



INNOVATIVE DESIGN. **CLASSIC RESULTS.**

**PRELIMINARY/FINAL DRAINAGE REPORT  
FOR  
REDTAIL RANCH FILING 1**

**MARCH 2019**

Prepared for:  
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COLORADO SPRINGS, CO 80908

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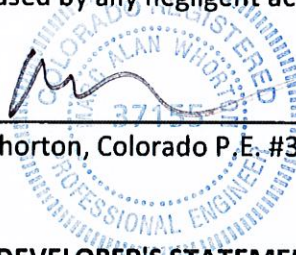
PCD Project No. SP-18-004/SF-18-021



**PRELIMINARY/FINAL DRAINAGE REPORT FOR  
REDTAIL RANCH FILING NO. 1**

**DESIGN ENGINEER'S STATEMENT:**

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage report and said report is in conformity with the applicable master plan and drainage basin. I accept responsibility for any liability caused by any negligent acts, errors, or omissions on my part in preparing this report.

  
\_\_\_\_\_  
Marc A. Whorton, Colorado P.E. #37155

\_\_\_\_\_  
3/11/19  
Date

**OWNERS/DEVELOPER'S STATEMENT:**

I, the owner/developer, have read and will comply with all of the requirements specified in this drainage report and plan.

Name: Michael S. Ludwig

  
\_\_\_\_\_

Title: owner

Address: 4255 Arrowhead Drive

Colorado Springs, CO 80908

**EL PASO COUNTY:**

Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 and 2, El Paso County Engineering Criteria Manual and Land Development Code, as amended.

\_\_\_\_\_  
Jennifer Irvine, P.E.  
County Engineer / ECM Administrator

\_\_\_\_\_  
Date

Conditions:



# **PRELIMINARY/FINAL DRAINAGE REPORT FOR REDTAIL RANCH FILING NO. 1**

## **TABLE OF CONTENTS:**

PURPOSE	Page 4
GENERAL DESCRIPTION	Page 4
EXISTING DRAINAGE CONDITIONS	Page 4
DEVELOPED DRAINAGE CONDITIONS	Page 7
HYDROLOGIC CALCULATIONS	Page 10
FLOODPLAIN STATEMENT	Page 12
EROSION CONTROL PLAN	Page 12
DRAINAGE/BRIDGE FEES	Page 12
SUMMARY	Page 14
REFERENCES	Page 15

## **APPENDICES**

VICINITY MAP  
SOILS MAP (WEB SOIL SURVEY)  
F.E.M.A. MAP  
HYDROLOGIC / HYDRAULIC CALCULATION  
BMP FACILITY CALCULATIONS / DESIGN DETAILS  
DRAINAGE MAPS



# **PRELIMINARY\FINAL DRAINAGE REPORT FOR REDTAIL RANCH FILING NO. 1**

## **PURPOSE**

This document is the Preliminary/Final Drainage Report for Redtail Ranch Filing No. 1. The purpose of this report is to address on-site and off-site drainage patterns and improvements required for this development to minimize impacts to the adjacent properties.

## **GENERAL DESCRIPTION**

This development is made up of multiple parcels all owned by a single property owner. The total acreage for the site is 67.9 acres and is located in the county of El Paso within Section 9, Township 12 South, Range 65 West of the Sixth Principal Meridian, El Paso County, Colorado. The site is bounded on the north, west and south by existing platted and unplatted residential properties (RR-5 Zone) and to the east by existing Vollmer Road. The overall site is proposed for 12 single-family 5-acre minimum lots and paved rural roads. The current zoning of the property is RR-5 (5-acre Residential Zoning).

The average soil condition reflects Hydrologic Group "B" (Elbeth sandy loam and Kettle gravelly loamy sand), as determined by the "Soil Survey of El Paso County Area," prepared by the Soil Conservation Service.

## **EXISTING DRAINAGE CONDITIONS**

This property sits at the very top of two major drainage basins – Upper Black Squirrel to the east and Kettle Creek to the west. Thus, a major ridge-line runs through the middle of the property from north to south. The existing drainage patterns generally run in a southwesterly and southeasterly direction in several natural drainage corridors at slopes ranging from 2% to 5%. Multiple stock ponds exist on the property within these natural drainageways. There are two culvert crossings at Vollmer Road that the east half of the property drain towards. Much of the property was burned in the Black Forest fire that happened in June 2013. The property owner has worked diligently over the past couple years to cut down and remove the remaining burnt trees and clean up much of the burn debris leaving some





sparse treed areas remaining along the ridgeline. Prior to lots sales, the property owner will haul off remaining tree debris piles throughout the site and revegetate disturbed areas as necessary for site stabilization. The remainder of the property is covered with native grasses. The west portion of the property is currently platted as Walker Place, Lots 1 & 2. Several home structures have recently been removed from the site leaving multiple well heads and some gravel paths remaining throughout the property. Current access to and from the property exists in multiple locations. Driveway access from the north off of Ward Lane and driveway access from the south off of Linwood Lane (private road). The public access proposed along with this development is the continuation of Ward Lane (paved) into the site from the north connected with a new east-west public roadway accessing Vollmer Road.

**Design Point H1** ( $Q_5 = 3$  cfs and  $Q_{100} = 18$  cfs) consists of pre-development flows from Basins OS-1 and EX-1 within the Kettle Creek Basin. These historic flows travel in a westerly direction within a natural drainageway towards the west boundary and then head off-site.

**Design Point H2** ( $Q_5 = 4$  cfs and  $Q_{100} = 19$  cfs) consists of pre-development flows from Basin EX-2 within the Kettle Creek Basin. These historic flows travel in a southwesterly direction within a natural drainageway towards the west boundary where they are collected in an existing stock pond. As mentioned in the previous Walker Place Drainage Report, this facility collects the minor flows while a grass-lined overflow swale directs the pond outflows around the earthen embankment located near the property line.

**Design Point H3** ( $Q_5 = 5$  cfs and  $Q_{100} = 25$  cfs) consists of pre-development flows from Basin EX-3 within the Kettle Creek Basin. These historic flows travel in a southwesterly direction within a natural drainageway. Currently, a good portion of this historic basin is collected into another stock pond just east of the existing gravel driveway. This facility was also mentioned in the Walker Place Drainage Report as collecting the pre-developed flows and then releasing them through an 18" pond outfall. This existing facility is proposed to be replaced with a formal BMP to handle the developed flows at this location. (See Developed Conditions)



**Design Point H4** ( $Q_5 = 0.3$  cfs and  $Q_{100} = 1.9$  cfs) consists of pre-development flows from Basin EX-4 within the Kettle Creek Basin. These historic sheet flows travel in a southwesterly direction towards the southwest corner of the property. No development is proposed within this small basin.

**Design Point H5** ( $Q_5 = 8$  cfs and  $Q_{100} = 43$  cfs) consists of pre-development flows from Basins OS-2, OS-3, OS-4, EX-5 and EX-7 within the Upper Black Squirrel Basin. These historic flows sheet flow in a southeasterly direction towards multiple stock ponds at the southeast corner of the property. These historic flows travel to the existing stock pond facilities with an ultimate release point at an existing 18" CMP crossing Vollmer Road.

**Design Point H6** ( $Q_5 = 2$  cfs and  $Q_{100} = 10$  cfs) consists of pre-development flows from Basin EX-8 within the Upper Black Squirrel Basin. These historic sheet flows travel in a easterly direction towards Vollmer Road where an existing 24" CMP conveys the flows under Vollmer Road. As mentioned earlier, this site was previously studied as part of the Walker Place Subdivision, prepared by ADP, Inc., approved January 2010. This report generally described the drainage characteristics for the majority of the west half of the property. Along with this Walker Place Final Plat, drainage fees were previously paid within the Kettle Creek Basin for the two lots currently platted. (See Drainage and Bridge Fees for additional information)

The attached developed conditions drainage map contains several design points related to proposed culvert crossings and BMP facilities. All proposed culverts have been designed for the 100-yr. developed flows. All proposed side road ditches have been designed to handle the developed flows with required improvements specified on the street improvement plans and ditch design calculations contained in the Appendix. The ditch design includes the following: 24" depth, std. 'V' ditch design with erosion control blanket/turf reinforcement mat and permanent rock check dams as specified. All proposed storm facilities within the public Right-of-way (roadside ditches and culverts) will be public with ownership and maintenance by El Paso County. All proposed BMP facilities within easements will be owned and maintained by the HOA.



## **DEVELOPED DRAINAGE CONDITIONS (KETTLE CREEK BASIN)**

**Design Point D1** ( $Q_5 = 3$  cfs and  $Q_{100} = 16$  cfs) consists of developed flows from Basins OS-1 and A. These existing off-site and on-site developed flows travel in a westerly direction within a natural drainageway towards the west boundary and then head off-site. With the reduction in tributary area due to the extension of Ward Lane, the developed flows at this location are equal to or below the pre-development conditions. Therefore, no further improvements within this basin are proposed at this time. The additional imperviousness with the construction of Ward Lane is collected in a sideroad ditch and conveyed south towards Pond 1.

**Design Point D2** ( $Q_5 = 3$  cfs and  $Q_{100} = 17$  cfs) consists of developed flows from Basin B. These on-site developed flows travel in a westerly direction within a natural drainageway towards the west boundary and the existing stock pond. This stock pond on lot 3 is planned to be removed by the developer. This decision was based on County Staffs' recent discussions with State Water Commissioner and water rights complications for the prospective purchaser of lot 3 if the existing stock pond were to remain. However, with the reduction in tributary area due to the extension of Ward Lane, the developed flows at this location are below the pre-development conditions. Therefore, no further improvements within this basin are proposed at this time. The additional imperviousness with the construction of Ward Lane is collected in a sideroad ditch and conveyed south towards Pond 1.

**Design Point D3** ( $Q_5 = 3$  cfs and  $Q_{100} = 13$  cfs) consists of developed flows from Basin E. These on-site developed flows sheet flow towards the extension of Ward Lane and then travel in a southerly direction within the sideroad ditch towards D3. At this location a 24" RCP culvert is proposed to convey these flows under the roadway. (See Appendix for Culvert Design)

**Design Point D4** ( $Q_5 = 7$  cfs and  $Q_{100} = 28$  cfs) consists of developed flows from Basins D, F and Design Point D3 and represents the total inflow to Pond 1. Prior to the developed flows entering Pond 1,



pretreatment by permanent rock check dams will be provided. At this location, the existing stock pond is proposed to be replaced with a formal BMP as described below:

**Pond 1 (Sand Filter Basin)** has the following design parameters as a full-spectrum facility:

(See UD-Detention in Appendix)

**Facility sized to release pre-development acreage of 14.8 ac. (Basin EX-3)**

**0.09 Ac.-ft. WQCV required**

**0.12 Ac.-ft. EURV required**

**0.19 Ac.-ft. EURV design with 4:1 max. slopes**

**0.45 Ac.-ft. 100-yr. storage**

**Total In-flow:  $Q_5 = 7$  cfs,  $Q_{100} = 28$  cfs**

**Pond Design Release:  $Q_5 = 0.18$  cfs,  $Q_{100} = 15.3$  cfs**

**Pre-development Release:  $Q_5 = 0.30$  cfs,  $Q_{100} = 17.6$  cfs**

This facility will be constructed within a drainage easement with ownership and maintenance by the HOA for the subdivision. The O&M Plan for this project will further specify maintenance responsibilities for this facility.

**Design Point D5** ( $Q_5 = 1.7$  cfs and  $Q_{100} = 24$  cfs) consists of developed flows from Basin C and the outflow from Pond 1. These on-site developed flows travel in a southwesterly direction within a natural drainageway and existing 30' drainage easement towards the south boundary. With the reduction in tributary area due to the extension of Ward Lane and the proposed Pond 1, the developed flows at this location are at or below the pre-development conditions. Therefore, no further improvements within this basin are proposed at this time.

#### **DEVELOPED DRAINAGE CONDITIONS (UPPER BLACK SQUIRREL BASIN)**

**Design Point D6** ( $Q_5 = 6$  cfs and  $Q_{100} = 29$  cfs) consists of developed flows from Basins OS-2, OS-3, EX-5 and G. These off and on-site developed flows sheet flow towards the sideroad ditch along the north



side of the proposed public road (Sanctuary Pine Dr.) and then in an easterly direction towards Design Point D6. At this location, the existing stock pond will be removed along with the road construction and a 30" RCP culvert is proposed to convey these flows under the roadway. (See Appendix for Culvert Design)

**Design Point D7** ( $Q_5 = 10$  cfs and  $Q_{100} = 46$  cfs) consists of developed flows from Basins OS-4, H and Design Point D6 and represents the total inflow to Pond 2. Prior to the developed flows entering Pond 2, pretreatment by permanent rock check dams will be provided. At this location, the existing stock pond is proposed to be replaced with a formal BMP as described below:

**Pond 2 (Sand Filter Basin)** has the following design parameters as a full-spectrum facility:

(See UD-Detention in Appendix)

**0.12 Ac.-ft. WQCV required**

**0.13 Ac.-ft. EURV required**

**0.22 Ac.-ft. EURV design with 4:1 max. slopes**

**0.78 Ac.-ft. 100-yr. storage**

<b>Total In-flow:</b>	<b><math>Q_5 = 10</math> cfs, <math>Q_{100} = 46</math> cfs</b>
<b>Pond Design Release:</b>	<b><math>Q_5 = 0.22</math> cfs, <math>Q_{100} = 22.1</math> cfs</b>
<b>Pre-development Release:</b>	<b><math>Q_5 = 0.49</math> cfs, <math>Q_{100} = 29.9</math> cfs</b>

This facility will be constructed within a drainage easement with ownership and maintenance by the HOA for the subdivision. The O&M Plan for this project will further specify maintenance responsibilities for this facility.

**Design Point D8** ( $Q_5 = 2$  cfs and  $Q_{100} = 10$  cfs) consists of on-site developed flows from Basin L. With a reduction of tributary area based on the proposed grading and only a single home anticipated to be built on lot 8 in this basin, the developed flows at Design Point 8 will not see any significant change from the pre-developed condition. These developed sheet flows continue to travel in an easterly direction towards Vollmer Road and the existing 24" CMP under Vollmer Road. With no significant



change in flows at this location, this existing culvert will continue to convey the developed flows under Vollmer Road. An additional drainage esmt. has been added on lot 8 to accommodate the necessary ponding at this existing culvert location, even though it is all contained within the proposed ROW and future 40' ROW easement. As mentioned above, there is no significant change from the pre-developed condition at this location. The total flow ( $Q_5 = 8$  cfs and  $Q_{100} = 56$  cfs), including the significant off-site ditch flows from the north currently ponds up and spills over the roadway in the 100 yr. event. (See Appendix DP-8 calculations) With no real evidence of this condition being an issue, this culvert may be further evaluated upon future improvements to Vollmer Road in this area.

**Design Point D9** ( $Q_5 = 1$  cfs and  $Q_{100} = 4$  cfs) consists of developed flows from Basin I. These on-site developed flows travel as sideroad ditch flows in an easterly direction towards Vollmer Road. At this location an 18" RCP culvert is proposed to convey these flows under the roadway. (See Appendix for Culvert Design) Sediment control will be provided with on-site grading operations and remain until site development is complete and vegetation within sideroad ditch is at 75% growth.

**Design Point D10** ( $Q_5 = 2$  cfs and  $Q_{100} = 29$  cfs) consists of developed flows from Basins I, J and K and the proposed outflow from Pond 2. With the construction of Sanctuary Pine Drive to divert the majority of the developed flows within this existing drainage corridor into the proposed Pond 2, the developed flows at Design Point 10 will be significantly lower than the pre-developed condition. These developed sheet flows continue to travel in an easterly direction towards Vollmer Road and the existing 24" CMP under Vollmer Road. With a significant reduction in the flows seen at this location, this existing culvert will continue to adequately convey the developed flows under Vollmer Road. The necessary ponding at this culvert location is all contained within the proposed ROW or future 40' ROW easement. Therefore, no further improvements within this basin are proposed at this time.

## HYDROLOGIC CALCULATIONS

Hydrologic calculations were performed using the City of Colorado Springs/El Paso County Drainage Criteria Manual, as revised in November 1991 and 1994 with County adopted Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs/El Paso County Drainage Criteria Manual as revised





in May 2014. Individual on-site developed basin design used for culvert sizing and system routing was calculated using the Rational Method. BMP design was calculated using the UD-Detention (Version 3.07) spreadsheet developed by the Urban Drainage and Flood Control District.

The City of Colorado Springs/El Paso County DCM requires the Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainage ways, and implementing long-term source controls. The Four Step Process pertains to management of smaller, frequently occurring storm events, as opposed to larger storms for which drainage and flood control infrastructure are sized. Implementation of these four steps helps to achieve storm water permit requirements. This site adheres to this **Four Step Process** as follows:

1. **Employ Runoff Reduction Practices:** Development of project site is proposed large lot single family residential (5.0 ac. min.) with homes and associated landscaping. Proposed impervious areas (roof tops, patios) will sheet flow across landscaped ground and through large open areas within the lots across natural vegetation to slow runoff and increase time of concentration prior to being conveyed to the proposed public roads and adjacent properties. This will minimize directly connected impervious areas within the project site.
2. **Stabilize Drainageways:** This site will utilize roadside ditches with culvert crossings throughout the site. These facilities will then direct the on-site development flows to the multiple BMPs, designed to release at or below historic rates into the Kettle Creek and Upper Black Squirrel drainage basins. Based upon the proposed reduction in released flows compared to the pre-developed flows, no impact to downstream drainageways is anticipated.
3. **Provide Water Quality Capture Volume (WQCV):** Runoff from the impervious road areas of this development will be treated through capture and slow release of the WQCV in two permanent Sand Filter Basins designed per current El Paso County drainage criteria.



4. **Consider need for Industrial and Commercial BMPs:** No industrial or commercial uses are proposed within this development. However, a site specific storm water quality and erosion control plan and narrative is being submitted concurrently with this report and development. Details such as site specific construction BMP's as well as permanent sediment control BMP's are detailed in this plan and narrative to protect receiving waters. Roadside ditch stabilization, in the form of erosion control blanketing, turf reinforcement matting and permanent rock check dams (as specified on the plans) are also proposed. (See appendix for calculations) The described BMP's will be constructed and maintained by the developer upon approval by El Paso County Staff.

#### **FLOODPLAIN STATEMENT**

No portion of this site is located within a FEMA floodplain as determined by the Flood Insurance Rate Maps (F.I.R.M.) Map Numbers 08041C 0320G, with effective date of December 7, 2018 (See Appendix).

#### **EROSION CONTROL PLAN**

The Drainage Criteria Manual specifies an Erosion Control Plan and associated cost estimate be submitted with the Final Drainage Report. We respectfully request that the Erosion Control Plan and cost estimate be submitted in conjunction with the Grading and Erosion Control Plan and construction assurances posted prior to obtaining a grading permit.

#### **DRAINAGE & BRIDGE FEES**

This site lies within two major drainage basins: Kettle Creek and Upper Black Squirrel. The total acreage for the property is 67.9 acres. The acreage within each drainage basin equals:

**Kettle Creek Basin – 32.17 Ac.** (Basin Fees as calculated below)

**Upper Black Squirrel Basin – 35.69 Ac.** (No current Basin Fees)

As mentioned previously, a portion of this site within the Kettle Creek Drainage Basin was platted as Lots 1 and 2 of Walker Subdivision. This previously platted acreage equals 19.91 ac. Fees were paid at that time in the amount of \$1,904.76 as documented on the recorded plat. It has recently been discovered that this amount paid during the original platting was incorrect. As described in the Final



Drainage Report for Walker Subdivision, the correct fees that should have been paid were \$2,857.00. Thus, this difference of \$952.24 will be added to the fees described below. This subdivision proposes to re-plat these existing two lots into 4 lots, with additional fees will be paid on the impervious acreage for the two additional lots. The resultant acreage removed from the total fee acreage within the Kettle Creek Basin is only two of the lots totaling 10.13 acres. The fees are calculated using the following impervious acreage method approved by El Paso County with current zoning of RR-5 (5-ac. residential land use). Thus, the percent imperviousness for this subdivision is calculated as follows:

**RR-5 Zone Area**

(Per El Paso County Percent Impervious Chart for 5.0 ac. lots: 7%)

$$32.17 - 10.13 \text{ Ac.} \times 7\% = \mathbf{1.54 \text{ Impervious Ac.}}$$

The following calculations are based on the 2018 drainage/bridge fees for the Kettle Creek Drainage Basin:

**FEE TOTALS (prior to reduction):**

**Bridge Fees - None**

**Drainage Fees (Kettle Creek)**

$$\$ 9,287.00 \times 1.54 \text{ Impervious Ac.} = \underline{\$ 14,301.98}$$

Per the ECM 3.10.2a, this development requests a 25% reduction of drainage fees based on the low density lots proposed (5 ac. min lot size). This reduction is as follows:

$$\text{Low Density Lot Reduction (25\%)} \quad \$ 14,301.98 \times 25\% = \$ 3,575.50$$

**FEE TOTALS (with reduction):**

**Bridge Fees - None**

**Drainage Fees (Kettle Creek)**

$$\$ 14,301.98 - 3,575.50 + \$952.24 = \underline{\$ 11,678.72}$$

Upper Black Squirrel currently has no bridge or drainage fees.



## SUMMARY

This proposed development remains consistent with pre-development drainage conditions with the construction of the proposed on-site Sand Filter Basins. These proposed facilities meet current criteria and provide full spectrum design. The proposed development will not adversely impact surrounding developments.

PREPARED BY:

**Classic Consulting Engineers & Surveyors, LLC**



Marc A. Whorton, P.E.  
Project Manager

mw/252500/Reports/FDR.doc



## REFERENCES

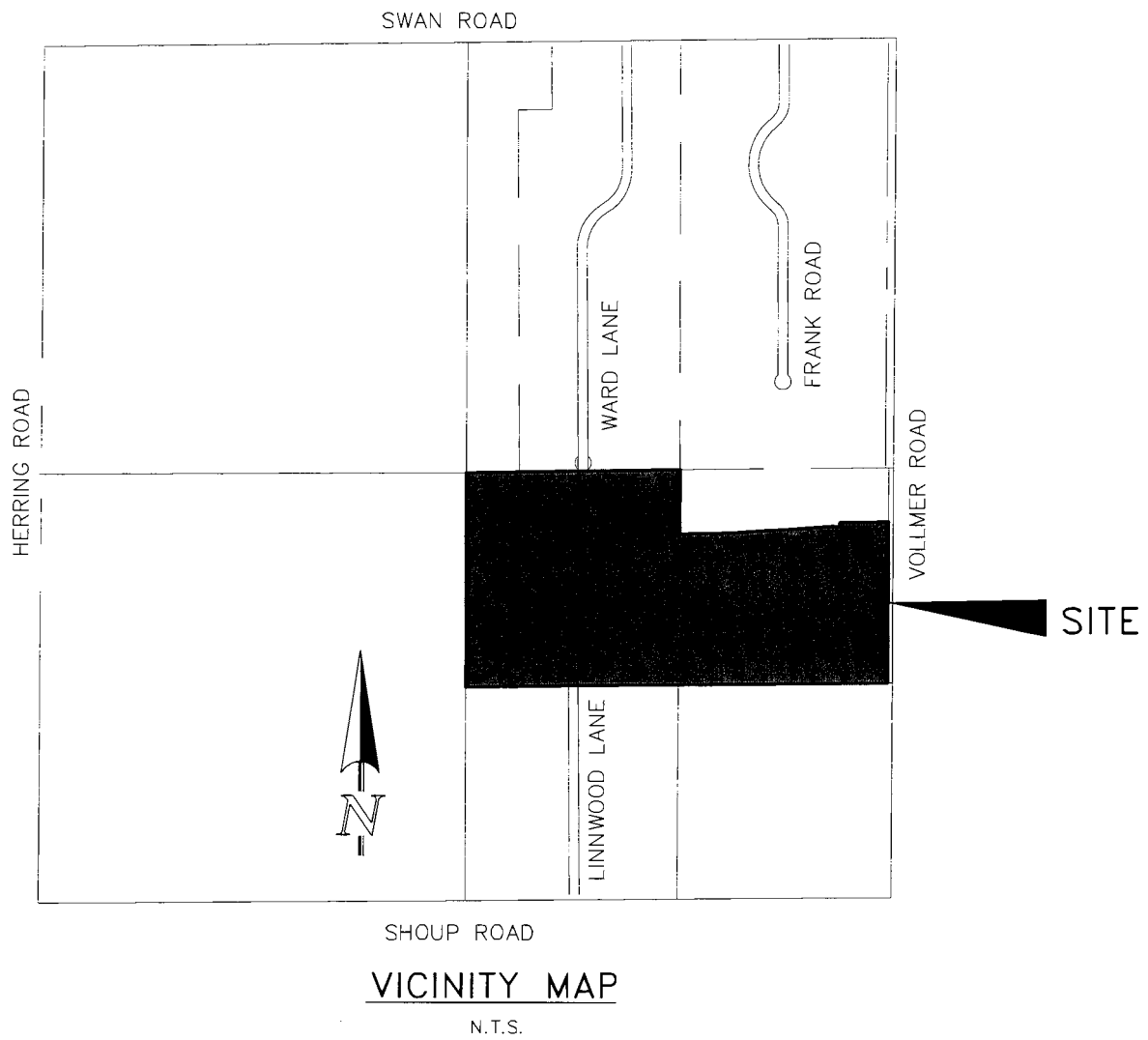
1. City of Colorado Springs/County of El Paso Drainage Criteria Manual, as revised in November 1991 and 1994 with County adopted Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs/El Paso County Drainage Criteria Manual as revised in May 2014.
2. Soil Survey of El Paso County Area, Colorado Soil Conservation Service, June 1981.
3. "Preliminary/Final Drainage Report for Walker Place Subdivision", by ADP, Inc., approved January 2010.



