.18 |
| 0.53 | | | | | | | | | | | |
| FML Chute | 3000 | 50 CFS | 50.00 | 286.43 | 287.64 | 287.19 | 287.75 | 0.003001 | 2.64 | 18.91 | 19.26 |
| 0.47 | | | | | | | | | | | |
| FML Chute | 3000 | 100 CFS | 100.00 | 286.43 | 288.20 | 287.60 | 288.36 | 0.003002 | 3.27 | 30.62 | 22.61 |
| 0.49 | | | | | | | | | | | |
| FML Chute | 3000 | 150 CFS | 150.00 | 286.43 | 288.63 | 287.91 | 288.84 | 0.003004 | 3.68 | 40.80 | 25.17 |
| 0.51 | | | | | | | | | | | |
| FML Chute | 3000 | 200 CFS | 200.00 | 286.43 | 288.98 | 288.18 | 289.23 | 0.003001 | 3.99 | 50.14 | 27.31 |
| 0.52 | | | | | | | | | | | |
| FML Chute | 3000 | 250 CFS | 250.00 | 286.43 | 289.29 | 288.42 | 289.57 | 0.003000 | 4.24 | 58.90 | 29.17 |
| 0.53 | | | | | | | | | | | |

PROPEX
GEOSYNTHETICS

# Pyramat® Turf Reinforcement Mat
Technical Data Sheet

Roll Sizes - 8.5 ft x 90 ft, 85 sq yd (2.6m x 27.4m, 8.44 sq m)

PYRAMAT high performance turf reinforcement mat (HPTRM) is a three-dimensional, lofty, woven polypropylene geotextile that is available in green or tan which is specially designed for erosion control applications on steep slopes and vegetated waterways. The matrix is composed of polypropylene monofilament yarns featuring X3® technology woven into a uniform configuration of resilient pyramid-like projections. The material exhibits very high interlock and reinforcement capacity with both soil and root systems, demonstrates superior UV resistance, and enhances seedling emergence.

PYRAMAT conforms to the property values listed below[1] and is manufactured at a Propex facility having achieved ISO 9001:2000 certification. Propex performs internal Manufacturing Quality Control (MQC) tests that have been accredited by the Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP).

| PRODUCT TEST DATA | | |
|---|---|---|
| Property | Test Method | MARV[2] |
| **Physical** | | |
| Mass Per Unit Area | ASTM D-6566 | 13.5 oz sq yd (455 g sq m) |
| Thickness | ASTM D-6525 | .4 in (10.2 mm) |
| Light Penetration (% Passing) | ASTM D-6567 | 10% (10%) |
| Color | Visual | Green, Tan |
| **Mechanical** | | |
| Tensile Strength (Grab) | ASTM D-6818 | 4000 x 3000 lbs/ft (58.4 x 43.8 kN/m) |
| Elongation | ASTM D-6818 | 65% max (65% max) |
| Resiliency | ASTM D-6524 | 80% (80%) |
| Flexibility | ASTM D-6575 | .534 in/lbs (615000 mg-cm) avg |
| **Endurance** | | |
| UV Resistance @ 6000 hrs | ASTM D-4355 | 90% (90%) |
| **Performance** | | |
| Velocity[3] (Vegetated) | Large Scale | 25 ft/sec (7.6 m/sec) |
| Shear Stress[3] (Vegetated) | Large Scale | 15 lbs sq ft (718 Pa) |
| Manning's "n"[4] (Unvegetated) | Calculated | .028 (.028) |
| Seedling Emergence | ECTC Draft Method #4 | 296% (296%) |

NOTES

1. The property values listed are effective 08/2006 and are subject to change without notice.
2. MARV indicates minimum average roll value calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample taken during quality assurance testing will exceed the value reported.
3. Maximum permissible velocity and shear stress has been obtained through vegetated testing programs featuring specific soil types, vegetation classes, flow conditions, and failure criteria. These conditions may not be relevant to every project nor are they replicated by other manufacturers. Please contact Propex for further information.
4. Calculated as typical values from large-scale flexible channel lining test programs with a flow depth of 6 to 12 inches.

The information presented herein, while not guaranteed, is to the best of our knowledge true and accurate. Except when agreed to in writing for specific conditions of use, no warranty or guarantee expressed or implied is made regarding the performance of any product, since the manner of use and handling are beyond our control. Nothing contained herein is to be construed as permission or as a recommendation to infringe any patent.

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Phone: (607) 729-5111 (800) 659-5111 Fax: (607) 729-5158

www.ivlindustries.com

IVI-EC-3442-0607-C547

| Type | Thickness m ft | Size mm | $d_{50}$ m ft | velocity m/s ft/sec | velocity m/s ft/sec |
|---|---|---|---|---|---|
| Reno mattress | 0.15 - 0.17 | 70 - 100 | 0.085 | 3.5 | 4.2 |
| | | 70 - 150 | 0.110 | 4.2 | 4.5 |
| | 0.23 - 0.25 | 70 - 100 | 0.085 | 3.6 | 5.5 |
| | | 70 - 150 | 0.120 | 4.5 | 6.1 |
| | 0.30 | 70 - 120 | 0.100 | 4.2 | 5.5 |
| | | 100 - 150 | 0.125 | 5.0 | 6.4 |
| Gabions | 0.50 1.64 | 100 - 200 | 0.150 0.49 | 5.8 19 | 7.6 25 |
| | | 120 - 250 | 0.190 0.62 | 6.4 21 | 8.0 26 |

Where the revetment has to be placed under water the thickness of the Reno mattress remains the same since it can be launched from a pontoon whereas rip rap has to be increased by 50% [12, 13, 49, 50, 51].

The big reduction in the revetment thickness, which is achieved using Reno mattress instead of rip rap, is of economic significance in protection projects in large rivers, given the same area of work, and, therefore, the quantity of material used.

## *2.2 Semi permeable and impermeable linings with sand asphalt mastic.*

a) General characteristics of sand asphalt mastic grouted Reno mattress.

The combination of the stone filled Reno mattress and sand asphalt mastic has the characteristics of both gabion work and asphalt concrete. The addition of bituminous mastic to the Reno mattress produces a structure which combines the properties and performances of both materials. The mattress retains its flexibility, while the density of the filling is increased and therefore the efficiency of the protection. If all the voids between the stones in the layer are filled and the surface of the mattress covered, the lining will be completely impervious. The mastic also protects the wire mesh against corrosion and from abrasion by transported material.

The wire mesh reinforces the grouted stone layer and gives it strength in tension. Hence, the thickness of the combined structure can be considerably less than that of ordinary mastic grouted stone to withstand the same stresses. The resulting saving in bitumen and aggregate, and the increased flexibility due to the reduced thickness, have given rise to extensive use of this type of lining for protection in a variety of waterways.

b) Mix design of sand asphalt mastic.

To avoid excessive detail, only the fundamental data on mix design is given here. For fuller information, reference should be made to the specific publications listed in the bibliography [5, 6].

