

**FINAL DRAINAGE REPORT  
FOR  
ELECTRONIC STORAGE  
LOT 2 MOUNTAIN STATES PIPE AND SUPPLY  
7765 ELECTRONIC DRIVE  
COLORADO SPRINGS, COLORADO**

**DECEMBER 2020**

Prepared For:  
**D. STEFANO-BUILDING & RESTORATION, INC.**  
520 West 21<sup>ST</sup> Street, G-2 #710  
Norfolk, VA 23517  
757.333.3144

Prepared By:  
**TERRA NOVA ENGINEERING, INC.**  
721 S. 23<sup>RD</sup> Street  
Colorado Springs, CO 80904  
719.635.6422

TNE Job No. 1971.00  
County Job No. PPR-20-020

**FINAL DRAINAGE REPORT  
FOR  
ELECTRONIC STORAGE  
LOT 2 MOUNTAIN STATES PIPE AND SUPPLY  
7765 ELECTRONIC DRIVE  
COLORADO SPRINGS, COLORADO**

**TABLE OF CONTENTS**

Engineer's Statement	Page 3
Purpose	Page 4
General Description	Page 4
Existing Drainage Conditions	Page 5
Proposed Drainage Conditions	Page 6
Hydrologic Calculations	Page 9
Hydraulic Calculations	Page 9
Floodplain Statement	Page 9
Water Quality	Page 9
Construction Cost Opinion	Page 10
Drainage Fees	Page 10
Maintenance	Page 10
Summary	Page 11
Bibliography	Page 11

**APPENDICES**

VICINITY MAP

S.C.S. SOILS MAP

FEMA FIRM MAP

HYDROLOGIC CALCULATIONS

HYDRAULIC CALCULATIONS

DETENTION CALCULATIONS

DRAINAGE PLAN

**FINAL DRAINAGE REPORT  
FOR  
ELECTRONIC STORAGE  
LOT 2 MOUNTAIN STATES PIPE AND SUPPLY  
7765 ELECTRONIC DRIVE  
COLORADO SPRINGS, COLORADO**

**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 reports and said report is in conformity with the applicable master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

*Dane Frank*

Dane Frank, P.E. 50207

On behalf of Terra Nova Engineering, Inc.



**OWNER/DEVELOPER'S STATEMENT:**

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

*Marci Gutierrez*

Authorized Signature

09/15/2021

Date

Marci Gutierrez, Managing Member

Printed Name, Title

CS Development Partners, LLC

Business Name

520 W. 21st Street, G-2, #710 Norfolk, VA 23517

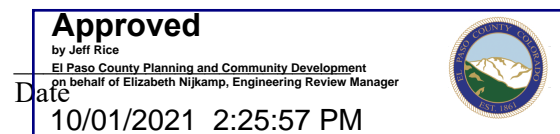
Address

**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



Conditions: The ESQCP shall not be issued until the downstream drainage easement is provided.

**FINAL DRAINAGE REPORT  
FOR  
ELECTRONIC STORAGE  
LOT 2 MOUNTAIN STATES PIPE AND SUPPLY  
7765 ELECTRONIC DRIVE  
COLORADO SPRINGS, COLORADO**

**PURPOSE**

The purpose of this Final Drainage Report is to identify and analyze the proposed drainage patterns, determine proposed runoff quantities, size drainage structures for conveyance of developed runoff, and present solutions to drainage impacts on-site and off-site resulting from this development. The site has previously been platted and has previously been studied in:

“Preliminary and Final Drainage Report for TMC Design Corporation”, dated December 2011, prepared by Stillwater Engineering.

Per El Paso County, there is no record on file that the above report was approved by the County.

**GENERAL DESCRIPTION**

This Final Drainage Report (FDR) is an analysis of approximately 2.25 acres of undeveloped land located at 7765 Electronic Drive. This site is being developed as a mini storage facility. The site is in the southeast quarter of Section 32, Township 13 South, Range 65 West of the 6<sup>th</sup> Principal Meridian within El Paso County. The parcels are bounded to the north by Electronic Drive, to the east by Marksheffel Road, to the south by LOT 6 AKERS ACRES SUB 1, EX THAT PT CONV TO COUNTY FOR R/W BY REC #210004057, and to the west by WLY 631.22 FT OF TRACT 5 AKERS ACRES SUB NO 1. (See vicinity map, Appendix).

The site lies within the Sand Creek Basin, with storm runoff surface draining from the southeast corner of the site, and flowing south, then west along streets, before entering Sand Creek. There are also storm inlets in Marksheffel Road that flow into a storm sewer that flows south along Markcheffel to an unknown outfall, which presumably also drains into Sand Creek.



Soils for this project are delineated by the map in the appendix as Blakeland loamy sand (8), 1 to 9 percent slopes. Soils in the study area are shown as mapped by S.C.S. in the “Soils Survey of El Paso County Area” and contains soils of Hydrologic Group A.

The site is undeveloped with mostly grass and dirt surfaces, and a small number of trees. The site drains to the southeast, with an average slope of 6.1%.

## **EXISTING DRAINAGE CONDITIONS**

There is one existing building and stormwater pond in the southeast corner of the site. There is also a small drainage swale on the south side of Electronic Drive, which is in the right of way, that prevents runoff flowing south from entering the site. There are 24” RCP culverts in this swale at each driveway to the site.

The existing stormwater pond is a 0.16 ac-ft water quality and detention structure that was designed in the 2011 drainage report. It collects runoff from basin EX-A. The pond has an outlet structure that drains to the public storm sewer system via a private storm pipe that leaves the pond/site to the south. This pond appears to be functioning as designed.

There are four drainage basins, two of which are offsite. See attached Existing Drainage Map (in appendix).

Basin OS-Z is 4.01 acres and drains to Design Point Z along Electronic Drive. This basin is offsite and no flow from it enters the site. Basin OS-Z has flows of  $Q_5 = 7.3$  cfs and  $Q_{100} = 16.5$  cfs.

Basin OS-Y is 2.55 acres and drains to Design Point Y at the west side of the site. This basin is offsite and runoff from this basin flows onto the site and into basin EX-B. Basin OS-Y has flows of  $Q_5 = 2.1$  cfs and  $Q_{100} = 8.2$  cfs.

Basin EX-A is 2.54 acres and drains to Design Point A at the existing stormwater pond. After going through the pond, runoff drains through an outlet structure to the public storm sewer system via a private storm pipe that leaves the pond/site to the south. There is also a 18” RCP culvert that

carries water under a paved portion of the basin to the pond. Basin EX-A has flows of  $Q_5 = 3.2$  cfs and  $Q_{100} = 9.5$  cfs.

Basin EX-B is 1.91 acres and drains to Design Point B at the south side of the site. Runoff flows off the site and onto the adjacent property. Basin EX-B has flows of  $Q_5 = 0.9$  cfs and  $Q_{100} = 5.4$  cfs. Design Point B has combined flows of  $Q_5 = 3.0$  cfs and  $Q_{100} = 13.6$  cfs from basins OS-Y and EX-B.

## **PROPOSED DRAINAGE CONDITIONS**

Runoff in the developed conditions consists of 9 basins; seven onsite basins and two offsite basins. Below is a description of the runoff in the developed conditions and how it will be safely routed, treated and detained. See appendix for calculations.

### Offsite Basins

Basin OS-E is 0.44 acres and drains to Design Point E on the western edge of the site. Runoff sheet flows onto the site from Basin OS-E. Basin OS-E has flows of  $Q_5 = 0.4$  cfs and  $Q_{100} = 1.7$  cfs.

Basin OS-F is 1.38 acres and drains to Design Point F on the western edge of the site. Runoff sheet flows onto the site from Basin OS-F. Basin OS-F has flows of  $Q_5 = 1.2$  cfs and  $Q_{100} = 4.6$  cfs.

### Onsite Basins

Basin PR-1 is 0.37 acres and drains to Design Point 1 at the northwest edge of the paved area onsite. Basin PR-1 is a hillside, the bottom of which will be at the top of curb at Design Point 1. Basin PR-1 has flows of  $Q_5 = 0.2$  cfs and  $Q_{100} = 1.1$  cfs. Design Point 1 has combined flows of  $Q_5 = 0.6$  cfs and  $Q_{100} = 2.8$  cfs from basins OS-E and PR-1.

Basin PR-2 is 0.62 acres and drains to Design Point 2 at the southeast edge of the paved area onsite. Basin PR-2 has flows of  $Q_5 = 0.2$  cfs and  $Q_{100} = 1.1$  cfs. Design Point 2 has combined flows of  $Q_5 = 3.8$  cfs and  $Q_{100} = 9.3$  cfs from basins OS-E, PR-1, and PR-2. There are valley gutters and

curb and gutter in this basin that channel runoff around the building and toward the pond. There is a 2'x2' area inlet on the southwest side of the building in this basin that is at the end of the storm sewer the roof drains will connect to, that will provide a cleanout location for this run of storm sewer (this inlet has zero runoff capture). There are two curb inlets at Design Point 2 that each take half of the basin's flow and send it to the pond via storm sewers.

Basin PR-3 is 0.45 acres and drains to Design Point 3 at the southwest edge of the building roof. Roof drains will connect to the adjacent storm sewer on the southwest side of the building. Basin PR-3 has flows of  $Q_5 = 2.3$  cfs and  $Q_{100} = 4.5$  cfs.

Basin PR-4 is 0.32 acres and drains to Design Point 4 at the outlet of the onsite detention basin. Basin PR-4 has flows of  $Q_5 = 0.2$  cfs and  $Q_{100} = 1.2$  cfs. Design Point 4 has combined flows of  $Q_5 = 6.3$  cfs and  $Q_{100} = 15.1$  cfs from basins OS-E, PR-1, PR-2, PR-3, and PR-4.

Basin PR-5 is 0.34 acres and drains to Design Point 5 at the southeast corner of the site. This basin is undeveloped/landscaping area. Basin PR-5 has flows of  $Q_5 = 0.1$  cfs and  $Q_{100} = 1.0$  cfs. Design Point 5 has combined flows of  $Q_5 = 1.3$  cfs and  $Q_{100} = 5.6$  cfs from basins OS-F and PR-5.

Basin PR-6 is 0.03 acres and drains to Design Point 6 at the northeast corner of the site. This basin is a landscaping area that flows offsite to the north into the drainage ditch/swale along Electronic Drive. Basin PR-6 has flows of  $Q_5 = 0.0$  cfs and  $Q_{100} = 0.1$  cfs.