## APPENDIX

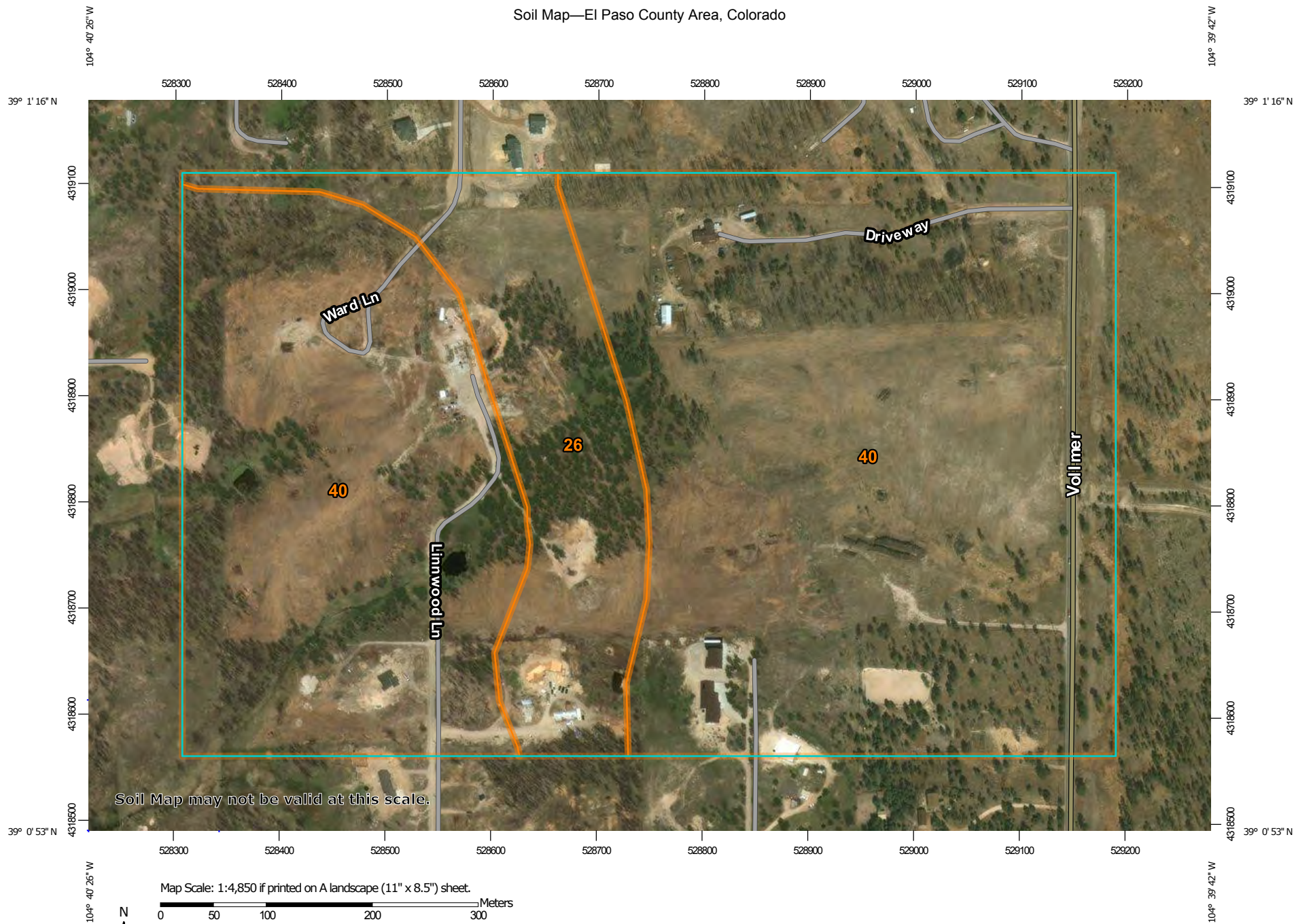


## VICINITY MAP




## SOILS MAP

# Soil Map—El Paso County Area, Colorado



## 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 1:24,000.

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

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

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

Source of Map: Natural Resources Conservation Service

Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: El Paso County Area, Colorado

Survey Area Data: Version 15, Oct 10, 2017

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

Date(s) aerial images were photographed: May 22, 2016—Mar 9, 2017

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

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
26	Elbeth sandy loam, 8 to 15 percent slopes	18.3	15.2%
40	Kettle gravelly loamy sand, 3 to 8 percent slopes	102.1	84.8%
<b>Totals for Area of Interest</b>		<b>120.4</b>	<b>100.0%</b>



## El Paso County Area, Colorado

### 26—Elbeth sandy loam, 8 to 15 percent slopes

#### Map Unit Setting

*National map unit symbol:* 367y

*Elevation:* 7,300 to 7,600 feet

*Farmland classification:* Not prime farmland

#### Map Unit Composition

*Elbeth and similar soils:* 85 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Elbeth

##### Setting

*Landform:* Hills

*Landform position (three-dimensional):* Side slope

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Alluvium derived from arkose

##### Typical profile

*A - 0 to 3 inches:* sandy loam

*E - 3 to 23 inches:* loamy sand

*Bt - 23 to 68 inches:* sandy clay loam

*C - 68 to 74 inches:* sandy clay loam

##### Properties and qualities

*Slope:* 8 to 15 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*Runoff class:* Medium

*Capacity of the most limiting layer to transmit water (Ksat):*

Moderately high (0.20 to 0.60 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Available water storage in profile:* Moderate (about 7.1 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 4e

*Hydrologic Soil Group:* B

*Hydric soil rating:* No

#### Minor Components

##### Other soils

*Percent of map unit:*

*Hydric soil rating:* No

**Pleasant**

*Percent of map unit:*

*Landform:* Depressions

*Hydric soil rating:* Yes

**Data Source Information**

Soil Survey Area: El Paso County Area, Colorado

Survey Area Data: Version 15, Oct 10, 2017

## El Paso County Area, Colorado

### 40—Kettle gravelly loamy sand, 3 to 8 percent slopes

#### Map Unit Setting

*National map unit symbol:* 368g

*Elevation:* 7,000 to 7,700 feet

*Farmland classification:* Not prime farmland

#### Map Unit Composition

*Kettle and similar soils:* 85 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Kettle

##### Setting

*Landform:* Hills

*Landform position (three-dimensional):* Side slope

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Sandy alluvium derived from arkose

##### Typical profile

*E - 0 to 16 inches:* gravelly loamy sand

*Bt - 16 to 40 inches:* gravelly sandy loam

*C - 40 to 60 inches:* extremely gravelly loamy sand

##### Properties and qualities

*Slope:* 3 to 8 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Somewhat excessively drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* High  
(2.00 to 6.00 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Available water storage in profile:* Low (about 3.4 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 4e

*Hydrologic Soil Group:* B

*Hydric soil rating:* No

#### Minor Components

##### Other soils

*Percent of map unit:*

*Hydric soil rating:* No

**Pleasant**

*Percent of map unit:*

*Landform:* Depressions

*Hydric soil rating:* Yes

**Data Source Information**

Soil Survey Area: El Paso County Area, Colorado

Survey Area Data: Version 15, Oct 10, 2017

**FEMA MAP**





## HYDROLOGIC/HYDRAULIC CALCULATIONS

**Table 6-6. Runoff Coefficients for Rational Method**  
(Source: UDFCD 2001)

Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
<b>Business</b>													
Commercial Areas	95	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.89
Neighborhood Areas	70	0.45	0.49	0.49	0.53	0.53	0.57	0.58	0.62	0.60	0.65	0.62	0.68
<b>Residential</b>													
1/8 Acre or less	65	0.41	0.45	0.45	0.49	0.49	0.54	0.54	0.59	0.57	0.62	0.59	0.65
1/4 Acre	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
1/3 Acre	30	0.18	0.22	0.25	0.30	0.32	0.38	0.39	0.47	0.43	0.52	0.47	0.57
1/2 Acre	25	0.15	0.20	0.22	0.28	0.30	0.36	0.37	0.46	0.41	0.51	0.46	0.56
1 Acre	20	0.12	0.17	0.20	0.26	0.27	0.34	0.35	0.44	0.40	0.50	0.44	0.55
<b>Industrial</b>													
Light Areas	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Heavy Areas	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
<b>Parks and Cemeteries</b>	7	0.05	0.09	0.12	0.19	0.20	0.29	0.30	0.40	0.34	0.46	0.39	0.52
<b>Playgrounds</b>	13	0.07	0.13	0.16	0.23	0.24	0.31	0.32	0.42	0.37	0.48	0.41	0.54
<b>Railroad Yard Areas</b>	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
<b>Undeveloped Areas</b>													
Historic Flow Analysis-- Greenbelts, Agriculture	2	0.03	0.05	0.09	0.16	0.17	0.26	0.26	0.38	0.31	0.45	0.36	0.51
Pasture/Meadow	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Forest	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Exposed Rock	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Offsite Flow Analysis (when landuse is undefined)	45	0.26	0.31	0.32	0.37	0.38	0.44	0.44	0.51	0.48	0.55	0.51	0.59
<b>Streets</b>													
Paved	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Gravel	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
<b>Drive and Walks</b>	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
<b>Roofs</b>	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
<b>Lawns</b>	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50

### 3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration ( $t_c$ ) consists of an initial time or overland flow time ( $t_i$ ) plus the travel time ( $t_t$ ) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time ( $t_i$ ) plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion ( $t_t$ ) of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

JOB NAME: REDTAIL RANCH FILING NO. 1  
 JOB NUMBER: 2525.00  
 DATE: 11/14/18  
 CALCULATED BY: MAW

### FINAL DRAINAGE REPORT ~ BASIN RUNOFF COEFFICIENT SUMMARY

BASIN	TOTAL AREA (AC)	IMPERVIOUS AREA / STREETS				LANDSCAPE/UNDEVELOPED AREAS				WEIGHTED			WEIGHTED CA		
		AREA (AC)	C(2)	C(5)	C(100)	AREA (AC)	C(2)	C(5)	C(100)	C(2)	C(5)	C(100)	CA(2)	CA(5)	CA(100)
EX-1	6.1	0.12	0.57	0.59	0.70	5.98	0.03	0.09	0.36	0.04	0.10	0.37	0.25	0.61	2.24
EX-2	10.1	1.00	0.57	0.59	0.70	9.10	0.03	0.09	0.36	0.08	0.14	0.39	0.84	1.41	3.98
EX-3	14.8	1.20	0.57	0.59	0.70	13.60	0.03	0.09	0.36	0.07	0.13	0.39	1.09	1.93	5.74
EX-4	0.9	0.00	0.89	0.90	0.96	0.90	0.03	0.09	0.36	0.03	0.09	0.36	0.03	0.08	0.32
EX-5	2.0	0.00	0.89	0.90	0.96	2.00	0.03	0.09	0.36	0.03	0.09	0.36	0.06	0.18	0.72
EX-6	1.5	0.00	0.89	0.90	0.96	1.50	0.03	0.09	0.36	0.03	0.09	0.36	0.05	0.14	0.54
EX-7	26.4	1.10	0.57	0.59	0.70	25.30	0.03	0.09	0.36	0.05	0.11	0.37	1.39	2.93	9.88
EX-8	6.1	0.10	0.57	0.59	0.70	6.00	0.03	0.09	0.36	0.04	0.10	0.37	0.24	0.60	2.23
OS-1	3.5	0.30	0.57	0.59	0.70	3.20	0.05	0.12	0.39	0.09	0.16	0.42	0.33	0.56	1.46
OS-2	1.3	0.10	0.57	0.59	0.70	1.20	0.05	0.12	0.39	0.09	0.16	0.41	0.12	0.20	0.54
OS-3	1.7	0.10	0.57	0.59	0.70	1.60	0.05	0.12	0.39	0.08	0.15	0.41	0.14	0.25	0.69
OS-4	1.2	0.00	0.57	0.59	0.70	1.20	0.05	0.12	0.39	0.05	0.12	0.39	0.06	0.14	0.47
OS-5	40.6	0.00	0.57	0.59	0.70	40.60	0.03	0.09	0.36	0.03	0.09	0.36	1.22	3.65	14.62
A	5.0	0.00	0.89	0.90	0.96	5.00	0.05	0.12	0.39	0.05	0.12	0.39	0.25	0.60	1.95
B	8.9	0.00	0.89	0.90	0.96	8.90	0.05	0.12	0.39	0.05	0.12	0.39	0.45	1.07	3.47
C	5.1	0.00	0.89	0.90	0.96	5.10	0.05	0.12	0.39	0.05	0.12	0.39	0.26	0.61	1.99
D	1.4	0.40	0.89	0.90	0.96	1.00	0.05	0.12	0.39	0.29	0.34	0.55	0.41	0.48	0.77
E	5.1	0.50	0.89	0.90	0.96	4.60	0.05	0.12	0.39	0.13	0.20	0.45	0.68	1.00	2.27
F	5.8	0.30	0.89	0.90	0.96	5.50	0.05	0.12	0.39	0.09	0.16	0.42	0.54	0.93	2.43
G	13.3	0.30	0.89	0.90	0.96	13.00	0.05	0.12	0.39	0.07	0.14	0.40	0.92	1.83	5.36
H	9.1	0.50	0.89	0.90	0.96	8.60	0.05	0.12	0.39	0.10	0.16	0.42	0.88	1.48	3.83
I	1.6	0.17	0.89	0.90	0.96	1.43	0.05	0.12	0.39	0.14	0.20	0.45	0.22	0.32	0.72
J	0.7	0.10	0.89	0.90	0.96	0.60	0.05	0.12	0.39	0.17	0.23	0.47	0.12	0.16	0.33
K	2.1	0.08	0.57	0.59	0.70	2.02	0.05	0.12	0.39	0.07	0.14	0.40	0.15	0.29	0.84
L	5.4	0.25	0.57	0.59	0.70	5.15	0.05	0.12	0.39	0.07	0.14	0.40	0.40	0.77	2.18

JOB NAME: **REDTAIL RANCH FILING NO. 1**  
 JOB NUMBER: **2525.00**  
 DATE: **11/14/18**  
 CALC'D BY: **MAW**

Table 6-7. Conveyance Coefficient,  $C_v$

Type of Land Surface	$C_v$
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)* $t_e = \frac{L}{180} + 10$	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

\*For buried riprap, select  $C_v$  value based on type of vegetative cover.

$$t_f = \frac{0.395(1.1 - C_s)\sqrt{L}}{S^{0.33}} \quad V = C_v S_w^{0.5} \quad T_c = L/V$$

### FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY

BASIN	TOTAL AREA (AC)	WEIGHTED			C(5)	OVERLAND			STREET / CHANNEL FLOW				Tc (min)	INTENSITY			TOTAL FLOWS		
		CA(2)	CA(5)	CA(100)		Length (ft)	Height (ft)	Tc (min)	Length (ft)	Slope (%)	Velocity (fps)	Tc (min)		I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)
EX-1		0.25	0.61	2.24	0.09	300	18	17.5	350	3.6%	1.3	4.4	21.9	2.36	2.95	4.96	1	2	11
EX-2		0.84	1.41	3.98	0.09	300	14	19.0	470	4.5%	1.5	5.3	24.3	2.24	2.80	4.70	2	4	19
EX-3		1.09	1.93	5.74	0.09	300	16	18.2	770	3.6%	1.3	9.7	27.8	2.08	2.59	4.35	2	5	25
EX-4		0.03	0.08	0.32	0.09	290	22	15.9					15.9	2.74	3.43	5.76	0.1	0.3	1.9
EX-5		0.06	0.18	0.72	0.09	300	12	20.0	100	2.5%	1.1	1.5	21.5	2.38	2.98	5.00	0.1	0.5	4
EX-6		0.05	0.14	0.54	0.09	250	12	17.2					17.2	2.65	3.32	5.57	0.1	0.4	3
EX-7		1.39	2.93	9.88	0.09	300	9	22.0	1800	3.0%	1.7	17.3	39.3	1.67	2.08	3.48	2	6	34
EX-8		0.24	0.60	2.23	0.09	300	13	19.5	480	3.1%	1.2	6.5	26.0	2.16	2.70	4.53	1	2	10
OS-1	3.5	0.33	0.56	1.46	0.12	300	14	18.4					18.4	2.57	3.21	5.39	0.8	2	8
OS-2	1.3	0.12	0.20	0.54	0.12	300	16	17.6					17.6	2.62	3.28	5.50	0.3	0.7	3
OS-3	1.7	0.14	0.25	0.69	0.12	300	12	19.4					19.4	2.51	3.14	5.26	0.3	0.8	4
OS-4	1.2	0.06	0.14	0.47	0.12	270	12	17.8					17.8	2.61	3.27	5.48	0.2	0.5	3
OS-5	40.6	1.22	3.65	14.62	0.09	300	12	20.0	1600	3.0%	1.2	22.0	42.0	1.59	1.98	3.32	2	7	48
A	5.0	0.25	0.60	1.95	0.12	300	18	17.0	250	3.6%	1.3	3.1	20.1	2.46	3.08	5.17	1	2	10
B	8.9	0.45	1.07	3.47	0.12	300	14	18.4	300	4.5%	1.5	3.4	21.8	2.37	2.96	4.97	1	3	17
C	5.1	0.26	0.61	1.99	0.12	300	15	18.0	350	3.6%	1.3	4.4	22.4	2.33	2.92	4.90	1	2	10
D	1.4	0.41	0.48	0.77	0.12	150	8	12.5	230	2.0%	1.4	2.7	15.2	2.80	3.50	5.88	1	2	5
E	5.1	0.68	1.00	2.27	0.12	300	22	15.9	100	3.0%	1.2	1.4	17.3	2.65	3.31	5.56	2	3	13
F	5.8	0.54	0.93	2.43	0.12	300	18	17.0	300	4.0%	1.4	3.6	20.5	2.44	3.05	5.12	1	3	12
G	13.3	0.92	1.83	5.36	0.12	300	9	21.3	1100	3.0%	1.7	10.6	31.9	1.91	2.39	4.01	2	4	21
H	9.1	0.88	1.48	3.83	0.12	300	12	19.4	650	3.0%	1.7	6.3	25.7	2.17	2.72	4.56	2	4	17
I	1.6	0.22	0.32	0.72	0.12	165	8	13.5	375	6.0%	2.4	2.6	16.1	2.73	3.42	5.74	0.6	1.1	4
J	0.7	0.12	0.16	0.33	0.12								5.0	4.12	5.17	8.68	0.5	0.8	3
K	2.1	0.15	0.29	0.84	0.12	300	22	15.9	100	4.0%	1.4	1.2	17.1	2.66	3.33	5.58	0.4	1.0	5
L	5.4	0.40	0.77	2.18	0.12	300	13	18.9	480	3.1%	1.2	6.5	25.4	2.19	2.73	4.59	1	2	10

JOB NAME: <u>REDTAIL RANCH FILING NO. 1</u> JOB NUMBER: <u>2525.00</u> DATE: <u>11/14/18</u> CALCULATED BY: <u>MAW</u>									
FINAL DRAINAGE REPORT ~ SURFACE ROUTING SUMMARY									
Design Point(s)	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		Outfall / Inlet Size
					I(5)	I(100)	Q(5)	Q(100)	
H1	OS-1, EX-1 (9.6 AC.)	1.17	3.69	21.9	2.95	4.96	3	18	
H2	EX-2 (10.1 AC.)	1.41	3.98	24.3	2.80	4.70	4	19	
H3	EX-3 (14.8 AC.)	1.93	5.74	27.8	2.59	4.35	5	25	
H4	EX-4 (0.9 AC.)	0.08	0.32	15.9	3.43	5.76	0.3	1.9	
H5	OS-2, OS-3, OS-4, EX-5, EX-7 (32.6 AC.)	3.70	12.30	39.3	2.08	3.48	8	43	
H6 (TOTAL FLOWS INCL. OFF-SITE)	EX-8 (6.1 AC.) & OS-5 (40.6 AC.)	4.25	16.85	42.0	1.98	3.32	8	56	EXIST. 24" CULVERT
H6 (ON-SITE FLOWS ONLY)	EX-8 (6.1 AC.)	0.60	2.23	26.0	2.70	4.53	2	10	EXIST. 24" CULVERT
D1	A, OS-1 (8.5 AC.)	1.05	3.12	20.1	3.08	5.17	3	16	
D2	B (8.9 AC.)	1.07	3.47	21.8	2.96	4.97	3	17	
D3	E (5.1 AC.)	1.00	2.27	17.3	3.31	5.56	3	13	24" RCP CULVERT
D4	DP-D3, D, F (12.3 AC.) (POND 1)	2.41	5.48	20.5	3.05	5.12	7	28	POND 1
D5	Pond 1 Outfall, Basin C (17.4 AC.)	SEE POND PACK MODEL					1.7	24	
D6	OS-2, OS-3, EX-5, G (18.3 AC.)	2.46	7.31	31.9	2.39	4.01	6	29	30" RCP CULVERT
D7	DP-D6, OS-4, H (28.6 AC.) (POND 2)	4.09	11.61	32.9	2.34	3.93	10	46	POND 2
D8 (TOTAL FLOWS INCL. OFF-SITE)	L (5.4 AC.) & OS-5 (40.6 AC.)	4.42	16.80	42.0	1.98	3.32	8	56	EXIST. 24" CULVERT
D8 (ON-SITE FLOWS ONLY)	L (5.4 AC.)	0.77	2.18	25.4	2.73	4.59	2	10	EXIST. 24" CULVERT
D9	I (1.6 AC.)	0.32	0.72	16.1	3.42	5.74	1	4	18" RCP CULVERT
D10	Pond 2 Outfall, Basins I, J, K (33.0 AC.)	SEE POND PACK MODEL					2.4	29	



619 N. Cascade Avenue, Suite 200  
Colorado Springs, CO 80903

Project: Redtail Ranch  
Date: 6/27/18  
Contact: \_\_\_\_\_  
Phone: \_\_\_\_\_  
By: MTW

# **NOTES**

- ☐ Telephone Record
- ☐ Note to the File
- ☐ Job Information
- ☐ Meeting Minutes
- ☐ \_\_\_\_\_

Pond 1

Imperviousness calcs.

Basin D 1.4 ac. total

0.40 ac. asphalt, 1.0 ac. 5 ac. lot

$$0.40 \times 100\% + 1.0 \times 7\% / 1.4 \text{ ac.} = \underline{34\%}$$

Basin E 5.1 ac. total

0.50 ac. asphalt, 4.6 ac. 5 ac. lot

$$0.50 \times 100\% + 4.6 \times 7\% / 5.1 \text{ ac.} = \underline{16\%}$$

Basin F 5.8 ac. total

0.30 ac. asphalt, 5.5 ac. 5 ac. lot

$$0.30 \times 100\% + 5.5 \times 7\% / 5.8 \text{ ac.} = \underline{12\%}$$

\* 2.5 ac. x 7% (to match pre-dev. basin)

$$\text{* Total Basin ac.} = 12.3 \text{ ac.} + 2.5 = 14.8 \text{ ac.}$$

$$1.4 \times 34\% + 5.1 \times 16\% + 5.8 \times 12\% / \underline{14.8 \text{ ac.}}$$

$$\text{Pond 1 Imp.} = \underline{\underline{14.6\%}}$$





619 N. Cascade Avenue, Suite 200  
Colorado Springs, CO 80903

Project: Redtail Ranch  
Date: 6/27/18  
Contact: \_\_\_\_\_  
Phone: \_\_\_\_\_  
By: MFW

#### NOTES

- ☐ Telephone Record
- ☐ Note to the File
- ☐ Job Information
- ☐ Meeting Minutes
- ☐ \_\_\_\_\_

Pond 2 Imp. calc.

Basin OS-2 1.3 ac. total all 5 ac. lot area

$$1.3 \times 7\% = \underline{7\% \text{ Imp.}}$$

Basin EX-5 and OS-3 ac. total 2.0 ac. + 1.7 ac.

all 5 ac. lot area 7% Imp.

Basin G 13.2 ac. total

0.30 ac. asphalt, 12.9 ac. 5 ac. lots

$$0.3 \times 100\% + 12.9 \times 7\% / 13.2 = \underline{9.1\%}$$

Basin H 11.5 ac. total

0.50 ac. asphalt, 11.0 ac. 5 ac. lots

$$0.50 \times 100\% + 11.0 \times 7\% / 11.5 = \underline{11\%}$$

Total Basin ac = 29.7 ac.

$$\underline{1.3 \times 7\% + 2.0 \times 7\% + 1.7 \times 7\% + 13.2 \times 9.1\% + 11.5 \times 11\%}$$

29.7 ac.

$$\underline{\underline{\text{Pond 2 Imp.} = 9.5\%}}$$

# Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Friday, Jun 29 2018

## DESIGN POINT D3

Invert Elev Dn (ft) = 7608.50  
Pipe Length (ft) = 70.00  
Slope (%) = 1.00  
Invert Elev Up (ft) = 7609.20  
Rise (in) = 24.0  
Shape = Circular  
Span (in) = 24.0  
No. Barrels = 1  
n-Value = 0.013  
Culvert Type = Circular Concrete  
Culvert Entrance = Square edge w/headwall (C)  
Coeff. K,M,c,Y,k = 0.0098, 2, 0.0398, 0.67, 0.5

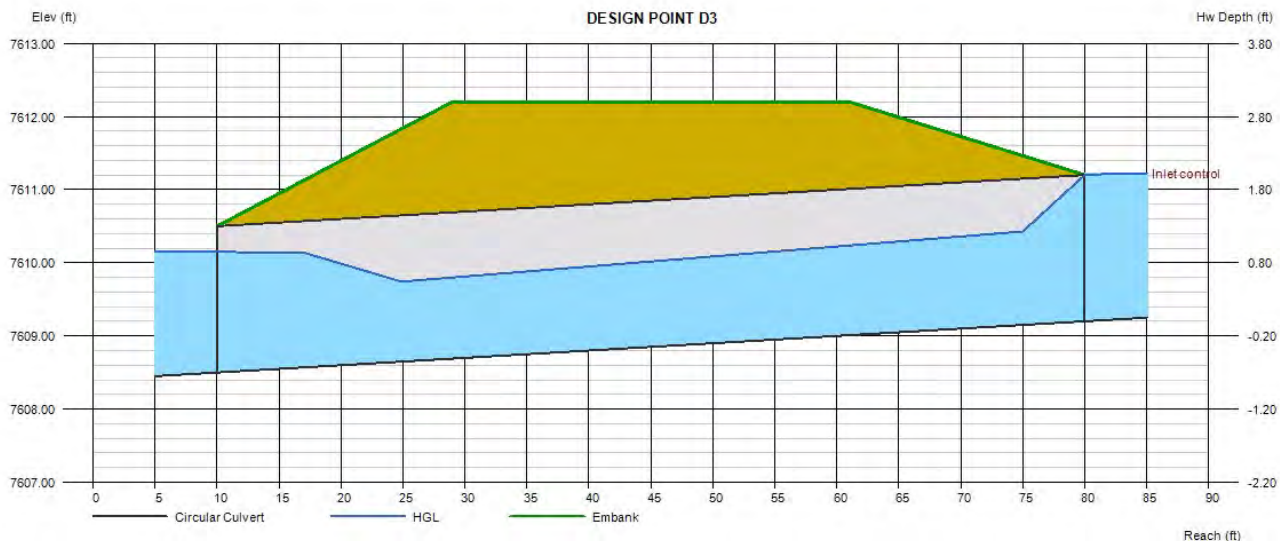
**Embankment**  
Top Elevation (ft) = 7612.20  
Top Width (ft) = 32.00  
Crest Width (ft) = 50.00

### Calculations

Qmin (cfs) = 0.00  
Qmax (cfs) = 13.00  
Tailwater Elev (ft) = (dc+D)/2

### Highlighted

Qtotal (cfs) = 13.00  
Qpipe (cfs) = 13.00  
Qovertop (cfs) = 0.00  
Veloc Dn (ft/s) = 4.69  
Veloc Up (ft/s) = 6.03  
HGL Dn (ft) = 7610.15  
HGL Up (ft) = 7610.50  
Hw Elev (ft) = 7611.22  
Hw/D (ft) = 1.01  
Flow Regime = Inlet Control





# Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Wednesday, Nov 14 2018

## DESIGN POINT D6

Invert Elev Dn (ft) = 7600.19  
Pipe Length (ft) = 65.00  
Slope (%) = 1.00  
Invert Elev Up (ft) = 7600.84  
Rise (in) = 30.0  
Shape = Circular  
Span (in) = 30.0  
No. Barrels = 1  
n-Value = 0.013  
Culvert Type = Circular Concrete  
Culvert Entrance = Square edge w/headwall (C)  
Coeff. K,M,c,Y,k = 0.0098, 2, 0.0398, 0.67, 0.5

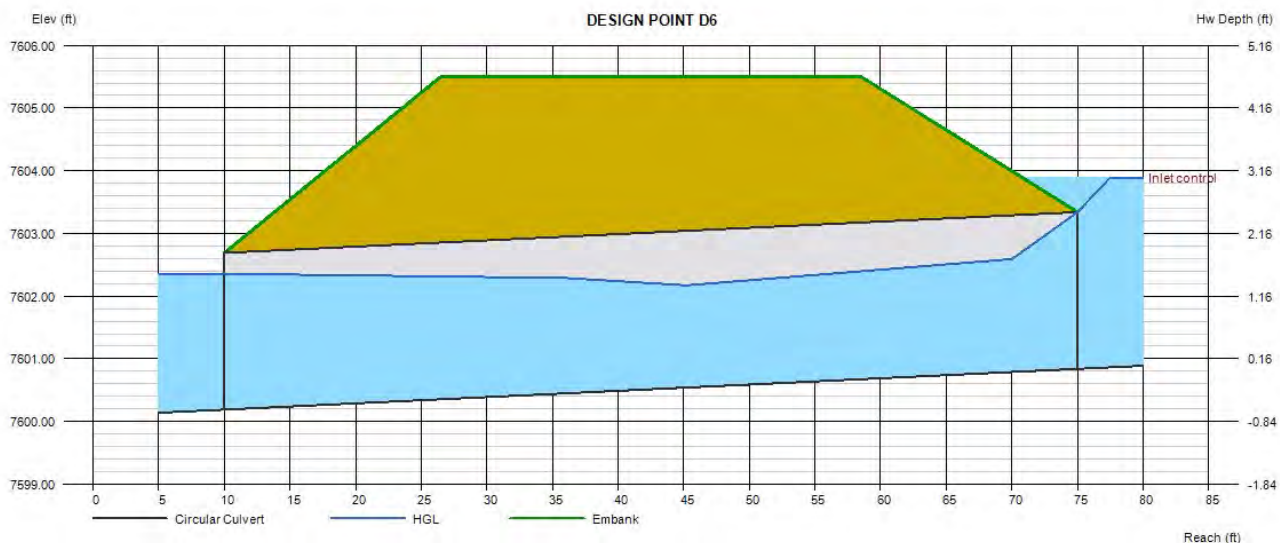
**Embankment**  
Top Elevation (ft) = 7605.50  
Top Width (ft) = 32.00  
Crest Width (ft) = 50.00

### Calculations

Qmin (cfs) = 0.00  
Qmax (cfs) = 29.00  
Tailwater Elev (ft) = (dc+D)/2

### Highlighted

Qtotal (cfs) = 29.00  
Qpipe (cfs) = 29.00  
Qovertop (cfs) = 0.00  
Veloc Dn (ft/s) = 6.41  
Veloc Up (ft/s) = 7.51  
HGL Dn (ft) = 7602.36  
HGL Up (ft) = 7602.67  
Hw Elev (ft) = 7603.89  
Hw/D (ft) = 1.22  
Flow Regime = Inlet Control



# Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Wednesday, Nov 14 2018

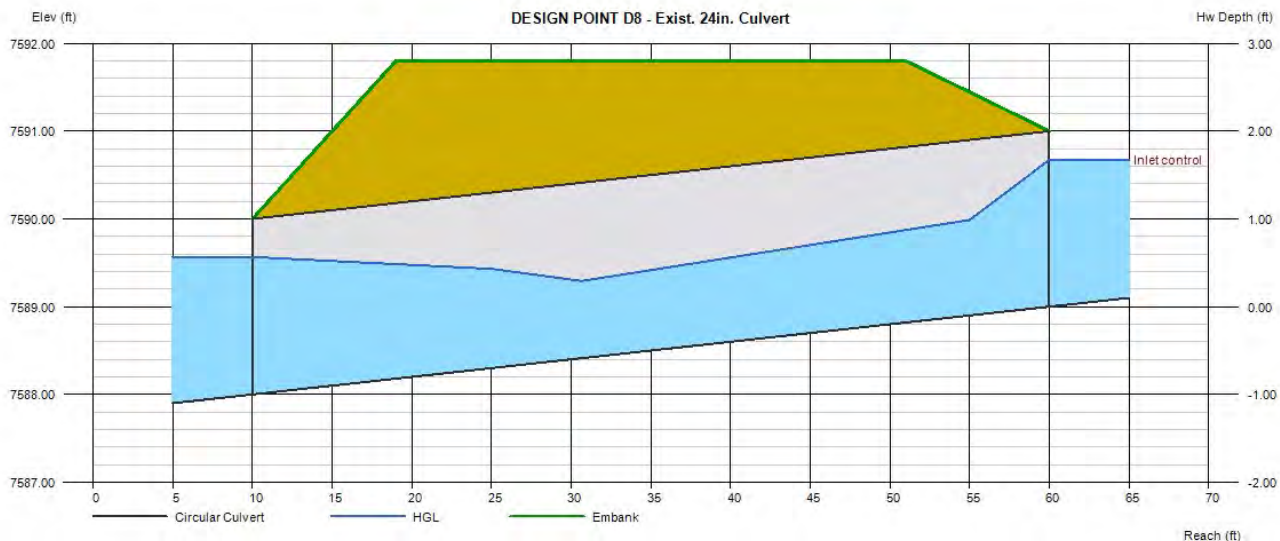
## DESIGN POINT D8 - Exist. 24in. Culvert