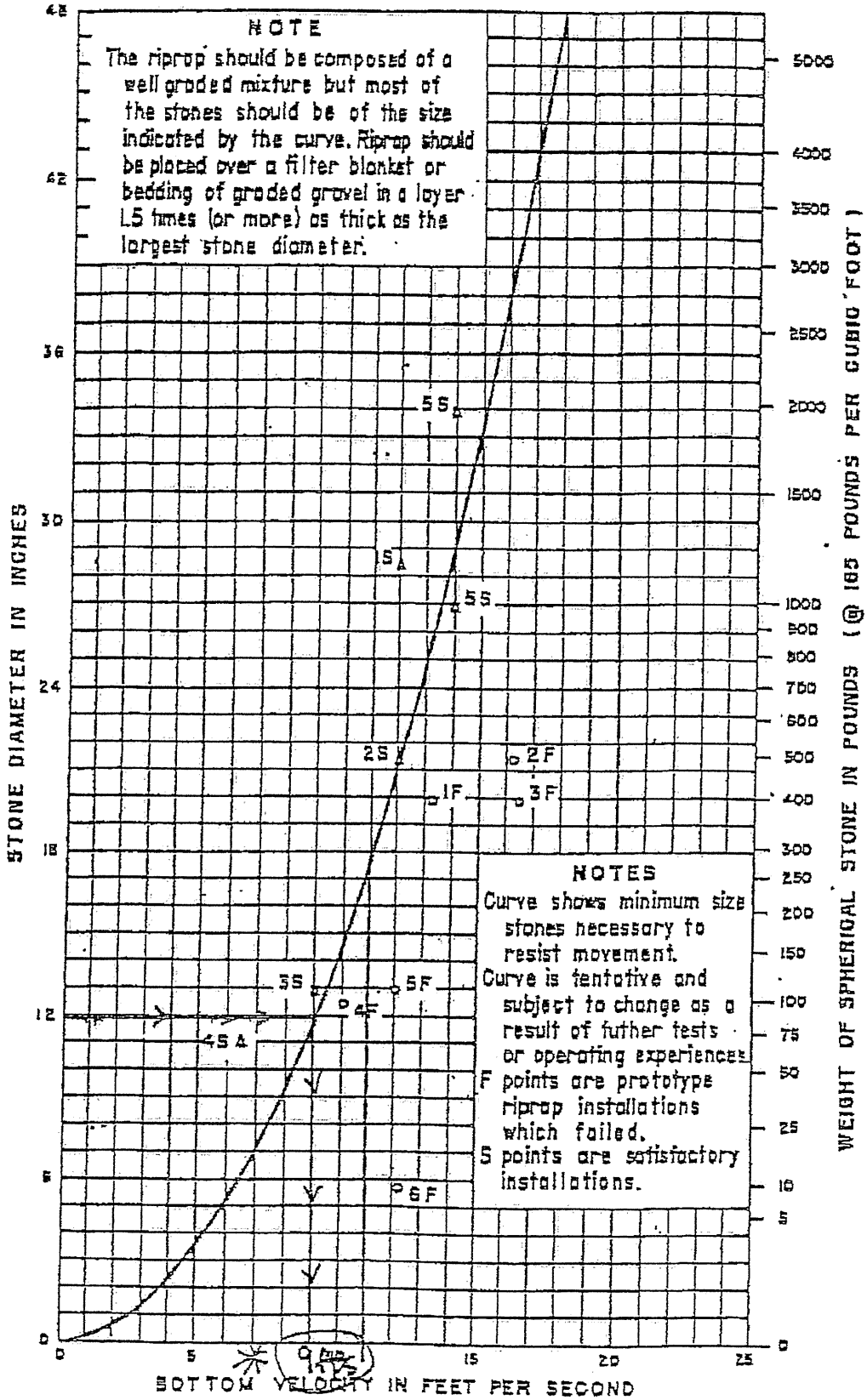



FIGURE 165.—Curve to determine minimum stone size in riprap mixture.

SOURCE: HYDRAULIC DESIGN OF STILLING BASINS AND ENERGY DISSIPATORS. US DEPT OF THE INTERIOR - BUREAU OF LAND RECLAMATION, 1964.

**Required:** Determine the maximum drainage area for 18-inch, 24-inch and 36-inch diameter letdown pipes using the BCAP computer program.

**Method:**
1. Determine the maximum flow for 18-inch, 24-inch and 36-inch diameter letdown pipes on the 25% side slope.
2. Determine the maximum drainage areas for the flows calculated in Step 1.

**Reference:**
1. State of Texas, Department of Transportation, Bridge Division, Hydraulic Manual, September 2019.
2. National Oceanic and Atmospheric Administration's Atlas 14 Point Precipitation Frequency Estimates.

**Note:** The pipe letdown analysis has been performed using "Broken-Back" Culvert Analysis Program (BCAP) which is available from the Federal Highway Administration Web Page:

http://www.dor.state.ne.us/roadway-design/ [follow link to downloadable files and info]

The program was developed to analyze culverts with changing slopes.

**Solution:**

1. Determine the maximum flow for 18-inch, 24-inch and 36-inch diameter letdown pipes on the 25% side slope.

The following pages include the program outputs for the 18-in dia culvert, 24-in dia culvert and 36-in diameter culvert. Pages IIIF-F-2-24 and IIIF-F-2-29 include rating tables that show if the hydraulic jump occurs within the pipe or not [ YES/NO]. The results also include pipe outlet velocity for each flow rate as well as the tailwater depth and velocity in the channel ("Tailwater Velocity").

The flow ratings are used to calculate the maximum allowable top dome drainage area for each pipe size analyzed (Step 2). The maximum flow rate that has hydraulic jump within the culvert is used for allowable drainage area calculations on page IIIF-F-2-33. The computer program does not have corrugated plastic pipe option; therefore, the corrugated metal pipe option has been used with a Manning's Coefficient of 0.024.

Results:

| | | | |
|---|---|---|---|
| Q18 = | 15.0 | cfs | maximum allowable flow in 18-in-dia pipe |
| Q24 = | 17.8 | cfs | maximum allowable flow in 24-in-dia pipe |
| Q36 = | 30.2 | cfs | maximum allowable flow in 36-in-dia pipe |

**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

**PROJECT INFO**

| | |
|---|---|
| Project: | City of Arlington Landfill Expansion |
| Station or Location: | |
| Date: | 02 / 28 / 2022 |

**DISCHARGE DATA**

| | |
|---|---|
| Minimum: | 5.00 cfs |
| Design Discharge: | 10.00 cfs |
| Maximum: | 15.00 cfs |
| Number of Barrels: | 1 |

**TAILWATER DATA**

| | |
|---|---|
| Type: | Downstream |
| Channel Shape: | Trapezoid |
| Left Side Slope: | 3 H:1V |
| Right Side Slope: | 3 H:1V |
| Bottom Width: | 20 ft |
| Bottom Slope: | 0.005 ft/ft |
| Roughness Coefficient: | 0.04 |

**CULVERT DATA**

| | |
|---|---|
| Type: | Circular Pipe |
| Pipe Diameter: | 1.5 ft |
| Culvert Material: | Corr. Metal Pipe |
| Inlet Type: | Mitered to Conform to Slope |
| Roughness Coefficient: | 0.024 |
| Outlet Section Roughness Coeff.: | 0.024 |
| Inlet Section Slope: | 0.05 ft/ft |
| Steep Section Slope: | 0.25 ft/ft |
| Outlet Section Slope: | 0 ft/ft |

**CULVERT PROFILE DATA**

| | |
|---|---|
| Type: | Double Broken-Back |
| Inlet Station: | 0.00 ft |
| Inlet Elevation: | 740.50 ft |
| Upper Break Station: | 10.00 ft |
| Upper Break Elevation: | 740.00 ft |
| Lower Break Station: | 1170.00 ft |
| Lower Break Elevation: | 450.00 ft |
| Outlet Station: | 1201.00 ft |
| Outlet Elevation: | 450.00 ft |

**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

**Project:** City of Arlington Landfill Expansion
**Station or Location:**
**Date:** 02/28/2022

| Discharge cfs | Headwater Depth ft | Inlet Control Elevation ft | Break Control Elevation ft | Critical Depth ft | Outlet Depth ft | Outlet Velocity ft/s | Outlet Froude Number | Tailwater Depth ft | Tailwater Velocity ft/s | Hydraulic Jump |
|---|---|---|---|---|---|---|---|---|---|---|
| 6.0 | 1.49 | 741.99 | 741.59 | .93 | .93 | 5.22 | 1.0 | .27 | 1.07 | YES |
| 7.0 | 1.70 | 742.20 | 741.81 | 1.00 | 1.00 | 5.57 | 1.0 | .29 | 1.16 | YES |
| 8.0 | 1.95 | 742.45 | 742.03 | 1.07 | 1.07 | 5.91 | 1.0 | .33 | 1.16 | YES |
| 9.0 | 2.22 | 742.72 | 742.27 | 1.14 | 1.14 | 6.26 | 1.0 | .35 | 1.22 | YES |
| 10.0 | 2.54 | 743.04 | 742.52 | 1.20 | 1.20 | 6.60 | 1.0 | .37 | 1.28 | YES |
| 11.0 | 2.88 | 743.38 | 742.79 | 1.26 | 1.26 | 6.95 | 1.0 | .39 | 1.33 | YES |
| 12.0 | 3.25 | 743.75 | 743.07 | 1.31 | 1.31 | 7.31 | 1.0 | .41 | 1.38 | YES |
| 13.0 | 3.64 | 744.14 | 743.34 | 1.37 | 1.37 | 7.69 | 1.0 | .43 | 1.42 | YES |
| 14.0 | 4.05 | 744.55 | 743.65 | 1.42 | 1.42 | 8.09 | 1.0 | .45 | 1.46 | YES |
| 15.0 | 4.48 | 744.98 | 744.05 | 1.47 | 1.47 | 8.53 | 1.0 | .47 | 1.49 | YES |