Basin PR-7 is 0.13 acres and drains to Design Point 7 at the east edge of the site. This basin is landscaping area that sheet flows offsite to the adjacent lot. Basin PR-7 has flows of  $Q_5 = 0.1$  cfs and  $Q_{100} = 0.6$  cfs. Some of the runoff from this basin will flow into the existing stormwater pond on adjacent Lot 1. The portion of this basin that will flow to the existing pond, is already flowing to the existing pond, so there won't be any change to the flow reaching the existing pond from this basin.

At Design Point 4 the combined flow ( $Q_5=6.3$  cfs and  $Q_{100}=15.1$  cfs) of the development will be captured in a 0.202 acre-foot Extended Detention Basin. Runoff entering the pond on the

northwest side will be routed through storm sewers into a 39 cu-ft concrete lined forebay with a 1.0 feet high concrete cutoff wall. A 3 inch notch in the wall drains the flow to a 1' concrete trickle channel, then the runoff is routed to the 3.0' deep micropool which has a 6" deep initial surcharge area. The 1.77 acres tributary to the EDB are 62% impervious. Based upon this we need a WQCV of 0.036 ac-ft, an EURV volume of 0.098 ac-ft and 100-year volume of 0.068 ac-ft for a total volume needed of 0.202 ac-ft. The bottom of the micropool elevation is at 6480.00 while the top of the ISV elevation is at 6483.00. The WQCV orifice starts at 6482.50 with 3 5/8 inch diameter holes spaced 14.60 inches apart. A 2'x2' outlet structure is set at 6485.75. The 100-year elevation tops out at 6486.54. A 12" HDPE outlet will release  $Q_5=0.0$  cfs and  $Q_{100}=1.4$  cfs discharge southeast, across two lots, and to an existing storm inlet (~5'x5' grate). This inlet is piped to an adjacent curb inlet in the Marksheffel Road right of way.

Runoff from the site currently flows to this offsite storm inlet being connected to, either by surface flow, or through the existing stormwater pond on Lot 1. The runoff directed to the proposed onsite pond will no longer surface flow to this offsite inlet, but will instead flow to this inlet through the proposed storm sewer.

In an effort to protect receiving water and as part of the "four-step process to minimize adverse impacts of urbanization" this site was analyzed in the following manner:

1. Reduce Runoff- The proposed impervious areas on the site are surrounded by landscaping and green space areas. Additionally, the new improvements and impervious areas on the site will be routed to a proposed private Extended Detention Basin. These items will reduce the volume of runoff using ponding and infiltration.
2. Stabilize Drainageways- There are no existing or proposed drainageways onsite. Additionally, the outflow of the Extended Detention Basin is carried by storm sewer until it connects with an existing public storm sewer system.
3. Provide Water Quality Capture Volume (WQCV)- The Extended Detention Basin has been sized and designed to sufficiently capture the required WQCV and slowly release it through the three hole outlet, thereby allowing solids and contaminants to settle out.
4. Consider Need for Industrial and Commercial BMPs- The proposed development is an indoor mini storage facility; therefore, no Industrial and Commercial BMPs have been

proposed.

## **HYDROLOGIC CALCULATIONS**

Hydrologic calculations were performed using the El Paso County Storm Drainage Design Criteria Manual - Volumes 1 & 2, latest editions. The Rational Method was used to estimate storm water runoff anticipated from design storms with 5-year and 100-year recurrence intervals. The Urban Drainage Criteria Manual was used to calculate the detention and water quality volume.

## **HYDRAULIC CALCULATIONS**

Hydraulic calculations were estimated using the Manning's Formula and the methods described in the El Paso County Storm Drainage Design Criteria Manual – Volumes 1 & 2, latest editions. The pertinent data sheets are included in the appendix of this report.

A culvert is proposed at the entrance to the site. Design calculations have been included for the proposed culvert.

Street runoff capacity calculations for the onsite drive isles have been included.

## **FLOODPLAIN STATEMENT**

No portion of this site is within a designated F.E.M.A. floodplain, as determined by Flood Insurance Rate Map No. 08041C0756 G, dated December 7, 2018 (see appendix).

## **WATER QUALITY**

The proposed detention basin provides water quality treatment for the proposed development.

Runoff from basins PR-5, PR-6, and PR-7 are not captured by the proposed detention basin. Basin PR-5 is a landscaping area, some of which is below the detention pond, with no impervious area. Basin PR-6 is a landscaping area, behind a curb, with no impervious area. Basin PR-7 is a landscaping area, all of which flows away from the detention pond, some of which flows to the existing stormwater pond on Lot 1. The combined area of these basins is 0.50 acres, with only 0.01 acres (driveway) being impervious. Basins PR-5, PR-6, and PR-7 would qualify as grass

buffers, which provide water quality treatment, and can be considered undeveloped (open space). Section I.7.1.C.1 of the ECM allows up to 20%, not to exceed 1 acre, of a development site to not be treated for water quality.

## **CONSTRUCTION COST OPINION**

### **Public Reimbursable**

None

### **Public Non-Reimbursable**

None

### **Private Non-Reimbursable**

1. 12" HDPE	707 LF	\$ 40	\$ 28,280
2. 15" HDPE	82 LF	\$ 45	\$ 3,690
3. 2'x2' Area Inlet	1 EA	\$ 3,000	\$ 3,000
4. 8' D-10-R Curb Inlet	2 EA	\$ 7,800	\$ 15,600
2. EDB	1 EA	\$ 60,000	<u>\$ 60,000</u>
<b>Total</b>			<b>\$ 110,570</b>

## **DRAINAGE FEES**

This drainage report is part of a site development application; therefore, no drainage fees are due.

## **MAINTENANCE**

The Extended Detention Basin is private and will be maintained by the property owner. The proposed storm sewers are private and will be maintained by the property owner.

## **SUMMARY**

Development of this site will not adversely affect the surrounding development. This report is in general conformance with the previous reports which included this site. Site runoff and storm drain appurtenances from the Electronic Storage development will not adversely affect the downstream and surrounding developments and will be safely routed to the proposed extended

detention basin and runoff reduced to the allowable pre-developed rates while slowly treating the water quality capture volume. Runoff leaving the proposed extended detention basin is then routed to the existing public storm sewer system.

**PREPARED BY:**  
**TERRA NOVA ENGINEERING, INC.**

Dane Frank, P.E.  
Project Engineer

Jobs/1971.00/drainage/197100 FDR.doc

## **BIBLIOGRAPHY**

El Paso County Drainage Criteria Manual-Volumes 1 & 2, latest edition

El Paso County Board Resolution No 15-042 (Adoption of Chapter 6 and Section 3.2.1 Chapter 13 of the City of Colorado Springs Drainage Criteria Manual dated May 2014, Hydrology and Full Spectrum Detention)

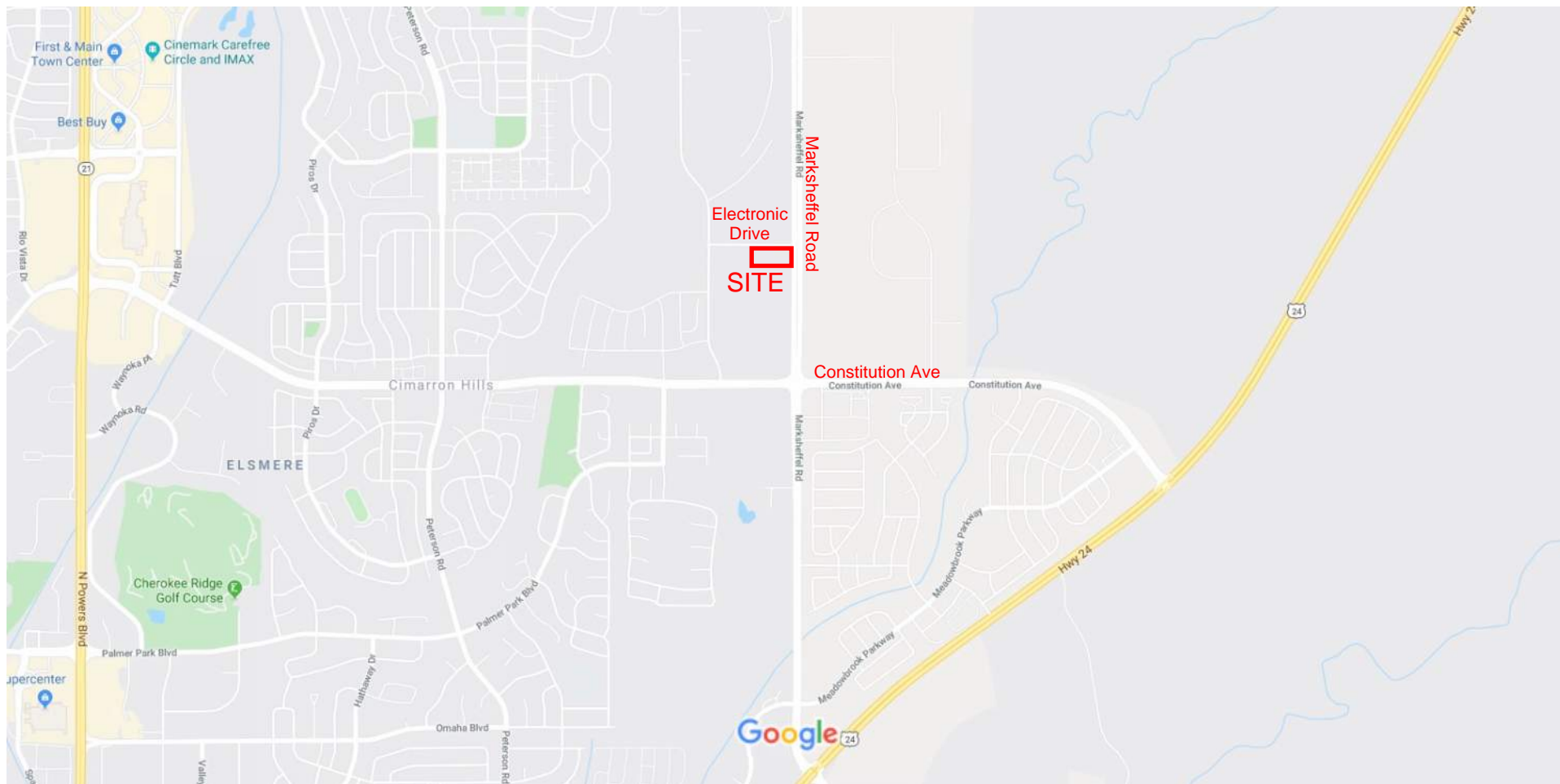
Preliminary and Final Drainage Report for TMC Design Corporation, dated December 2011, prepared by Stillwater Engineering