Invert Elev Dn (ft) = 7588.00  
Pipe Length (ft) = 50.00  
Slope (%) = 2.00  
Invert Elev Up (ft) = 7589.00  
Rise (in) = 24.0  
Shape = Circular  
Span (in) = 24.0  
No. Barrels = 1  
n-Value = 0.013  
Culvert Type = Circular Concrete  
Culvert Entrance = Square edge w/headwall (C)  
Coeff. K,M,c,Y,k = 0.0098, 2, 0.0398, 0.67, 0.5

**Embankment**  
Top Elevation (ft) = 7591.80  
Top Width (ft) = 32.00  
Crest Width (ft) = 50.00

**Calculations**  
Qmin (cfs) = 0.00  
Qmax (cfs) = 10.00  
Tailwater Elev (ft) = (dc+D)/2

**Highlighted**  
Qtotal (cfs) = 10.00  
Qpipe (cfs) = 10.00  
Qovertop (cfs) = 0.00  
Veloc Dn (ft/s) = 3.79  
Veloc Up (ft/s) = 5.46  
HGL Dn (ft) = 7589.57  
HGL Up (ft) = 7590.13  
Hw Elev (ft) = 7590.67  
Hw/D (ft) = 0.84  
Flow Regime = Inlet Control



# Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Friday, Mar 8 2019

## DESIGN POINT D8 - Exist. 24 in. Culvert (total flow)

Invert Elev Dn (ft) = 7588.00  
Pipe Length (ft) = 50.00  
Slope (%) = 2.00  
Invert Elev Up (ft) = 7589.00  
Rise (in) = 24.0  
Shape = Circular  
Span (in) = 24.0  
No. Barrels = 1  
n-Value = 0.013  
Culvert Type = Circular Concrete  
Culvert Entrance = Square edge w/headwall (C)  
Coeff. K,M,c,Y,k = 0.0098, 2, 0.0398, 0.67, 0.5

### Embankment

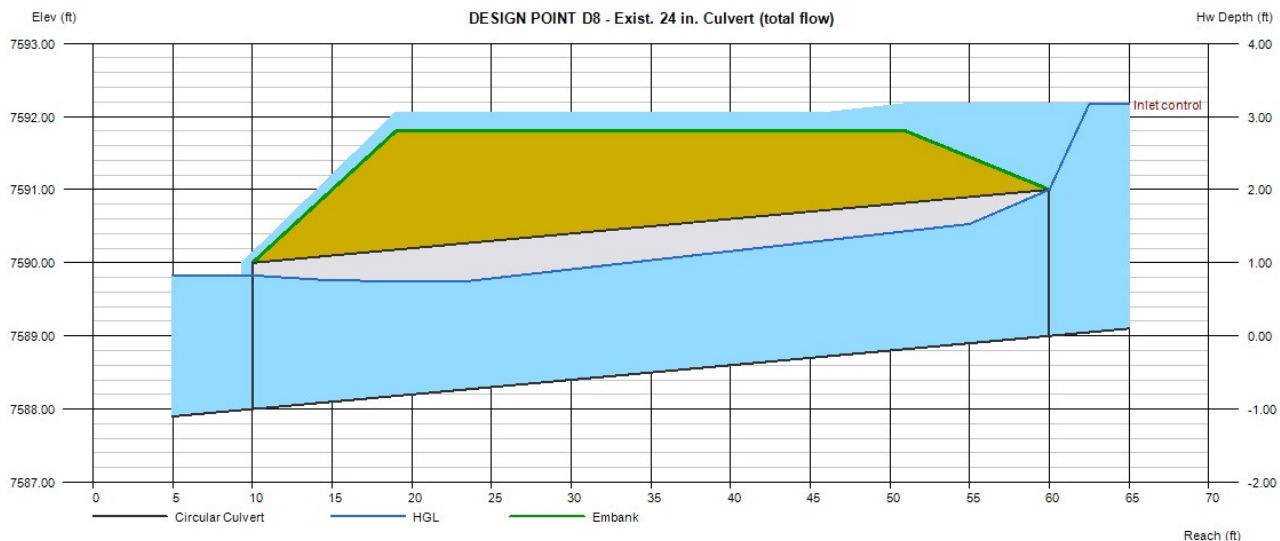
Top Elevation (ft) = 7591.80  
Top Width (ft) = 32.00  
Crest Width (ft) = 50.00

### Calculations

Qmin (cfs) = 0.00  
Qmax (cfs) = 56.00  
Tailwater Elev (ft) = (dc+D)/2

### Highlighted

Qtotal (cfs) = 56.00  
Qpipe (cfs) = 21.42  
Qovertop (cfs) = 34.58  
Veloc Dn (ft/s) = 7.12  
Veloc Up (ft/s) = 7.71  
HGL Dn (ft) = 7589.83  
HGL Up (ft) = 7590.66  
Hw Elev (ft) = 7592.17  
Hw/D (ft) = 1.58  
Flow Regime = Inlet Control



# Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Friday, Jun 29 2018

## DESIGN POINT D9

Invert Elev Dn (ft) = 7586.50  
Pipe Length (ft) = 70.00  
Slope (%) = 1.00  
Invert Elev Up (ft) = 7587.20  
Rise (in) = 18.0  
Shape = Circular  
Span (in) = 18.0  
No. Barrels = 1  
n-Value = 0.013  
Culvert Type = Circular Concrete  
Culvert Entrance = Square edge w/headwall (C)  
Coeff. K,M,c,Y,k = 0.0098, 2, 0.0398, 0.67, 0.5

### Embankment

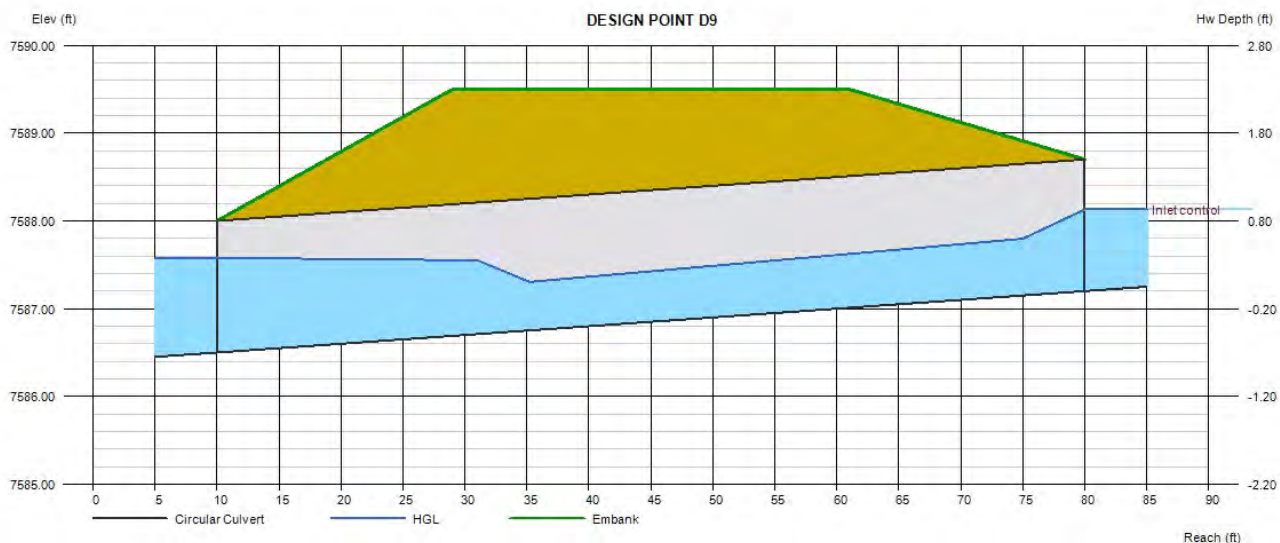
Top Elevation (ft) = 7589.50  
Top Width (ft) = 32.00  
Crest Width (ft) = 50.00

### Calculations

Qmin (cfs) = 0.00  
Qmax (cfs) = 3.00  
Tailwater Elev (ft) = (dc+D)/2

### Highlighted

Qtotal (cfs) = 3.00  
Qpipe (cfs) = 3.00  
Qovertop (cfs) = 0.00  
Veloc Dn (ft/s) = 2.20  
Veloc Up (ft/s) = 4.02  
HGL Dn (ft) = 7587.58  
HGL Up (ft) = 7587.86  
Hw Elev (ft) = 7588.13  
Hw/D (ft) = 0.62  
Flow Regime = Inlet Control



# Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Wednesday, Nov 14 2018

## DESIGN POINT D10 - Exist. 24in. Culvert

Invert Elev Dn (ft) = 7582.00  
Pipe Length (ft) = 45.00  
Slope (%) = 1.00  
Invert Elev Up (ft) = 7582.45  
Rise (in) = 24.0  
Shape = Circular  
Span (in) = 24.0  
No. Barrels = 2  
n-Value = 0.013  
Culvert Type = Circular Concrete  
Culvert Entrance = Square edge w/headwall (C)  
Coeff. K,M,c,Y,k = 0.0098, 2, 0.0398, 0.67, 0.5

### Embankment

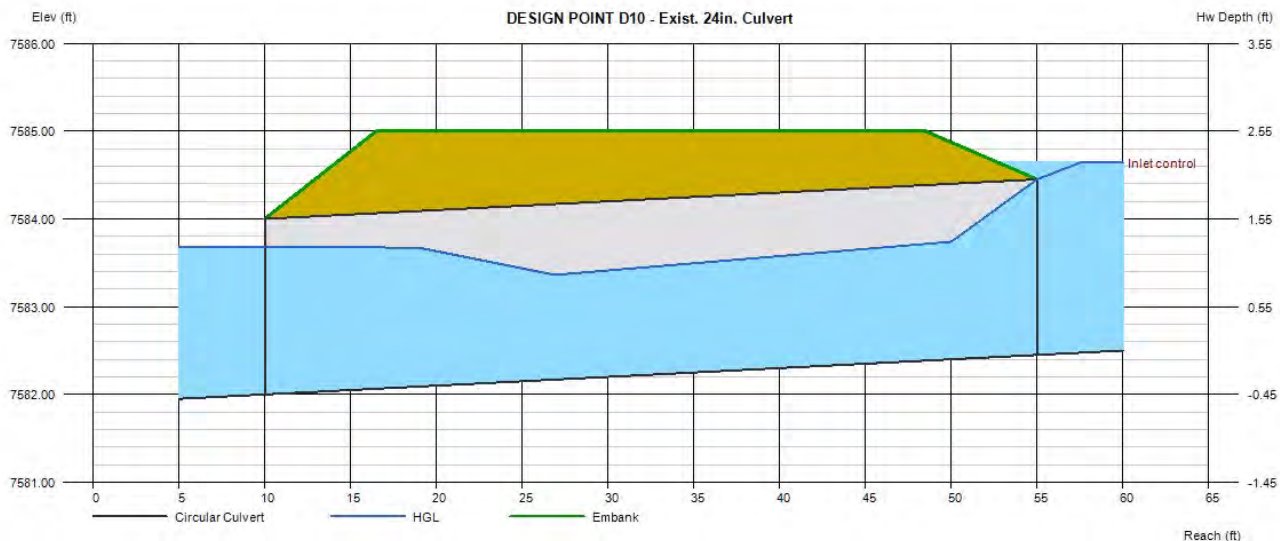
Top Elevation (ft) = 7585.00  
Top Width (ft) = 32.00  
Crest Width (ft) = 50.00

### Calculations

Qmin (cfs) = 0.00  
Qmax (cfs) = 29.00  
Tailwater Elev (ft) = (dc+D)/2

### Highlighted

Qtotal (cfs) = 29.00  
Qpipe (cfs) = 29.00  
Qovertop (cfs) = 0.00  
Veloc Dn (ft/s) = 5.13  
Veloc Up (ft/s) = 6.32  
HGL Dn (ft) = 7583.69  
HGL Up (ft) = 7583.82  
Hw Elev (ft) = 7584.64  
Hw/D (ft) = 1.09  
Flow Regime = Inlet Control



## ROADSIDE DITCH CALCUALTIONS

Sanctuary Pine Dr. - North side of roadway (Sta. 0+00 to Sta. 1+50)

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	6.0		6.0		6.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	3.0%		3.0%		3.0%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.96		1.96		1.96
	Wetted Perimeter (ft.)	5.78		5.78		5.78
	Hydraulic Radius	0.34		0.34		0.34
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.7		0.7		0.7
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	1.3		1.3		1.3
	Velocity (ft./sec.)	3.1		3.1		3.1
	Allowed Flow (cfs)	7.0		8.2		8.2

## ROADSIDE DITCH CALCUALTIONS

Sanctuary Pine Dr. - North side of roadway (Sta. 1+50 to Sta. 4+00)

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	3.0		3.0		3.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	6.0%		6.0%		6.0%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.00		1.00		1.96
	Wetted Perimeter (ft.)	4.13		4.13		5.78
	Hydraulic Radius	0.24		0.24		0.34
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.5		0.5		0.7
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	1.9		1.9		2.6
	Velocity (ft./sec.)	3.0		3.0		1.5
	Allowed Flow (cfs)	4.1		4.7		11.6

## ROADSIDE DITCH CALCUALTIONS

Sanctuary Pine Dr. - South side of roadway (Sta. 4+00 to Sta. 7+50)

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	3.0		3.0		3.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	1.5%		1.5%		1.5%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.44		1.44		1.96
	Wetted Perimeter (ft.)	4.96		4.96		5.78
	Hydraulic Radius	0.29		0.29		0.34
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.6		0.6		0.7
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	0.6		0.6		0.7
	Velocity (ft./sec.)	2.1		2.1		1.5
	Allowed Flow (cfs)	3.3		3.8		5.8



## ROADSIDE DITCH CALCUALTIONS

Sanctuary Pine Dr. - South side of roadway (Sta. 7+00 to Sta. 13+50)

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	9.0		9.0		9.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	4.0%		4.0%		4.0%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	2.25		1.96		1.96
	Wetted Perimeter (ft.)	6.20		5.78		5.78
	Hydraulic Radius	0.36		0.34		0.34
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.8		0.7		0.7
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	1.9		1.7		1.7
	Velocity (ft./sec.)	4.0		4.6		4.6
	Allowed Flow (cfs)	9.8		9.5		9.5

## ROADSIDE DITCH CALCUALTIONS

**Sanctuary Pine Dr. - North side of roadway (Sta. 13+50 to Sta. 16+00)**

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	2.0		2.0		2.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	1.0%		1.0%		1.0%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.21		1.21		1.96
	Wetted Perimeter (ft.)	4.54		4.54		5.78
	Hydraulic Radius	0.27		0.27		0.34
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.6		0.6		0.7
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	0.3		0.3		0.4
	Velocity (ft./sec.)	1.7		1.7		1.0
	Allowed Flow (cfs)	2.1		2.5		4.7

## ROADSIDE DITCH CALCUALTIONS

Sanctuary Pine Dr. - North side of roadway (Sta. 16+00 to Sta. 19+00)

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	3.0		3.0		3.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	6.0%		6.0%		6.0%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	0.81		0.81		1.96
	Wetted Perimeter (ft.)	3.72		3.72		5.78
	Hydraulic Radius	0.22		0.22		0.34
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.5		0.5		0.7
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	1.7		1.7		2.6
	Velocity (ft./sec.)	3.7		3.7		1.5
	Allowed Flow (cfs)	3.1		3.6		11.6

## ROADSIDE DITCH CALCUALTIONS

**Sanctuary Pine Dr. - South side of roadway (Sta. 16+00 to Sta. 19+00)**

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	2.0		2.0		2.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	6.0%		6.0%		6.0%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	0.64		0.64		1.96
	Wetted Perimeter (ft.)	3.30		3.30		5.78
	Hydraulic Radius	0.19		0.19		0.34
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.4		0.4		0.7
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	1.5		1.5		2.6
	Velocity (ft./sec.)	3.1		3.1		1.0
	Allowed Flow (cfs)	2.2		2.6		11.6

## ROADSIDE DITCH CALCUALTIONS

**Ward Lane - East side of roadway (Sta. 0+00 to Sta. 1+50)**

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	19.0		19.0		19.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	2.0%		2.0%		2.0%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	4.84		4.84		9.00
	Wetted Perimeter (ft.)	9.09		9.09		12.39
	Hydraulic Radius	0.53		0.53		0.73
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	1.1		1.1		1.5
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	1.4		1.4		1.9
	Velocity (ft./sec.)	3.9		3.9		2.1
	Allowed Flow (cfs)	19.1		22.3		51.1

## ROADSIDE DITCH CALCUALTIONS

**Ward Lane - West side of roadway (Sta. 0+00 to Sta. 1+50)**

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	5.0		5.0		5.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	2.0%		2.0%		2.0%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.96		9.00		1.96
	Wetted Perimeter (ft.)	5.78		12.39		5.78
	Hydraulic Radius	0.34		0.73		0.34
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.7		1.5		0.7
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	0.9		1.9		0.9
	Velocity (ft./sec.)	2.6		0.6		2.6
	Allowed Flow (cfs)	5.7		51.1		6.7

## ROADSIDE DITCH CALCUALTIONS

**Ward Lane - East side of roadway (Sta. 1+50 to Sta. 4+50)**

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	6.0		6.0		6.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	5.5%		5.5%		5.5%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.00		1.44		1.00
	Wetted Perimeter (ft.)	4.13		4.96		4.13
	Hydraulic Radius	0.24		0.29		0.24
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.5		0.6		0.5
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	1.7		2.1		1.7
	Velocity (ft./sec.)	6.0		4.2		6.0
	Allowed Flow (cfs)	3.9		7.4		4.5

## ROADSIDE DITCH CALCUALTIONS

**Ward Lane - West side of roadway (Sta. 1+50 to Sta. 4+50)**

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	3.0		3.0		3.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	5.5%		5.5%		5.5%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.00		9.00		1.00
	Wetted Perimeter (ft.)	4.13		12.39		4.13
	Hydraulic Radius	0.24		0.73		0.24
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.5		1.5		0.5
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	1.7		5.1		1.7
	Velocity (ft./sec.)	3.0		0.3		3.0
	Allowed Flow (cfs)	3.9		84.7		4.5



## ROADSIDE DITCH CALCUALTIONS

**Ward Lane - East side of roadway (Sta. 4+50 to Sta. 10+00)**

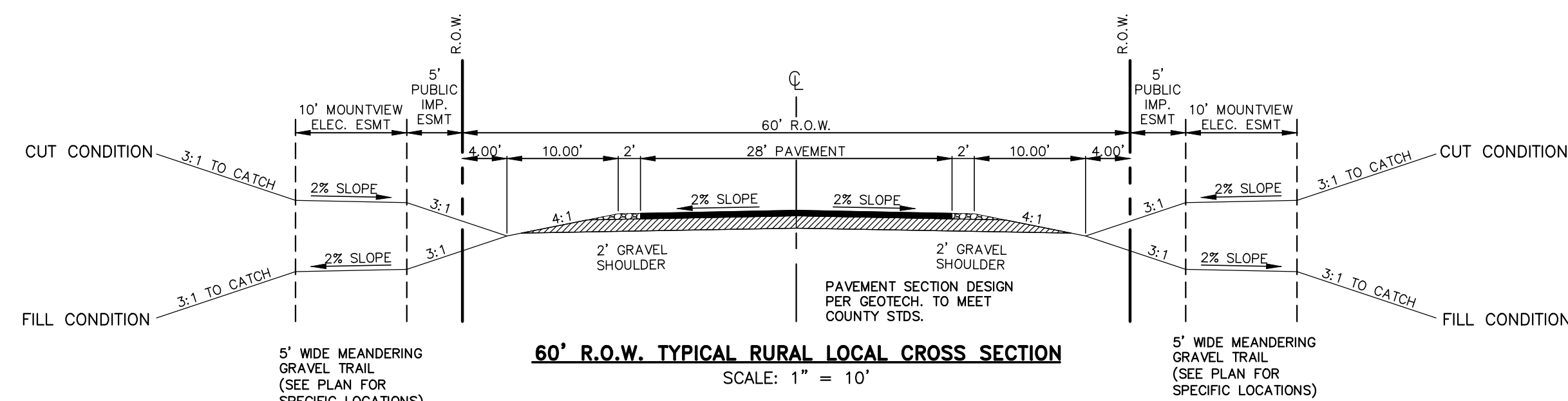
		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	4.0		4.0		4.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	1.5%		1.5%		1.5%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.96		1.96		1.00
	Wetted Perimeter (ft.)	5.78		5.78		4.13
	Hydraulic Radius	0.34		0.34		0.24
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.7		0.7		0.5
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	0.7		0.7		0.5
	Velocity (ft./sec.)	2.0		2.0		4.0
	Allowed Flow (cfs)	5.0		5.8		2.4

## ROADSIDE DITCH CALCUALTIONS

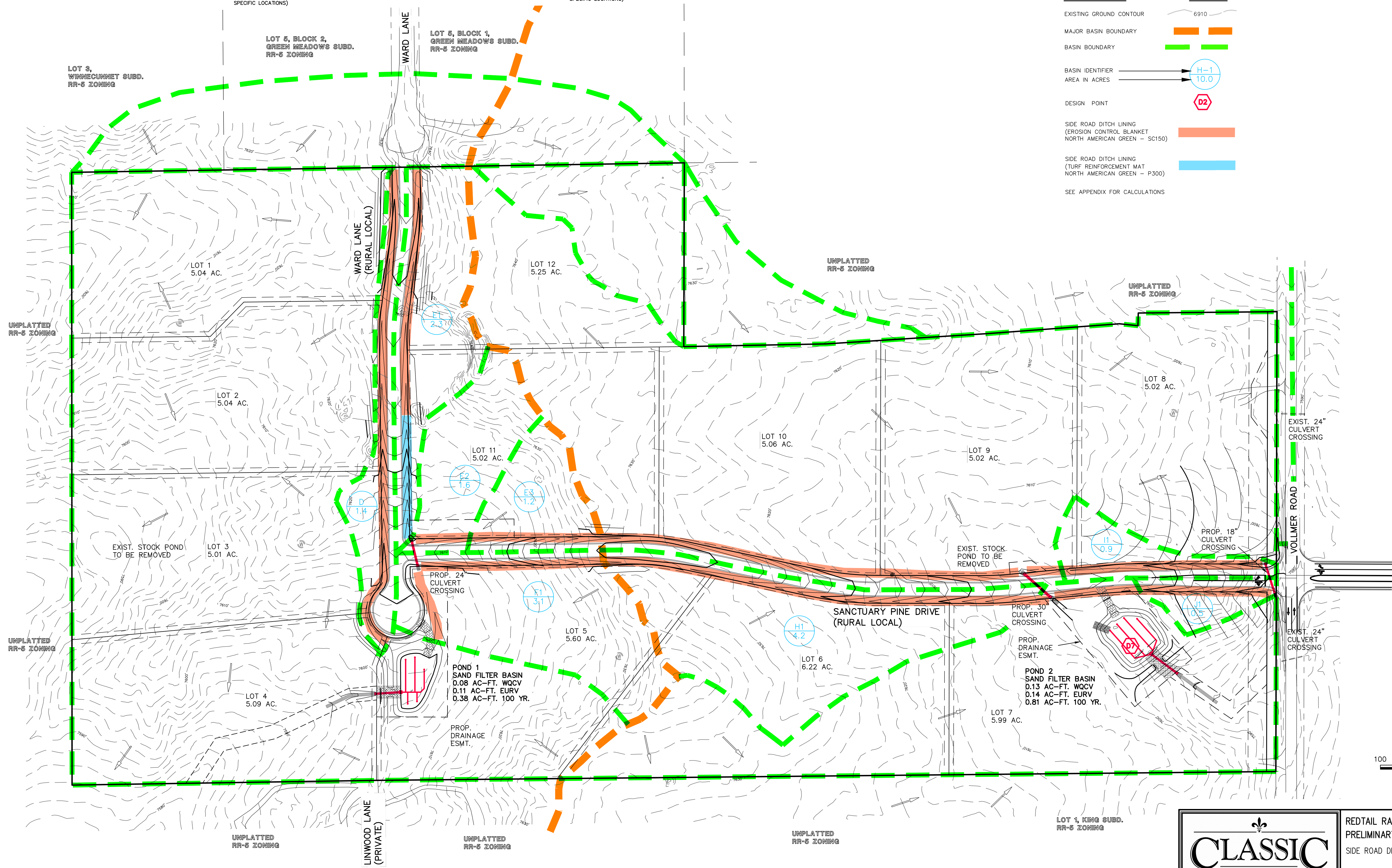
**Ward Lane - West side of roadway (Sta. 4+50 to Sta. 10+00)**

		<b>Erosion Control Blanket (ECB)</b>		<b>Turf Reinforcement Mat (TRM)</b>		<b>Revegetation - Grass lined</b>
		<b>(North American Green - SC150)</b>		<b>(North American Green - P300)</b>		<b>(Native Seed Mix)</b>
	<b>Given:</b>	<b>(Temporary - 24 months)</b>		<b>(Permanent)</b>		
	Design Flow (cfs)	2.0		2.0		2.0
	Permissible Shear (lbs/ft. <sup>2</sup> )	2.0		8.0		0.1
	Permissible Velocity (ft./sec.)	8.0		16.0		3.0
	Safety Factor	1		1		1
	Ditch Slope (Max.)	1.5%		1.5%		1.5%
	Ditch Section (24 in. depth)	V-Ditch		V-Ditch		V-Ditch
	Flow Area (ft. <sup>2</sup> )	1.00		1.00		1.00
	Wetted Perimeter (ft.)	4.13		4.13		4.13
	Hydraulic Radius	0.24		0.24		0.24
	Mannings n	0.035		0.030		0.030
	Depth of Flow (max.)	0.5		0.5		0.5
	<b>Calculations:</b>					
	Shear Stress (lbs/ft. <sup>2</sup> )	0.5		0.5		0.5
	Velocity (ft./sec.)	2.0		2.0		2.0
	Allowed Flow (cfs)	2.0		2.4		2.4





DESCRIPTION	SYMBOL
EXISTING GROUND CONTOUR	6910
MAJOR BASIN BOUNDARY	
BASIN BOUNDARY	
BASIN IDENTIFIER	
AREA IN ACRES	
DESIGN POINT	
SIDE ROAD DITCH LINING (EROSION CONTROL BLANKET NORTH AMERICAN GREEN - SC150)	
SIDE ROAD DITCH LINING (TURF REINFORCEMENT MAT NORTH AMERICAN GREEN - P300)	
SEE APPENDIX FOR CALCULATIONS	



REDTAIL RANCH  
PRELIMINARY/FINAL DRAINAGE REPORT  
SIDE ROAD DITCH DESIGN EXHIBIT

DESIGNED BY	MAW	SCALE	DATE	7-3-18
DRAWN BY	MAW	(H) 1"= 100'	SHEET	1 OF 1
CHECKED BY		(V) 1"= N/A	JOB NO.	2525.00

619 N. Cascade Avenue, Suite 200  
Colorado Springs, Colorado 80903  
(719) 785-0790  
(719) 785-0799 (Fax)



## **BMP FACILITY DESIGN CALCULATIONS**

# Design Procedure Form: Sand Filter (SF)

UD-BMP (Version 3.06, November 2016)

Sheet 1 of 2

Designer: Marc A. Whorton, P.E.

Company: Classic Consulting

Date: November 14, 2018

Project: Redtail Ranch Filing No. 1 (Pond 1)

Location: Black Forest, CO

## 1. Basin Storage Volume

A) Effective Imperviousness of Tributary Area,  $I_a$   
(100% if all paved and roofed areas upstream of sand filter)

$I_a = 14.6$  %

B) Tributary Area's Imperviousness Ratio ( $i = I_a/100$ )

$i = 0.146$

C) Water Quality Capture Volume (WQCV) Based on 12-hour Drain Time  
 $WQCV = 0.8 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i)$

$WQCV = 0.07$  watershed inches

D) Contributing Watershed Area (including sand filter area)

Area = 644,688 sq ft

E) Water Quality Capture Volume (WQCV) Design Volume  
 $V_{WQCV} = WQCV / 12 * \text{Area}$

$V_{WQCV} = 3,926$  cu ft

F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm

$d_b = 0.42$  in

G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume

$V_{WQCV \text{ OTHER}} = 3,835$  cu ft

H) User Input of Water Quality Capture Volume (WQCV) Design Volume  
(Only if a different WQCV Design Volume is desired)

$V_{WQCV \text{ USER}} =$  cu ft

## 2. Basin Geometry

A) WQCV Depth

$D_{WQCV} = 0.6$  ft

B) Sand Filter Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred). Use "0" if sand filter has vertical walls.