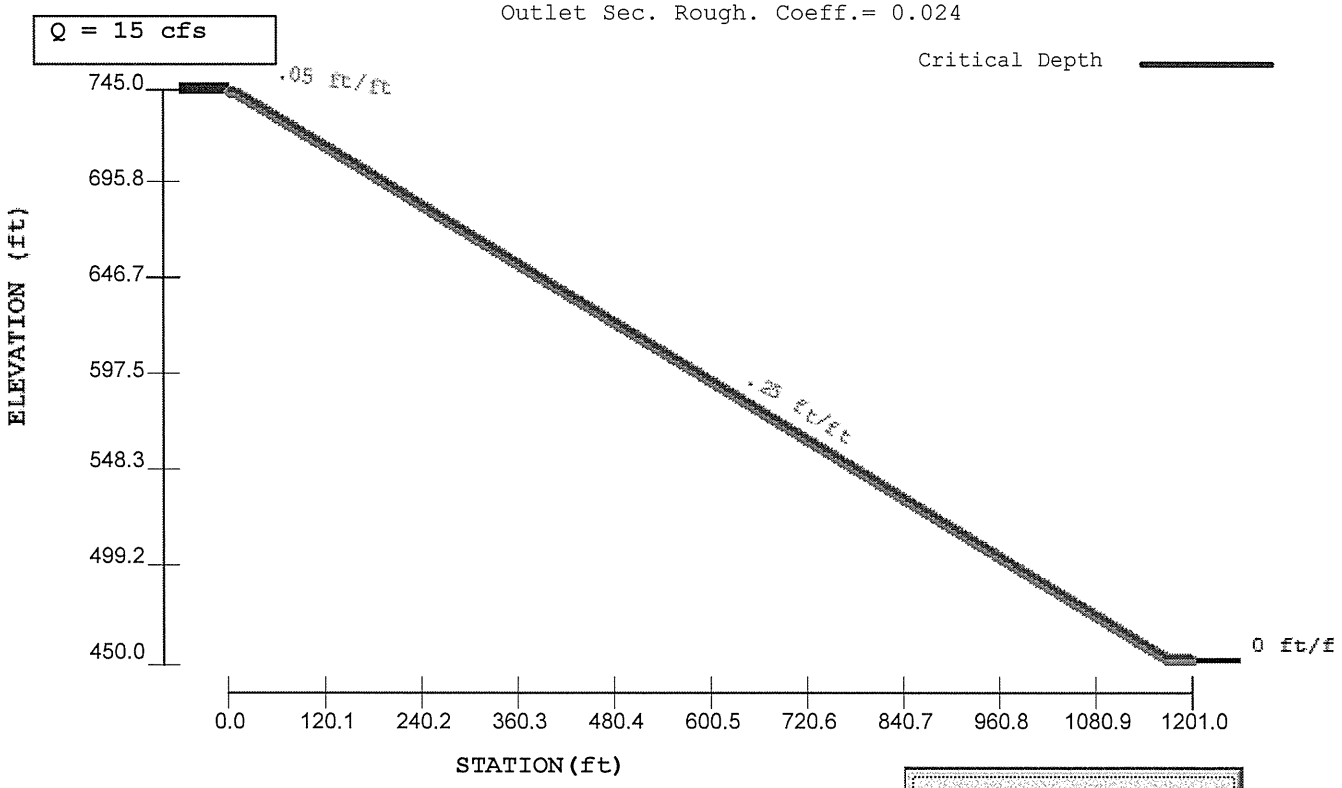
**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

| | |
|---|---|
| **PROJECT INFO** | |
| Project: | City of Arlington Landfill Expansion |
| Station or Location: | |
| Date: | 02/28/2022 |
| **CULVERT DATA** | |
| Discharge: | 15.0 cfs |
| Shape: | Circular |
| Material: | Corr. Metal Pipe |
| Size: | 1-1.5 ft x 1.5 ft |
| Inlet Type: | Mitered to Conform to Slope |
| **WATER SURFACE PROFILE** | |
| Inlet Depth: | 1.50 ft |
| Inlet Velocity: | 8.49 ft/s |
| Upper Break Depth: | 1.47 ft |
| Upper Break Velocity: | 8.53 ft/s |
| Lower Break Depth: | 0.77 ft |
| Lower Break Velocity: | 16.42 ft/s |
| Depth at End of Hydraulic Jump: | 1.50 ft |
| Velocity at End of Hydraulic Jump: | 8.49 ft/s |
| Depth at End of Hydraulic Jump: | 0.47 ft |
| Velocity at End of Hydraulic Jump: | 1.49 ft/s |
| **OUTPUT DATA** | |
| Head Water Depth: | 4.48 ft |
| Inlet Control Elevation: | 744.98 ft |
| Break Control Elevation: | 744.05 ft |
| Critical Depth: | 1.47 ft |
| Tailwater Depth: | 0.47 ft |
| Hydraulic Jump? | YES |
| Jump Station: | 1182.91 ft |
| Jump Length: | 11.46 ft |
| Outlet Depth: | 1.47 ft |
| Outlet Velocity: | 8.53 ft/s |
| Outlet Froude No.: | 1.0 |

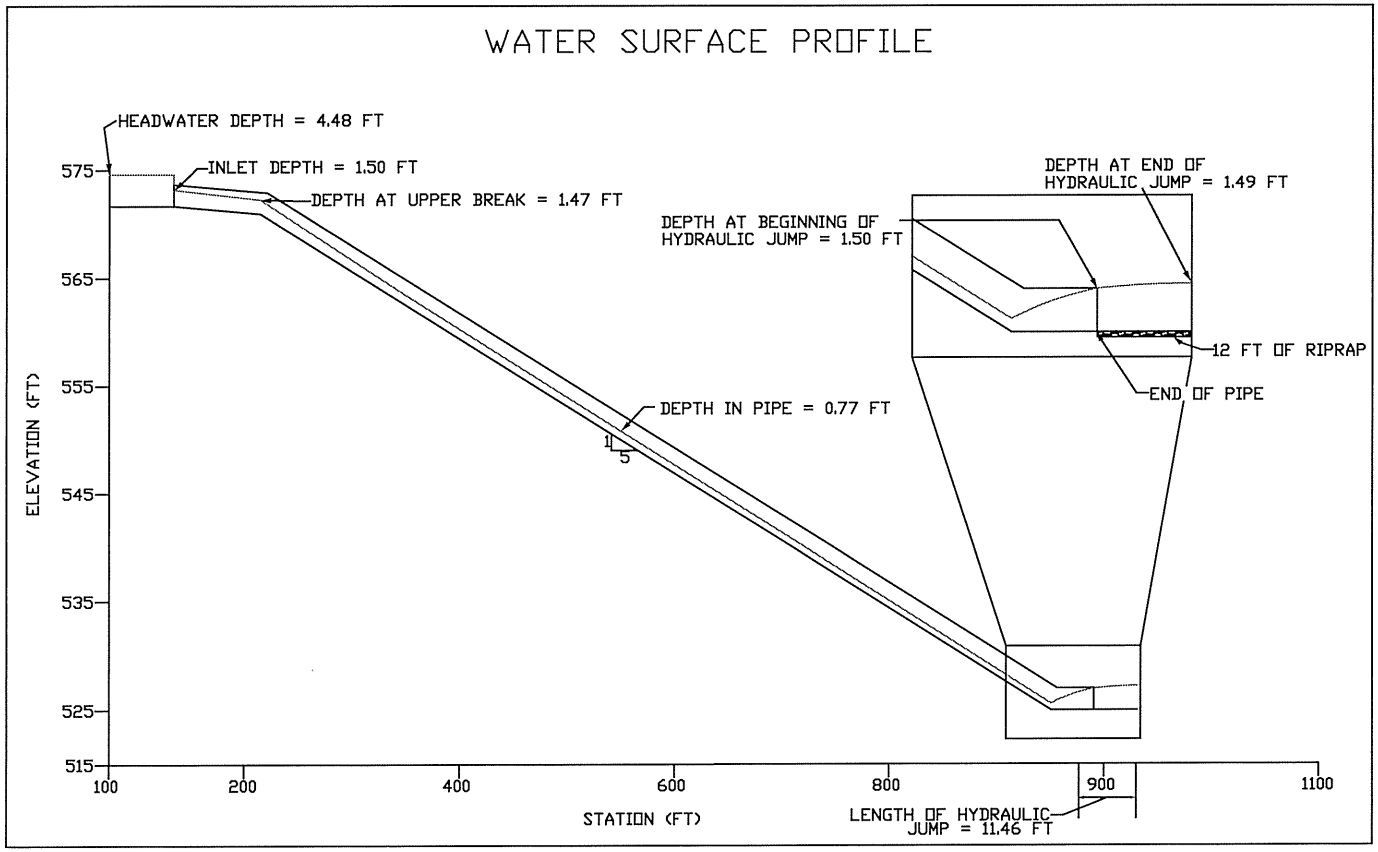
**Project: City of Arlington Landfill Expansion** **Location:** **Date:**

Circle Pipe Culvert
Diameter=1.5 ft
Culvert Material: Corr. Metal Pipe

Inlet Type
Mitered to Conform to Slope
Rough. Coeff.= 0.024
Outlet Sec. Rough. Coeff.= 0.024




**Source:** P:\SOLID WASTE\REPUBLIC\ARLINGTON\EXPANSION 2020\ Press to Return to Output Form LINGTON






P:\Solid waste\Republic\Arlington\Expansion 2020\Part III\IIIF\IIIF-F\Pipe Water Profile 1.5 ft.dwg, byoung, 1:1