## **VICINITY MAP**





## Electronic Storage - Vicinity Map



Map data ©2019 Google 1000 ft

North is up ^



# Electronic Storage - Location Map

Image Dated Oct 2018

Electronic Dr

SITE

Markshoff Rd

Google Earth

© 2018 Google

400 ft





## **S.C.S. SOILS MAP**

# Soil Map—El Paso County Area, Colorado (Electronic Storage)



## 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 17, Sep 13, 2019

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

Date(s) aerial images were photographed: Jun 3, 2014—Jun 17, 2014

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
8	Blakeland loamy sand, 1 to 9 percent slopes	4.6	97.6%
10	Blendon sandy loam, 0 to 3 percent slopes	0.1	2.4%
<b>Totals for Area of Interest</b>		<b>4.7</b>	<b>100.0%</b>

## El Paso County Area, Colorado

### 8—Blakeland loamy sand, 1 to 9 percent slopes

#### Map Unit Setting

*National map unit symbol:* 369v

*Elevation:* 4,600 to 5,800 feet

*Mean annual precipitation:* 14 to 16 inches

*Mean annual air temperature:* 46 to 48 degrees F

*Frost-free period:* 125 to 145 days

*Farmland classification:* Not prime farmland

#### Map Unit Composition

*Blakeland and similar soils:* 98 percent

*Minor components:* 2 percent

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

#### Description of Blakeland

##### Setting

*Landform:* Hills, flats

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

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Alluvium derived from sedimentary rock and/or  
eolian deposits derived from sedimentary rock

##### Typical profile

*A - 0 to 11 inches:* loamy sand

*AC - 11 to 27 inches:* loamy sand

*C - 27 to 60 inches:* sand

##### Properties and qualities

*Slope:* 1 to 9 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 to  
very high (5.95 to 19.98 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 5 percent

*Available water storage in profile:* Low (about 4.5 inches)

##### Interpretive groups

*Land capability classification (irrigated):* 3e

*Land capability classification (nonirrigated):* 6e

*Hydrologic Soil Group:* A

*Ecological site:* Sandy Foothill (R049BY210CO)

*Hydric soil rating:* No

### **Minor Components**

#### **Other soils**

*Percent of map unit:* 1 percent

*Hydric soil rating:* No

#### **Pleasant**

*Percent of map unit:* 1 percent

*Landform:* Depressions

*Hydric soil rating:* Yes

## **Data Source Information**

Soil Survey Area: El Paso County Area, Colorado

Survey Area Data: Version 17, Sep 13, 2019



## El Paso County Area, Colorado

### 10—Blendon sandy loam, 0 to 3 percent slopes

#### Map Unit Setting

*National map unit symbol:* 3671

*Elevation:* 6,000 to 6,800 feet

*Mean annual precipitation:* 14 to 16 inches

*Mean annual air temperature:* 46 to 48 degrees F

*Frost-free period:* 125 to 145 days

*Farmland classification:* Not prime farmland

#### Map Unit Composition

*Blendon and similar soils:* 98 percent

*Minor components:* 2 percent

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

#### Description of Blendon

##### Setting

*Landform:* Terraces, alluvial fans

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Sandy alluvium derived from arkose

##### Typical profile

*A - 0 to 10 inches:* sandy loam

*Bw - 10 to 36 inches:* sandy loam

*C - 36 to 60 inches:* gravelly sandy loam

##### Properties and qualities

*Slope:* 0 to 3 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*Runoff class:* Low

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

Moderately high to high (0.60 to 2.00 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 2 percent

*Available water storage in profile:* Moderate (about 6.2 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 3e

*Hydrologic Soil Group:* B

*Ecological site:* Sandy Foothill (R049BY210CO)

*Hydric soil rating:* No

### **Minor Components**

#### **Other soils**

*Percent of map unit:* 1 percent

*Hydric soil rating:* No

#### **Pleasant**

*Percent of map unit:* 1 percent

*Landform:* Depressions

*Hydric soil rating:* Yes

## **Data Source Information**

Soil Survey Area: El Paso County Area, Colorado

Survey Area Data: Version 17, Sep 13, 2019

## **FEMA FIRM MAP**

**NOTES TO USERS**

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations (BFEs)** and/or **Floodway** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

**Coastal Base Flood Elevations** shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The projection used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The horizontal datum was NAD83, GRS80 spheroid. Differences in datum, spheroid projection or UTM zone codes used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

Flood elevations on this map are referenced to the **North American Vertical Datum of 1988 (NAVD88)**. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov/> or contact the National Geodetic Survey at the following address:

NGS Information Services  
NOAA, NGS512  
National Geodetic Survey  
SSM3-3, #5002  
1315 East-West Highway  
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242 or visit its website at <http://www.ngs.noaa.gov/>.

**Base Map** information shown on this FIRM was provided in digital format by El Paso County, Colorado Springs Utilities, City of Fountain, Bureau of Land Management, National Oceanic and Atmospheric Administration, United States Geological Survey, and Anderson Consulting Engineers, Inc. These data are current as of 2006.

This map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map. The profile baselines depicted on this map represent the hydraulic modeling baselines that match the flood profiles and Floodway Data Tables if applicable, in the FIS report. As a result, the profile baselines may deviate significantly from the new base map channel representation and may appear outside of the floodplain.

**Corporate limits** shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

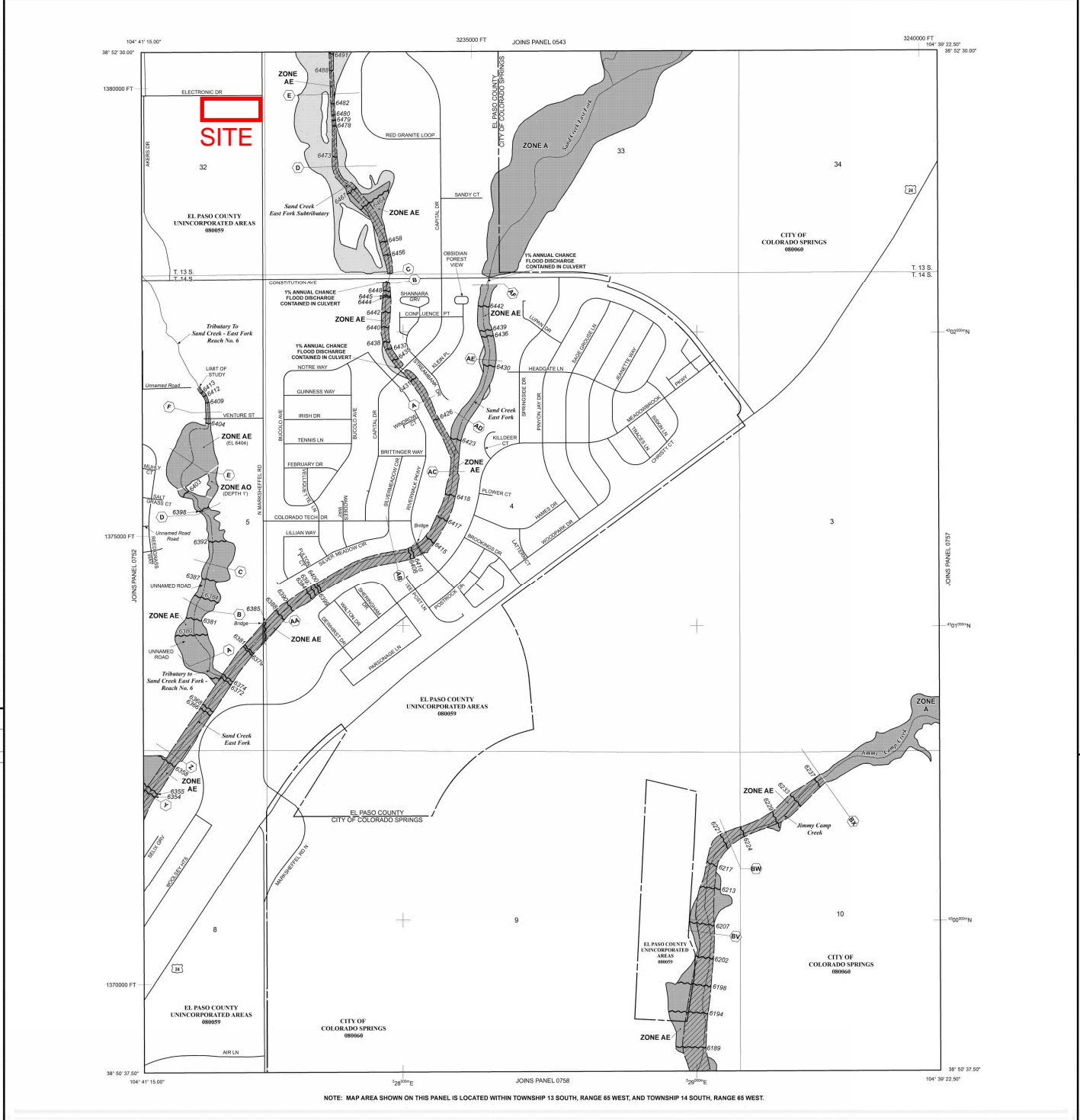
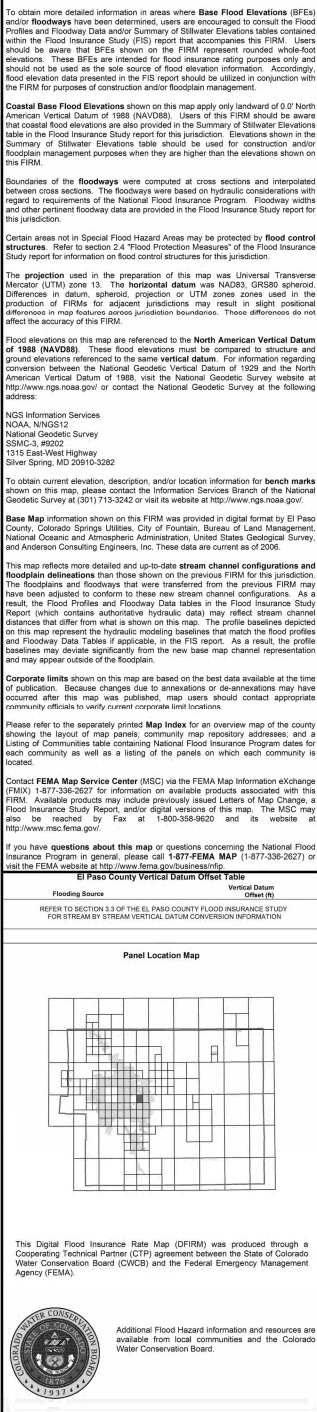
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels, community map repository addresses, and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact **FEMA Map Service Center (MSC)** via the FEMA map information exchange (PMIX) 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The MSC may also be reached by Fax at 1-800-358-9620 and its website at <http://www.msc.fema.gov/>.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call 1-877-FEMA MAP (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov/businessinfo>.