$Z = 4.00$  ft / ft

C) Minimum Filter Area (Flat Surface Area)

$A_{Min} = 1177$  sq ft

D) Actual Filter Area

$A_{Actual} = 6421$  sq ft

E) Volume Provided

$V_T = 7043$  cu ft

## 3. Filter Material

Choose One

☒ 18" CDOT Class B or C Filter Material

☐ Other (Explain):

## 4. Underdrain System

A) Are underdrains provided?

Choose One

☒ YES

☐ NO

B) Underdrain system orifice diameter for 12 hour drain time

$y = 1.5$  ft

i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice

$Vol_{12} = 3,835$  cu ft

ii) Volume to Drain in 12 Hours

$D_o = 1 - 1/2$  in

iii) Orifice Diameter, 3/8" Minimum

**Design Procedure Form: Sand Filter (SF)**

Sheet 2 of 2

Designer: Marc A. Whorton, P.E.Company: Classic ConsultingDate: November 14, 2018Project: Redtail Ranch Filing No. 1 (Pond 1)Location: Black Forest, CO

## 5. Impermeable Geomembrane Liner and Geotextile Separator Fabric

- A) Is an impermeable liner provided due to proximity of structures or groundwater contamination?

Choose One

☐ YES☒ NO

## 6-7. Inlet / Outlet Works

- A) Describe the type of energy dissipation at inlet points and means of conveying flows in excess of the WQCV through the outlet

Rip-Rap at inlet pointsConcrete Box Structure for detention and release of 100 yr. flows

Notes: \_\_\_\_\_

# Design Procedure Form: Sand Filter (SF)

UD-BMP (Version 3.06, November 2016)

Sheet 1 of 2

Designer: Marc A. Whorton, P.E.

Company: Classic Consulting

Date: November 14, 2018

Project: Redtail Ranch Filing No. 1 (Pond 2)

Location: Black Forest, CO

## 1. Basin Storage Volume

A) Effective Imperviousness of Tributary Area,  $I_a$   
(100% if all paved and roofed areas upstream of sand filter)

$I_a = 9.5$  %

B) Tributary Area's Imperviousness Ratio ( $i = I_a/100$ )

$i = 0.095$

C) Water Quality Capture Volume (WQCV) Based on 12-hour Drain Time  
 $WQCV = 0.8 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i)$

$WQCV = 0.05$  watershed inches

D) Contributing Watershed Area (including sand filter area)

$Area = 1,245,816$  sq ft

E) Water Quality Capture Volume (WQCV) Design Volume  
 $V_{WQCV} = WQCV / 12 * Area$

$V_{WQCV} = 5,327$  cu ft

F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm

$d_b = 0.42$  in

G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume

$V_{WQCV \text{ OTHER}} = 5,203$  cu ft

H) User Input of Water Quality Capture Volume (WQCV) Design Volume  
(Only if a different WQCV Design Volume is desired)

$V_{WQCV \text{ USER}} =$  cu ft

## 2. Basin Geometry

A) WQCV Depth

$D_{WQCV} = 0.6$  ft

B) Sand Filter Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred). Use "0" if sand filter has vertical walls.

$Z = 4.00$  ft / ft

C) Minimum Filter Area (Flat Surface Area)

$A_{Min} = 1479$  sq ft

D) Actual Filter Area

$A_{Actual} = 7895$  sq ft

E) Volume Provided

$V_T = 5410$  cu ft

## 3. Filter Material

Choose One  
☒ 18" CDOT Class B or C Filter Material  
☐ Other (Explain):

## 4. Underdrain System

A) Are underdrains provided?

Choose One  
☒ YES  
☐ NO

B) Underdrain system orifice diameter for 12 hour drain time

i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice

$y = 1.5$  ft

ii) Volume to Drain in 12 Hours

$Vol_{12} = 5,203$  cu ft

iii) Orifice Diameter, 3/8" Minimum

$D_o = 1 - 3 / 4$  in

**Design Procedure Form: Sand Filter (SF)**

Sheet 2 of 2

Designer: Marc A. Whorton, P.E.Company: Classic ConsultingDate: November 14, 2018Project: Redtail Ranch Filing No. 1 (Pond 2)Location: Black Forest, CO

## 5. Impermeable Geomembrane Liner and Geotextile Separator Fabric

A) Is an impermeable liner provided due to proximity of structures or groundwater contamination?

Choose One

☐ YES☒ NO

## 6-7. Inlet / Outlet Works

A) Describe the type of energy dissipation at inlet points and means of conveying flows in excess of the WQCV through the outlet

Rip-Rap at InflowConcrete Box Outlet for 100 Yr. flows

Notes:

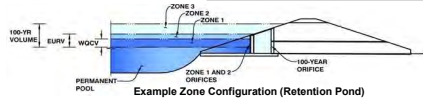


## DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: REDTAIL RANCH FILING NO. 1

Basin ID: POND 1



### Required Volume Calculation

Selected BMP Type =		SF	
Watershed Area =	14.80	acres	
Watershed Length =	1.200	ft	
Watershed Slope =	0.020	ft/ft	
Watershed Imperviousness =	14.650	percent	
Percentage Hydrologic Soil Group A =	0.0%	percent	
Percentage Hydrologic Soil Group B =	100.0%	percent	
Percentage Hydrologic Soil Group C/D =	0.0%	percent	
Desired WOCV Drain Time =	12.0	hours	
Location for 1-hr Rainfall Depths =		User Input	
Water Quality Capture Volume (WQCV) =	0.090	acre-feet	Optional User Override
Excess Urban Runoff Volume (EURV) =	0.209	acre-feet	1-hr Precipitation
2-yr Runoff Volume (P1 = 1.19 in.) =	0.149	acre-feet	1.19 inches
5-yr Runoff Volume (P1 = 1.75 in.) =	0.225	acre-feet	1.50 inches
10-yr Runoff Volume (P1 = 1.5 in.) =	0.436	acre-feet	1.75 inches
25-yr Runoff Volume (P1 = 2 in.) =	0.983	acre-feet	2.00 inches
50-yr Runoff Volume (P1 = 2.52 in.) =	1.328	acre-feet	2.25 inches
100-yr Runoff Volume (P1 = 2.52 in.) =	1.780	acre-feet	2.52 inches
500-yr Runoff Volume (P1 = 3.85 in.) =	3.262	acre-feet	3.85 inches
Approximate 2-yr Detention Volume =	0.139	acre-feet	
Approximate 5-yr Detention Volume =	0.211	acre-feet	
Approximate 10-yr Detention Volume =	0.378	acre-feet	
Approximate 25-yr Detention Volume =	0.494	acre-feet	
Approximate 50-yr Detention Volume =	0.521	acre-feet	
Approximate 100-yr Detention Volume =	0.657	acre-feet	

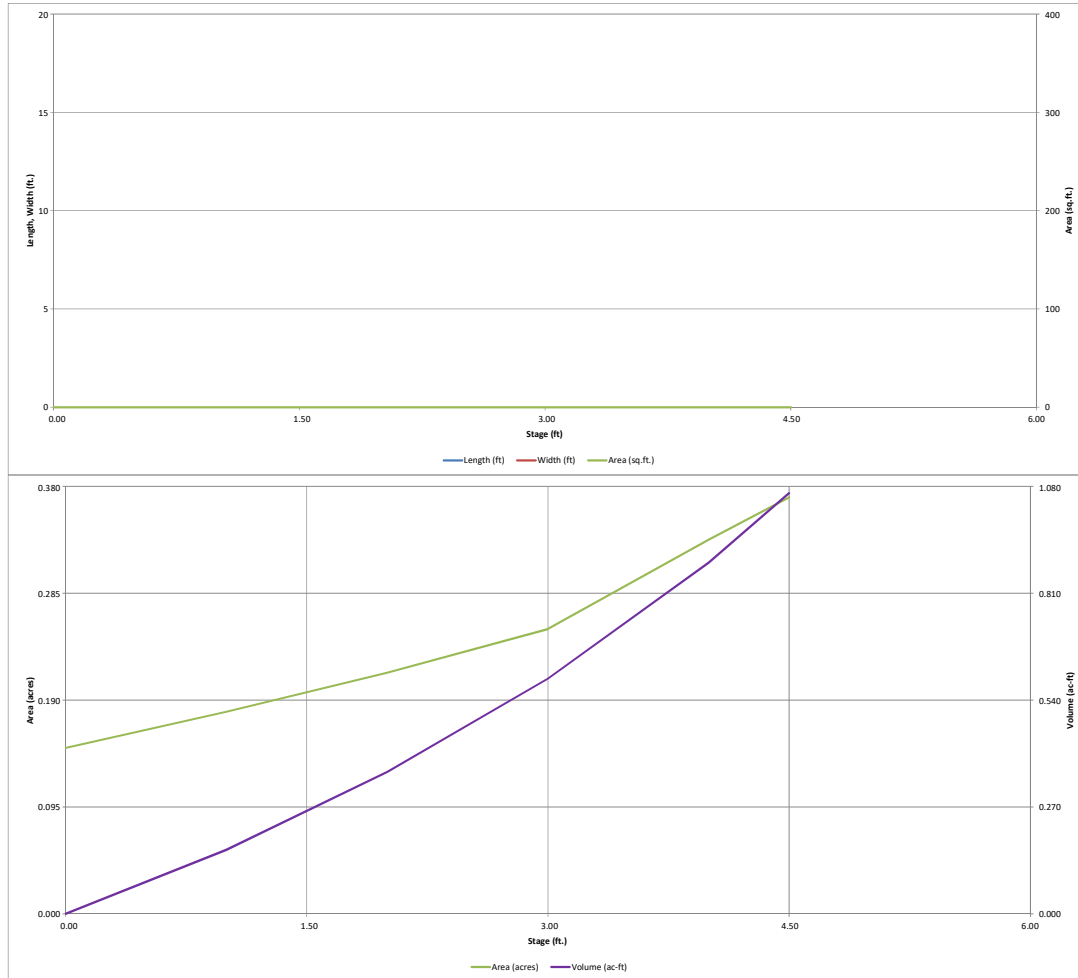
### Stage-Storage Calculation

Zone 1 Volume ( $V_{WCV1}$ ) =	0.090	acre-feet
Zone 2 Volume ( $E_{URV} - \text{Zone 1}$ ) =	0.119	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.448	acre-feet
Total Detention Basin Volume =	0.657	acre-feet
Initial Surge Volume ( $ISV$ ) =	N/A	#/3
Initial Surge Depth ( $ISD$ ) =	N/A	ft
Total Available Detention Depth ( $H_{tavail}$ ) =	user#	ft
Depth of Trickle Channel ( $H_{TC}$ ) =	N/A	ft
Slope of Trickle Channel ( $S_{TC}$ ) =	N/A	ft/ft
Slopes of Main Basin Sides ( $S_{main}$ ) =	user#	H:V
Basin Length-to-Width Ratio ( $R_{L/W}$ ) =	user#	
Initial Surge Area ( $A_{SI}$ ) =	user#	#/2
Surge Volume Length ( $L_{SV}$ ) =	user#	ft
Surge Volume Width ( $W_{SV}$ ) =	user#	ft
Depth of Basin Floor ( $H_{BDF}$ ) =	user#	ft
Length of Basin Floor ( $L_{BDF}$ ) =	user#	ft
Width of Basin Floor ( $W_{BDF}$ ) =	user#	ft
Area of Basin Floor ( $A_{BDF}$ ) =	user#	ft <sup>2</sup>
Volume of Basin Floor ( $V_{BDF}$ ) =	user#	#/3
Depth of Main Basin ( $H_{MB}$ ) =	user#	ft
Length of Main Basin ( $L_{MB}$ ) =	user#	ft
Width of Main Basin ( $W_{MB}$ ) =	user#	ft
Area of Main Basin ( $A_{MB}$ ) =	user#	ft <sup>2</sup>
Volume of Main Basin ( $V_{MB}$ ) =	user#	ft <sup>3</sup>
Calculated Total Basin Volume ( $V_{total}$ ) =	user#	acre-feet

[illegible]

# DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

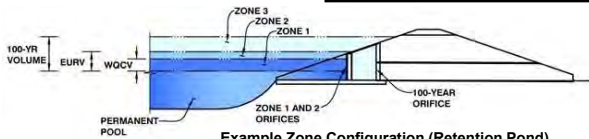


## Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: REDTAIL RANCH FILING NO. 1

Basin ID: POND 1



**Example Zone Configuration (Retention Pond)**

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.58	0.090	Filtration Media
Zone 2 (EURV)	1.25	0.119	Orifice Plate
Zone 3 (100-year)	3.24	0.448	Weir&Pipe (Restrict)
		0.657	Total

**User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)**

Underdrain Orifice Invert Depth =	1.50	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	1.64	inches

**Calculated Parameters for Underdrain**

Underdrain Orifice Area =	0.0	ft <sup>2</sup>
Underdrain Orifice Centroid =	0.07	feet

**User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)**

Invert of Lowest Orifice =	0.58	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	2.25	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	6.68	inches
Orifice Plate: Orifice Area per Row =	1.80	sq. inches (diameter = 1-1/2 inches)

**Calculated Parameters for Plate**

WQ Orifice Area per Row =	1.250E-02	ft <sup>2</sup>
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft <sup>2</sup>

**User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)**

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.58	1.14	1.69					
Orifice Area (sq. inches)	1.80	1.80	1.80					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

**User Input: Vertical Orifice (Circular or Rectangular)**

	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

**Calculated Parameters for Vertical Orifice**

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft <sup>2</sup>
Vertical Orifice Centroid =	N/A	N/A	feet

**User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)**

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	2.25	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	4.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	4.00	N/A	feet
Overflow Grate Open Area % =	75%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

**Calculated Parameters for Overflow Weir**

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H <sub>u</sub> =	2.25	N/A	feet
Over Flow Weir Slope Length =	4.00	N/A	feet
Grate Open Area / 100-yr Orifice Area =	8.78	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	12.00	N/A	ft <sup>2</sup>
Overflow Grate Open Area w/ Debris =	6.00	N/A	ft <sup>2</sup>

**User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)**

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.50	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	18.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	13.00		inches

**Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate**

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	1.37	N/A	ft <sup>2</sup>
Outlet Orifice Centroid =	0.60	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	2.03	N/A	radians

**User Input: Emergency Spillway (Rectangular or Trapezoidal)**

Spillway Invert Stage=	3.50	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	10.00	feet
Spillway End Slopes =	3.00	H:V
Freeboard above Max Water Surface =		feet

**Calculated Parameters for Spillway**

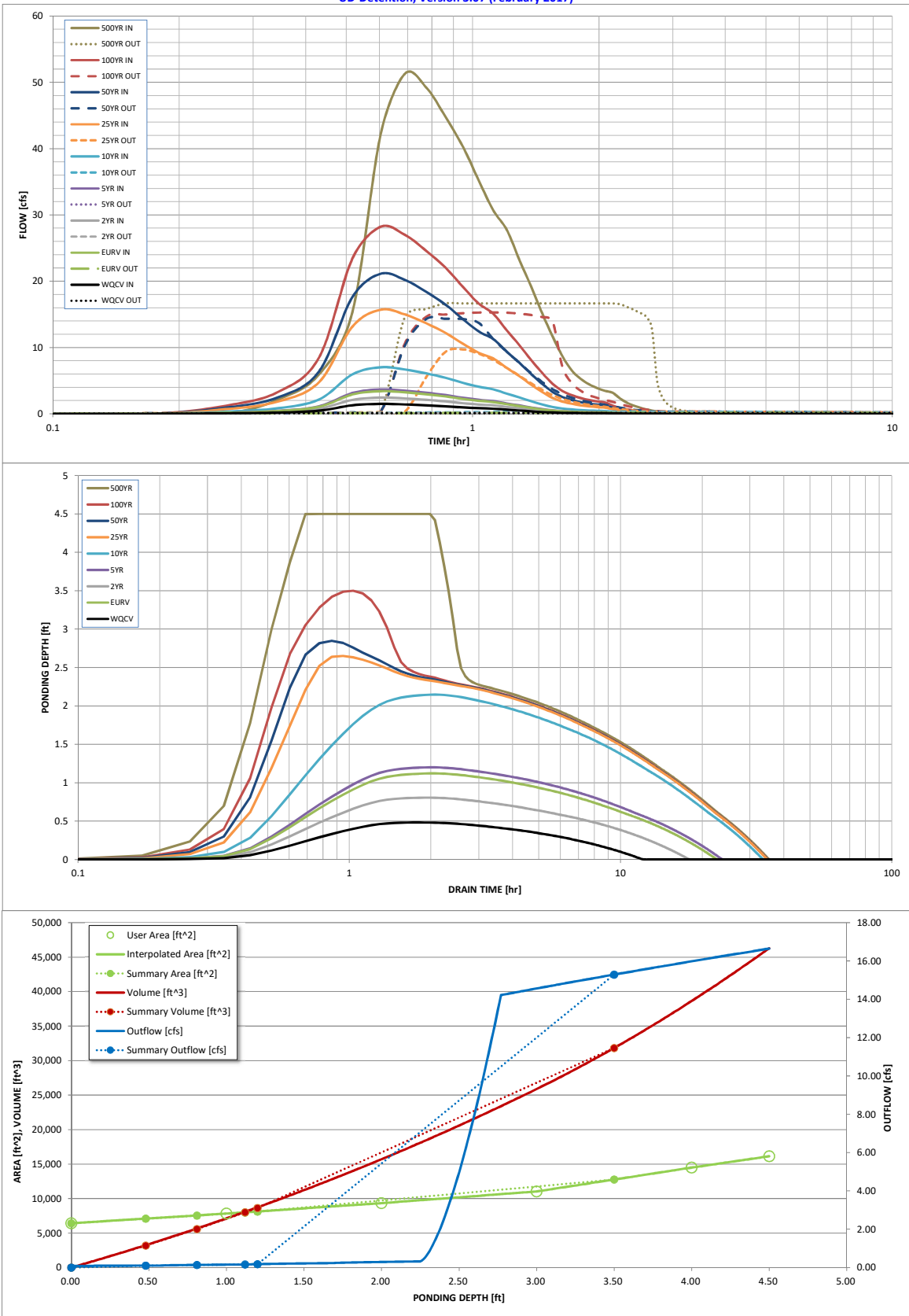
Spillway Design Flow Depth=	0.96	feet
Stage at Top of Freeboard =	4.46	feet
Basin Area at Top of Freeboard =	0.37	acres

### Routed Hydrograph Results

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =									
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.85
Calculated Runoff Volume (acre-ft) =	0.090	0.209	0.149	0.225	0.436	0.983	1.328	1.780	3.262
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.090	0.209	0.149	0.225	0.435	0.981	1.326	1.777	3.259
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.02	0.19	0.64	0.88	1.19	2.16
Predevelopment Peak Q (cfs) =	0.0	0.0	0.2	0.295	2.8	9.4	13.1	17.6	31.9
Peak Inflow Q (cfs) =	1.5	3.4	2.4	3.7	7.0	15.7	21.1	28.2	51.3
Peak Outflow Q (cfs) =	0.1	0.2	0.1	0.177	0.3	9.7	14.3	15.3	16.6
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.6	0.1	1.0	1.1	0.9	0.5
Structure Controlling Flow =	Filtration Media	Plate	Plate	Plate	Plate	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	0.8	1.2	1.2	1.3
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	12	22	17	23	32	31	30	28	23
Time to Drain 99% of Inflow Volume (hours) =	12	22	18	23	33	33	33	33	31
Maximum Ponding Depth (ft) =	0.48	1.12	0.81	1.20	2.15	2.65	2.85	3.50	4.50
Area at Maximum Ponding Depth (acres) =	0.16	0.18	0.17	0.19	0.22	0.24	0.25	0.29	0.37
Maximum Volume Stored (acre-ft) =	0.074	0.185	0.128	0.200	0.391	0.506	0.554	0.731	1.063

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)



S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			



## Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

### Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

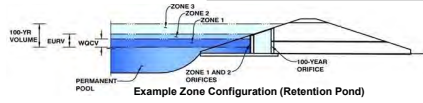
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## DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: REDTAIL RANCH FILING NO. 1

Basin ID: **POND 2**



### Required Volume Calculation

Selected BMP Type =	SF	
Watershed Area =	28.60	acres
Watershed Length =	2.000	ft
Watershed Slope =	0.020	ft/ft
Watershed Imperviousness =	9.50%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	100.0%	percent
Percentage Hydrologic Soil Groups CD =	0.0%	percent
Desired WQCV Drain Time =	12.0	hours
Location for 1-hr Rainfall Depth =		
Water Quality Capture Volume (WQCV) =	0.122	acre-feet
Excess Urban Runoff Volume (EURV) =	0.254	acre-feet
2-yr Runoff Volume ( $P1 = 1.19$ in.) =	0.174	acre-feet
5-yr Runoff Volume ( $P1 = 1.5$ in.) =	0.272	acre-feet
10-yr Runoff Volume ( $P1 = 1.75$ in.) =	0.635	acre-feet
25-yr Runoff Volume ( $P1 = 2$ in.) =	1.715	acre-feet
50-yr Runoff Volume ( $P1 = 2.25$ in.) =	2.389	acre-feet
100-yr Runoff Volume ( $P1 = 2.52$ in.) =	3.270	acre-feet
500-yr Runoff Volume ( $P1 = 3.85$ in.) =	6.102	acre-feet
Approximate 2-yr Detention Volume =	0.161	acre-feet
Approximate 5-yr Detention Volume =	0.254	acre-feet
Approximate 10-yr Detention Volume =	0.540	acre-feet
Approximate 25-yr Detention Volume =	0.761	acre-feet
Approximate 50-yr Detention Volume =	0.795	acre-feet
Approximate 100-yr Detention Volume =	1.030	acre-feet

**Optional User Override**  
**1-hr Precipitation**

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.52	inches
3.85	inches

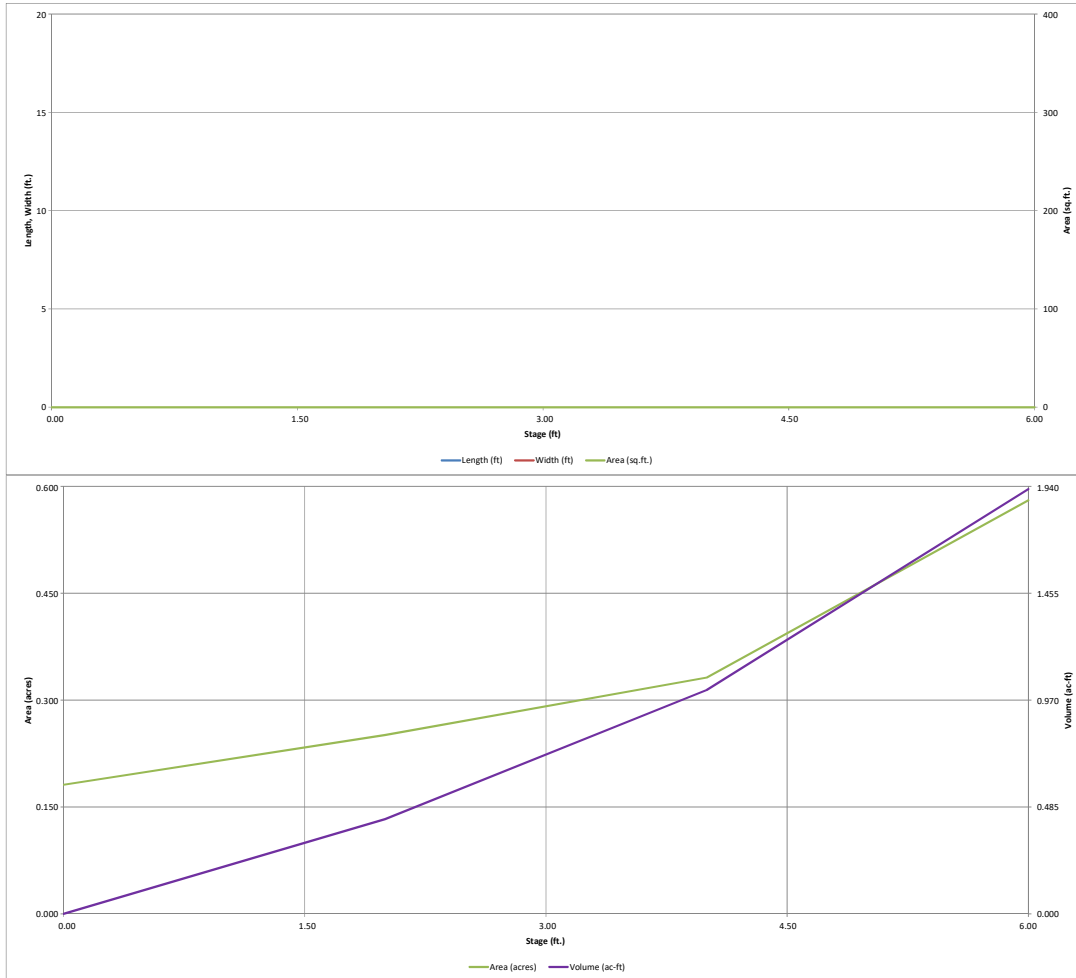
### Stage-Storage Calculation

Zone 1 Volume ( $WQCV_1$ )	0.122	acre-feet
Zone 2 Volume ( $EURV - Zone 1$ )	0.132	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2)	0.776	acre-feet
Total Detention Basin Volume =	1.030	acre-feet
Initial Surcharge Volume ( $ISV$ )	N/A	ft <sup>3</sup>
Initial Surcharge Depth ( $ISD$ )	user	ft
Total Available Detention Depth ( $H_{DAV}$ )	user	ft
Depth of Trickle Channel ( $H_{TC}$ )	N/A	ft
Slope of Trickle Channel ( $S_{TC}$ )	N/A	ft/ft
Slopes of Main Basin Sides ( $S_{MBin}$ )	user	H:V
Basin Length-to-Width Ratio ( $R_{BW}$ )	user	
Initial Surcharge Area ( $A_{ISD}$ )	user	ft <sup>2</sup>
Surcharge Volume Length ( $L_{ISD}$ )	user	ft
Surcharge Volume Width ( $W_{ISD}$ )	user	ft
Depth of Basin Floor ( $H_{1,100A}$ )	user	ft
Length of Basin Floor ( $W_{1,100A}$ )	user	ft
Width of Basin Floor ( $W_{1,100A}$ )	user	ft
Area of Basin Floor ( $A_{1,100A}$ )	user	ft <sup>2</sup>
Volume of Basin Floor ( $V_{1,100A}$ )	user	ft <sup>3</sup>
Depth of Main Basin ( $H_{MBin}$ )	user	ft
Length of Main Basin ( $L_{MBin}$ )	user	ft
Width of Main Basin ( $W_{MBin}$ )	user	ft
Area of Main Basin ( $A_{MBin}$ )	user	ft <sup>2</sup>
Volume of Main Basin ( $V_{MBin}$ )	user	ft <sup>3</sup>
Calculated Total Basin Volume ( $V_{DAV}$ )	user	acre-feet

[illegible]

# DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



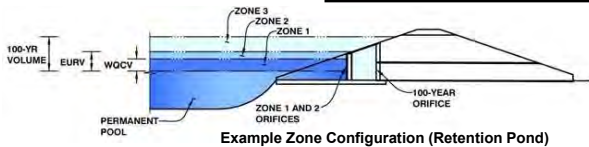


## Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: REDTAIL RANCH FILING NO. 1

Basin ID: POND 2



	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.64	0.122	Filtration Media
Zone 2 (EURV)	1.26	0.132	Orifice Plate
Zone 3 (100-year)	4.05	0.776	Weir&Pipe (Restrict)
		1.030	Total

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	1.50	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	1.92	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	0.0	ft <sup>2</sup>
Underdrain Orifice Centroid =	0.08	feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.64	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	2.50	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	7.44	inches
Orifice Plate: Orifice Area per Row =	2.50	sq. inches (diameter = 1-3/4 inches)

Calculated Parameters for Plate

WQ Orifice Area per Row =	1.736E-02	ft <sup>2</sup>
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft <sup>2</sup>

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.64	1.20	1.85					
Orifice Area (sq. inches)	2.50	2.50	2.50					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft <sup>2</sup>
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	2.50	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	4.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	4.00	N/A	feet
Overflow Grate Open Area % =	75%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H <sub>u</sub> =	2.50	N/A	feet
Over Flow Weir Slope Length =	4.00	N/A	feet
Grate Open Area / 100-yr Orifice Area =	6.79	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	12.00	N/A	ft <sup>2</sup>
Overflow Grate Open Area w/ Debris =	6.00	N/A	ft <sup>2</sup>

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.50	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	18.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	18.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	1.77	N/A	ft <sup>2</sup>
Outlet Orifice Centroid =	0.75	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	3.14	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	5.00	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	18.00	feet
Spillway End Slopes =	3.00	H:V
Freeboard above Max Water Surface =		feet