**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

**PROJECT INFO**

| | |
|---|---|
| Project: | City of Arlington Landfill Expansion |
| Station or Location: | |
| Date: | 01 / 30 / 2022 |

**DISCHARGE DATA**

| | |
|---|---|
| Minimum: | 1.00 cfs |
| Design Discharge: | 15.00 cfs |
| Maximum: | 25.00 cfs |
| Number of Barrels: | 1 |

**TAILWATER DATA**

| | |
|---|---|
| Type: | Downstream |
| Channel Shape: | Trapezoid |
| Left Side Slope: | 3 H:1V |
| Right Side Slope: | 3 H:1V |
| Bottom Width: | 20 ft |
| Bottom Slope: | 0.005 ft/ft |
| Roughness Coefficient: | 0.04 |

**CULVERT DATA**

| | |
|---|---|
| Type: | Circular Pipe |
| Pipe Diameter: | 2 ft |
| Culvert Material: | Corr. Metal Pipe |
| Inlet Type: | Mitered to Conform to Slope |
| Roughness Coefficient: | 0.024 |
| Outlet Section Roughness Coeff.: | 0.024 |
| Inlet Section Slope: | 0.05 ft/ft |
| Steep Section Slope: | 0.25 ft/ft |
| Outlet Section Slope: | 0 ft/ft |

**CULVERT PROFILE DATA**

| | |
|---|---|
| Type: | Double Broken-Back |
| Inlet Station: | 0.00 ft |
| Inlet Elevation: | 740.50 ft |
| Upper Break Station: | 10.00 ft |
| Upper Break Elevation: | 740.00 ft |
| Lower Break Station: | 1170.00 ft |
| Lower Break Elevation: | 450.00 ft |
| Outlet Station: | 1201.00 ft |
| Outlet Elevation: | 450.00 ft |

**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

**Project:** City of Arlington Landfill Expansion
**Station or Location:**
**Date:** 01/30/2022

| Discharge cfs | Headwater Depth ft | Inlet Control Elevation ft | Break Control Elevation ft | Critical Depth ft | Outlet Depth ft | Outlet Velocity ft/s | Outlet Froude Number | Tailwater Depth ft | Tailwater Velocity ft/s | Hydraulic Jump |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.4 | .90 | 741.40 | 740.95 | .65 | .65 | 3.83 | 1.0 | .19 | .87 | YES |
| 5.8 | 1.24 | 741.74 | 741.29 | .85 | .85 | 4.56 | 1.0 | .27 | 1.03 | YES |
| 8.2 | 1.51 | 742.01 | 741.59 | 1.01 | 1.01 | 5.15 | 1.0 | .33 | 1.18 | YES |
| 10.6 | 1.78 | 742.28 | 741.87 | 1.15 | 1.15 | 5.67 | 1.0 | .37 | 1.36 | YES |
| 15.0 | 2.36 | 742.86 | 742.43 | 1.37 | 1.37 | 6.56 | 1.0 | .47 | 1.49 | YES |
| 15.4 | 2.43 | 742.93 | 742.48 | 1.39 | 1.39 | 6.63 | 1.0 | .47 | 1.53 | YES |
| 17.8 | 2.84 | 743.34 | 742.82 | 1.49 | 1.80 | 5.98 | .7 | .51 | 1.62 | YES |
| 20.2 | 3.31 | 743.81 | 743.18 | 1.59 | 1.89 | 6.56 | .7 | .55 | 1.70 | NO |
| 22.6 | 3.84 | 744.34 | 743.57 | 1.68 | 2.00 | 7.19 | .7 | .59 | 1.76 | NO |
| 25.0 | 4.43 | 744.93 | 743.98 | 1.77 | 2.00 | 7.96 | .8 | .63 | 1.81 | NO |

**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

| **PROJECT INFO** | |
|---|---|
| Project: | City of Arlington Landfill Expansion |
| Station or Location: | |
| Date: | 01/30/2022 |

| **CULVERT DATA** | |
|---|---|
| Discharge: | 15.0 cfs |
| Shape: | Circular |
| Material: | Corr. Metal Pipe |
| Size: | 1-2.0 ft x 2.0 ft |
| Inlet Type: | Mitered to Conform to Slope |

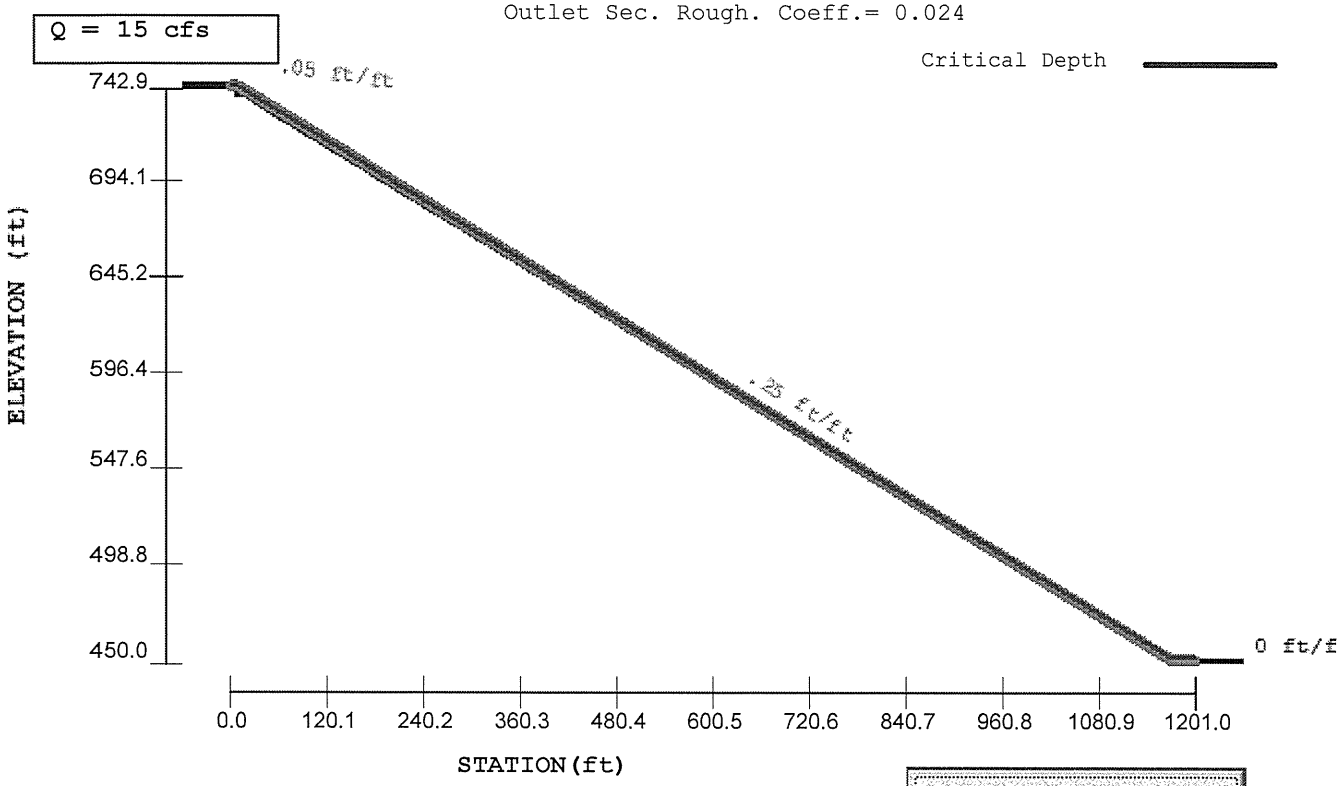
| **WATER SURFACE PROFILE** | |
|---|---|
| Inlet Depth: | 2.00 ft |
| Inlet Velocity: | 4.77 ft/s |
| Upper Break Depth: | 1.37 ft |
| Upper Break Velocity: | 6.56 ft/s |
| Lower Break Depth: | 0.68 ft |
| Lower Break Velocity: | 15.93 ft/s |
| Depth at End of Hydraulic Jump: | 1.78 ft |
| Velocity at End of Hydraulic Jump: | 5.08 ft/s |
| Depth at End of Hydraulic Jump: | 0.47 ft |
| Velocity at End of Hydraulic Jump: | 1.49 ft/s |

| **OUTPUT DATA** | |
|---|---|
| Head Water Depth: | 2.36 ft |
| Inlet Control Elevation: | 742.86 ft |
| Break Control Elevation: | 742.43 ft |
| Critical Depth: | 1.37 ft |
| Tailwater Depth: | 0.47 ft |
| Hydraulic Jump? | YES |
| Jump Station: | 1189.21 ft |
| Jump Length: | 10.68 ft |
| Outlet Depth: | 1.37 ft |
| Outlet Velocity: | 6.56 ft/s |
| Outlet Froude No.: | 1.0 |