**El Paso County Vertical Datum Offset Table**

Flooding Source	Vertical Datum Offset (ft)
REFER TO SECTION 3.3 OF THE EL PASO COUNTY FLOOD INSURANCE STUDY FOR STREAM BY STREAM VERTICAL DATUM CONVERSION INFORMATION	



**NATIONAL FLOOD INSURANCE PROGRAM**

**PANEL 0756G**

**FIRM**  
FLOOD INSURANCE RATE MAP  
EL PASO COUNTY,  
COLORADO  
AND INCORPORATED AREAS

**PANEL 756 OF 1300**  
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

COUNTY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	0800	075	G
EL PASO COUNTY	0800	076	G

Notice to User: The Map Number shown below should be used when placing map orders. The Community Number shown above should be used on insurance applications for the subject community.

**MAP NUMBER**  
08041C0756G

**MAP REVISED**  
DECEMBER 7, 2018

**Federal Emergency Management Agency**

## **HYDROLOGIC CALCULATIONS**

***ELECTRONIC STORAGE***  
***(Area Runoff Coefficient Summary)***

**EXISTING CONDITIONS**

		<i>STREETS / DEVELOPED</i>			<i>OVERLAND / UNDEVELOPED</i>			<i>WEIGHTED</i>	
BASIN	TOTAL AREA	AREA	C <sub>5</sub>	C <sub>100</sub>	AREA	C <sub>5</sub>	C <sub>100</sub>	C <sub>5</sub>	C <sub>100</sub>
	(Acres)	(Acres)			(Acres)				
OS-Z	4.01	4.01	0.45	0.59	0.00	0.09	0.36	0.45	0.59
OS-Y	2.55	2.55	0.20	0.44	0.00	0.09	0.36	0.20	0.44
EX-A	2.54	2.54	0.30	0.50	0.00	0.09	0.36	0.30	0.50
EX-B	1.91	1.91	0.12	0.39	0.00	0.09	0.36	0.12	0.39

Note: Basin C values are based on measured impervious values.

Percent impervious values are: 64%, 20%, 37%, and 7%.

Calculated by: DLF

Date: 8/5/2020

Checked by: LD

**DEVELOPED CONDITIONS**

		<i>STREETS / DEVELOPED</i>			<i>OVERLAND / UNDEVELOPED</i>			<i>WEIGHTED</i>	
BASIN	TOTAL AREA	AREA	C <sub>5</sub>	C <sub>100</sub>	AREA	C <sub>5</sub>	C <sub>100</sub>	C <sub>5</sub>	C <sub>100</sub>
	(Acres)	(Acres)			(Acres)				
OS-E	0.44	0.44	0.20	0.44	0.00	0.09	0.36	0.20	0.44
OS-F	1.38	1.38	0.20	0.44	0.00	0.09	0.36	0.20	0.44
OS-G	0.01	0.01	0.90	0.96	0.00	0.09	0.36	0.90	0.96
PR-1	0.37	0.00	0.90	0.96	0.37	0.09	0.36	0.09	0.36
PR-2	0.62	0.62	0.90	0.96	0.00	0.09	0.36	0.90	0.96
PR-3	0.45	0.45	0.90	0.96	0.00	0.09	0.36	0.90	0.96
PR-4	0.32	0.32	0.09	0.36	0.00	0.09	0.36	0.09	0.36
PR-5	0.34	0.34	0.09	0.36	0.00	0.09	0.36	0.09	0.36
PR-6	0.03	0.03	0.09	0.36	0.00	0.09	0.36	0.09	0.36
PR-7	0.13	0.13	0.20	0.44	0.00	0.09	0.36	0.20	0.44

Calculated by: DLF

Date: 1/10/2020

Checked by: LD

# ELECTRONIC STORAGE AREA DRAINAGE SUMMARY

## EXISTING CONDITIONS

		WEIGHTED		OVERLAND				STREET / CHANNEL FLOW				T <sub>i</sub>	INTENSITY		TOTAL FLOWS	
BASIN	AREA TOTAL (Acres)	C <sub>5</sub>	C <sub>100</sub>	C <sub>5</sub>	Length (ft)	Height (ft)	T <sub>C</sub> (min)	Length (ft)	Slope (%)	Velocity (fps)	T <sub>i</sub> (min)	TOTAL (min)	I <sub>5</sub> (in/hr)	I <sub>100</sub> (in/hr)	Q <sub>5</sub> (c.f.s.)	Q <sub>100</sub> (c.f.s.)
		* For Calcs See Runoff Summary														
OS-Z	4.01	0.45	0.59	0.45	300	20.0	6.2	900	6.0%	3.7	4.1	10.3	4.0	7.0	7.3	16.5
OS-Y	2.55	0.20	0.44	0.20	300	16.6	9.1	0	6.0%	4.9	0.0	9.1	4.2	7.3	2.1	8.2
EX-A	2.54	0.30	0.50	0.30	300	13.2	8.8	0	4.0%	1.0	0.0	8.8	4.3	7.5	3.2	9.5
EX-B	1.91	0.12	0.39	0.12	300	18.2	9.6	0	6.0%	4.9	0.0	9.6	4.1	7.2	0.9	5.4

## DEVELOPED CONDITIONS

		WEIGHTED		OVERLAND				STREET / CHANNEL FLOW				T <sub>i</sub>	INTENSITY		TOTAL FLOWS	
BASIN	AREA TOTAL (Acres)	C <sub>5</sub>	C <sub>100</sub>	C <sub>5</sub>	Length (ft)	Height (ft)	T <sub>C</sub> (min)	Length (ft)	Slope (%)	Velocity (fps)	T <sub>i</sub> (min)	TOTAL (min)	I <sub>5</sub> (in/hr)	I <sub>100</sub> (in/hr)	Q <sub>5</sub> (c.f.s.)	Q <sub>100</sub> (c.f.s.)
		* For Calcs See Runoff Summary														
OS-E	0.44	0.20	0.44	0.20	100	7.0	5.4	0	5.0%	1.1	0.0	5.4	4.9	8.8	0.4	1.7
OS-F	1.38	0.20	0.44	0.20	300	21.0	8.4	0	5.0%	1.1	0.0	8.4	4.3	7.6	1.2	4.6
OS-G	0.01	0.90	0.96	0.90	20	2.0	0.6	0	5.0%	4.5	0.0	0.6	6.7	13.0	0.1	0.1
PR-1	0.37	0.09	0.36	0.09	100	6.0	6.4	0	5.0%	4.5	0.0	6.4	4.7	8.4	0.2	1.1
PR-2	0.62	0.90	0.96	0.90	100	5.0	1.4	300	6.0%	4.9	1.0	2.4	5.8	10.9	3.2	6.5
PR-3	0.45	0.90	0.96	0.90	100	0.5	2.9	0	5.0%	4.5	0.0	2.9	5.6	10.4	2.3	4.5
PR-4	0.32	0.09	0.36	0.09	40	10.0	2.8	0	5.0%	1.1	0.0	2.8	5.7	10.5	0.2	1.2
PR-5	0.34	0.09	0.36	0.09	100	5.0	6.8	0	5.0%	1.1	0.0	6.8	4.6	8.2	0.1	1.0
PR-6	0.03	0.09	0.36	0.09	20	2.7	2.6	0	5.0%	1.1	0.0	2.6	5.7	10.7	0.0	0.1
PR-7	0.13	0.20	0.44	0.20	20	1.2	3.0	0	5.0%	1.1	0.0	3.0	5.6	10.4	0.1	0.6

Calculated by: DLF

Date: 8/5/2020

Checked by: LD

# ***ELECTRONIC STORAGE PROPOSED SURFACE ROUTING SUMMARY***

<b><i>Design Point(s)</i></b>	<b><i>Contributing Basins</i></b>	<b><i>Area Ac</i></b>	<b><i>Flow</i></b>	
			<b><i>Q<sub>5</sub></i></b>	<b><i>Q<sub>100</sub></i></b>
<b>Z</b>	<b>OS-Z</b>	4.01	<b>7.3</b>	<b>16.5</b>
<b>Y</b>	<b>OS-Y</b>	2.55	<b>2.1</b>	<b>8.2</b>
<b>A</b>	<b>EX-A</b>	2.54	<b>3.2</b>	<b>9.5</b>
<b>B</b>	<b>EX-B, OS-Y</b>	4.46	<b>3.1</b>	<b>13.6</b>
<b>E</b>	<b>OS-E</b>	0.44	<b>0.4</b>	<b>1.7</b>
<b>F</b>	<b>OS-F</b>	1.38	<b>1.2</b>	<b>4.6</b>
<b>G</b>	<b>OS-G</b>	0.01	<b>0.1</b>	<b>0.1</b>
<b>1</b>	<b>OS-A, PR-1</b>	0.81	<b>0.6</b>	<b>2.8</b>
<b>2</b>	<b>OS-A, OS-C, PR-1, PR-2</b>	1.44	<b>3.9</b>	<b>9.4</b>
<b>3</b>	<b>PR-3</b>	0.45	<b>2.3</b>	<b>4.5</b>
<b>4</b>	<b>OS-A, OS-C, PR-1, PR-2, PR-3, PR-4</b>	2.21	<b>6.3</b>	<b>15.1</b>
<b>5</b>	<b>OS-B, PR-5</b>	1.72	<b>1.3</b>	<b>5.6</b>
<b>6</b>	<b>PR-6</b>	0.03	<b>0.0</b>	<b>0.1</b>
<b>7</b>	<b>PR-7</b>	0.13	<b>0.1</b>	<b>0.6</b>