Calculated Parameters for Spillway

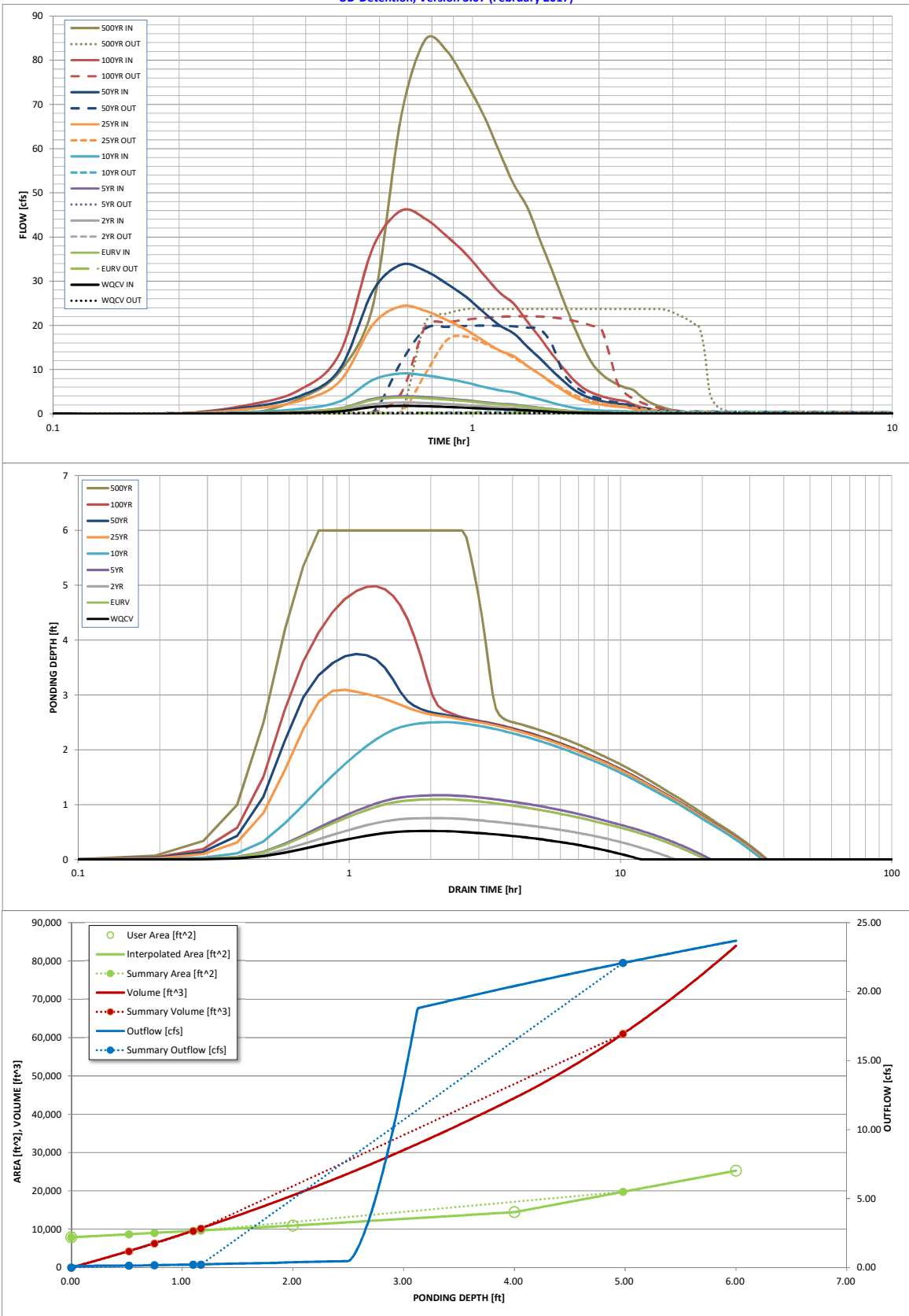
Spillway Design Flow Depth=	0.83	feet
Stage at Top of Freeboard =	5.83	feet
Basin Area at Top of Freeboard =	0.56	acres

### Routed Hydrograph Results

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =									
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.85
Calculated Runoff Volume (acre-ft) =	0.122	0.254	0.174	0.272	0.635	1.715	2.389	3.270	6.102
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.121	0.254	0.174	0.272	0.635	1.715	2.390	3.271	6.104
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.02	0.16	0.56	0.77	1.05	1.90
Predevelopment Peak Q (cfs) =	0.0	0.0	0.3	0.494	4.7	15.9	22.1	29.9	54.4
Peak Inflow Q (cfs) =	1.8	3.7	2.5	3.9	9.1	24.3	33.7	46.0	84.7
Peak Outflow Q (cfs) =	0.1	0.2	0.2	0.217	0.5	17.5	19.9	22.1	23.7
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.4	0.1	1.1	0.9	0.7	0.4
Structure Controlling Flow =	Filtration Media	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.0	1.4	1.6	1.8	1.9
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	12	20	15	21	32	29	27	25	19
Time to Drain 99% of Inflow Volume (hours) =	12	21	16	21	33	32	32	31	29
Maximum Ponding Depth (ft) =	0.52	1.10	0.75	1.17	2.50	3.09	3.75	4.98	6.00
Area at Maximum Ponding Depth (acres) =	0.20	0.22	0.21	0.22	0.27	0.30	0.32	0.45	0.58
Maximum Volume Stored (acre-ft) =	0.097	0.218	0.146	0.236	0.563	0.730	0.930	1.400	1.927

# Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)



S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			



## Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

### Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

[illegible]

Project Summary	
Title	Redtail Ranch Filing No. 1
Engineer	MAW
Company	CCES
Date	7/2/2018

Notes	5 Year
-------	--------

## Table of Contents

	Master Network Summary	2
CO SPRINGS	I-D-F Table, 5 years	3
Pond 1		
	Elevation-Area Volume Curve, 5 years	4
Pond 2		
	Elevation-Area Volume Curve, 5 years	5

## Subsection: Master Network Summary

### Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft <sup>3</sup> /s)
Basin C	Post-Development 5 YR	5	0.055	0.350	1.70
Basin K	Post-Development 5 YR	5	0.024	0.300	0.98
Basins E, D, F	Post-Development 5 YR	5	0.211	0.350	7.29
Basins I, J	Post-Development 5 YR	5	0.033	0.250	1.38
Basins OS-2, EX-5, OS-3, OS-4, G, H	Post-Development 5 YR	5	0.430	0.550	9.47

### Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft <sup>3</sup> /s)
D10	Post-Development 5 YR	5	0.297	0.950	2.39
D5	Post-Development 5 YR	5	0.166	0.350	1.74

### Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft <sup>3</sup> /s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Pond 1 (IN)	Post-Development 5 YR	5	0.211	0.350	7.29	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 5 YR	5	0.111	0.700	0.22	7,601.27	0.208
Pond 2 (IN)	Post-Development 5 YR	5	0.430	0.550	9.47	(N/A)	(N/A)
Pond 2 (OUT)	Post-Development 5 YR	5	0.240	0.950	2.39	7,596.56	0.378

Subsection: I-D-F Table  
Label: CO SPRINGS

Return Event: 5 years  
Storm Event: CO SPRINGS - 5 Year

**I-D-F Curve**

Time (hours)	Intensity (in/h)
0.083	5.170
0.167	4.130
0.250	3.520
0.333	3.090
0.417	2.750
0.500	2.480
0.583	2.250
0.667	2.050
0.750	1.870
0.833	1.710
0.917	1.570
1.000	1.440



Subsection: Elevation-Area Volume Curve  
 Label: Pond 1

Return Event: 5 years  
 Storm Event: CO SPRINGS - 5 Year

Elevation (ft)	Planimeter (ft <sup>2</sup> )	Area (acres)	A1+A2+sqr (A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
7,600.00	0.000	0.144	0.000	0.000	0.000
7,601.00	0.000	0.174	0.476	0.159	0.159
7,602.00	0.000	0.206	0.569	0.190	0.349
7,603.00	0.000	0.241	0.670	0.223	0.572
7,604.00	0.000	0.333	0.857	0.286	0.858

Subsection: Elevation-Area Volume Curve  
 Label: Pond 2

Return Event: 5 years  
 Storm Event: CO SPRINGS - 5 Year

Elevation (ft)	Planimeter (ft <sup>2</sup> )	Area (acres)	A1+A2+sqr (A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
7,595.00	0.000	0.215	0.000	0.000	0.000
7,596.00	0.000	0.249	0.695	0.232	0.232
7,597.00	0.000	0.286	0.802	0.267	0.499
7,598.00	0.000	0.325	0.916	0.305	0.804
7,599.00	0.000	0.424	1.120	0.373	1.178
7,600.00	0.000	0.579	1.498	0.499	1.677

## Index

### C

CO SPRINGS (I-D-F Table, 5 years)...3

### M

Master Network Summary...2

### P

Pond 1 (Elevation-Area Volume Curve, 5 years)...4

Pond 2 (Elevation-Area Volume Curve, 5 years)...5

Project Summary	
Title	Redtail Ranch Filing No. 1
Engineer	MAW
Company	CCES
Date	7/2/2018
Notes	
100 Year	

## Table of Contents

	Master Network Summary	2
CO SPRINGS	I-D-F Table, 100 years	3
Pond 1		
	Elevation-Area Volume Curve, 100 years	4
Pond 2		
	Elevation-Area Volume Curve, 100 years	5

## Subsection: Master Network Summary

### Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft <sup>3</sup> /s)
Basin C	Post-Development 100 YR	100	0.303	0.350	9.26
Basin K	Post-Development 100 YR	100	0.127	0.300	4.61
Basins E, D, F	Post-Development 100 YR	100	0.804	0.350	27.79
Basins I, J	Post-Development 100 YR	100	0.099	0.250	4.20
Basins OS-2, EX-5, OS-3, OS-4, G, H	Post-Development 100 YR	100	2.064	0.550	45.41

### Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft <sup>3</sup> /s)
D10	Post-Development 100 YR	100	2.098	0.750	29.07
D5	Post-Development 100 YR	100	1.003	0.450	24.57

### Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft <sup>3</sup> /s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Pond 1 (IN)	Post-Development 100 YR	100	0.804	0.350	27.79	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 100 YR	100	0.700	0.500	16.87	7,602.51	0.457
Pond 2 (IN)	Post-Development 100 YR	100	2.064	0.550	45.41	(N/A)	(N/A)
Pond 2 (OUT)	Post-Development 100 YR	100	1.872	0.750	29.07	7,598.35	0.925

Subsection: I-D-F Table  
Label: CO SPRINGS

Return Event: 100 years  
Storm Event: CO SPRINGS - 100 Year

**I-D-F Curve**

Time (hours)	Intensity (in/h)
0.083	8.680
0.167	6.930
0.250	5.910
0.333	5.190
0.417	4.620
0.500	4.160
0.583	3.780
0.667	3.440
0.750	3.140
0.833	2.880
0.917	2.640
1.000	2.420

Subsection: Elevation-Area Volume Curve  
Label: Pond 1

Return Event: 100 years  
Storm Event: CO SPRINGS - 100 Year

Elevation (ft)	Planimeter (ft <sup>2</sup> )	Area (acres)	A1+A2+sqr (A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
7,600.00	0.000	0.144	0.000	0.000	0.000
7,601.00	0.000	0.174	0.476	0.159	0.159
7,602.00	0.000	0.206	0.569	0.190	0.349
7,603.00	0.000	0.241	0.670	0.223	0.572
7,604.00	0.000	0.333	0.857	0.286	0.858



Subsection: Elevation-Area Volume Curve  
 Label: Pond 2

Return Event: 100 years  
 Storm Event: CO SPRINGS - 100 Year

Elevation (ft)	Planimeter (ft <sup>2</sup> )	Area (acres)	A1+A2+sqr (A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
7,595.00	0.000	0.215	0.000	0.000	0.000
7,596.00	0.000	0.249	0.695	0.232	0.232
7,597.00	0.000	0.286	0.802	0.267	0.499
7,598.00	0.000	0.325	0.916	0.305	0.804
7,599.00	0.000	0.424	1.120	0.373	1.178
7,600.00	0.000	0.579	1.498	0.499	1.677

## Index

### C

CO SPRINGS (I-D-F Table, 100 years)...3

### M

Master Network Summary...2

### P

Pond 1 (Elevation-Area Volume Curve, 100 years)...4

Pond 2 (Elevation-Area Volume Curve, 100 years)...5

## Description

A sand filter is a filtering or infiltrating BMP that consists of a surcharge zone underlain by a sand bed with an underdrain system. During a storm, accumulated runoff collects in the surcharge zone and gradually infiltrates into the underlying sand bed, filling the void spaces of the sand. The underdrain gradually dewateres the sand bed and discharges the runoff to a nearby channel, swale, or storm drain. It is similar to a BMP designed for bioretention in that it utilizes filtering, but differs in that it is not specifically designed for vegetative growth. The absence of vegetation in a sand filter allows for active maintenance at the surface of the filter, (i.e., raking for removing a layer of sediment). For this reason, sand filter criteria allows for a larger contributing area and greater depth of storage. A sand filter is also a dry basin, which can be designed to include the flood control volume above the WQCV or EURV. Sand filters can also be placed in a vault. Underground sand filters have additional requirements. See Fact Sheet T-11 for additional discussion on underground BMPs.



**Photograph SF-1.** This sand filter, constructed on two sides of a parking garage, is accessible for maintenance, yet screened from public view by a landscape buffer.

## Site Selection

Sand filters require a stable watershed. When the watershed includes phased construction, sparsely vegetated areas, or steep slopes in sandy soils, consider another BMP or provide pretreatment before runoff from these areas reach the rain garden.

When sand filters (and other BMPs used for infiltration) are located adjacent to buildings or pavement areas, protective measures should be implemented to avoid adverse impacts to these structures. Oversaturated subgrade soil underlying a structure can cause the structure to settle or result in moisture-related problems. Wetting of expansive soils or bedrock can cause swelling, resulting in structural movements. A geotechnical engineer should evaluate the potential impact of the BMP on adjacent structures based on an evaluation of the subgrade soil, groundwater, and bedrock conditions at the site.

In locations where potentially expansive soils or bedrock exist, placement of a sand filter adjacent to a structure should only be considered if the BMP includes a drainage layer (with underdrain)

Sand/Media Filter	
Functions	
LID/Volume Red.	Yes
WQCV Capture	Yes
WQCV+Flood Control	Yes
Fact Sheet Includes EURV Guidance	No
Typical Effectiveness for Targeted Pollutants <sup>3</sup>	
Sediment/Solids	Very Good <sup>1</sup>
Nutrients	Good
Total Metals	Good
Bacteria	Moderate
Other Considerations	
Life-cycle Costs <sup>4</sup>	Moderate
<sup>1</sup> Not recommended for watersheds with high sediment yields (unless pretreatment is provided).	
<sup>3</sup> Based primarily on data from the International Stormwater BMP Database ( <a href="http://www.bmpdatabase.org">www.bmpdatabase.org</a> ).	
<sup>4</sup> Based primarily on BMP-REALCOST available at <a href="http://www.udfed.org">www.udfed.org</a> . Analysis based on a single installation (not based on the maximum recommended watershed tributary to each BMP).	



structure, and is lined with an impermeable geomembrane liner designed to restrict seepage.

## Designing for Maintenance

Recommended maintenance practices for all BMPs are provided in Chapter 6 of this manual. During design, the following should be considered to ensure ease of maintenance over the long-term:

- Do not put a filter sock on the underdrain. This is not necessary and can cause the BMP to clog.
- Install cleanouts. Cleanouts can be used for inspection (by camera) immediately following construction to ensure that the underdrain pipe was not crushed during construction. They can also be used to for ongoing maintenance practices. Consider locating cleanouts in the side slopes of the basin and above the depth of ponding.
- Provide vegetated side slopes to pre-treat runoff by filtering (straining). This will reduce the frequency of maintenance.

## Design Procedure and Criteria

The following steps outline the design procedure and criteria for a sand filter.

1. **Basin Storage Volume:** Provide a storage volume above the sand bed of the basin equal to the WQCV based on a 12-hour drain time.
  - Determine the imperviousness of the tributary area (or effective imperviousness where LID techniques are implemented). Determine the required WQCV (watershed inches of runoff) using Figure 3-2 in Chapter 3 of this manual. The volume should be based on a drain time of 12 hours.
  - Calculate the design volume as follows:

$$V = \left[ \frac{\text{WQCV}}{12} \right] A$$

Equation SF-1

Where:

$V$  = design volume (ft<sup>3</sup>)

$A$  = watershed area tributary to the sand filter (ft<sup>2</sup>)

2. **Basin Geometry:** Use equation SF-2 to calculate the minimum filter area, which is the flat surface of the sand filter. Sediment will reside on the filter area of the sand filter. Therefore, if the filter area is too small, the filter may clog prematurely. If this is of particular concern, increasing the filter area will decrease the frequency of maintenance. The following equation provides the minimum filter area allowing for some of the volume to be stored beyond the area of the filter. **Note that the total**

## Benefits

- Filtering BMPs provide effective water quality enhancement including phosphorus removal.

## Limitations

- This BMP may clog and require maintenance if a moderate to high level of silts and clays are allowed to flow into the facility.
- This BMP should not be located within 10 feet of a building foundation without an impermeable membrane. See *Bioretention* (BMP Fact Sheet T-3) of this manual for additional information.
- The sand filter should not be put into operation while construction or major landscaping activities are taking place in the watershed.

volume must also equal or exceed the design volume.

The side slopes of the basin should be stable and maintainable. For vegetated side slopes, a 4:1 (horizontal: vertical) minimum slope is recommended. Use vertical walls where side slopes are steeper than 3:1

$$A_F = 0.0125AI$$

Equation SF-2

Where:

$A_F$  = minimum filter area (flat surface area) (ft<sup>2</sup>)

$A$  = area tributary to the sand filter (ft<sup>2</sup>)

$I$  = imperviousness of area tributary to the sand filter (percent expressed as a decimal)

**Filter Material:** Provide, at a minimum, an 18-inch layer of CDOT Class B or C filter material (see Table SF-1). Maintain a flat surface on the top of the sand bed.

**Table SF-1. Gradation specifications for CDOT Class B or C filter material**  
(Source: CDOT Table 703-7)

	CDOT Class B filter material	CDOT Class C filter material
Sieve Size	Mass Percent Passing Square Mesh Sieves	
37.5 mm (1.5")	100	
19.0 mm (0.75")		100
4.75 mm (No.4)	20-60	60-100
1.18 mm (No. 16)	10-30	
300 um (No. 50)	0-10	10-30
150 um (No. 100)		0-10
75 um (No. 200)	0-3	0-3

4. **Underdrain System:** Underdrains are typically required for sand filters and should be provided if infiltration tests show rates slower than 2 times that required to drain the WQCV over 12 hours, or where required to divert water away from structures as determined by a professional engineer. Infiltration tests should be performed or supervised by a licensed professional engineer and conducted at a minimum depth equal to the bottom of the sand filter. Additionally, underdrains are required where impermeable membranes are used. There are three basic types of sand filters:
- **No-Infiltration Section:** This section includes an underdrain and an impermeable liner that prevents infiltration of stormwater into the subgrade soils. Consider using this section when any of the following conditions exist:
    - The site is a stormwater hotspot and infiltration could result in contamination of groundwater.
    - The site is located over contaminated soils and infiltration could mobilize these contaminants.
    - The facility is located over potentially expansive soils or bedrock that could swell due to infiltration and potentially damage adjacent structures (e.g., building foundation or pavement).
  - **Partial Infiltration Section:** This section does not include an impermeable liner, and allows some infiltration. Stormwater that does not infiltrate is collected and removed by an underdrain system.
  - **Full Infiltration Section:** This section is designed to infiltrate the water stored in the basin into the subgrade below. UDFCD recommends a minimum infiltration rate of 2 times the rate needed to drain the WQCV over 12 hours. A conservative design could utilize the partial infiltration section with the addition of a valve at the underdrain outlet. In the event that infiltration does not remain adequate following construction, the valve could be opened and allow this section to operate as a partial infiltration section. It is rare that sand filters are designed to fully infiltrate.

When using an underdrain system, provide a control orifice sized to drain the design volume in approximately 12 hours or more (see Equation SF-3). Use a minimum orifice size of 3/8 inch to avoid clogging. This will provide detention and slow release of the WQCV to offset hydromodification. Provide cleanouts to allow inspection of the drainpipe system during and after construction to ensure that the pipe was not crushed or disconnected during construction and to allow for maintenance of the underdrain. Space underdrain pipes a maximum of 20 feet on-center.

$$D_{12 \text{ hour drain time}} = \sqrt{\frac{V}{1414 y^{0.41}}} \quad \text{Equation SF-3}$$

Where:

$D$  = orifice diameter (in)

$y$  = distance from the lowest elevation of the storage volume (ft) (i.e., surface of the filter) to the center of the orifice

$V$  = volume to drain in 12 hours (WQCV) (ft<sup>3</sup>)

In previous versions of this manual, UDFCD recommended that the underdrain be placed in an aggregate layer and that a geotextile (separator fabric) be placed between this aggregate and the growing medium. This version of the manual replaces that section with materials that, when used

together, eliminate the need for a separator fabric.

The underdrain system should be placed below the 18-inch (minimum) filter layer. The underdrain system should be placed within an 5-inch-thick section of CDOT Class C filter material meeting the gradation in Table SF-1. Areas of the underdrain layer may be deeper due to the slope of the underdrain. If no underdrain is required, the minimum section can be reduced to the 18-inch filter layer. Use slotted pipe that meets the slot dimensions provided in Table SF-2.

**Table SF-2. Dimensions for Slotted Pipe<sup>1</sup>**

Pipe Size	Slot Length	Maximum Slot Width	Slot Centers	Open Area (per foot)
4"	1-1/16"	0.032"	0.413"	1.90 in <sup>2</sup>
6"	1-3/8"	0.032"	0.516"	1.98 in <sup>2</sup>

<sup>1</sup> Pipe must conform to requirements of ASTM designation F949. There shall be no evidence of splitting, cracking, or breaking when the pipe is tested per ASTM test method D2412 in accordance with F949 section 7.5 and ASTM F794 section 8.5. Contech A-2000 slotted pipe (or equal).

**Table SF-3. Physical Requirements for Separator Fabric<sup>1</sup>**

Property	Class B		Test Method
	Elongation < 50% <sup>2</sup>	Elongation > 50% <sup>2</sup>	
Grab Strength, N (lbs)	800 (180)	510 (115)	ASTM D 4632
Puncture Resistance, N (lbs)	310 (70)	180 (40)	ASTM D 4833
Trapezoidal Tear Strength, N (lbs)	310 (70)	180 (40)	ASTM D 4533
Apparent Opening Size, mm (US Sieve Size)	AOS < 0.3mm (US Sieve Size No. 50)		ASTM D 4751
Permittivity, sec <sup>-1</sup>	0.02 default value, must also be greater than that of soil		ASTM D 4491
Permeability, cm/sec	k fabric > k soil for all classes		ASTM D 4491
Ultraviolet Degradation at 500 hours	50% strength retained for all classes		ASTM D 4355

<sup>1</sup> Strength values are in the weaker principle direction

<sup>2</sup> As measured in accordance with ASTM D 4632

5. **Impermeable Geomembrane Liner and Geotextile Separator Fabric:** For no-infiltration sections, install a minimum 30-mil thick PVC geomembrane liner, per Table SF-4, on the bottom and sides of the basin, extending up at least to the top of the underdrain layer. Provide at least 9 inches (12 inches if possible) of cover over the membrane where it is attached to the wall to protect the membrane from UV deterioration. The geomembrane should be field-seamed using a dual track welder, which allows for non-destructive testing of almost all field seams. A small amount of single track and/or adhesive seaming should be allowed in limited areas to seam around pipe perforations, to patch seams removed for destructive seam testing, and for limited repairs. The liner should be installed with slack to prevent tearing due to backfill, compaction, and settling. Place CDOT Class B geotextile separator fabric above the geomembrane to protect it from being punctured during the placement of the filter material above the liner. If the subgrade contains angular rocks or other material that could puncture the geomembrane, smooth-roll the surface to create a suitable surface. If smooth-rolling the surface does not provide a suitable surface, also place the separator fabric between the geomembrane and the underlying subgrade. This should only be done when necessary because fabric placed under the geomembrane can increase seepage losses through pinholes or other geomembrane defects. Connect the geomembrane to perimeter concrete walls around the basin perimeter, creating a watertight seal between the geomembrane and the walls using a continuous batten bar and anchor connection (see Figure SF-3). Where the need for the impermeable membrane is not as critical, the membrane can be attached with a nitrile-based vinyl adhesive. Use watertight PVC boots for underdrain pipe penetrations through the liner (see Figure SF-2).

**Table SF-4. Physical Requirements for Geomembrane**

Property	Thickness 0.76 mm (30 mil)	Test Method
Thickness, % Tolerance	±5	ASTM D 1593
Tensile Strength, kN/m (lbs/in) width	12.25 (70)	ASTM D 882, Method B
Modulus at 100% Elongation, kN/m (lbs/in)	5.25 (30)	ASTM D 882, Method B
Ultimate Elongation, %	350	ASTM D 882, Method A
Tear Resistance, N (lbs)	38 (8.5)	ASTM D 1004
Low Temperature Impact, °C (°F)	-29 (-20)	ASTM D 1790
Volatile loss, % max.	0.7	ASTM D 1203, Method A
Pinholes, No. Per 8 m <sup>2</sup> (No. per 10 sq. yds.) max.	1	N/A
Bonded Seam Strength, % of tensile strength	80	N/A

6. **Inlet Works:** Provide energy dissipation and a forebay at all locations where concentrated flows enter the basin. Use an impact basin for pipes and a baffle chute or grouted sloping boulder drop if a channel or swale is used, or install a Type VL or L riprap basin underlain with geotextile fabric at the inlet (see Figure SF-1). Fill all rock voids with the filter material specified in Table SF-1.



7. **Outlet Works:** Slope the underdrain into a larger outlet structure. As discussed in Step 4, use an orifice plate to drain the WQCV over approximately 12 hours. Flows exceeding the WQCV should also drain into the outlet structure. Additional flow restrictions may be incorporated to provide full spectrum detention, as discussed in the *Storage* chapter of Volume 2, or peak reduction for other specific storm events.

For full spectrum detention, perform reservoir routing calculations to design the outlet structure. The *UD-Detention* workbook, available at [www.udfcd.org](http://www.udfcd.org), can be used for this purpose. The design could include a second orifice located at the WQCV elevation or could include a downstream point of control designed to drain the full excess urban runoff volume (EURV).

## Construction Considerations

Proper construction of sand filters involves careful attention to material specifications and construction details. For a successful project, do the following:

- Protect area from excessive sediment loading during construction. The portion of the site draining to the sand filter must be stabilized before allowing flow into the sand filter.
- When using an impermeable liner, ensure enough slack in the liner to allow for backfill, compaction, and settling without tearing the liner.