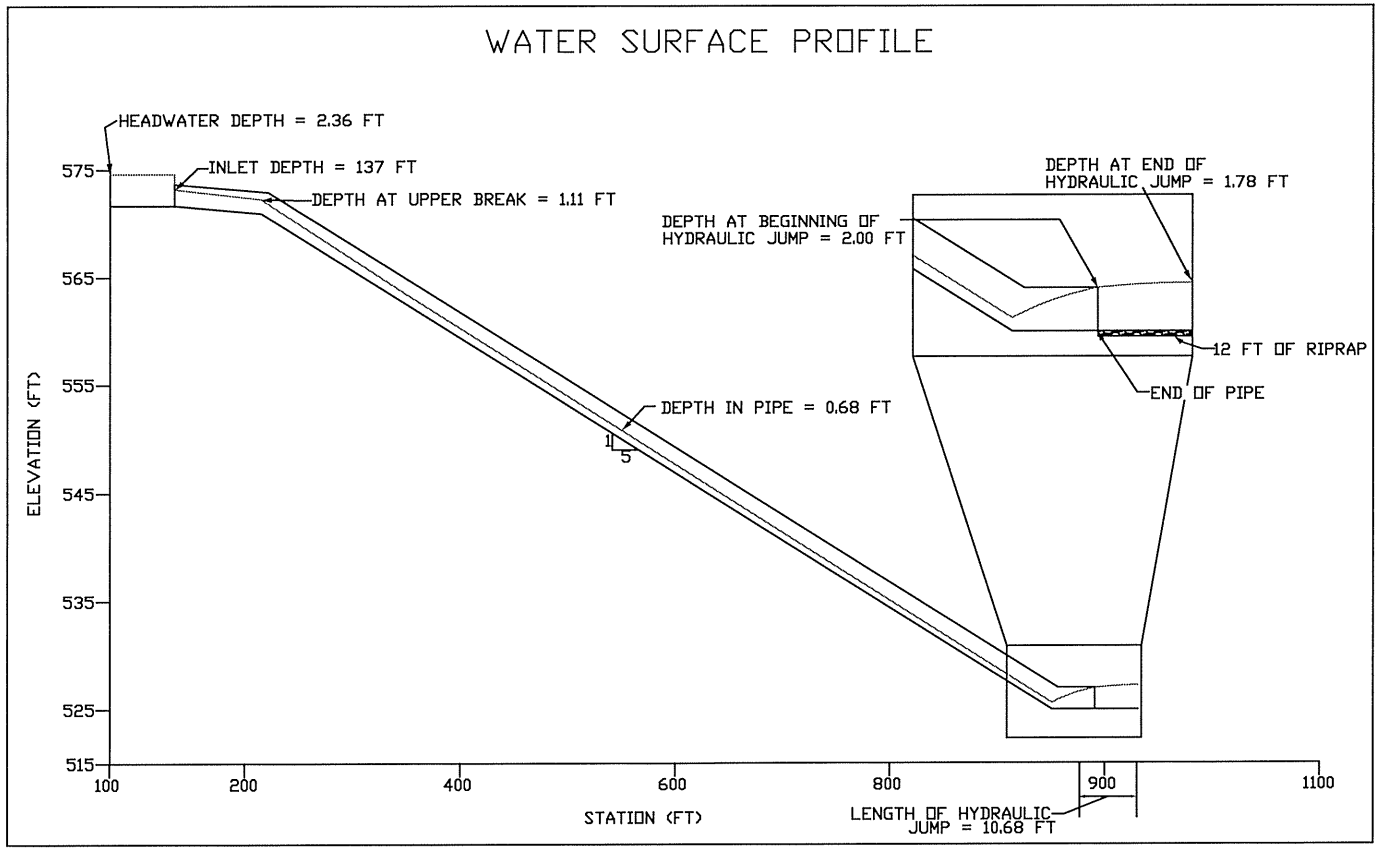
**Project: City of Arlington Landfill Expansion** **Location:** **Date:**

Circle Pipe Culvert
Diameter=2 ft
Culvert Material: Corr. Metal Pipe

Inlet Type
Mitered to Conform to Slope
Rough. Coeff.= 0.024
Outlet Sec. Rough. Coeff.= 0.024




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IIIF-F-2-32

P:\Solid waste\Republic\Arlington\Expansion 2020\Part III\IIIF\IIIF-F\Pipe Water Profile 2 ft.dwg, byoung, 1:1

**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

| | |
|---|---|
| **PROJECT INFO** | |
| Project: | Ciyt of Arlington Landfill Expansion |
| Station or Location: | |
| Date: | 01 / 30 / 2022 |
| **DISCHARGE DATA** | |
| Minimum: | 23.00 cfs |
| Design Discharge: | 25.00 cfs |
| Maximum: | 35.00 cfs |
| Number of Barrels: | 1 |
| **TAILWATER DATA** | |
| Type: | Downstream |
| Channel Shape: | Trapezoid |
| Left Side Slope: | 3 H:1V |
| Right Side Slope: | 3 H:1V |
| Bottom Width: | 20 ft |
| Bottom Slope: | 0.005 ft/ft |
| Roughness Coefficient: | 0.04 |
| **CULVERT DATA** | |
| Type: | Circular Pipe |
| Pipe Diameter: | 3 ft |
| Culvert Material: | Corr. Metal Pipe |
| Inlet Type: | Mitered to Conform to Slope |
| Roughness Coefficient: | 0.024 |
| Outlet Section Roughness Coeff.: | 0.024 |
| Inlet Section Slope: | 0.05 ft/ft |
| Steep Section Slope: | 0.25 ft/ft |
| Outlet Section Slope: | 0 ft/ft |
| **CULVERT PROFILE DATA** | |
| Type: | Double Broken-Back |
| Inlet Station: | 0.00 ft |
| Inlet Elevation: | 740.50 ft |
| Upper Break Station: | 10.00 ft |
| Upper Break Elevation: | 740.00 ft |
| Lower Break Station: | 1170.00 ft |
| Lower Break Elevation: | 450.00 ft |
| Outlet Station: | 1216.00 ft |
| Outlet Elevation: | 450.00 ft |

**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

**Project:** Ciyt of Arlington Landfill Expansion
**Station or Location:**
**Date:** 01/30/2022

| Discharge | Headwater Depth | Inlet Control Elevation | Break Control Elevation | Critical Depth | Outlet Depth | Outlet Velocity | Outlet Froude Number | Tailwater Depth | Tailwater Velocity | Hydraulic Jump |
|---|---|---|---|---|---|---|---|---|---|---|
| cfs | ft | ft | ft | ft | ft | ft/s | | ft | ft/s | |
| 25.0 | 2.41 | 742.91 | 742.53 | 1.59 | 1.59 | 6.55 | 1.0 | .63 | 1.81 | YES |
| 25.4 | 2.43 | 742.93 | 742.56 | 1.61 | 1.61 | 6.59 | 1.0 | .63 | 1.84 | YES |
| 26.6 | 2.51 | 743.01 | 742.63 | 1.65 | 1.65 | 6.70 | 1.0 | .65 | 1.87 | YES |
| 27.8 | 2.58 | 743.08 | 742.71 | 1.68 | 1.68 | 6.82 | 1.0 | .67 | 1.89 | YES |
| 29.0 | 2.66 | 743.16 | 742.78 | 1.72 | 1.72 | 6.93 | 1.0 | .69 | 1.91 | YES |
| 30.2 | 2.73 | 743.23 | 742.86 | 1.75 | 1.94 | 6.26 | .8 | .71 | 1.92 | YES |
| 31.4 | 2.81 | 743.31 | 742.93 | 1.79 | 1.97 | 6.40 | .8 | .71 | 2.00 | NO |
| 32.6 | 2.89 | 743.39 | 743.00 | 1.82 | 1.99 | 6.55 | .8 | .73 | 2.01 | NO |
| 33.8 | 2.97 | 743.47 | 743.08 | 1.85 | 2.02 | 6.68 | .8 | .75 | 2.03 | NO |
| 35.0 | 3.06 | 743.56 | 743.15 | 1.89 | 2.05 | 6.80 | .8 | .77 | 2.04 | NO |

**NEBRASKA DEPARTMENT OF ROADS**
**Broken-Back Culvert Analysis Program (BCAP)**

**PROJECT INFO**

| | |
|---|---|
| Project: | Ciyt of Arlington Landfill Expansion |
| Station or Location: | |
| Date: | 01/30/2022 |

**CULVERT DATA**

| | |
|---|---|
| Discharge: | 25.0 cfs |
| Shape: | Circular |
| Material: | Corr. Metal Pipe |
| Size: | 1-3.0 ft x 3.0 ft |
| Inlet Type: | Mitered to Conform to Slope |