Calculated by: DLF

Date: 8/5/2020

Checked by: LD

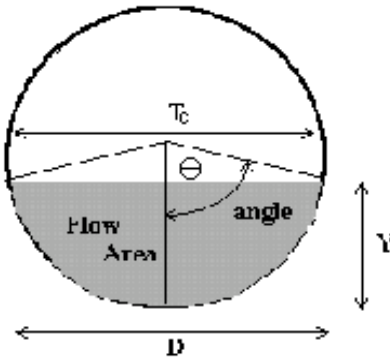


## **HYDRAULIC CALCULATIONS**

## CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

Project: **Electronic Storage**

Pipe ID: **Entrance Culvert**



### Design Information (Input)

Pipe Invert Slope	$S_o =$	<input type="text" value="0.0200"/>	ft/ft
Pipe Manning's n-value	$n =$	<input type="text" value="0.0130"/>	
Pipe Diameter	$D =$	<input type="text" value="24.00"/>	inches
Design discharge	$Q =$	<input type="text" value="5.00"/>	cfs

### Full-flow Capacity (Calculated)

Full-flow area	$A_f =$	<input type="text" value="3.14"/>	sq ft
Full-flow wetted perimeter	$P_f =$	<input type="text" value="6.28"/>	ft
Half Central Angle	$\theta =$	<input type="text" value="3.14"/>	radians
Full-flow capacity	$Q_f =$	<input type="text" value="32.08"/>	cfs

### Calculation of Normal Flow Condition

Half Central Angle ( $0 < \theta < 3.14$ )	$\theta =$	<input type="text" value="1.09"/>	radians
Flow area	$A_n =$	<input type="text" value="0.67"/>	sq ft
Top width	$T_n =$	<input type="text" value="1.77"/>	ft
Wetted perimeter	$P_n =$	<input type="text" value="2.17"/>	ft
Flow depth	$Y_n =$	<input type="text" value="0.53"/>	ft
Flow velocity	$V_n =$	<input type="text" value="7.42"/>	fps
Discharge	$Q_n =$	<input type="text" value="5.00"/>	cfs
Percent Full Flow	$\text{Flow} =$	<input type="text" value="15.6%"/>	of full flow
Normal Depth Froude Number	$Fr_n =$	<input type="text" value="2.12"/>	supercritical

### Calculation of Critical Flow Condition

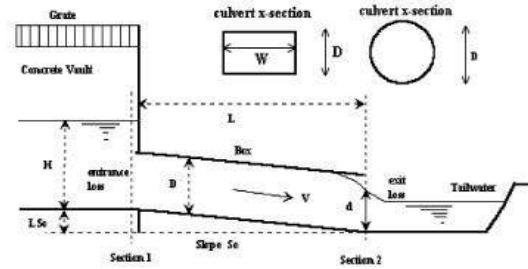
Half Central Angle ( $0 < \theta_c < 3.14$ )	$\theta_c =$	<input type="text" value="1.36"/>	radians
Critical flow area	$A_c =$	<input type="text" value="1.15"/>	sq ft
Critical top width	$T_c =$	<input type="text" value="1.95"/>	ft
Critical flow depth	$Y_c =$	<input type="text" value="0.79"/>	ft
Critical flow velocity	$V_c =$	<input type="text" value="4.35"/>	fps
Critical Depth Froude Number	$Fr_c =$	<input type="text" value="1.00"/>	

# CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: **Electronic Storage**

Basin ID: **Entrance Culvert**

Status:



## Design Information (Input):

**Circular Culvert:** Barrel Diameter in Inches  
Inlet Edge Type (choose from pull-down list)

D = 24 inches

Grooved End with Headwall

OR:

**Box Culvert:** Barrel Height (Rise) in Feet  
Barrel Width (Span) in Feet  
Inlet Edge Type (choose from pull-down list)

Height (Rise) = ft.

Width (Span) = ft.

Square Edge w/ 30-78 deg. Flared Wingwall

Number of Barrels  
Inlet Elevation at Culvert Invert  
Outlet Elevation at Culvert Invert OR Slope of Culvert (ft v./ft h.)  
Culvert Length in Feet  
Manning's Roughness  
Bend Loss Coefficient  
Exit Loss Coefficient

No = 1

Inlet Elev = 6497.5 ft. elev.

Outlet Elev = 6496.5 ft. elev.

L = 50 ft.

n = 0.013

K<sub>b</sub> = 0

K<sub>x</sub> = 1

## Design Information (calculated):

Entrance Loss Coefficient  
Friction Loss Coefficient  
Sum of All Loss Coefficients  
Orifice Inlet Condition Coefficient  
Minimum Energy Condition Coefficient

K<sub>e</sub> = 0.20

K<sub>f</sub> = 0.62

K<sub>s</sub> = 1.82

C<sub>d</sub> = 0.99

KE<sub>low</sub> = -0.0794

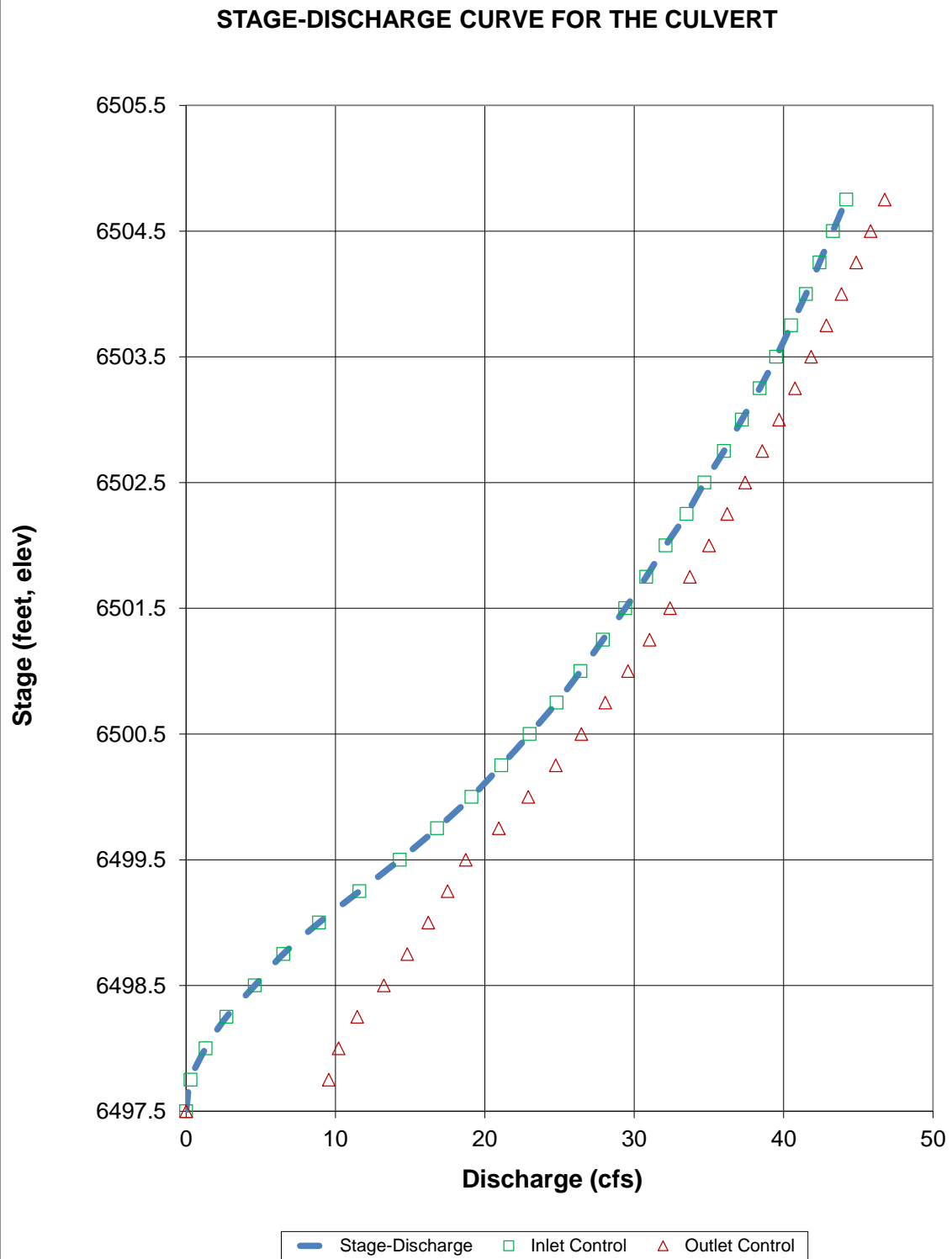
## Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
6497.50		0.00	0.00	0.00	No Flow (WS < inlet)	N/A
6497.75		0.30	9.55	0.30	Min. Energy Eqn.	INLET
6498.00		1.30	10.21	1.30	Min. Energy Eqn.	INLET
6498.25		2.70	11.45	2.70	Min. Energy Eqn.	INLET
6498.50		4.60	13.23	4.60	Min. Energy Eqn.	INLET
6498.75		6.50	14.80	6.50	Regression Eqn.	INLET
6499.00		8.90	16.20	8.90	Regression Eqn.	INLET
6499.25		11.60	17.50	11.60	Regression Eqn.	INLET
6499.50		14.30	18.72	14.30	Regression Eqn.	INLET
6499.75		16.80	20.92	16.80	Regression Eqn.	INLET
6500.00		19.10	22.91	19.10	Regression Eqn.	INLET
6500.25		21.10	24.75	21.10	Regression Eqn.	INLET
6500.50		23.00	26.46	23.00	Regression Eqn.	INLET
6500.75		24.80	28.06	24.80	Regression Eqn.	INLET
6501.00		26.40	29.58	26.40	Regression Eqn.	INLET
6501.25		27.90	31.02	27.90	Regression Eqn.	INLET
6501.50		29.40	32.39	29.40	Regression Eqn.	INLET
6501.75		30.80	33.72	30.80	Regression Eqn.	INLET
6502.00		32.10	35.00	32.10	Regression Eqn.	INLET
6502.25		33.50	36.22	33.50	Regression Eqn.	INLET
6502.50		34.70	37.42	34.70	Regression Eqn.	INLET
6502.75		36.00	38.57	36.00	Regression Eqn.	INLET
6503.00		37.20	39.69	37.20	Regression Eqn.	INLET
6503.25		38.40	40.76	38.40	Regression Eqn.	INLET
6503.50		39.50	41.83	39.50	Regression Eqn.	INLET
6503.75		40.50	42.85	40.50	Orifice Eqn.	INLET
6504.00		41.50	43.86	41.50	Orifice Eqn.	INLET
6504.25		42.40	44.85	42.40	Orifice Eqn.	INLET
6504.50		43.30	45.81	43.30	Orifice Eqn.	INLET
6504.75		44.20	46.76	44.20	Orifice Eqn.	INLET

Processing Time: 00.89 Seconds

## CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

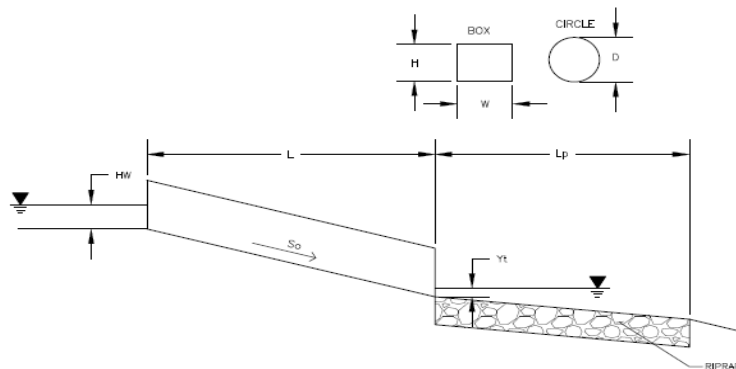
Project: Electronic Storage  
Basin ID: Entrance Culvert



## Determination of Culvert Headwater and Outlet Protection

Project: **Electronic Storage**

Basin ID: **Entrance Culvert**



### Soil Type:

Choose One:

☒ Sandy

☐ Non-Sandy

Supercritical Flow! Using  $D_a$  to calculate protection type.