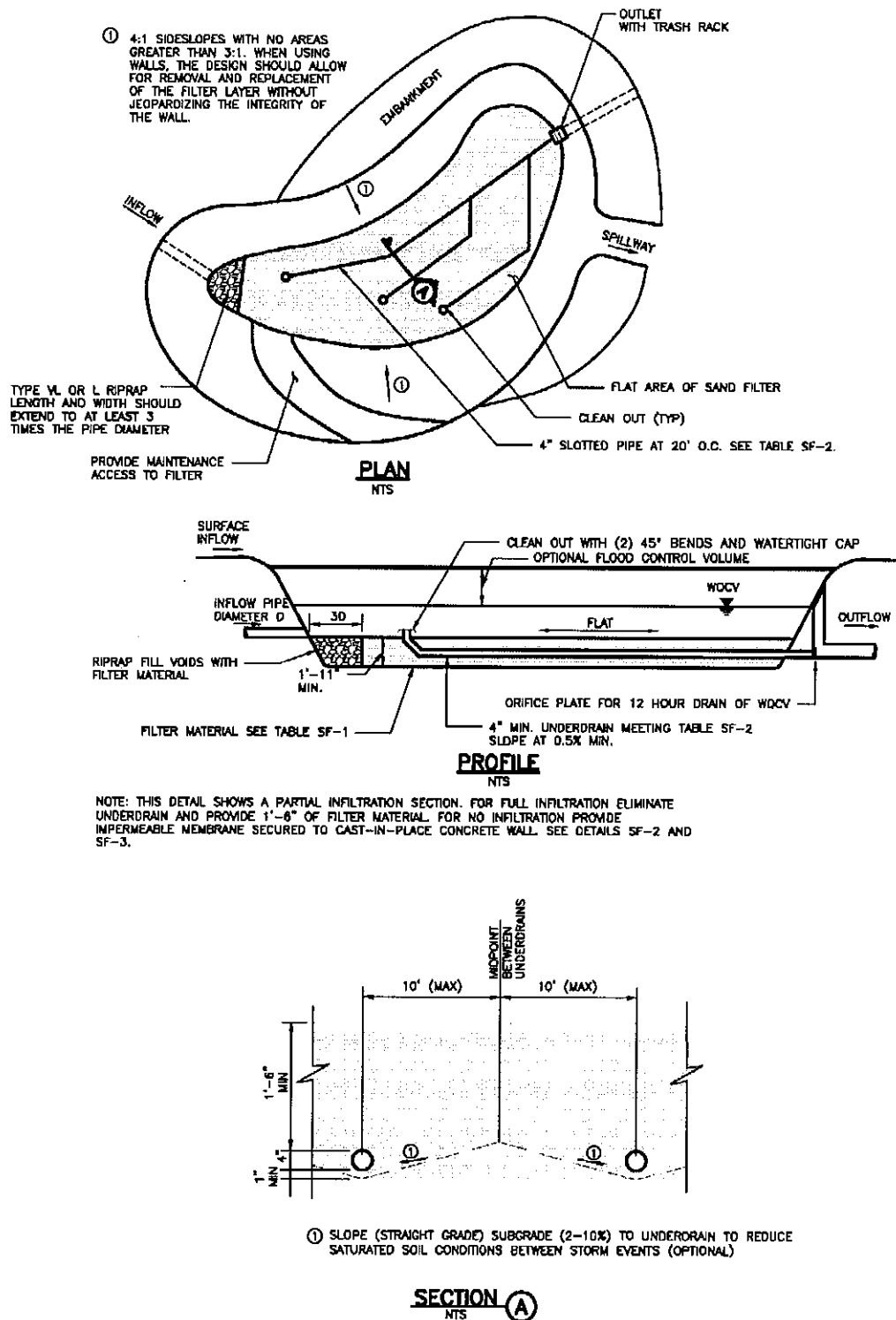
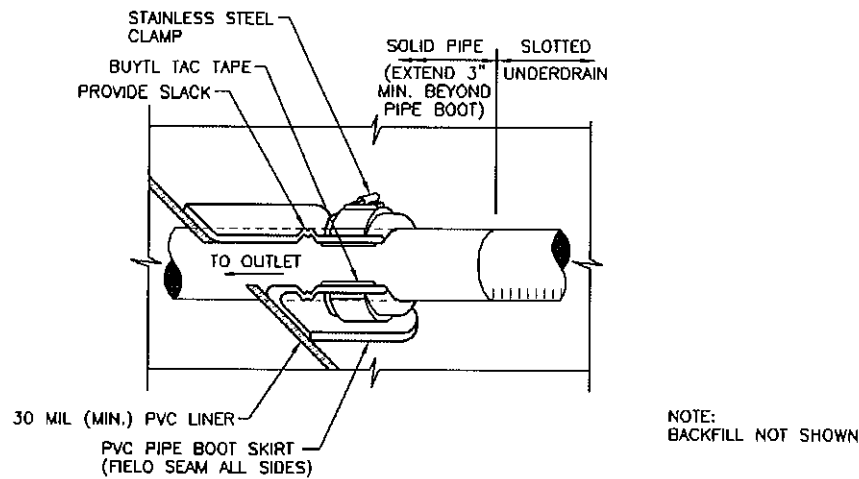
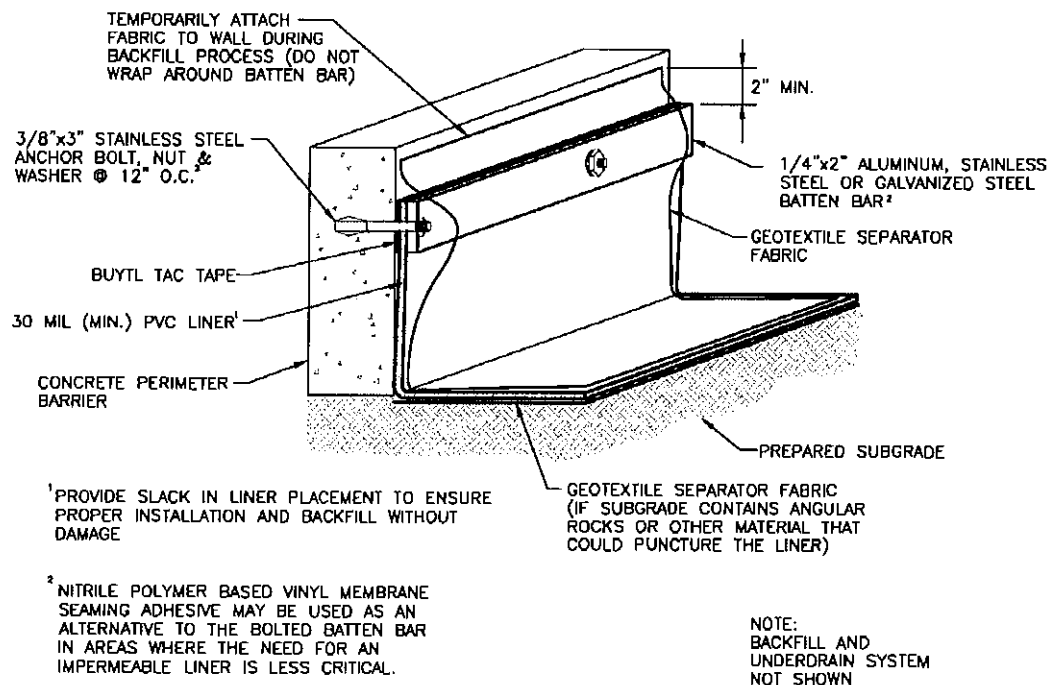


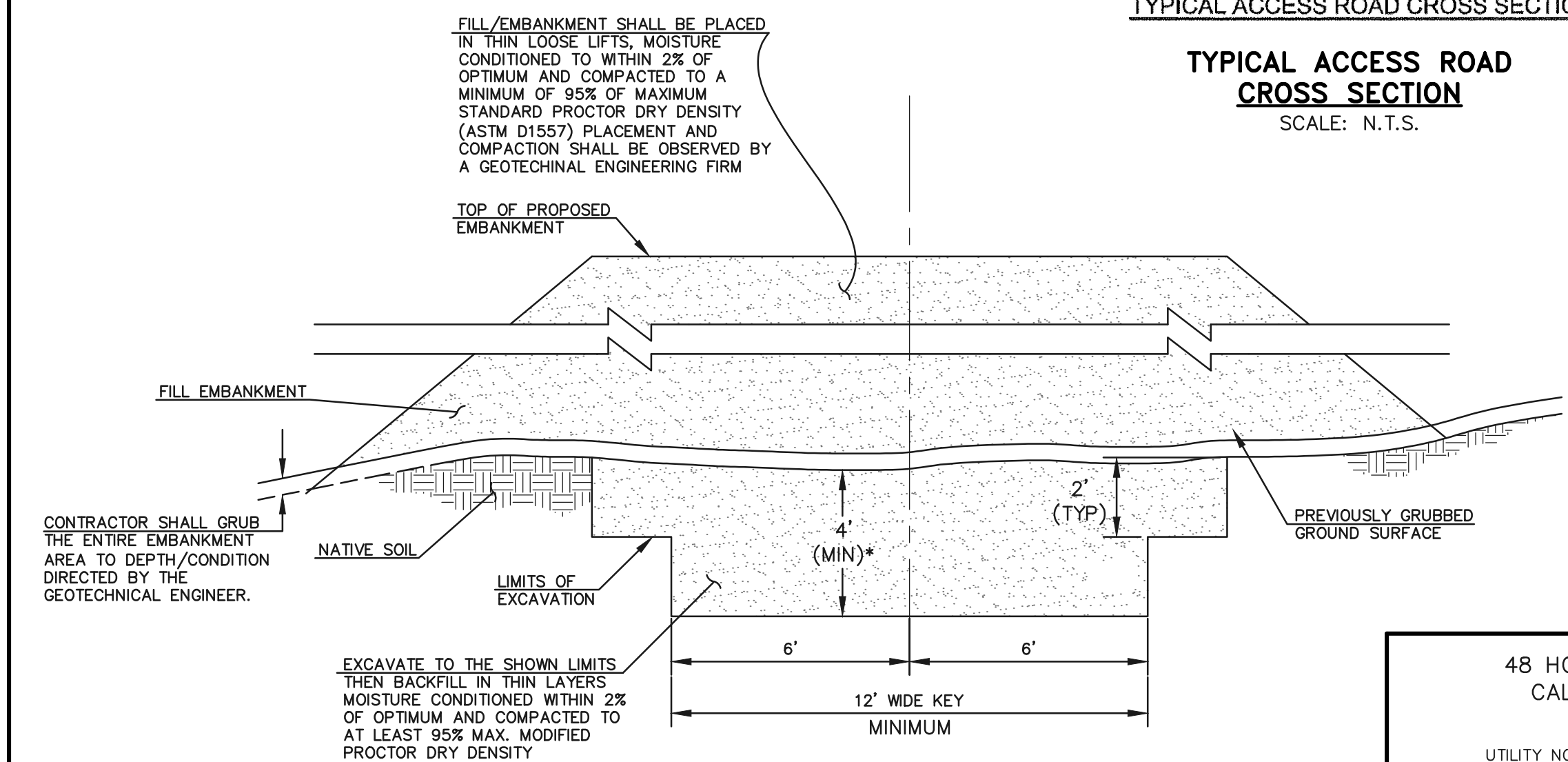
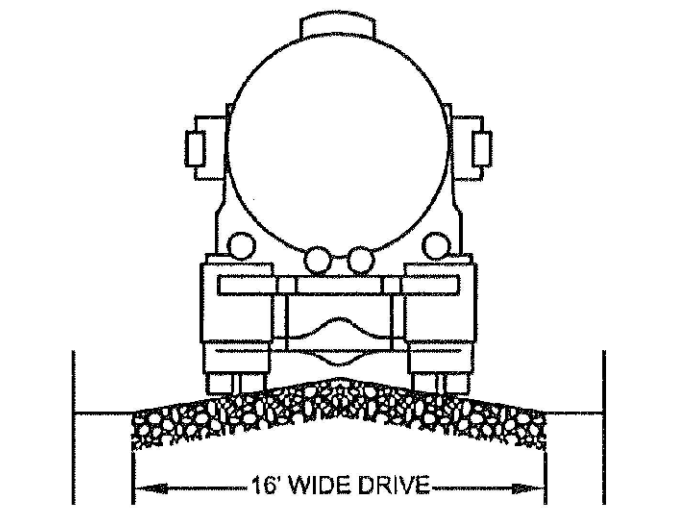
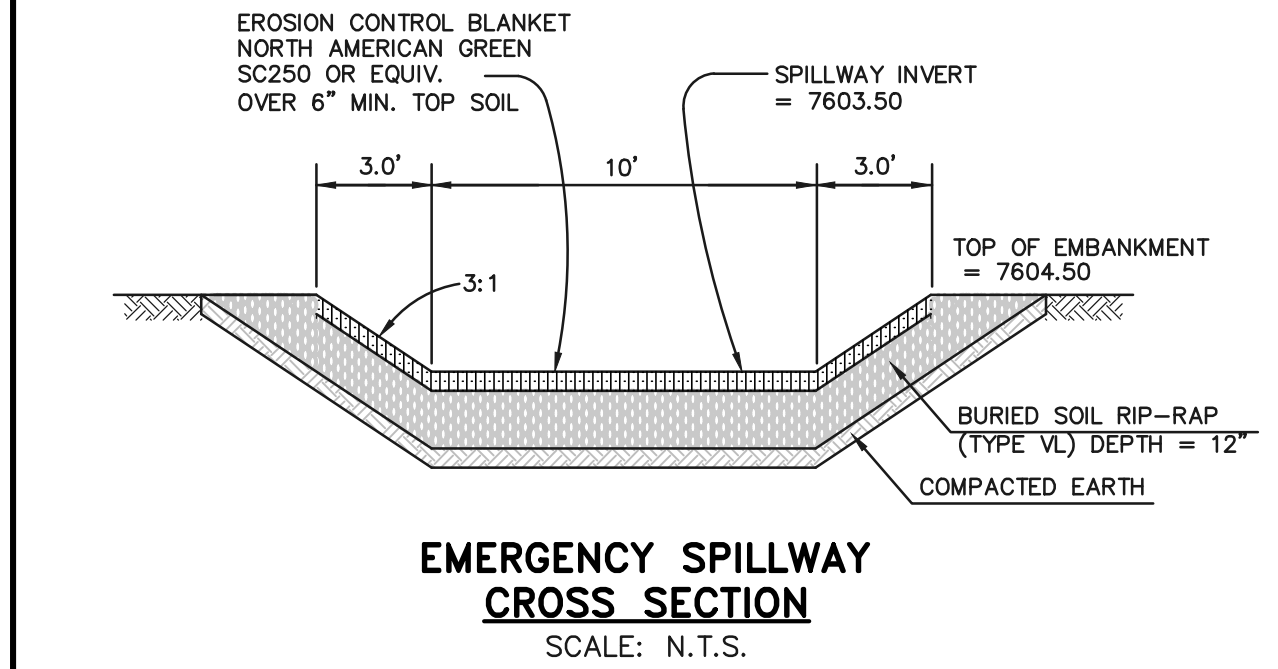
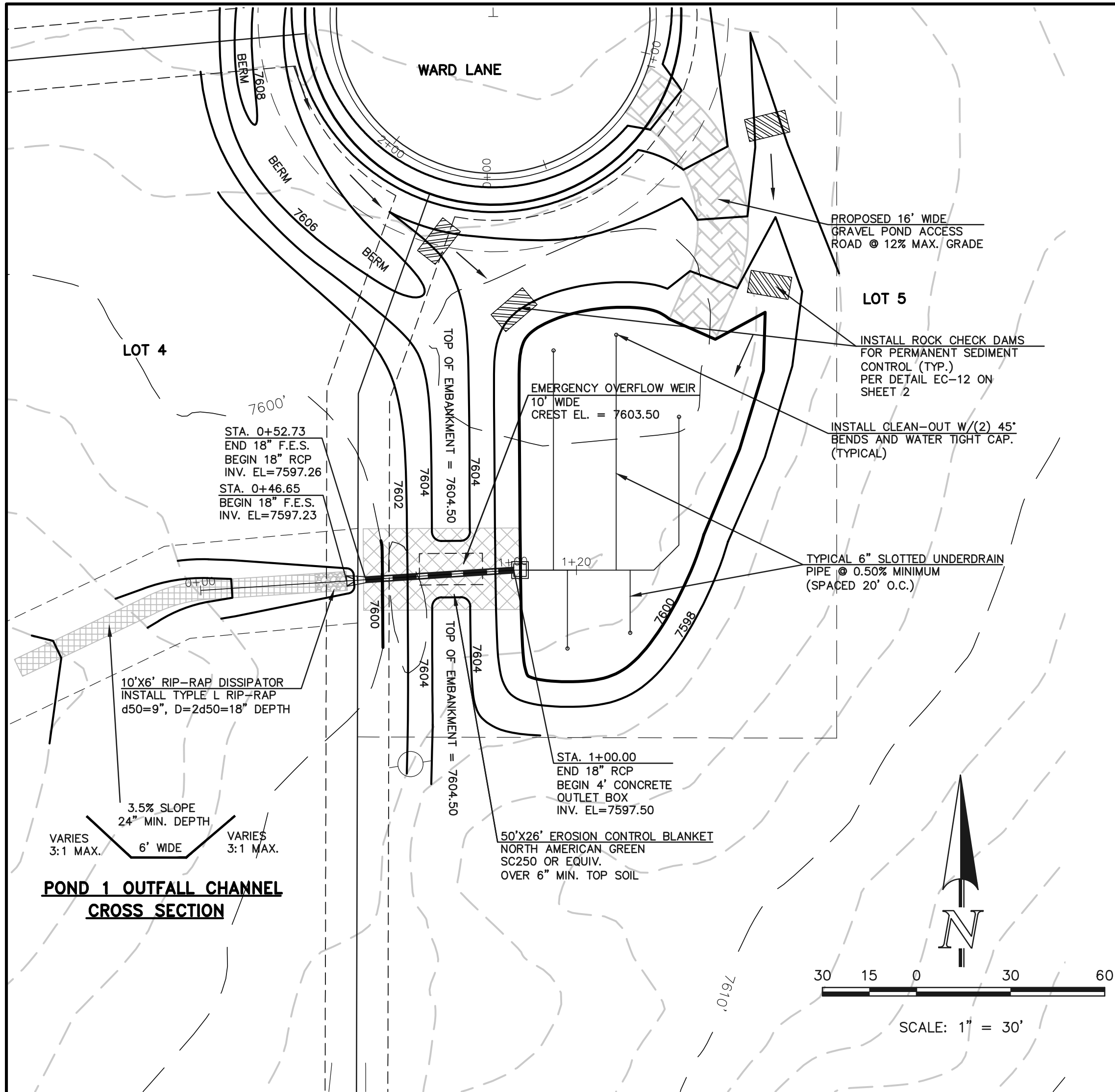
Figure SF-1. Sand Filter Plan and Sections



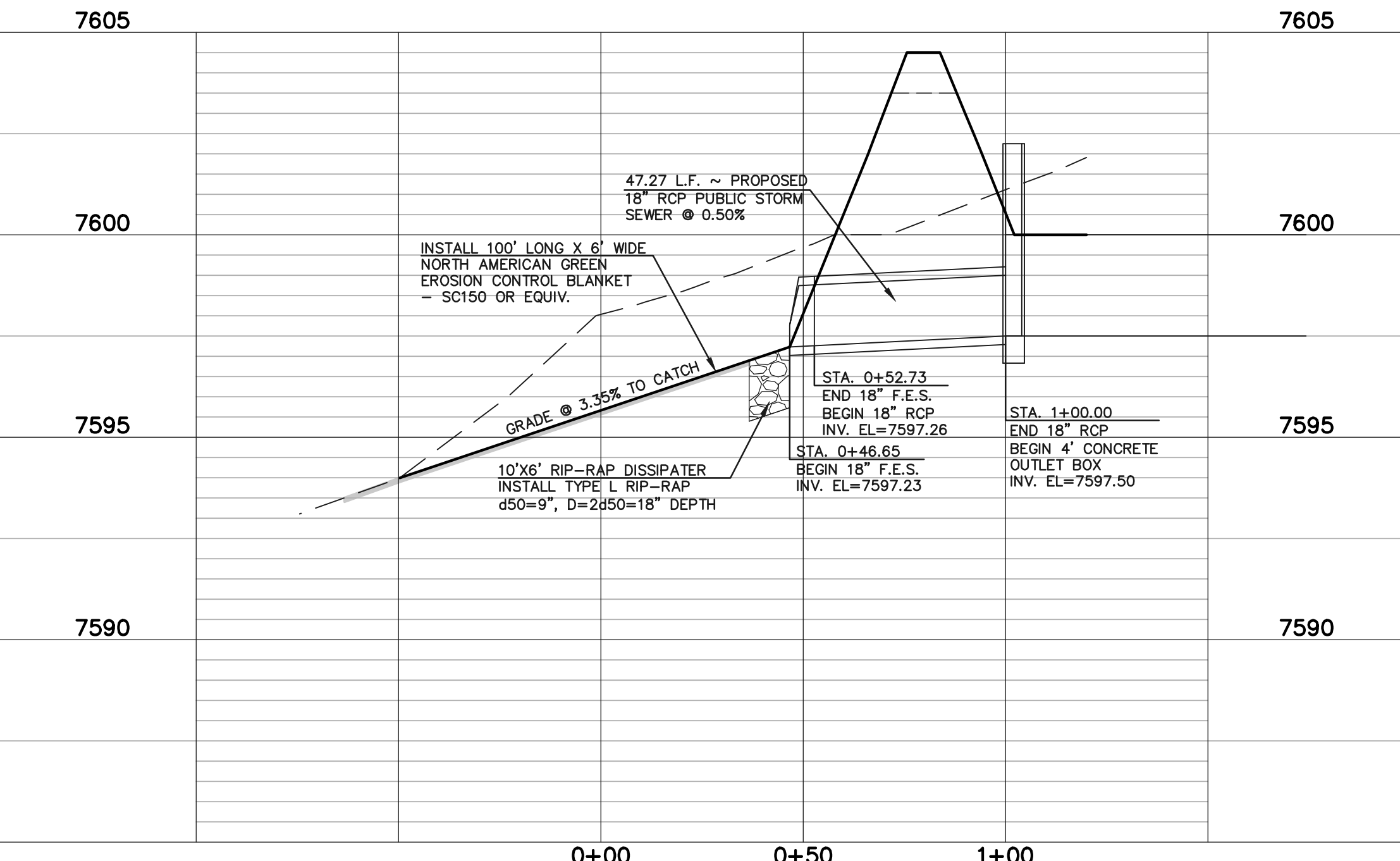
**Figure SF-2. Geomembrane Liner/Underdrain Penetration Detail**



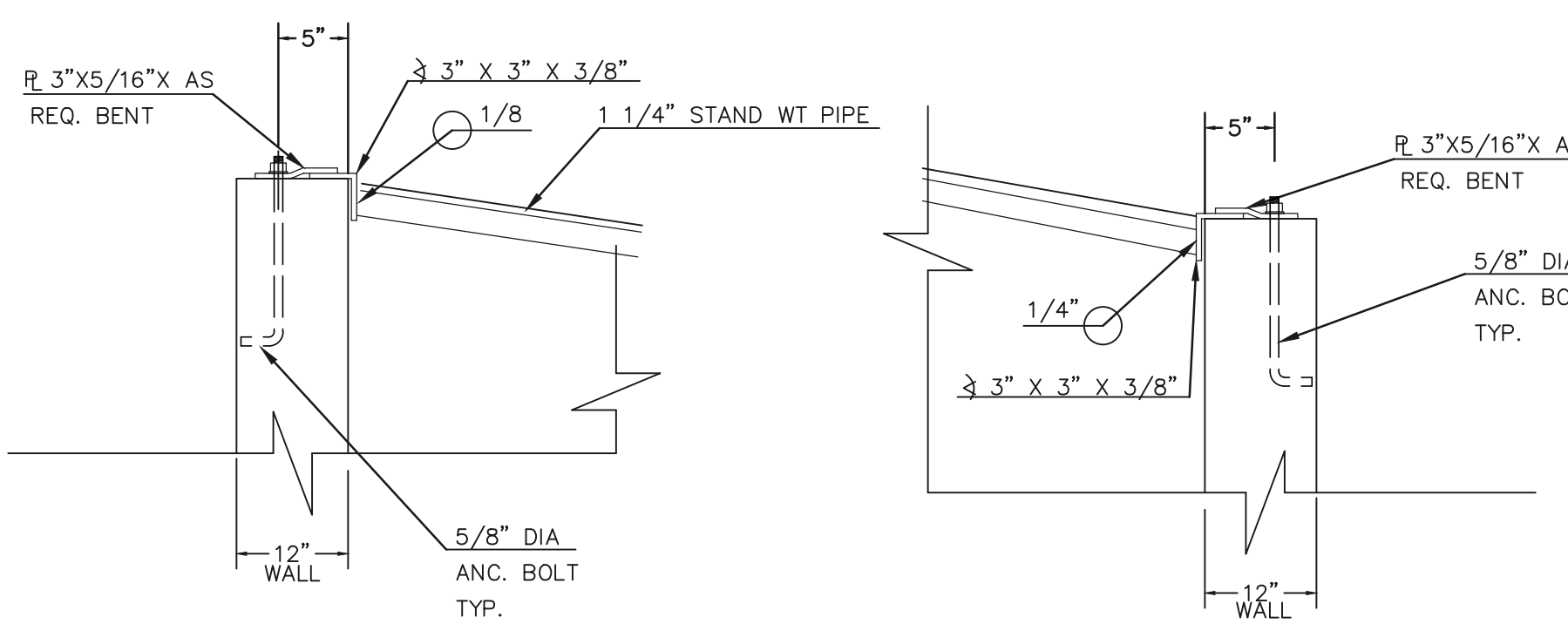
**Figure SF-3. Geomembrane Liner/Concrete Connection Detail**



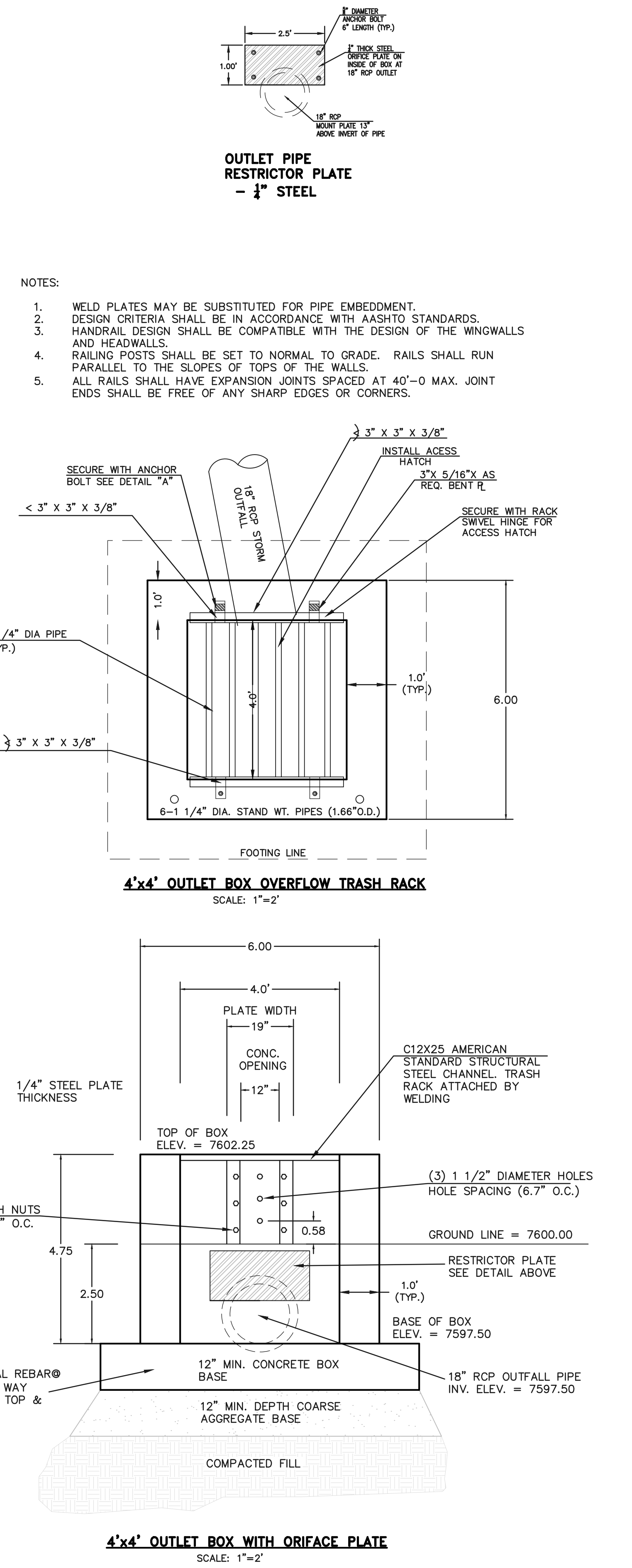
SECTION A  
TYPICAL EMBANKMENT  
WITH SOIL KEYWAY  
SCALE: N.T.S.



SAND FILTER BASIN 1 ~ 18" RCP POND OUTLET PROFILE  
SCALE: HORIZONTAL 1"=30'  
VERTICAL 1"=3'



- (ALL MATERIALS PER TOWN OF MONUMENT SPECIFICATIONS)
- ORIFICE PLATE NOTES:
- INSTALL HOLES AS SHOWN ON DETAIL TO LEFT.
  - PROVIDE GASKET MATERIAL BETWEEN THE ORIFICE PLATE AND CONCRETE
- EURV AND WQCV TRASH RACKS:
- WELL-SCREEN TRASH RACKS SHALL BE STAINLESS STEEL AND SHALL BE ATTACHED BY INTERMITTENT WELDS ALONG THE EDGE OF THE MOUNTING FRAME.
  - BAR GRATE TRASH RACKS SHALL BE ALUMINUM AND SHALL BE BOLTED USING STAINLESS STEEL HARDWARE.
  - STRUCTURAL DESIGN OF TRASH RACKS SHALL BE BASED ON FULL HYDROSTATIC HEAD WITH ZERO HEAD DOWNSTREAM OF RACK
- OVERFLOW TRASH RACKS:
- ALL TRASH RACKS SHALL BE MOUNTED USING STAINLESS STEEL HARDWARE AND PROVIDED WITH HINGED AND LOCKABLE OR BOLTABLE ACCESS PANELS
  - TRASH RACKS SHALL BE STAINLESS STEEL, ALUMINUM, OR STEEL. STEEL TRASH RACKS SHALL BE HOT DIP GALVANIZED AND MAY BE HOT POWDER COATED AFTER GALVANIZING.
  - TRASH RACKS SHALL BE DESIGNED SUCH THAT THE DIAGONAL DIMENSION OF EACH OPENING IS SMALLER THAN THE DIAMETER OF THE OUTLET PIPE.
  - STRUCTURAL DESIGN OF THE TRASH RACKS SHALL BE BASED ON FULL HYDROSTATIC HEAD WITH ZERO HEAD DOWNSTREAM OF THE RACK.