**WATER SURFACE PROFILE**

| | |
|---|---|
| Inlet Depth: | 2.35 ft |
| Inlet Velocity: | 4.20 ft/s |
| Upper Break Depth: | 1.59 ft |
| Upper Break Velocity: | 6.55 ft/s |
| Lower Break Depth: | 0.76 ft |
| Lower Break Velocity: | 17.76 ft/s |
| Depth at End of Hydraulic Jump: | 2.08 ft |
| Velocity at End of Hydraulic Jump: | 4.79 ft/s |
| Depth at End of Hydraulic Jump: | 0.63 ft |
| Velocity at End of Hydraulic Jump: | 1.81 ft/s |

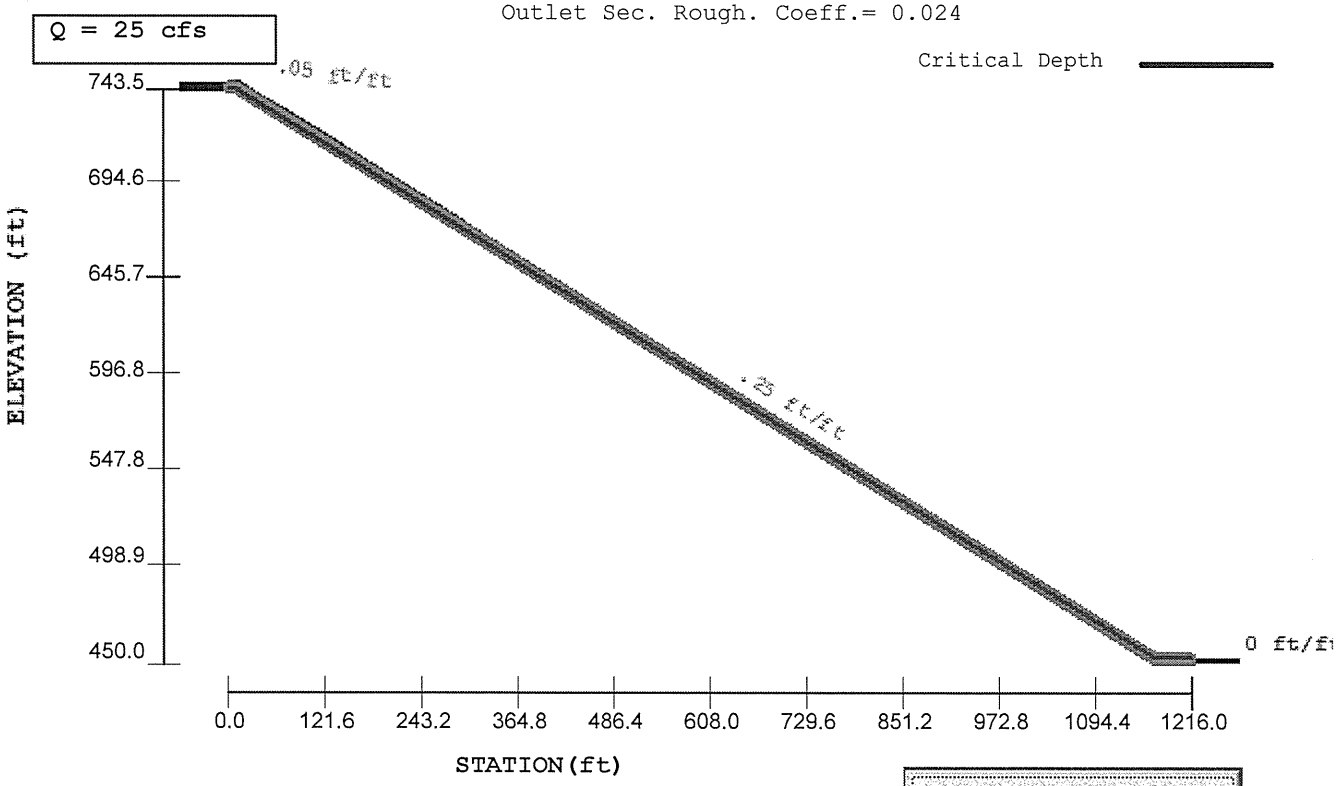
**OUTPUT DATA**

| | |
|---|---|
| Head Water Depth: | 2.41 ft |
| Inlet Control Elevation: | 742.91 ft |
| Break Control Elevation: | 742.53 ft |
| Critical Depth: | 1.59 ft |
| Tailwater Depth: | 0.63 ft |
| Hydraulic Jump? | YES |
| Jump Station: | 1200.15 ft |
| Jump Length: | 12.46 ft |
| Outlet Depth: | 1.59 ft |
| Outlet Velocity: | 6.55 ft/s |
| Outlet Froude No.: | 1.0 |

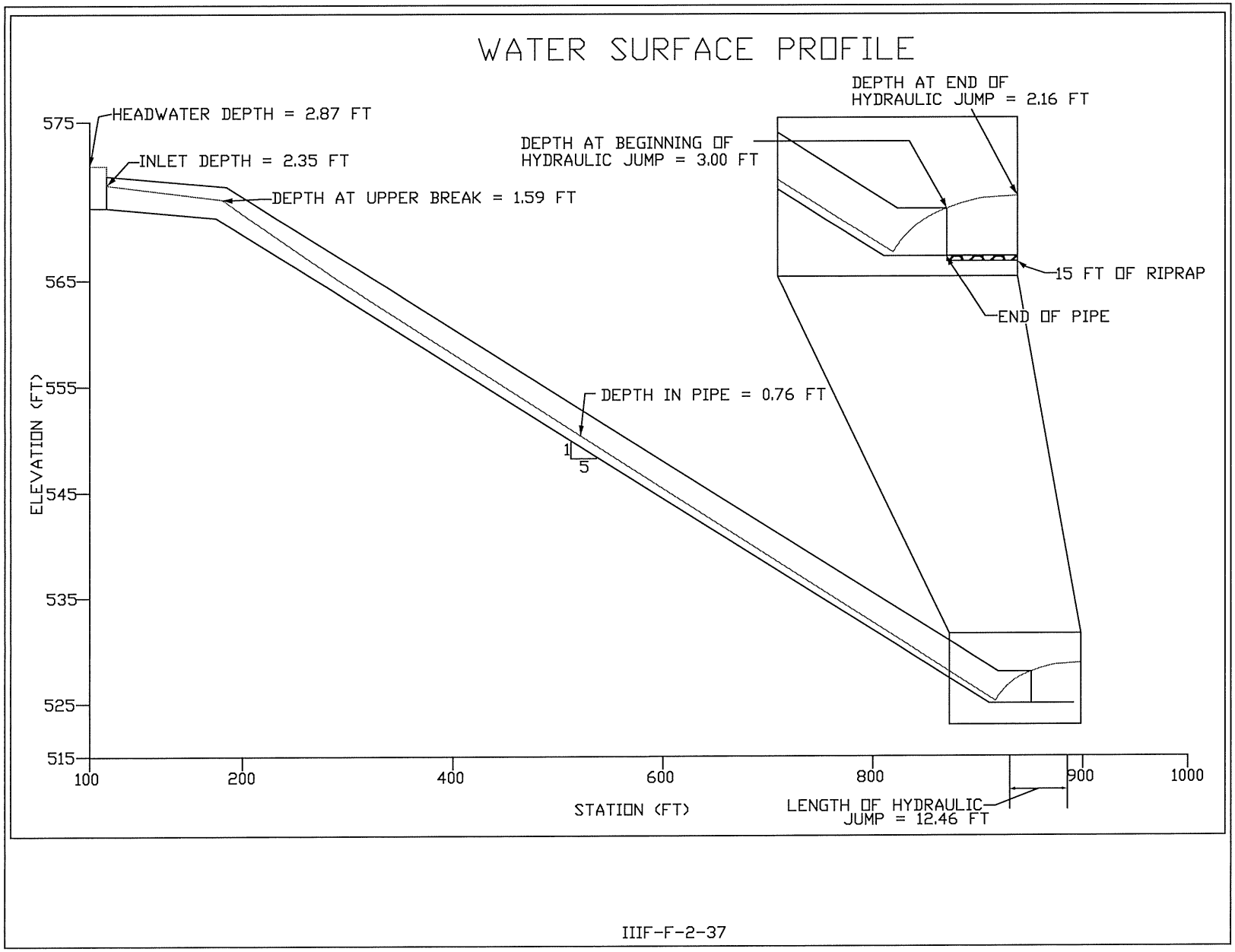
**Project: Ciyt of Arlington Landfill Expansion** **Location:** **Date:**

Circle Pipe Culvert
Diameter=3 ft
Culvert Material: Corr. Metal Pipe

Inlet Type
Mitered to Conform to Slope
Rough. Coeff.= 0.024
Outlet Sec. Rough. Coeff.= 0.024




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IIIF-F-2-37

P:\Solid waste\Republic\Arlington\Expansion 2020\Part III\IIIF\IIIF-F\Pipe Water Profile 3 ft pipe.dwg, byoung, 1:1

2. Determine the maximum drainage areas for the flows calculated in Step 1.

$Q = CIA$

Where: C= 0.7 (runoff coefficient, Ref 1.)
I = intensity in/hr
A= drainage area, ac

From Ref. 2, for
25-year storm event

$t_c$ is assumed to be 10 min.