### Design Information (Input):

Design Discharge

Q = 5 cfs

#### Circular Culvert:

Barrel Diameter in Inches

D = 24 inches

Inlet Edge Type (Choose from pull-down list)

Square End with Headwall

#### Box Culvert:

Barrel Height (Rise) in Feet

Height (Rise) = ft

Barrel Width (Span) in Feet

Width (Span) = ft

Inlet Edge Type (Choose from pull-down list)

Number of Barrels

No = 1

Inlet Elevation

Elev IN = 6497.5 ft

Outlet Elevation **OR** Slope

Elev OUT = 6496.5 ft

Culvert Length

L = 50 ft

Manning's Roughness

n = 0.013

Bend Loss Coefficient

$k_b$  = 0

Exit Loss Coefficient

$k_x$  = 1

Tailwater Surface Elevation

Elev  $Y_t$  = ft

Max Allowable Channel Velocity

V = 5 ft/s

### Required Protection (Output):

Tailwater Surface Height

$Y_t$  = 0.80 ft

Flow Area at Max Channel Velocity

$A_t$  = 1.00  $\text{ft}^2$

Culvert Cross Sectional Area Available

A = 3.14  $\text{ft}^2$

Entrance Loss Coefficient

$k_e$  = 0.50

Friction Loss Coefficient

$k_f$  = 0.62

Sum of All Losses Coefficients

$k_s$  = 2.12

Culvert Normal Depth

$Y_n$  = 0.53 ft

Culvert Critical Depth

$Y_c$  = 0.79 ft

Tailwater Depth for Design

d = 1.39 ft

Adjusted Diameter **OR** Adjusted Rise

$D_a$  = 1.27 ft

Expansion Factor

$1/(2*\tan(\Theta))$  = 6.70

Flow/Diameter<sup>2.5</sup> **OR** Flow/(Span \* Rise<sup>1.5</sup>)

$Q/D^{2.5}$  = 0.88  $\text{ft}^{0.5}/\text{s}$

Froude Number

Fr = 2.12

Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise

$Y_t/D$  = 0.63

Supercritical!

Inlet Control Headwater

$HW_i$  = 1.09 ft

Outlet Control Headwater

$HW_o$  = 0.48 ft

Design Headwater Elevation

HW = 6,498.59 ft

Headwater/Diameter **OR** Headwater/Rise Ratio

$HW/D$  = 0.55

Minimum Theoretical Riprap Size

$d_{50}$  = 2 in

Nominal Riprap Size

$d_{50}$  = 6 in

UDFCD Riprap Type

Type = VL

Length of Protection

$L_p$  = 6 ft

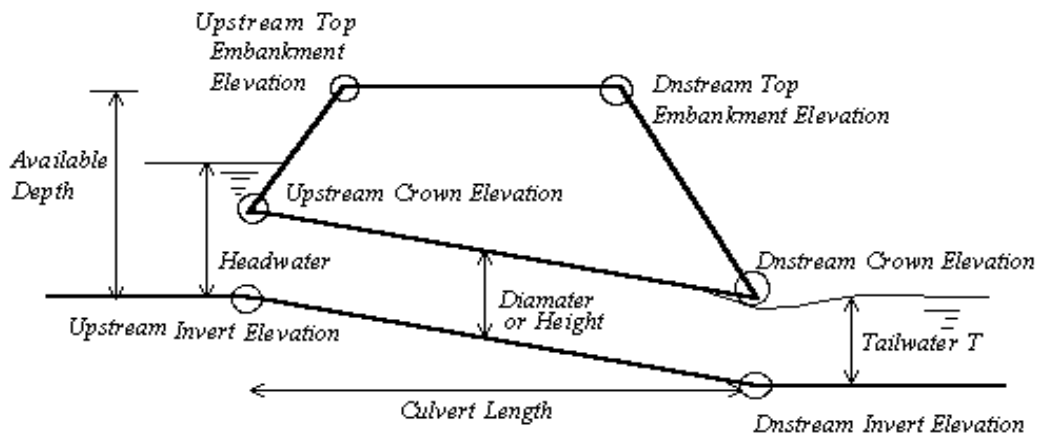
Width of Protection

T = 3 ft

## Vertical Profile for the Culvert

Project = **Electronic Storage**

Box ID = **Entrance Culvert**



### **Culvert Information (Input)**

Barrel Diameter or Height	D or H =	24.00	inches
Barrel Length	L =	50.00	ft
Barrel Invert Slope	So =	0.0200	ft/ft
Downstream Invert Elevation	EDI =	6496.50	ft
Downstream Top Embankment Elevation	EDT =	6499.50	ft
Upstream Top Embankment Elevation	EUT =	6501.00	ft
Design Headwater Depth (not elev.)	Hw =	1.09	ft
Tailwater Depth (not elev.)	Yt =	1.39	ft

### **Culvert Hydraulics (Calculated)**

Available Headwater Depth	HW-a =	3.50	ft
Design Hw/D ratio	Hw/D =	0.55	

### **Culvert Vertical Profile**

Upstream Invert Elevation	EUI =	6497.50	ft
Upstream Crown Elevation	EUC =	6499.50	ft
Upstream Soil Cover Depth	Upsoil =	1.50	ft
Downstream Invert Elevation	EDI =	6496.50	ft
Downstream Crown Elevation	EDC =	6498.50	ft
Downstream Soil Cover Depth	Dnsoil =	1.00	ft

# MANNING'S EQUATION FOR PIPE FLOW

Project: Electronic Storage Location: Roof Drains Storm Pipe (Need Q=4.5 cfs)  
 By: Dane Frank Date: 1/13/2020  
 Chk. By: Date: mdo version 12.8.00

Clear Data  
Entry Cells

## INPUT

D= 12 inches  
 d= 12 inches  
 n= 0.012 mannings coeff  
 θ= 0.0 degrees  
 S= 0.1 slope in/in

Mannings Formula

$$Q = (1.486/n) A R_h^{2/3} S^{1/2}$$

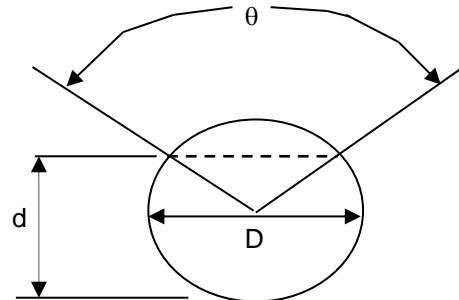
$$R = A/P$$

A=cross sectional area

P=wetted perimeter

S=slope of channel

n=Manning's roughness coefficient



$$V = (1.49/n) R_h^{2/3} S^{1/2}$$

$$Q = V \times A$$

			Solution to Mannings Equation		Manning's n-values	
Area, ft <sup>2</sup>	Wetted Perimeter, ft	Hydraulic Radius, ft	velocity ft/s	flow, cfs		
0.79	3.14	0.25	15.54	12.20	PVC	0.01
					PE (<9"dia)	0.015
					PE (>12"dia)	0.02
					PE(9-12"dia)	0.017
					CMP	0.025
					ADS N12	0.012
					HCMP	0.023
					Conc	0.013

Created by: Mike O'Shea

# MANNING'S EQUATION FOR PIPE FLOW

Project: Electronic Storage Location: SW Pond Inlet ST Pipe (Need Q=9.2 cfs)

By: Dane Frank

Date: 8/28/2020

Chk. By:

Date:

mdo version 12.8.00

Clear Data  
Entry Cells

INPUT

D= 15 inches  
d= 15 inches  
n= 0.012 mannings coeff  
θ= 0.0 degrees  
S= 0.049 slope in/in

Mannings Formula

$$Q = (1.486/n) A R_h^{2/3} S^{1/2}$$

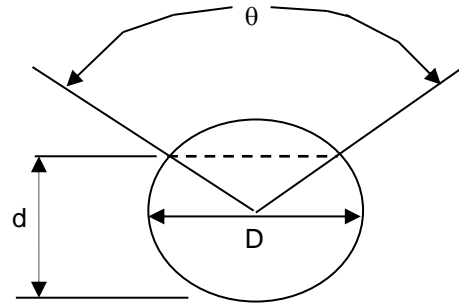
$$R = A/P$$

A=cross sectional area

P=wetted perimeter

S=slope of channel

n=Manning's roughness coefficient



$$V = (1.49/n) R_h^{2/3} S^{1/2}$$

$$Q = V \times A$$

			Solution to Mannings Equation		Manning's n-values	
Area, ft <sup>2</sup>	Wetted Perimeter, ft	Hydraulic Radius, ft	velocity ft/s	flow, cfs		
1.23	3.93	0.31	12.62	15.49	PVC	0.01
					PE (<9" dia)	0.015
					PE (>12" dia)	0.02
					PE(9-12" dia)	0.017
					CMP	0.025
					ADS N12	0.012
					HCMP	0.023
					Conc	0.013

Created by: Mike O'Shea



# MANNING'S EQUATION FOR PIPE FLOW

Project: Electronic Storage Location: NE Pond Inlet ST Pipe (Need Q=4.7 cfs)  
By: Dane Frank Date: 1/13/2020  
Chk. By: Date: mdo version 12.8.00