REDTAIL RANCH FILING NO. 1  
DRAINAGE IMPROVEMENT PLANS  
SAND FILTER BASIN 1  
POND PLAN AND DETAILS

DESIGNED BY	MAW	SCALE	DATE	07-03-18
DRAWN BY	MAW	(H) 1"= 30'	SHEET	9 OF 10
CHECKED BY		(V) 1"= N/A	JOB NO.	2525.00

CLASSIC  
CONSULTING  
ENGINEERS & SURVEYORS

619 N. Cascade Avenue, Suite 200  
Colorado Springs, Colorado 80903  
(719)785-0790  
(719)785-0799(Fax)

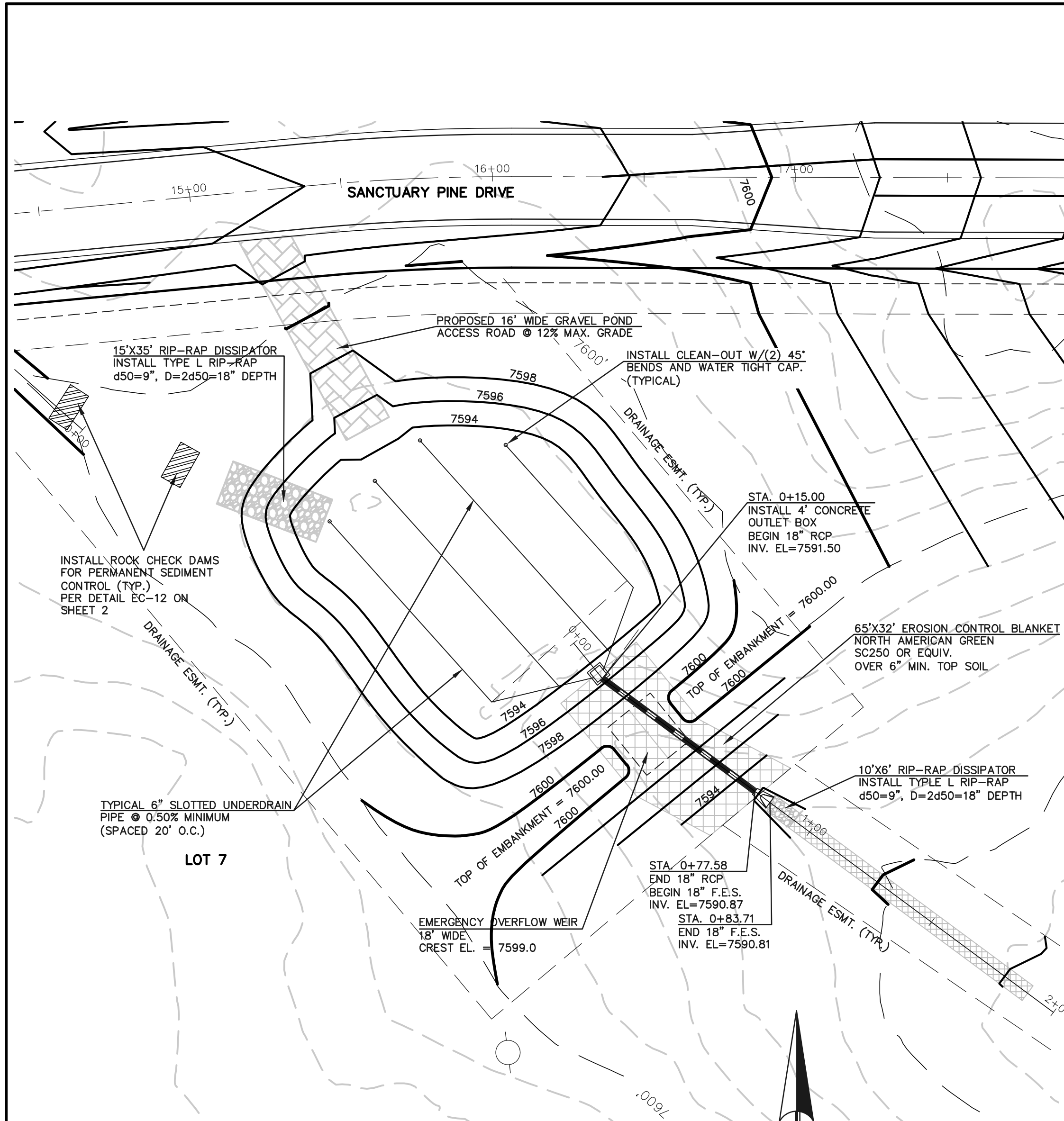
REVIEW:

PREPARED UNDER MY DIRECT SUPERVISION FOR AND ON BEHALF OF  
CLASSIC CONSULTING ENGINEERS AND SURVEYORS, LLC

MARC A. WHORTON, COLORADO P.E. #37155

DATE

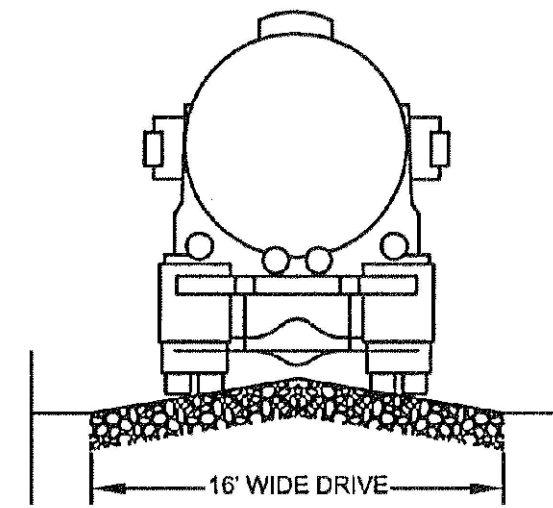
N:\252500\DRAWINGS\CONSTRUCT\RDN\252500-POND 1-09.dwg, 1/28/2019 11:55:04 AM, 1:1



DETENTION FACILITY NO. 2



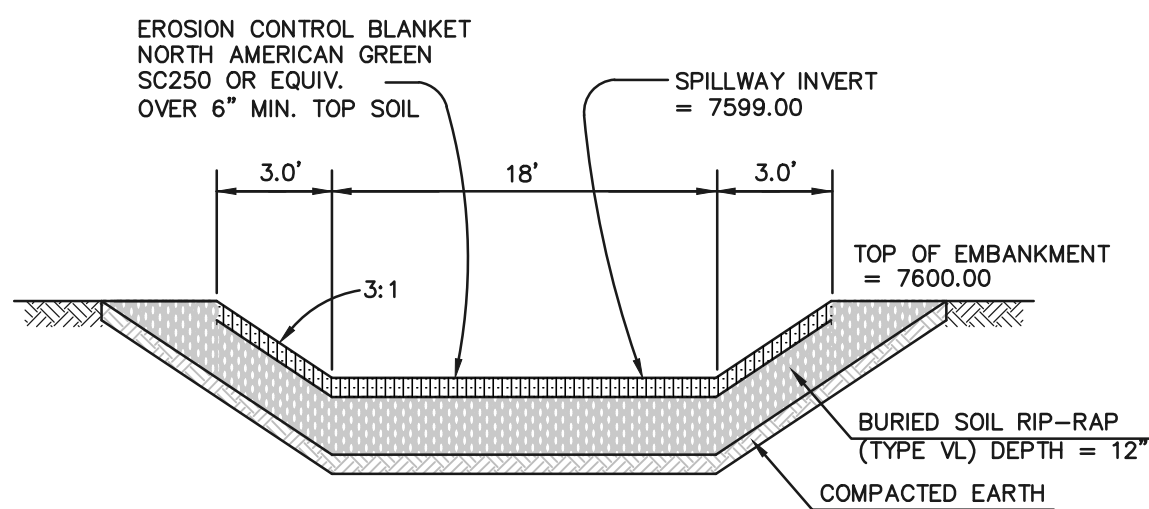
SCALE: 1" = 30'



TYPICAL ACCESS ROAD CROSS SECTION

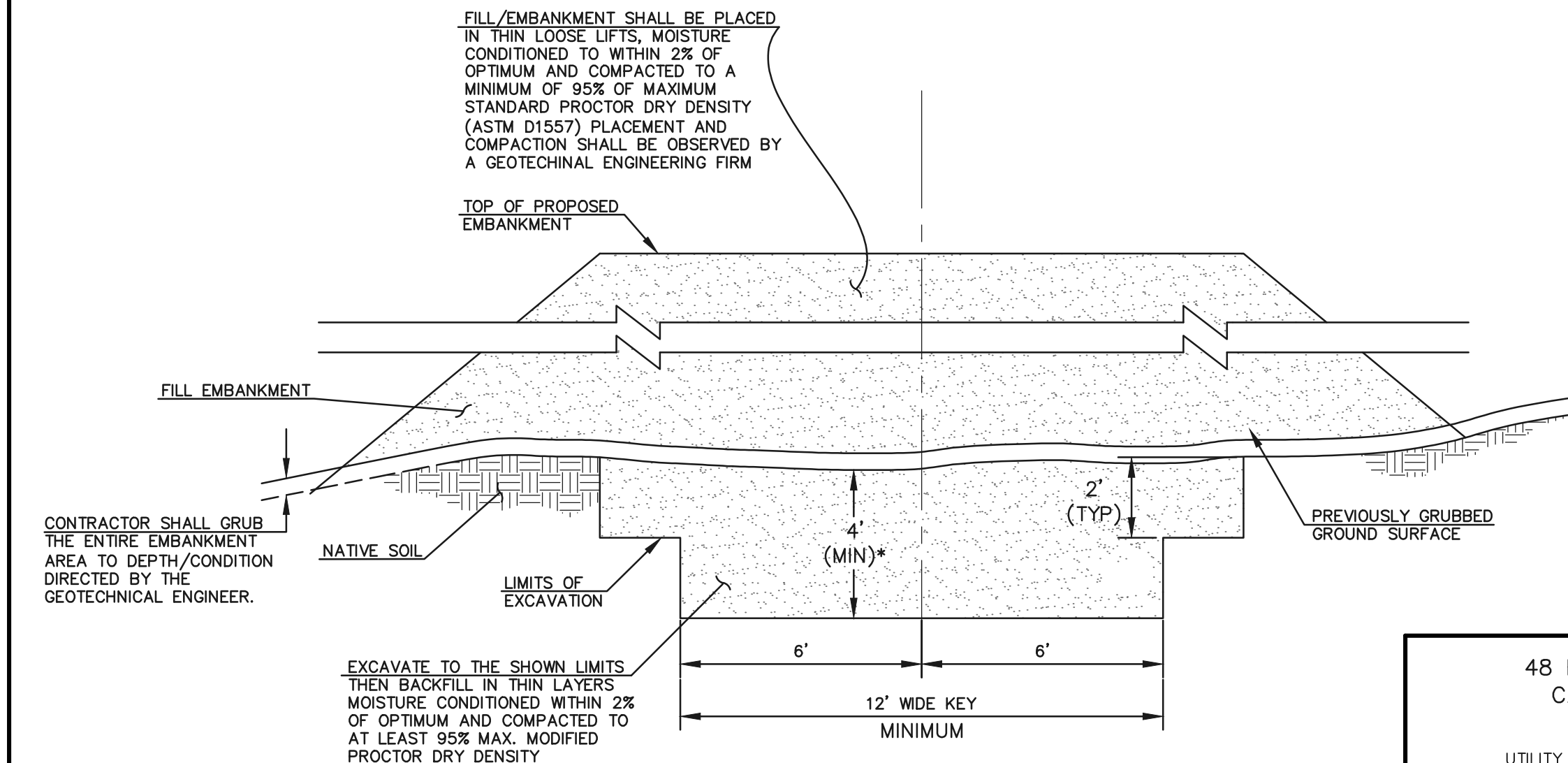
TYPICAL ACCESS ROAD CROSS SECTION

SCALE: N.T.S.



EMERGENCY SPILLWAY CROSS SECTION

SCALE: N.T.S.



SECTION A  
TYPICAL EMBANKMENT  
WITH SOIL KEYWAY

SCALE: N.T.S.

48 HOURS BEFORE YOU DIG,  
CALL UTILITY LOCATORS  
**811**

UTILITY NOTIFICATION CENTER OF COLORADO  
IT'S THE LAW

THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK. THE CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE CAUSED BY HIS FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.

NO. REVISION

DATE

1 REVISED PER COUNTY COMMENTS  
2 REVISED PER COUNTY COMMENTS

11-14-18  
1-14-19

REVIEW:

PREPARED UNDER MY DIRECT SUPERVISION FOR AND ON BEHALF OF  
CLASSIC CONSULTING ENGINEERS AND SURVEYORS, LLC

MARC A. WHORTON, COLORADO P.E. #37155

DATE

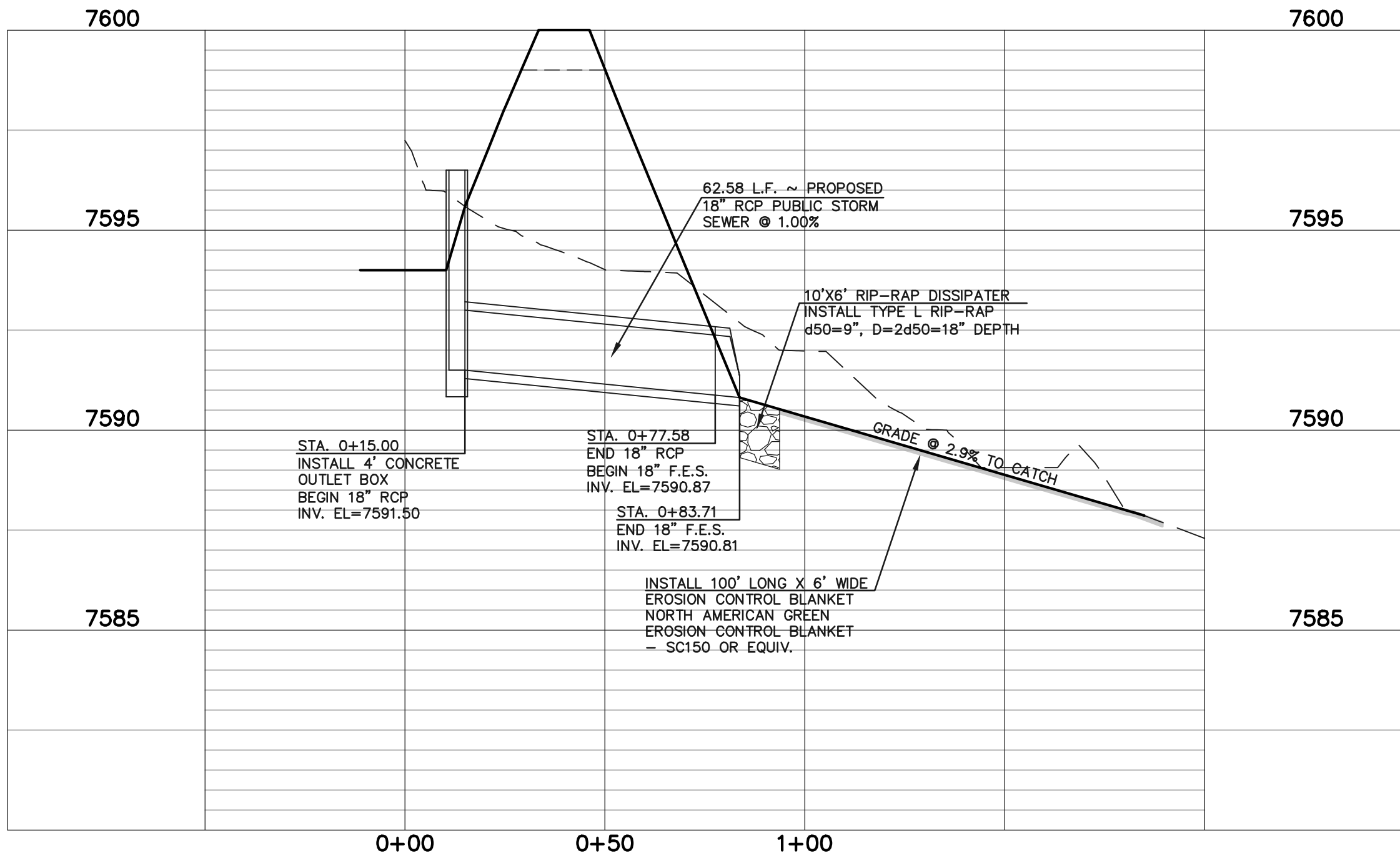


619 N. Cascade Avenue, Suite 200  
Colorado Springs, Colorado 80903  
(719) 785-0790  
(719) 785-0799 (Fax)

RETAIL RANCH FILING NO. 1  
DRAINAGE IMPROVEMENT PLANS

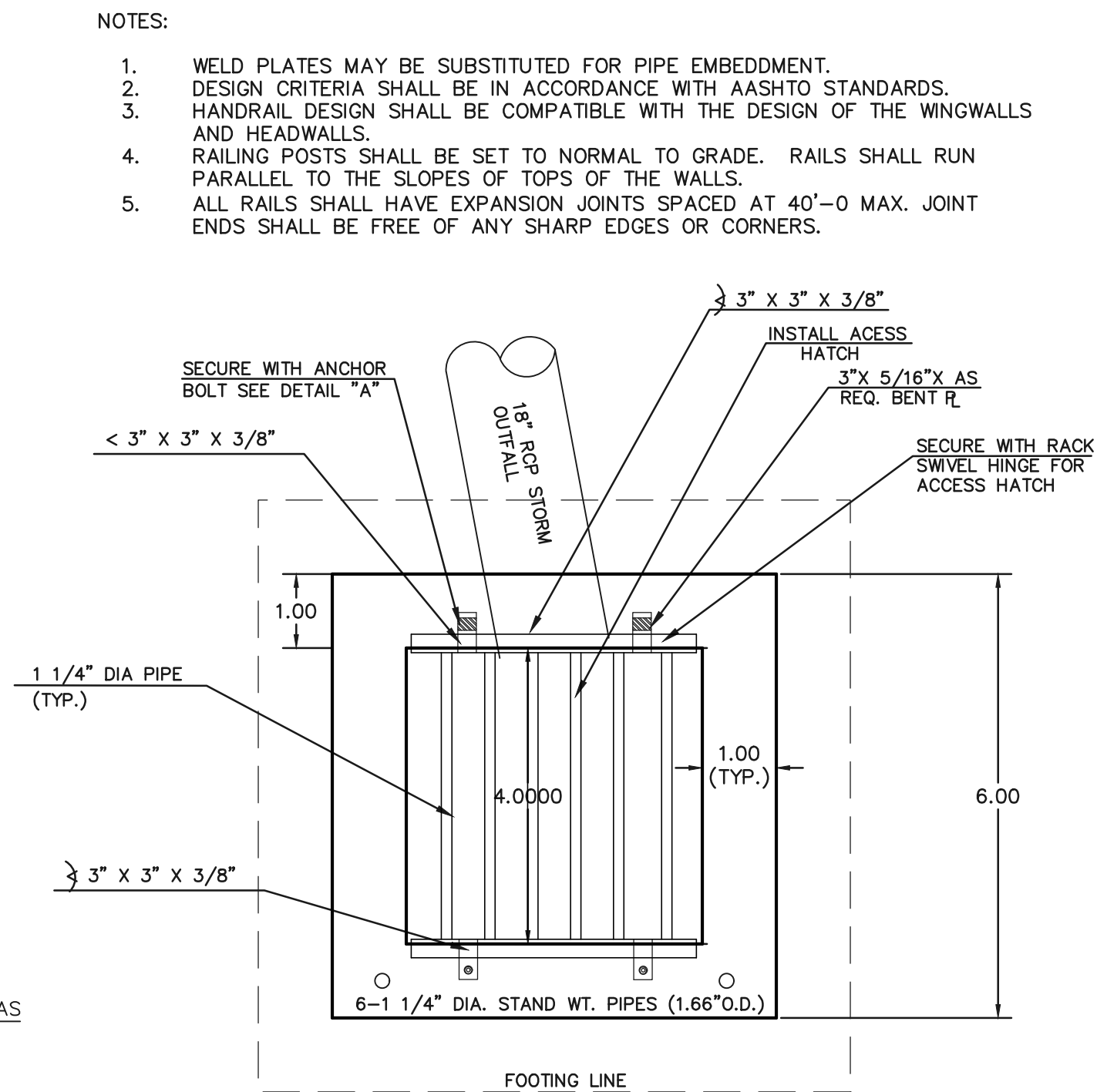
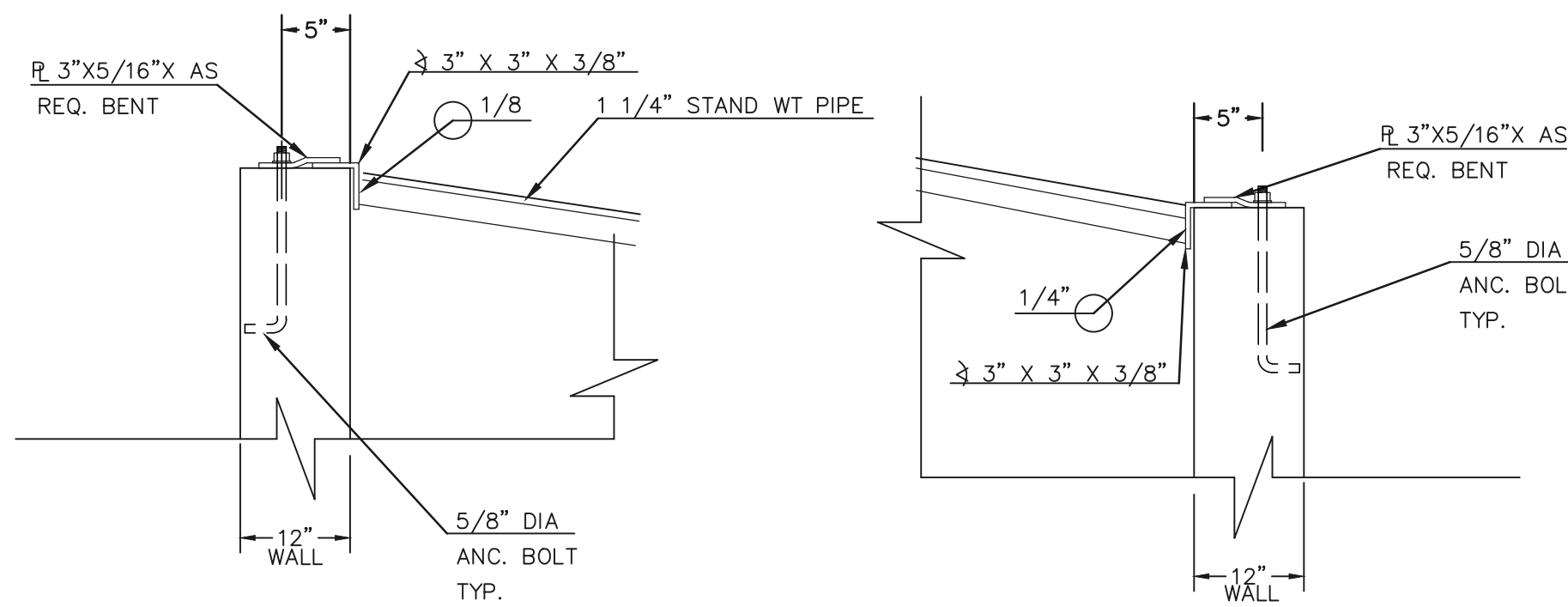
DETENTION FACILITY NO. 2  
POND PLAN

DESIGNED BY	MAW	SCALE	DATE	07-03-18
DRAWN BY	MAW	(H) 1"= 30'	SHEET	10 OF 10
CHECKED BY		(V) 1"= N/A	JOB NO.	2525.00



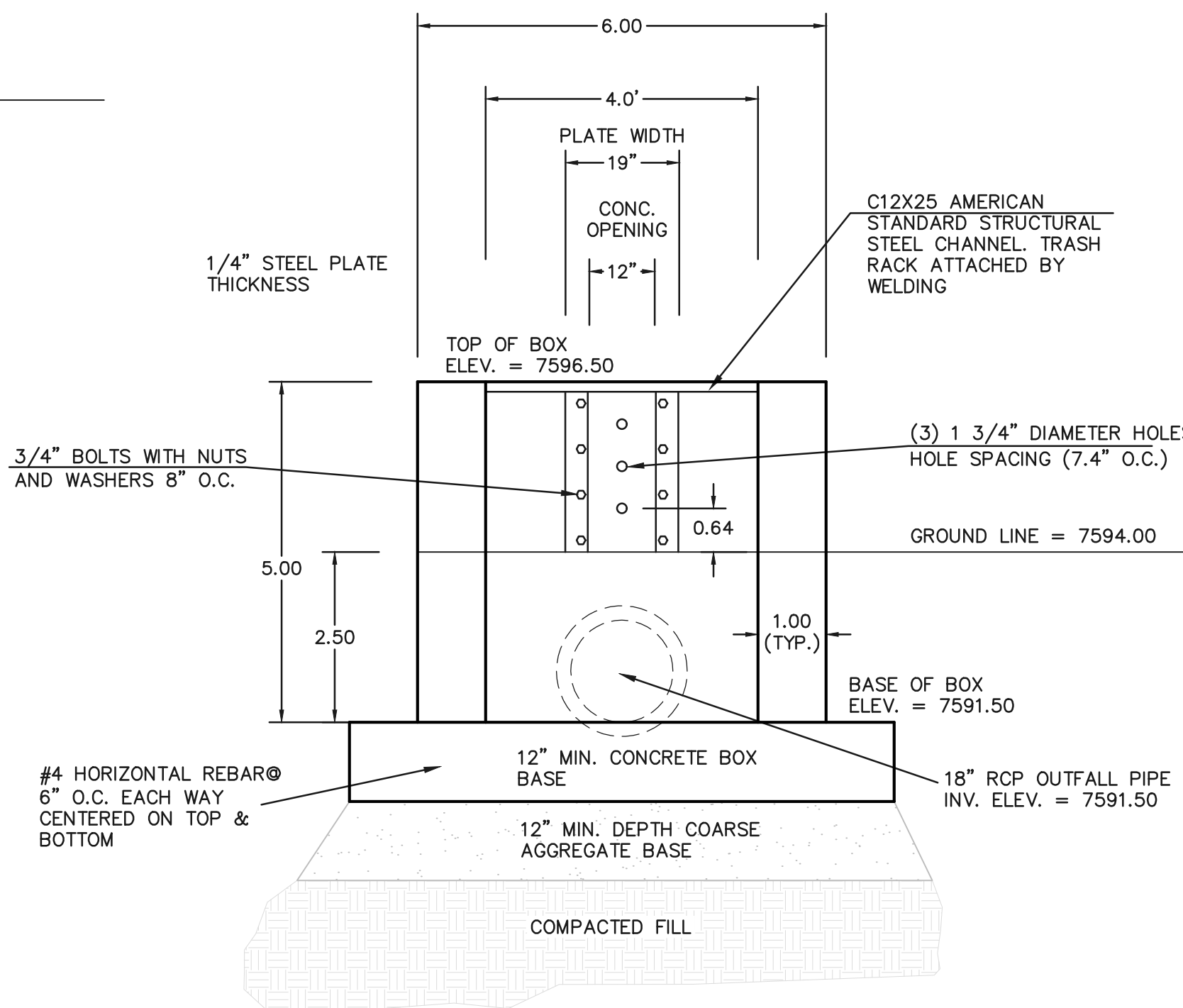
DETENTION FACILITY NO. 2 ~ 18" RCP POND OUTLET PROFILE

SCALE: HORIZONTAL 1"=30'  
VERTICAL 1"=3'



4'x4' OUTLET BOX OVERFLOW TRASH RACK

SCALE: 1"=2'



4'x4' OUTLET BOX WITH ORIFACE PLATE

SCALE: 1"=2'

(ALL MATERIALS PER TOWN OF MONUMENT SPECIFICATIONS)

ORIFICE PLATE NOTES:

1. INSTALL HOLES AS SHOWN ON DETAIL TO LEFT.
2. PROVIDE GASKET MATERIAL BETWEEN THE ORIFICE PLATE AND CONCRETE

EURV AND WQCV TRASH RACKS:

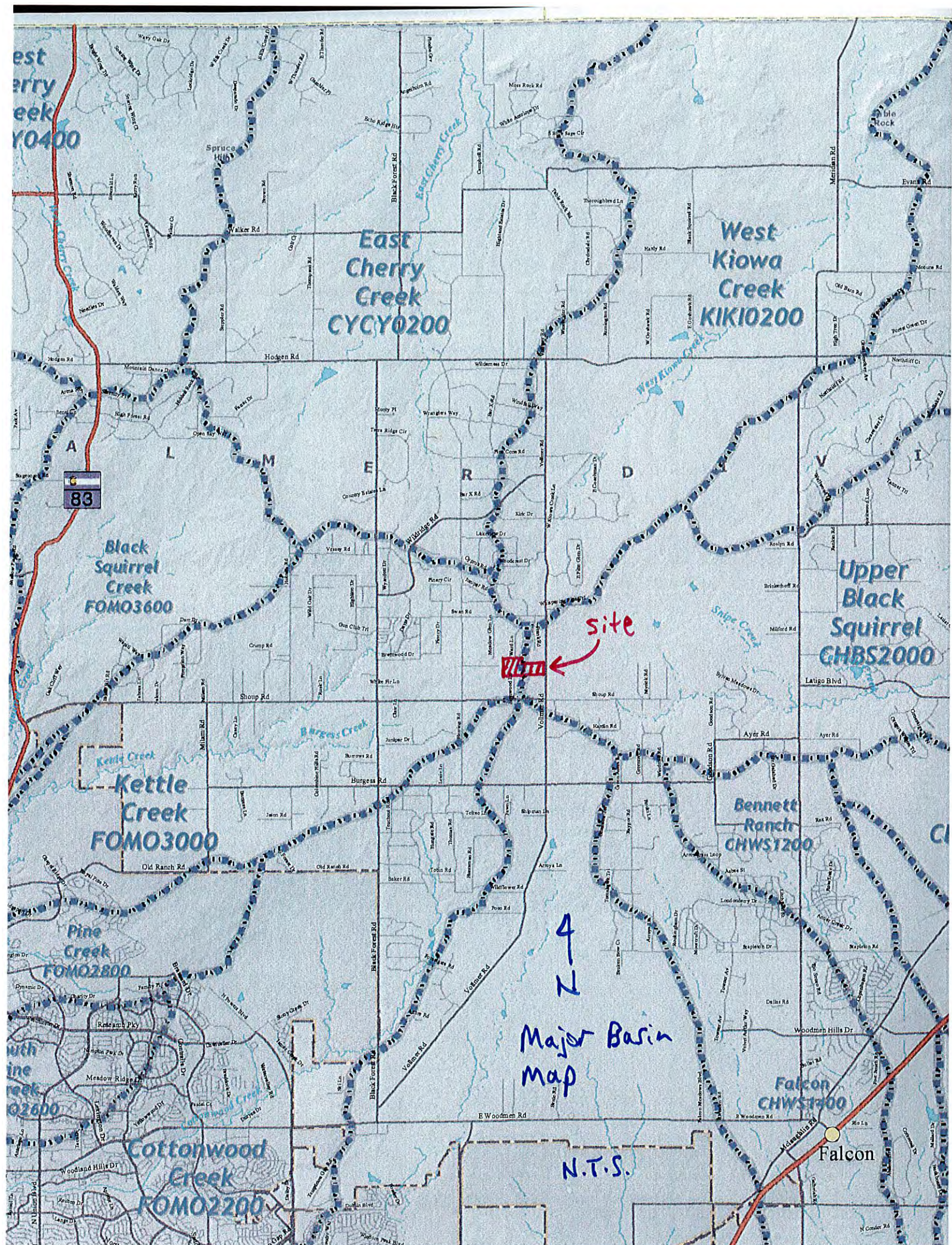
3. WELL-SCREEN TRASH RACKS SHALL BE STAINLESS STEEL AND SHALL BE ATTACHED BY INTERMITTENT WELDS ALONG THE EDGE OF THE MOUNTING FRAME.
4. BAR GRATE TRASH RACKS SHALL BE ALUMINUM AND SHALL BE BOLTED USING STAINLESS STEEL HARDWARE.
5. STRUCTURAL DESIGN OF TRASH RACKS SHALL BE BASED ON FULL HYDROSTATIC HEAD WITH ZERO HEAD DOWNSTREAM OF RACK