I = 7.87 in/hr

$A = Q / (CI)$

| Pipe Diameter (in) | Flow (cfs) | Area (ac) |
|---|---|---|
| 18 | 15.0 | 2.7 |
| 24 | 17.8 | 3.2 |
| 36 | 30.2 | 5.5 |

**Conclusion:** The maximum allowable drainage area for a 18-inch diameter letdown pipe is 2.7 acres for each inlet, for a 24-inch diameter letdown pipe is 3.2 acres for each inlet and for a 36-inch diameter letdown pipe is 5.5 acres for each inlet. The minimum berm height is 3 feet for a 24-inch diameter pipe and 4 feet for 36-inch diameter pipe. (Figure 3 details indicate 1 foot berm above the pipe).

**Required:** Determine the Riprap size and Dimensions for 18-inch, 24-inch and 36-inch diameter letdown pipes using Riprap Apron Design provided by the Reference 1.

**Method:**

1. Determine the hydraulic conditions at the outlet of 18-inch, 24-inch and 36-inch diameter letdown pipes using the hydraulic design developed using the BCAP computer simulation.
2. Determine the riprap size and apron dimensions for each pipe letdown

**Reference:**

1. U.S. Department of Transportation - Federal Highway Administration. Hydraulic Engineering Circular No. 14, Third Edition. *Hydraulic Design of Energy Dissipators for Culverts and Channels*. Publication No. FHWA-NHI-06-086, July 2006.

**Solution:**

1. Determine the hydraulic parameters from pages IIIF-F-2-25 (pipe diameter 24-inches) and IIIF-F-2-30 (pipe diameter 36-inches):

| Parameter | Symbol | 18-inch Dia. Culvert | 24-inch Dia. Culvert | 36-inch Dia. Culvert |
|---|---|---|---|---|
| Design flow rates, cfs | Q= | 15.0 | 17.8 | 30.2 |
| Pipe Diameters, ft | D= | 1.5 | 2 | 3 |
| Depth at the pipe outlet, ft | $y_n$= | 1.49 | 1.78 | 2.08 |
| Adjusted culvert rise, ft | D'= | 1.12 | 1.78 | 3.12 |
| Tailwater Depth[1], ft | TW= | 0.47 | 0.47 | 0.63 |

[1]Tailwater depth is the pipe diameter when the calculated tailwater depth is higher per Reference 1.

$$D_{50} = 0.2 \times D\left[\frac{Q}{\sqrt{g} \times D^{2.5}}\right]^{4/3} \times \left[\frac{D}{TW}\right]$$ Eq. 10.4 (page 10-17 of Ref. 1)

$$D' = \frac{D \times y_n}{2}$$ Eq. 10.5 (page 10-17 of Ref. 1)

$D_{50}$ = Riprap Size in feet

Riprap Classes and Apron Dimensions[1]

| Class | $D_{50}$ (in) | Apron Length[2] (ft) | Apron Depth (ft) |
|---|---|---|---|
| 1 | 5 | 4xD | $3.5xD_{50}$ |
| 2 | 6 | 4xD | $3.3xD_{50}$ |
| 3 | 10 | 5xD | $2.4xD_{50}$ |
| 4 | 14 | 6xD | $2.2xD_{50}$ |
| 5 | 20 | 7xD | $2.0xD_{50}$ |
| 6 | 22 | 8xD | $2.0xD_{50}$ |

[1]This table has been reproduced from Table 10.1 included on page 10-18 of Reference 1.

[2]D is the culvert rise.

| Design Parameter | 24-inch Dia. Culvert | 24-inch Dia. Culvert | 36-inch Dia. Culvert |
|---|---|---|---|
| $D_{50}$, calculated, inches = | 16.1 | 10.9 | 7.8 |
| $D_{50}$, selected, inches = | 12 | 12 | 12 |
| Apron Length, calculated, feet = | 5.6 | 8.9 | 15.6 |
| Apron Length, selected, feet = | 7 | 10 | 16 |
| Apron Depth, calculated, inches = | 28.8 | 28.8 | 28.8 |
| Apron Depth, selected, inches = | 30 | 30 | 30 |

**Conclusion:**

Riprap sizes for pipe diameters of 18-inches, 24-inches and 36-inches are selected conservatively. The calculated apron length is increased to 20 feet in the design. The apron depth used is higher than the calculated apron depth. Therefore, the design of the pipe letdown outlet energy dissipater calculations are acceptable and channels at the pipe outlets will be stable.

# APPENDIX IIIF-F-3

# SEDIMENT CONTROL POND DESIGN

Includes pages IIIF-F-3-1 through IIIF-F-3-7



# SEDIMENT CONTROL POND DESIGN

This appendix includes supporting information for the sedimentation pond sizing procedure presented on Sheet IIIF-F-13 (refer to Section 2.2 of the Erosion Control Plan for All Phases of Development). In the event that certain percent ground cover that limits the soil loss to 50/tons/acres/year is not achieved and soil loss is temporarily greater than 50 tons/acre/year, a sedimentation pond will be used along with other structural and non-structural BMPs approved as part of this plan to limit the discharge of eroded soil. The sedimentation pond option is a secondary erosion control option, similar to mulch, wood chips, compost, or straw/hay, and will only be used if the required percent vegetation specification is not met. If the sedimentation pond option is implemented, the swales and letdowns specified will remain in-place. The sedimentation pond option simply allows for the control of sediment while vegetation is being established. The pond design procedure has been developed for reducing discharge of eroded soil to less than the allowable amount for external side slopes (i.e., 50 tons/acre/year) if the required percent vegetation coverage is not obtained soil loss is greater than 50 tons/acre/year. The stormwater sedimentation pond design provided is for a 25-year frequency storm event. This provides for a conservative design because the efficiency of the pond will be higher for more frequent storms (e.g., one year frequency). The example calculation included on pages IIIF-F-3-2 through IIIF-F-3-6 demonstrates that a 0.5-acre detention pond is capable of reducing the discharge of 60 tons/acre/year of soil to less than 50 tons/acre/year of soil from the external slopes for a 20-acre area. A factor has been calculated that will be used to determine the required pond size for a specified external slope area. For a summary of the efficiencies of ponds for various required soil loss reduction amounts, refer to Sheet IIIF-F-13 – Sediment Control Pond Plan as well as the table on page IIIF-F-3-7.

**Required:** Develop a procedure to size a sedimentation pond to reduce sediment discharge from the external embankment area to 50 tons/acre/year or less.

**Method:**

1. Determine the 25-year frequency peak flow rate upstream of the sediment control pond using the Rational Method.
2. Calculate the settling velocity of sediment particles using Stokes equation.
3. Calculate the fraction of sediment trapped under dynamic conditions.
4. Calculate the fraction of sediment trapped under quiescent conditions.
5. Calculate the total fraction of sediment trapped under combined conditions.
6. Verify that pond design is adequate to reduce given soil loss to 50 tons/acre/year or less.

**Reference:**

1. State of Texas, Department of Transportation, Bridge Division, Hydraulic Manual, September 2019.
2. Chin, David. A. Water-Resources Engineering. Prentice Hall, Inc., 2000.
3. Haan, C.T., et al. Design Hydrology and Sedimentology for Small Catchments, 1994.
4. Cooperative Studies Section, Hydrologic Serices Division. U.S. Department of Commerence. *Technical Paper No. 40.*

**Solution:**

1. Determine the 25-year intensity flow rates.

$$Q = CIA$$

Where:

C= 0.7 (runoff coefficient, Ref 1.)
I = intensity in/hr
A= drainage area, ac

From Ref. 2, for
25-year storm event

$t_c$ is assumed to be 10 min.

| | | | |
|---|---|---|---|
| I = | 7.87 | in/hr | From Ref. 1, for Hunt County |
| A = | 20.0 | acres | |
| Q = | 110.18 | cfs | |

2. Calculate the settling velocity, $V_s$ (ft/hr), of sediment particles using Stokes equation.

$$V_s = \frac{\alpha (\rho_s/\rho_w - 1) g\phi^2}{18\nu_w} \quad \text{(Ref. 2)}$$

Where:

$\alpha$ = factor that measures the effect of particle shape (assume spherical, $\alpha = 1$)
$\rho_s$ = density of sediment particle (pcf)
$\rho_w$ = density of ambient water (62.4 pcf)
$g$ = gravity (32.2 ft/s$^2$)
$\phi$ = particle diameter (ft)
$\nu_w$ = kinematic viscosity of the ambient water (ft$^2$/s)

| | | |
|---|---|---|
| $\alpha$ = | 1 | |
| $\rho_s$ = | 165 | pcf |
| $\nu_w$ = | 1.08E-05 | ft$^2$/s |

| Particle Class[1] | Percent in Class | Particle Diameter[2] (ft) | Settling Velocity, $V_s$ (ft/hr) |
|---|---|---|---|
| 1 | 10 | 1.31E-05 | 0.17 |
| 2 | 20 | 1.97E-05 | 0.38 |
| 3 | 30 | 2.62E-05 | 0.68 |
| 4 | 20 | 3.28E-05 | 1.06 |
| 5 | 20 | 3.94E-05 | 1.52 |
| **Total** | **100** | | |

[1] Particle class corresponds to particle diameter.