Clear Data  
Entry Cells

INPUT

D= 12 inches  
d= 12 inches  
n= 0.012 manning's coeff  
θ= 0.0 degrees  
S= 0.049 slope in/in

Mannings Formula

$$Q=(1.486/n)AR_h^{2/3}S^{1/2}$$

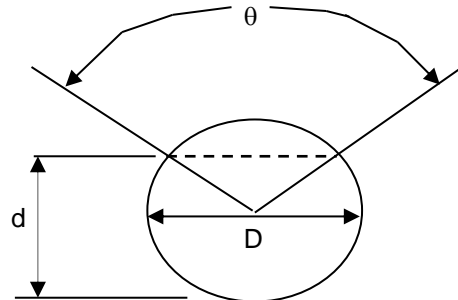
$$R=A/P$$

A=cross sectional area

P=wetted perimeter

S=slope of channel

n=Manning's roughness coefficient



$$V=(1.49/n)R_h^{2/3}S^{1/2}$$

$$Q=V \times A$$

			Solution to Mannings Equation		Manning's n-values	
Area,ft <sup>2</sup>	Wetted Perimeter, ft	Hydraulic Radius, ft	velocity ft/s	flow, cfs		
0.79	3.14	0.25	10.88	8.54	PVC	0.01
					PE (<9"dia)	0.015
					PE (>12"dia)	0.02
					PE(9-12"dia)	0.017
					CMP	0.025
					ADS N12	0.012
					HCMP	0.023
					Conc	0.013

Created by: Mike O'Shea

# MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **NW of Bldg Street Capacity (Need 3 cfs)**

By: **Dane Frank**

Date: **1/13/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

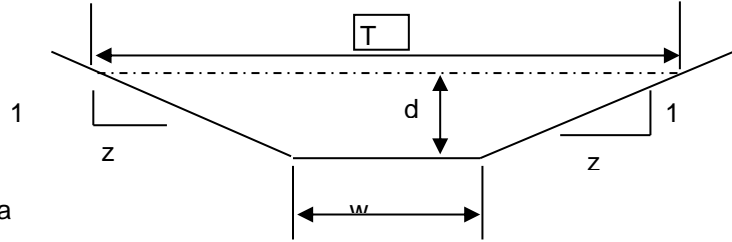
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 25  
z (sideslope)= 50  
b (btm width, ft)= 0  
d (depth, ft)= 0.6  
S (slope, ft/ft) 0.005  
n low = 0.013  
n high = 0.013

Clear Data  
Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs	T =	
0.6	13.50	45.02	0.30	3.62110768	48.885	3.621108	48.885		45
								Dm =	0.300
				Sc low =	0.0037	Sc high =	0.0037		
s <sub>c</sub> = critical slope    ft / ft									
T = top width of the stream				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
d <sub>m</sub> = a/T = mean depth of flow				0.0026	0.0048	0.0026	0.0048		

$s_c$  = critical slope ft / ft

T = top width of the stream

$d_m = a/T$  = mean depth of flow

Created by: Mike O'Shea

# MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **NE of Bldg Street Capacity (Need 4.7 cfs)**

By: **Dane Frank**

Date: **8/28/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

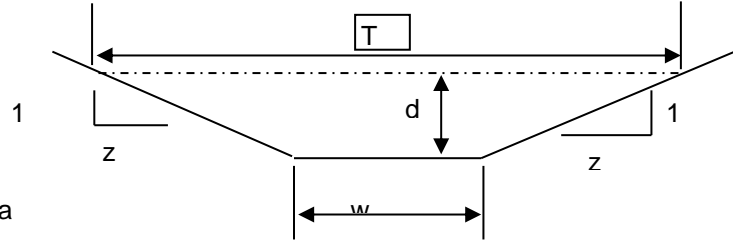
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 25  
z (sideslope)= 25  
b (btm width, ft)= 0  
d (depth, ft)= 0.6  
S (slope, ft/ft) 0.1  
n low = 0.013  
n high = 0.013

Clear Data  
Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity,				T =	
				Velocity, fps	Flow, cfs	fps	Flow, cfs		
0.6	9.00	30.02	0.30	16.1897726	145.708	16.18977	145.708		30
								Dm =	0.300
				Sc low =	0.0037	Sc high =	0.0037		
s <sub>c</sub> = critical slope    ft / ft									
T = top width of the stream				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
d <sub>m</sub> = a/T = mean depth of flow				0.0026	0.0048	0.0026	0.0048		

s<sub>c</sub> = critical slope ft / ft

T = top width of the stream

d<sub>m</sub> = a/T = mean depth of flow

Created by: Mike O'Shea

# MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **SE of Bldg Street Capacity (Need 4.7 cfs)**

By: **Dane Frank**

Date: **8/28/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

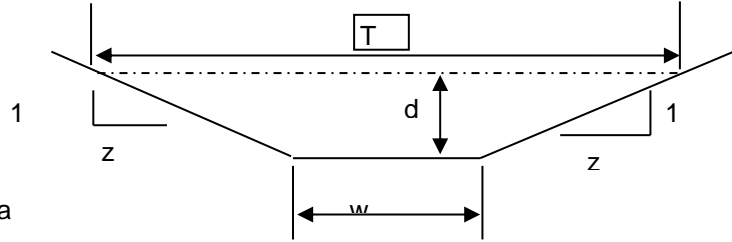
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 50  
z (sideslope)= 0  
b (btm width, ft)= 0  
d (depth, ft)= 0.5  
S (slope, ft/ft) 0.01  
n low = 0.013  
n high = 0.013

Clear Data  
Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
0.5	6.25	25.50	0.25	4.47601532	27.9751	4.476015	27.9751	T =	25
				Sc low =		Sc high =		Dm =	0.250
				.7 Sc		.7 Sc			
				0.0028		0.0028			
				1.3 Sc		1.3 Sc			
				0.0052		0.0052			

s<sub>c</sub> = critical slope ft / ft

T = top width of the stream

d<sub>m</sub> = a/T = mean depth of flow

Created by: Mike O'Shea

# MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **SW of Bldg Street Capacity (Need 4.7 cfs)**

By: **Dane Frank**

Date: **8/28/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

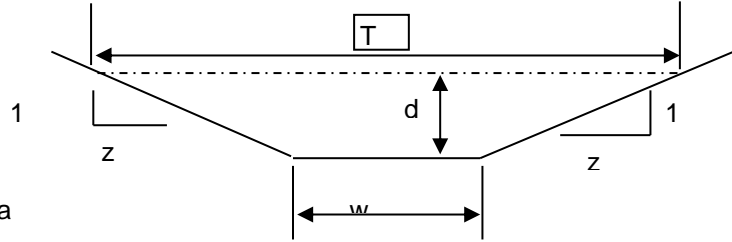
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 25  
z (sideslope)= 0  
b (btm width, ft)= 0  
d (depth, ft)= 0.5  
S (slope, ft/ft) 0.1  
n low = 0.013  
n high = 0.013

Clear Data  
Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity,				T =	
				Velocity, fps	Flow, cfs	fps	Flow, cfs		
0.5	3.13	13.01	0.24	13.967008	43.6469	13.96701	43.6469	Dm =	12.5
				Sc low =	0.0041	Sc high =	0.0041		0.250
s <sub>c</sub> = critical slope    ft / ft									
T = top width of the stream				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
d <sub>m</sub> = a/T = mean depth of flow				0.0029	0.0054	0.0029	0.0054		

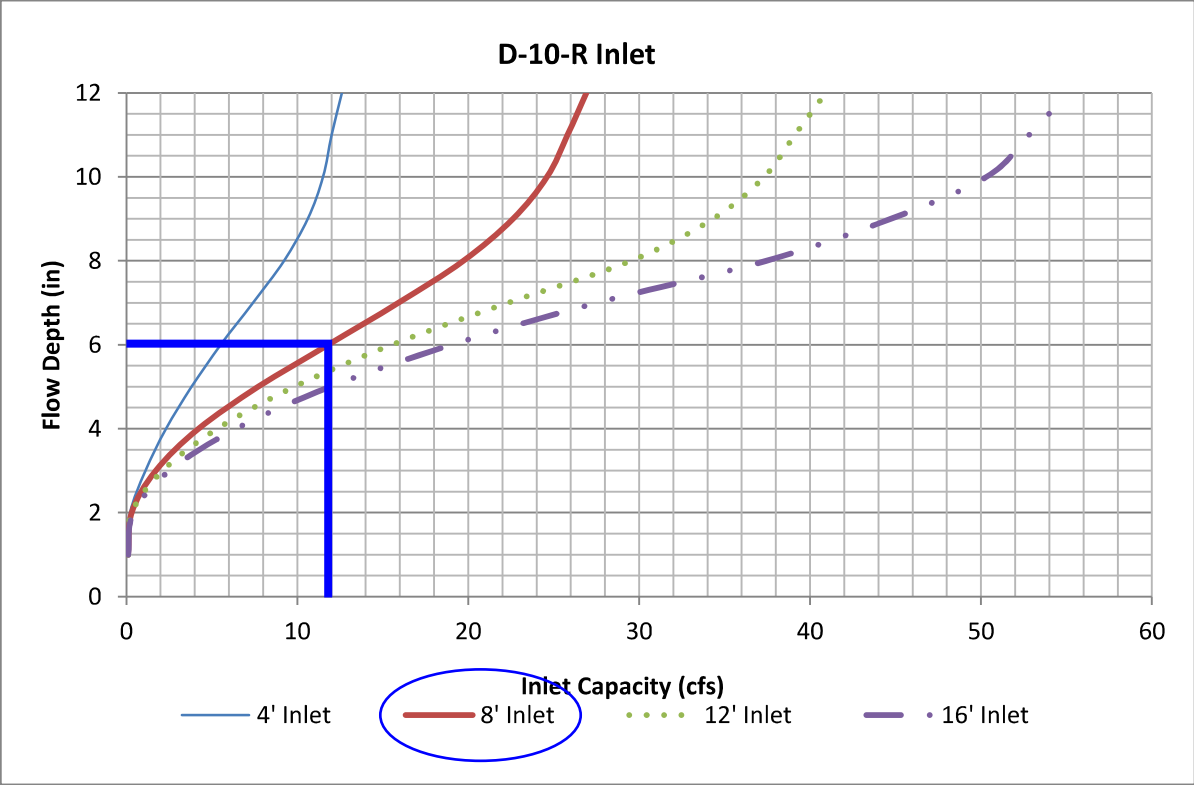
s<sub>c</sub> = critical slope ft / ft

T = top width of the stream

d<sub>m</sub> = a/T = mean depth of flow

Created by: Mike O'Shea

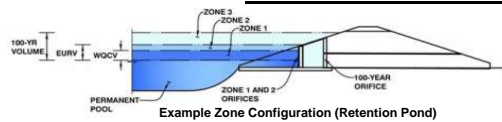
Figure 8-12. Inlet Capacity Chart Sump Conditions, Curb Opening (D-10-R) Inlet