OVERFLOW TRASH RACKS:

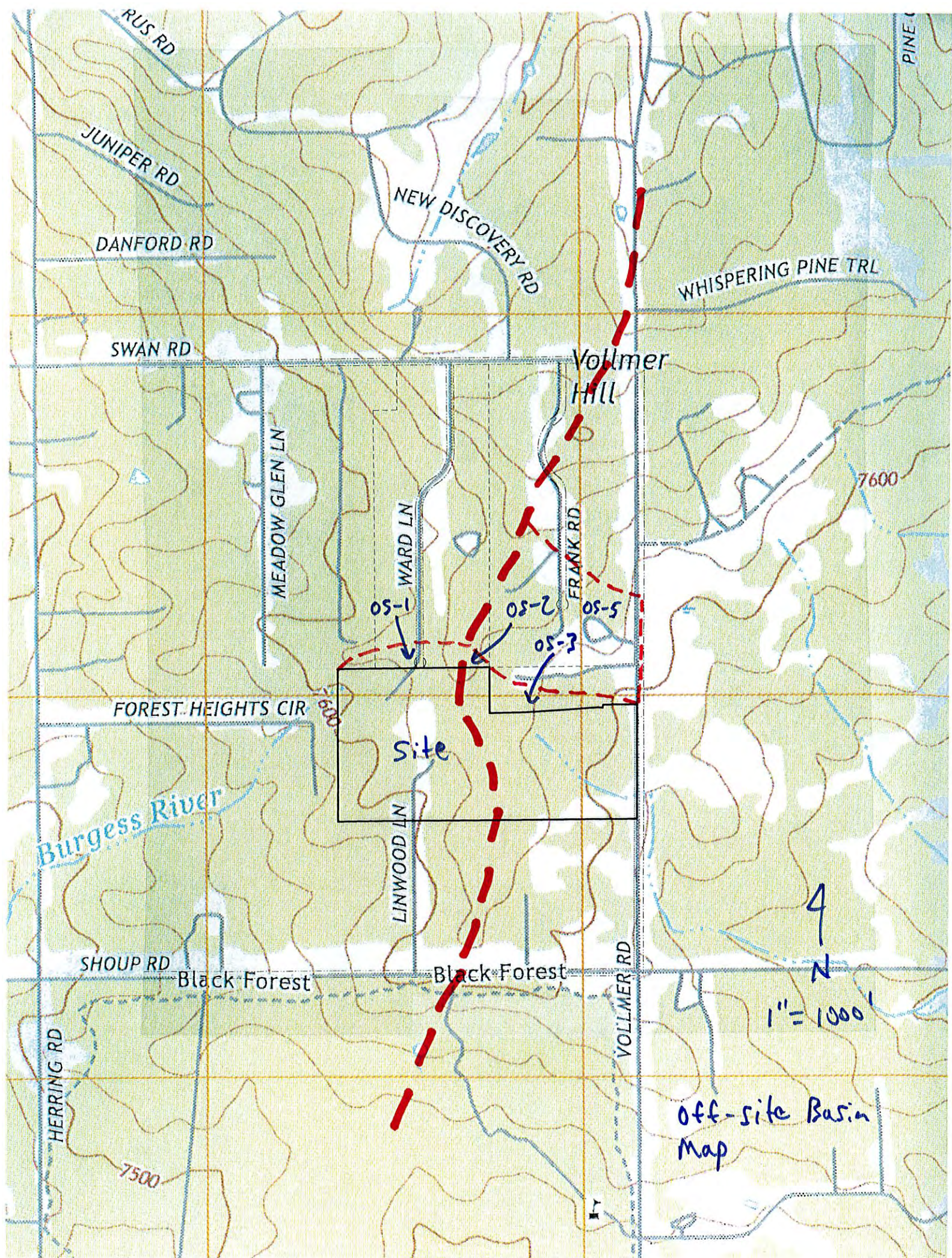
1. ALL TRASH RACKS SHALL BE MOUNTED USING STAINLESS STEEL HARDWARE AND PROVIDED WITH HINGED AND LOCKABLE OR BOLTABLE ACCESS PANELS
2. TRASH RACKS SHALL BE STAINLESS STEEL, ALUMINUM, OR STEEL. STEEL TRASH RACKS SHALL BE HOT DIP GALVANIZED AND MAY BE HOT POWDER COATED AFTER GALVANIZING.
3. TRASH RACKS SHALL BE DESIGNED SUCH THAT THE DIAGONAL DIMENSION OF EACH OPENING IS SMALLER THAN THE DIAMETER OF THE OUTLET PIPE.
4. STRUCTURAL DESIGN OF THE TRASH RACKS SHALL BE BASED ON FULL HYDROSTATIC HEAD WITH ZERO HEAD DOWNSTREAM OF THE RACK.

## **DRAINAGE MAPS**







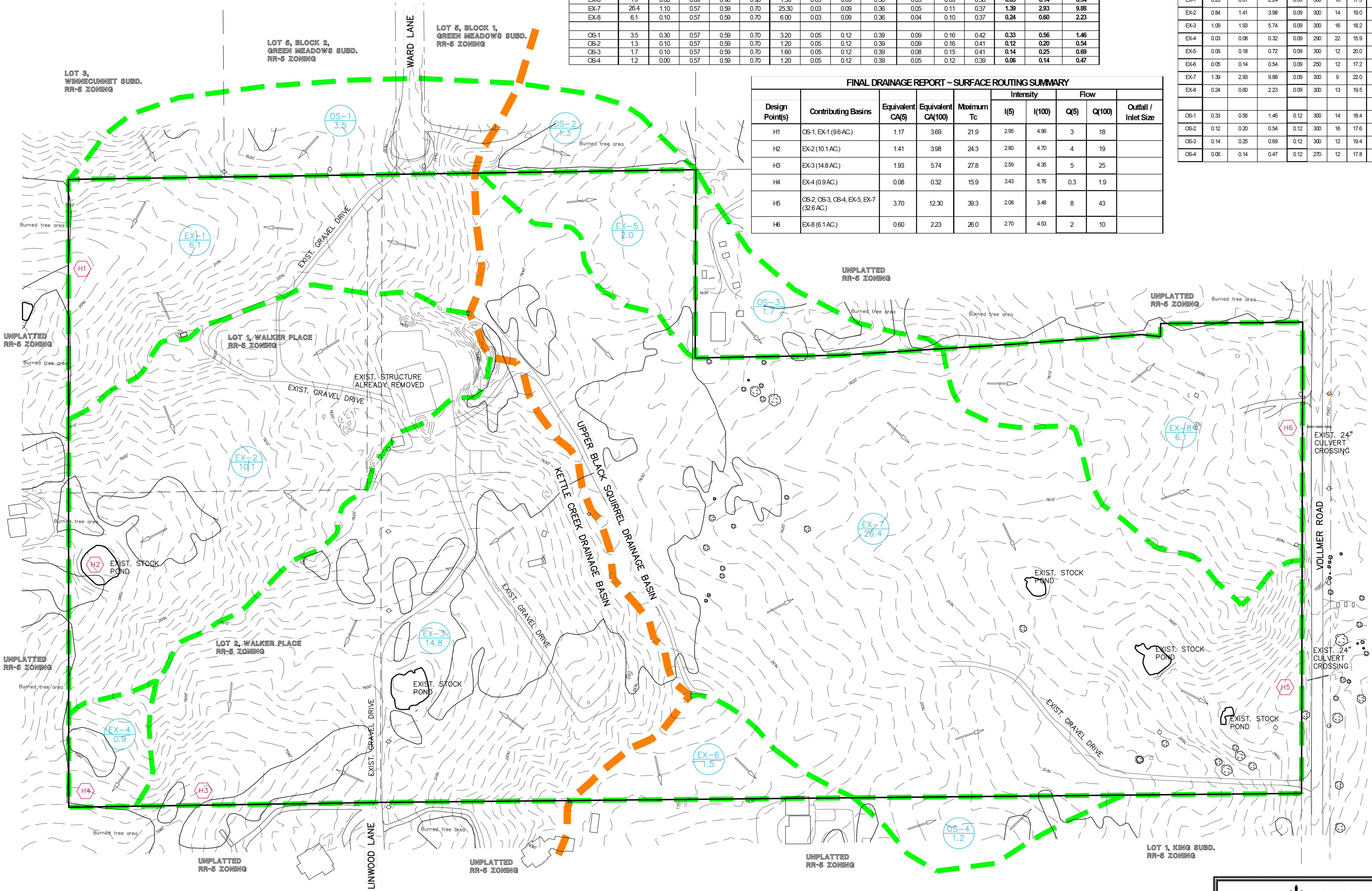




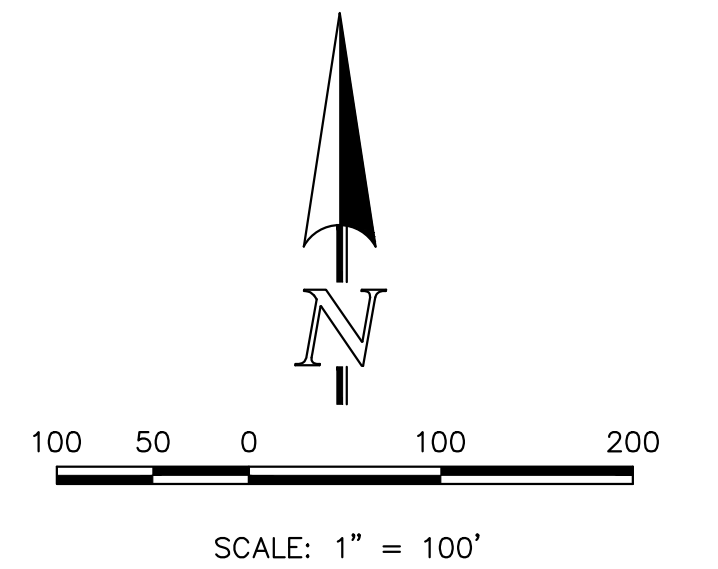
FINAL DRAINAGE REPORT ~ BASIN RUNOFF COEFFICIENT SUMMARY															
BASIN	TOTAL AREA (AC)	IMPERVIOUS AREA / STREETS				LANDSCAPE/UNDEVELOPED AREAS				WEIGHTED			WEIGHTED CA		
		AREA (AC)	C(2)	C(5)	C(100)	AREA (AC)	C(2)	C(5)	C(100)	C(2)	C(5)	C(100)	CA(2)	CA(5)	CA(100)
EX-1	6.1	0.12	0.57	0.59	0.70	5.98	0.03	0.09	0.36	0.04	0.10	0.37	0.25	0.61	2.24
EX-2	10.1	1.00	0.57	0.59	0.70	9.10	0.03	0.09	0.36	0.08	0.14	0.39	0.84	1.41	3.98
EX-3	14.8	1.20	0.57	0.59	0.70	13.60	0.03	0.09	0.36	0.07	0.13	0.39	1.09	1.93	5.74
EX-4	0.9	0.00	0.89	0.90	0.96	0.90	0.03	0.09	0.36	0.03	0.09	0.36	0.03	0.08	0.32
EX-5	2.0	0.00	0.89	0.90	0.96	2.00	0.03	0.09	0.36	0.03	0.09	0.36	0.06	0.18	0.72
EX-6	1.5	0.00	0.89	0.90	0.96	1.50	0.03	0.09	0.36	0.03	0.09	0.36	0.05	0.14	0.54
EX-7	26.4	1.10	0.57	0.59	0.70	25.30	0.03	0.09	0.36	0.05	0.11	0.37	1.39	2.93	9.88
EX-8	6.1	0.10	0.57	0.59	0.70	6.00	0.03	0.09	0.36	0.04	0.10	0.37	0.24	0.60	2.23
OS-1	3.5	0.30	0.57	0.59	0.70	3.20	0.05	0.12	0.39	0.09	0.16	0.42	0.33	0.56	1.46
OS-2	1.3	0.10	0.57	0.59	0.70	1.20	0.05	0.12	0.39	0.09	0.16	0.41	0.12	0.20	0.54
OS-3	1.7	0.10	0.57	0.59	0.70	1.60	0.05	0.12	0.39	0.08	0.15	0.41	0.14	0.25	0.69
OS-4	1.2	0.00	0.57	0.59	0.70	1.20	0.05	0.12	0.39	0.05	0.12	0.39	0.06	0.14	0.47

FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY																				
BASIN	WEIGHTED			C(5)	OVERLAND			STREET / CHANNEL FLOW				Tc (min)	INTENSITY				TOTAL FLOWS			
	CA(2)	CA(5)	CA(100)		Length (ft)	Height (ft)	Tc (min)	Length (ft)	Slope (%)	Velocity (fps)	Tc (min)		I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)		
EX-1	0.25	0.61	2.24	0.09	300	18	17.5	350	3.6%	1.3	4.4	21.9	2.36	2.95	4.96	1	2	11		
EX-2	0.84	1.41	3.98	0.09	300	14	19.0	470	4.5%	1.5	5.3	24.3	2.24	2.80	4.70	2	4	19		
EX-3	1.09	1.93	5.74	0.09	300	16	18.2	770	3.6%	1.3	9.7	27.8	2.08	2.59	4.35	2	5	25		
EX-4	0.03	0.08	0.32	0.09	250	22	15.9					15.9	2.74	3.43	5.76	0.1	0.3	1.9		
EX-5	0.06	0.18	0.72	0.09	300	12	20.0	100	2.5%	1.1	1.5	21.5	2.38	2.98	5.00	0.1	0.5	4		
EX-6	0.05	0.14	0.54	0.09	250	12	17.2					17.2	2.65	3.32	5.57	0.1	0.4	3		
EX-7	1.39	2.93	9.88	0.09	300	9	22.0	1800	3.0%	1.7	17.3	39.3	1.67	2.08	3.48	2	6	34		
EX-8	0.24	0.60	2.23	0.09	300	13	19.5	480	3.1%	1.2	6.5	26.0	2.16	2.70	4.53	1	2	10		
OS-1	0.33	0.56	1.46	0.12	300	14	18.4					18.4	2.57	3.21	5.39	0.8	2	8		
OS-2	0.12	0.20	0.54	0.12	300	16	17.6					17.6	2.62	3.28	5.50	0.3	0.7	3		
OS-3	0.14	0.25	0.69	0.12	300	12	19.4					19.4	2.51	3.14	5.26	0.3	0.8	4		
OS-4	0.06	0.14	0.47	0.12	270	12	17.8					17.8	2.61	3.27	5.48	0.2	0.5	3		

FINAL DRAINAGE REPORT ~ SURFACE ROUTING SUMMARY									
Design Point(s)	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		Outfall / Inlet Size
					I(5)	I(100)	Q(5)	Q(100)	
H1	OS-1, EX-1 (9.6 AC)	1.17	3.69	21.9	2.95	4.96	3	18	
H2	EX-2 (10.1 AC)	1.41	3.98	24.3	2.80	4.70	4	19	
H3	EX-3 (14.8 AC)	1.93	5.74	27.8	2.99	4.36	5	25	
H4	EX-4 (0.9 AC)	0.08	0.32	15.9	3.43	5.76	0.3	1.9	
H5	OS-2, OS-3, OS-4, EX-5, EX-7 (32.6 AC)	3.70	12.30	39.3	2.08	3.48	8	43	
H6	EX-8 (6.1 AC)	0.60	2.23	26.0	2.70	4.53	2	10	



LEGEND	
DESCRIPTION	SYMBOL
EXISTING GROUND CONTOUR	6910
MAJOR BASIN BOUNDARY	Orange dashed line
BASIN BOUNDARY	Green dashed line
BASIN IDENTIFIER	H-1 10.0
AREA IN ACRES	Blue circle
DESIGN POINT	Red hexagon
EXISTING TREES / SHRUBS	Tree/shrub symbol
EXISTING FORESTED AREA OUTLINE	Irregular outline



CLASSIC  
CONSULTING  
ENGINEERS & SURVEYORS

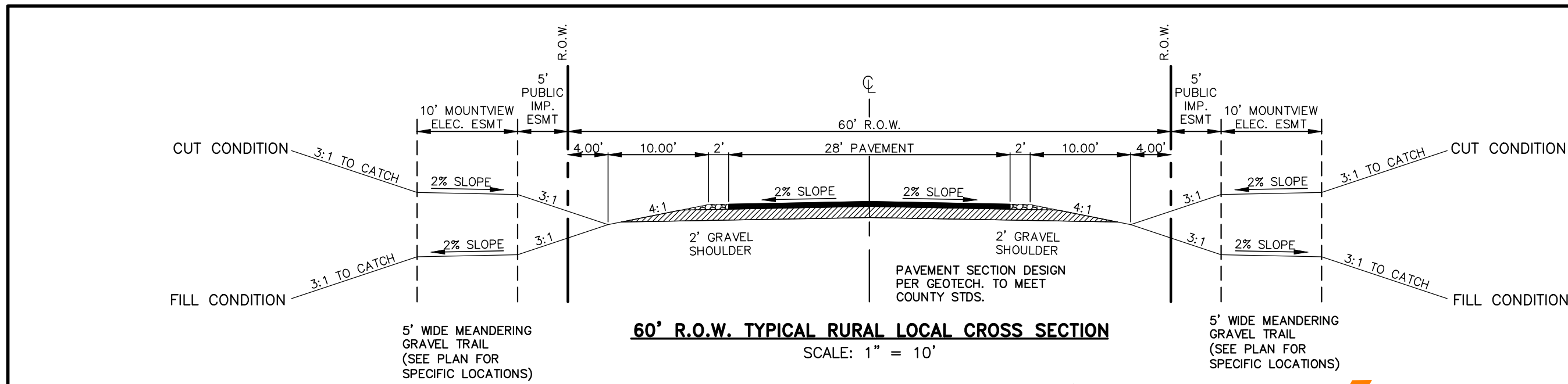
REDTAIL RANCH  
PRELIMINARY/FINAL DRAINAGE REPORT  
PRE-DEVELOPMENT DRAINAGE MAP

DESIGNED BY	MAW	SCALE	DATE
DRAWN BY	MAW	(H) 1" = 100'	7-3-18
CHECKED BY		(V) 1" = N/A	SHEET 1 OF 2
			JOB NO. 2525.00

619 N. Cascade Avenue, Suite 200  
Colorado Springs, Colorado 80903

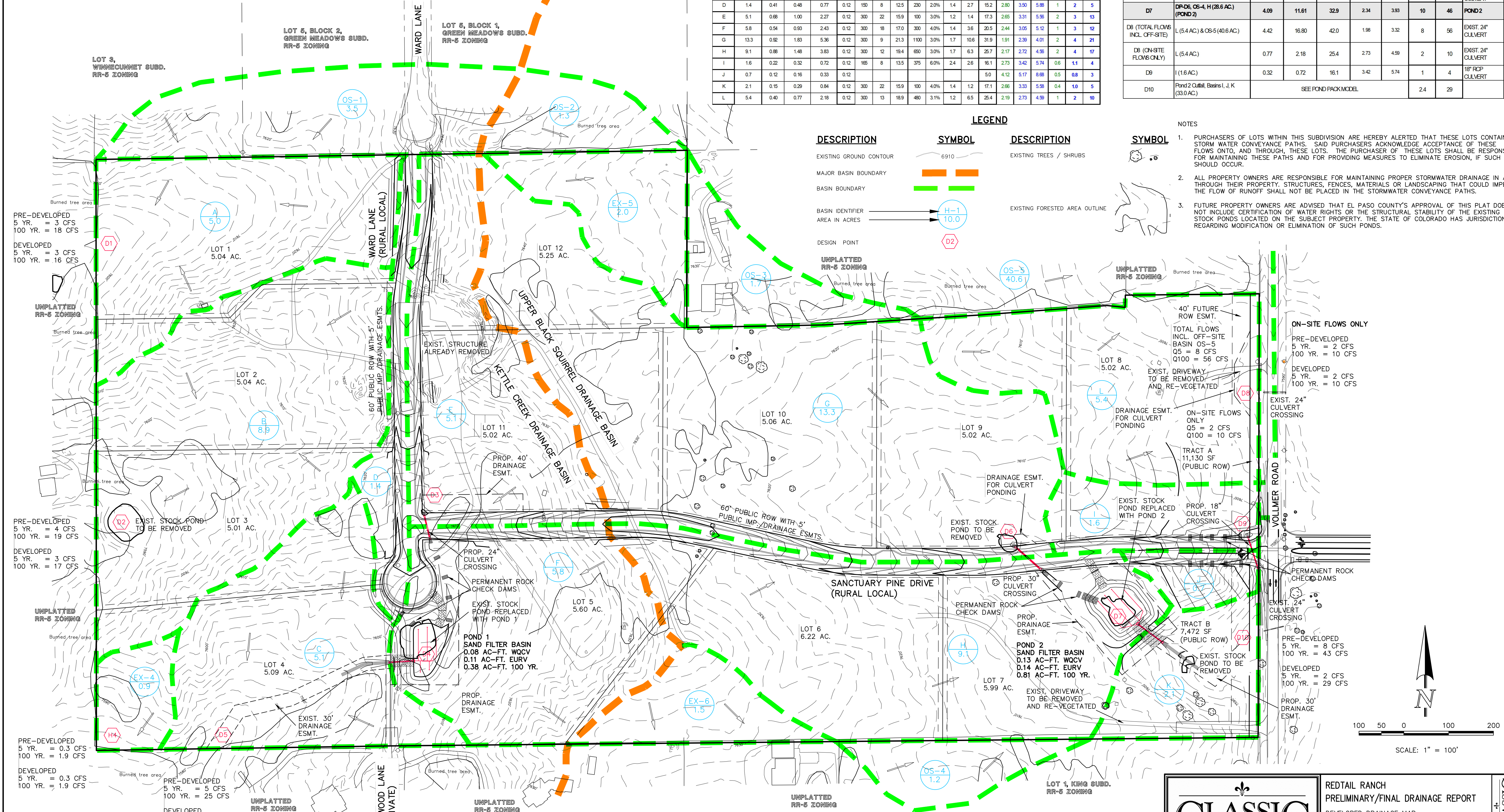
(719) 785-0790  
(719) 785-0799 (Fax)





FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY														
BASIN	TOTAL AREA (AC)	WEIGHTED				OVERLAND				STREET / CHANNEL FLOW				TOTAL FLOWS
		CA(2)	CA(5)	CA(100)	Q(5)	Length (ft)	Height (ft)	Tc (min)		Length (ft)	Slope (%)	Velocity (ft/s)	Tc (min)	
OS-1	3.5	0.33	0.56	1.46	0.12	300	14	184						18.4
OS-2	1.3	0.12	0.20	0.54	0.12	300	16	176						17.6
OS-3	1.7	0.14	0.25	0.69	0.12	300	12	194						19.4
OS-4	1.2	0.06	0.14	0.47	0.12	270	12	178						17.8
OS-5	40.6	1.22	3.65	14.62	0.09	300	12	200	1800	3.0%	12	220	40	40.0
A	5.0	0.25	0.60	1.95	0.12	300	18	170	250	3.6%	13	31	20.1	24.6
B	8.9	0.45	1.07	3.47	0.12	300	14	184	300	4.5%	15	34	21.8	23.7
C	5.1	0.26	0.61	1.99	0.12	300	15	180	350	3.6%	13	44	22.4	23.3
D	1.4	0.41	0.48	0.77	0.12	150	8	125	230	2.0%	14	27	15.2	28.0
E	5.1	0.68	1.00	2.27	0.12	300	22	159	100	3.0%	12	14	17.3	2.65
F	5.8	0.54	0.93	2.43	0.12	300	18	170	300	4.0%	14	36	20.5	2.44
G	13.3	0.92	1.83	5.36	0.12	300	9	213	1100	3.0%	17	106	31.9	1.91
H	9.1	0.88	1.48	3.83	0.12	300	12	194	650	3.0%	17	63	25.7	2.17
I	1.6	0.22	0.32	0.72	0.12	165	8	135	375	6.0%	24	26	16.1	2.73
J	0.7	0.12	0.16	0.33	0.12								5.0	4.12
K	2.1	0.15	0.29	0.84	0.12	300	22	159	100	4.0%	14	12	17.1	2.66
L	5.4	0.40	0.77	2.18	0.12	300	13	189	480	3.1%	12	65	25.4	2.19

FINAL DRAINAGE REPORT ~ SURFACE ROUTING SUMMARY									
Design Point(s)	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		Outfall / Inlet Size
					I(5)	I(100)	Q(5)	Q(100)	
D1	A OS-1 (8.5 AC)	1.05	3.12	20.1	3.08	5.17	3	46	
D2	B (8.9 AC)	1.07	3.47	21.8	2.96	4.97	3	17	
D3	E (5.1 AC)	1.00	2.27	17.3	3.31	5.56	3	13	24" RCP CULVERT
D4	DP-D3, D, F (12.3 AC) (POND 1)	2.41	5.48	20.5	3.05	5.12	7	28	POND 1
D5	Pond 1 Outfall, Basin C (17.4 AC)	SEE POND PACK MODEL						1.7	24
D6	OS-2, OS-3, EX-5, G (18.3 AC)	2.46	7.31	31.9	2.39	4.01	6	29	30" RCP CULVERT
D7	DP-D6, OS-4, H (28.6 AC) (POND 2)	4.09	11.61	32.9	2.34	3.93	10	46	POND 2
D8 (TOTAL FLOWS INCL. OFF-SITE)	L (5.4 AC) & OS-5 (40.6 AC)	4.42	16.80	42.0	1.98	3.32	8	56	EXIST. 24" CULVERT
D8 (ON-SITE FLOWS ONLY)	L (5.4 AC)	0.77	2.18	25.4	2.73	4.59	2	10	EXIST. 24" CULVERT
D9	I (1.6 AC)	0.32	0.72	16.1	3.42	5.74	1	4	18" RCP CULVERT
D10	Pond 2 Outfall, Basins I, J, K (33.0 AC)	SEE POND PACK MODEL						2.4	29



PRE-DEVELOPED  
5 YR. = 3 CFS  
100 YR. = 18 CFS

DEVELOPED  
5 YR. = 3 CFS  
100 YR. = 16 CFS

PRE-DEVELOPED  
5 YR. = 4 CFS  
100 YR. = 19 CFS

DEVELOPED  
5 YR. = 3 CFS  
100 YR. = 17 CFS

PRE-DEVELOPED  
5 YR. = 0.3 CFS  
100 YR. = 1.9 CFS

DEVELOPED  
5 YR. = 0.3 CFS  
100 YR. = 1.9 CFS

PRE-DEVELOPED  
5 YR. = 5 CFS  
100 YR. = 25 CFS

DEVELOPED  
5 YR. = 2 CFS  
100 YR. = 24 CFS

ON-SITE FLOWS ONLY

PRE-DEVELOPED  
5 YR. = 2 CFS  
100 YR. = 10 CFS

DEVELOPED  
5 YR. = 2 CFS  
100 YR. = 10 CFS

PRE-DEVELOPED  
5 YR. = 8 CFS  
100 YR. = 43 CFS

DEVELOPED  
5 YR. = 2 CFS  
100 YR. = 29 CFS

REDTAIL RANCH  
PRELIMINARY/FINAL DRAINAGE REPORT  
DEVELOPED DRAINAGE MAP

DESIGNED BY: MAW  
DRAWN BY: MAW  
CHECKED BY:

SCALE: (H) 1" = 100'  
(V) 1" = N/A

DATE: 7-3-18  
SHEET: 2 OF 2  
JOB NO.: 2525.00

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