[2] Particle diameter ranges from 4μm to 12μm, which is typical for clay and silt particles.

3. Calculate the fraction of sediment trapped under dynamic conditions.

a. Determine the overflow rate.

$$V_c = Q/A_p \qquad \text{(EPA Pond Performance Model from Ref. 3)}$$

Where:

$V_c$ = overflow rate
$A_p$ = area of sediment control pond (ac)

$Q$ = 110.18 cfs (from Step 2)
$A_p$ = 0.50 acre

$V_c$ = 18.21 ft/hr

b. Determine the fraction of sediment removed.

$$F = 1 - (1 + 1/\beta * V_s/V_c)^{-\beta} \qquad \text{(Ref. 3)}$$

Where:

$F$ = single-storm trapping of sediment
$\beta$ = turbulence or short-circuiting parameter reflecting non-ideal performance of pond (assume good performance, $\beta = 3$)

$\beta$ = 3

$$D_R = L_F\,[(1/CV_Q^2) / (1/CV_Q^2 - \ln (E_m/L_F))]^{(1/CVQ\text{^}2)+1} \qquad \text{(Ref. 3)}$$

Where:

$D_R$ = long-term dynamic removal fraction for stormwater
$L_F$ = removal ratio for very low flow rates
$E_m$ = mean storm removal fraction
$CV_Q$ = coefficient of variation of flows

$L_F$ = 1
$E_m$ = assume equals single-storm trapping, F
$CV_Q$ = 1.74 (from Table 9B.1, p. 570, Ref. 3)

**Table 1 - Summary for Dynamic Conditions**

| Particle Class | Percent in Class | Particle Diameter (ft) | Settling Velocity, $V_s$ (ft/hr) | Single-storm Trapping, F | Fraction Removed Over All Storms, $D_R$ | Fraction Captured Under Dynamic Conditions, $E_D$[1] |
|---|---|---|---|---|---|---|
| 1 | 10 | 1.31E-05 | 0.17 | 0.009 | 0.027 | 0.27 |
| 2 | 20 | 1.97E-05 | 0.38 | 0.021 | 0.034 | 0.68 |
| 3 | 30 | 2.62E-05 | 0.68 | 0.036 | 0.041 | 1.23 |
| 4 | 20 | 3.28E-05 | 1.06 | 0.056 | 0.048 | 0.97 |
| 5 | 20 | 3.94E-05 | 1.52 | 0.079 | 0.056 | 1.13 |
| **Total** | **100** | | | | | **4.3** |

[1] $E_D$ is the product of percent in class and $D_R$.

4. Calculate the fraction of sediment trapped under quiescent conditions.

$$RR = \frac{T_{IA} V_s A_Q}{V_R} \qquad \text{(Ref. 3)}$$

$$V_R = RA$$

Where:

RR = removal ratio
$T_{IA}$ = average time interval between storms (hr)
$V_s$ = settling velocity (ft/hr) from Step 2
$A_Q$ = average surface area under quiescent conditions ($ft^2$)
$V_R$ = mean runoff volume ($ft^3$)
R = runoff depth for 25-year, 24-hour storm (ft)
A = upstream drainage area (ac)

| | | | |
|---|---|---|---|
| $A_Q$ = | 21,780 | $ft^2$ | (assume equal to $A_p$) |
| $T_{IA}$ = | 108 | hrs | (from Table 9B.1, p. 570 of Ref. 3) |
| R = | 0.61 | ft | (Ref. 4) |
| A = | 20.0 | ac | (from Step 1) |

$V_R$ = 529,980 $ft^3$

**Table 2 - Summary for Quiescent Conditions**

| Particle Class | Percent in Class | Settling Velocity, $V_s$ (ft/hr) | Removal Ratio, RR ($ft^3$/hr) | Effective Volume Ratio, $V_E/V_R$ [1] | Fraction Removed Under Quiescent Conditions [2] | Fraction Captured Under Quiescent Conditions, $E_Q$ |
|---|---|---|---|---|---|---|
| 1 | 10 | 0.17 | 0.75 | 0.120 | 0.12 | 1.20 |
| 2 | 20 | 0.38 | 1.69 | 0.130 | 0.12 | 2.40 |
| 3 | 30 | 0.68 | 3.00 | 0.140 | 0.13 | 3.90 |
| 4 | 20 | 1.06 | 4.68 | 0.145 | 0.14 | 2.80 |
| 5 | 20 | 1.52 | 6.74 | 0.150 | 0.15 | 3.00 |
| **Total** | **100** | | | | | **13.3** |

[1] Based on Figure 9.29 from Ref. 3, using RR and $V_B/V_R$.

$V_B$ = reservoir volume = 87,120 $ft^3$, assuming a 0.5-acre pond with an average depth of 4 feet.

$V_B/V_R$ = 0.164

[2] Based on Figure 9.30 from Ref. 3 with $CV_R$ = 1.74.

5. Calculate the total fraction of sediment trapped under combined conditions, $E_T$.

$$E_T = 1 - (1 - E_D) * (1 - E_Q) \qquad \text{(Ref. 3)}$$

**$E_T$ = 17.0 %**

Refer to page IIIF-F-3-7 for the total efficiency of ponds for different soil loss reduction amounts.

6. Verify that pond design is adequate to reduce given soil loss to 50 tons/acre/year or less.

a. Calculate net soil loss (i.e., sediment not captured by pond).

| | | | |
|---|---|---|---|
| Total Soil Loss = | 60.0 | tons/ac/yr | |
| $E_T$ = | 17.0 | % | (from Step 5) |

Net Soil Loss = Total Soil Loss x (1 - $E_T$/100)

| | | |
|---|---|---|
| **Net Soil Loss =** | **49.8** | **tons/ac/yr** |

Refer to page IIIF-F-3-7 for the net soil loss for different soil loss reduction amounts.

b. Calculate the required pond size per unit drainage area factor.

| | | | |
|---|---|---|---|
| Drainge Area = | 20.0 | acres | (from Step 1) |
| Pond Area = | 0.5 | acres | (from Step 3) |
| **Required Pond Size / Unit Drainage Area Factor =** | **0.025** | | |

This factor was calculated using a drainage area of 20 acres and a pond area of 0.5 acres. If a 40-acre drainage area drains to the pond, then a 1.0-acre pond will be required to achieve the above efficiency and net soil loss estimate (40 acres x 0.025 = 1.0 acre). Refer to page IIIF-F-3-7 for the required pond size/unit drainage area factor for different soil loss reduction amounts.

**Conclusion:**

A 0.5-acre pond will sufficiently capture enough sediment from a 20-acre drainage area so that no more than 50 tons/acre/year of net soil loss occurs on external embankment slopes. If the size of the drainage area changes, this procedure will need to be updated. Refer to the table on page IIIF-F-3-7 for a summary of the pond efficiencies and net soil loss estimates for different soil loss reduction amounts.

**SEDIMENT CONTROL POND SUMMARY**

| External Slope Area Soil Loss (Tons/Acre/Year) | Percent Efficiency of Pond (Dynamic Conditions) | Percent Efficiency of Pond (Quiescent Conditions) | Total Efficiency of Pond (%) | Net Soil Loss (Tons/Acre/Year) | Pond Area Required Per Unit Drainage Area[1] | 50 Tons/Acre/Year or Less? |
|---|---|---|---|---|---|---|
| 60 | 4.3 | 13.3 | 17.0 | 49.8 | 0.025 | YES |
| 70 | 5.1 | 25.5 | 29.3 | 49.5 | 0.040 | YES |
| 80 | 6.2 | 34.0 | 38.1 | 49.5 | 0.060 | YES |
| 90 | 6.9 | 41.5 | 45.5 | 49.0 | 0.075 | YES |
| 100 | 8.5 | 46.4 | 50.9 | 49.1 | 0.110 | YES |
| 200 | 16.5 | 71.2 | 75.9 | 48.1 | 0.300 | YES |

[1] This factor multiplied by a given drainage area will give the required pond size to achieve the efficiencies shown in the table.