## **DETENTION CALCULATIONS**

## MHFD-Detention, Version 4.03 (May 2020)

Basin ID: EDB



Selected BMP Type =	<b>EDB</b>	
Watershed Area =	1.77	acres
Watershed Length =	340	ft
Watershed Length to Centroid =	170	ft
Watershed Slope =	0.060	ft/ft
Watershed Imperviousness =	62.00%	percent
Percentage Hydrologic Soil Group A =	98.0%	percent
Percentage Hydrologic Soil Group B =	2.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths = Denver - Capitol Building		

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

Water Quality Capture Volume (WQCV) =	0.036	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.134	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.091	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.120	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.143	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	0.175	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	0.205	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.242	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3 in.) =	0.305	acre-feet	3.00	inches
Approximate 2-yr Detention Volume =	0.087	acre-feet		
Approximate 5-yr Detention Volume =	0.114	acre-feet		
Approximate 10-yr Detention Volume =	0.138	acre-feet		
Approximate 25-yr Detention Volume =	0.167	acre-feet		
Approximate 50-yr Detention Volume =	0.184	acre-feet		
Approximate 100-yr Detention Volume =	0.202	acre-feet		

Zone 1 Volume (WQCV) =	0.036	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.098	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.068	acre-feet
Total Detention Basin Volume =	0.202	
Initial Surge Volume (ISV) =	user	ft <sup>3</sup>
Initial Surge Depth (ISD) =	user	ft
Total Available Detention Depth (H <sub>total</sub> ) =	user	ft
Depth of Trickle Channel (H <sub>TC</sub> ) =	user	ft
Slope of Trickle Channel (S <sub>TC</sub> ) =	user	ft/ft
Slopes of Main Basin Sides (S <sub>main</sub> ) =	user	H:V
Basin Length-to-Width Ratio (R <sub>L/W</sub> ) =	user	

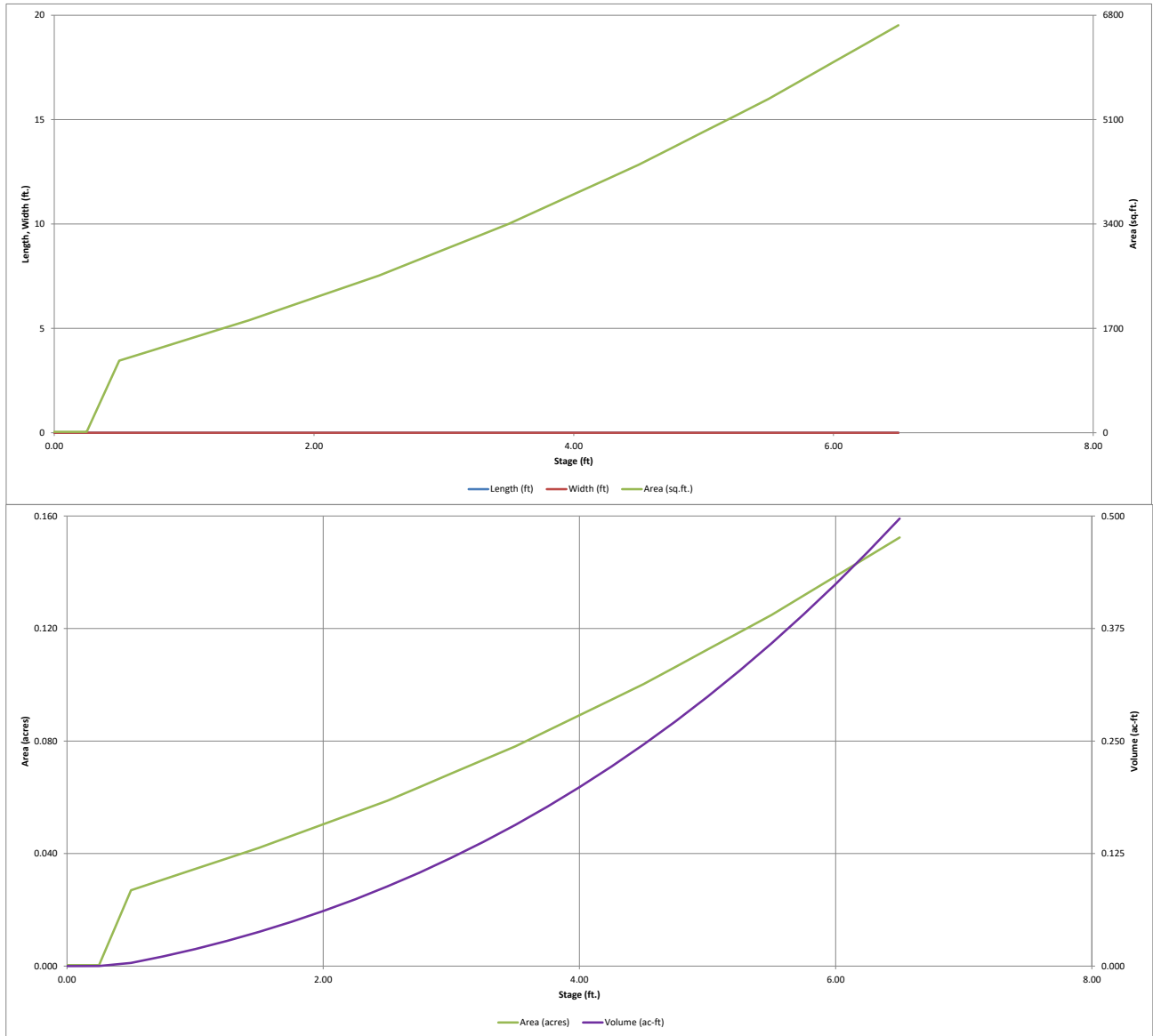
Initial Surcharge Area ( $A_{ISV}$ )	=	user	ft <sup>2</sup>
Surcharge Volume Length ( $L_{ISV}$ )	=	user	ft
Surcharge Volume Width ( $W_{ISV}$ )	=	user	ft
Depth of Basin Floor ( $H_{FLOOR}$ )	=	user	ft
Length of Basin Floor ( $L_{FLOOR}$ )	=	user	ft
Width of Basin Floor ( $W_{FLOOR}$ )	=	user	ft
Area of Basin Floor ( $A_{FLOOR}$ )	=	user	ft <sup>2</sup>
Volume of Basin Floor ( $V_{FLOOR}$ )	=	user	ft <sup>3</sup>
Depth of Main Basin ( $H_{MAIN}$ )	=	user	ft
Length of Main Basin ( $L_{MAIN}$ )	=	user	ft
Width of Main Basin ( $W_{MAIN}$ )	=	user	ft
Area of Main Basin ( $A_{MAIN}$ )	=	user	ft <sup>2</sup>
Volume of Main Basin ( $V_{MAIN}$ )	=	user	ft <sup>3</sup>
Calculated Total Basin Volume ( $V_{TBD}$ )	=	user	acre-feet

[illegible]



# DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)

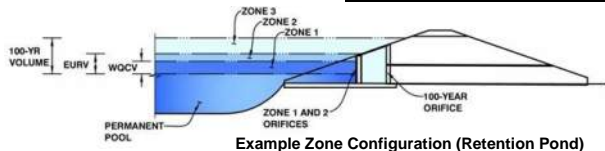


# DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.03 (May 2020)

Project: **Electronic Storage**

Basin ID: **EDB**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.45	0.036	Orifice Plate
Zone 2 (EURV)	3.20	0.098	Orifice Plate
Zone 3 (100-year)	4.04	0.068	Weir&Pipe (Rect.)
Total (all zones)		0.202	

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

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

Calculated Parameters for Underdrain  
Underdrain Orifice Area =  ft<sup>2</sup>  
Underdrain Orifice Centroid =  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 =  ft (relative to basin bottom at Stage = 0 ft)  
Depth at top of Zone using Orifice Plate =  ft (relative to basin bottom at Stage = 0 ft)  
Orifice Plate: Orifice Vertical Spacing =  inches  
Orifice Plate: Orifice Area per Row =  sq. inches (diameter = 5/8 inch)

Calculated Parameters for Plate  
WQ Orifice Area per Row =  ft<sup>2</sup>  
Elliptical Half-Width =  feet  
Elliptical Slot Centroid =  feet  
Elliptical Slot Area =  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)	0.00	1.07	2.13					
Orifice Area (sq. inches)	0.31	0.31	0.31					

	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)

Invert of Vertical Orifice =  ft (relative to basin bottom at Stage = 0 ft)  
Depth at top of Zone using Vertical Orifice =  ft (relative to basin bottom at Stage = 0 ft)  
Vertical Orifice Diameter =  inches

Calculated Parameters for Vertical Orifice  
Vertical Orifice Area =  ft<sup>2</sup>  
Vertical Orifice Centroid =  feet

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir (and No Outlet Pipe))

Overflow Weir Front Edge Height, H<sub>o</sub> =  ft (relative to basin bottom at Stage = 0 ft)  
Overflow Weir Front Edge Length =  feet  
Overflow Weir Grate Slope =  H:V  
Horiz. Length of Weir Sides =  feet  
Overflow Grate Open Area % =  %  
Debris Clogging % =  %

Calculated Parameters for Overflow Weir  
Height of Grate Upper Edge, H<sub>u</sub> =  feet  
Overflow Weir Slope Length =  feet  
Grate Open Area / 100-yr Orifice Area =   
Overflow Grate Open Area w/o Debris =  ft<sup>2</sup>  
Overflow Grate Open Area w/ Debris =  ft<sup>2</sup>

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

Depth to Invert of Outlet Pipe =  ft (distance below basin bottom at Stage = 0 ft)  
Rectangular Orifice Width =  inches  
Rectangular Orifice Height =  inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate  
Outlet Orifice Area =  ft<sup>2</sup>  
Outlet Orifice Centroid =  feet  
Half-Central Angle of Restrictor Plate on Pipe =  radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

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

Calculated Parameters for Spillway  
Spillway Design Flow Depth =  feet  
Stage at Top of Freeboard =  feet  
Basin Area at Top of Freeboard =  acres  
Basin Volume at Top of Freeboard =  acre-ft

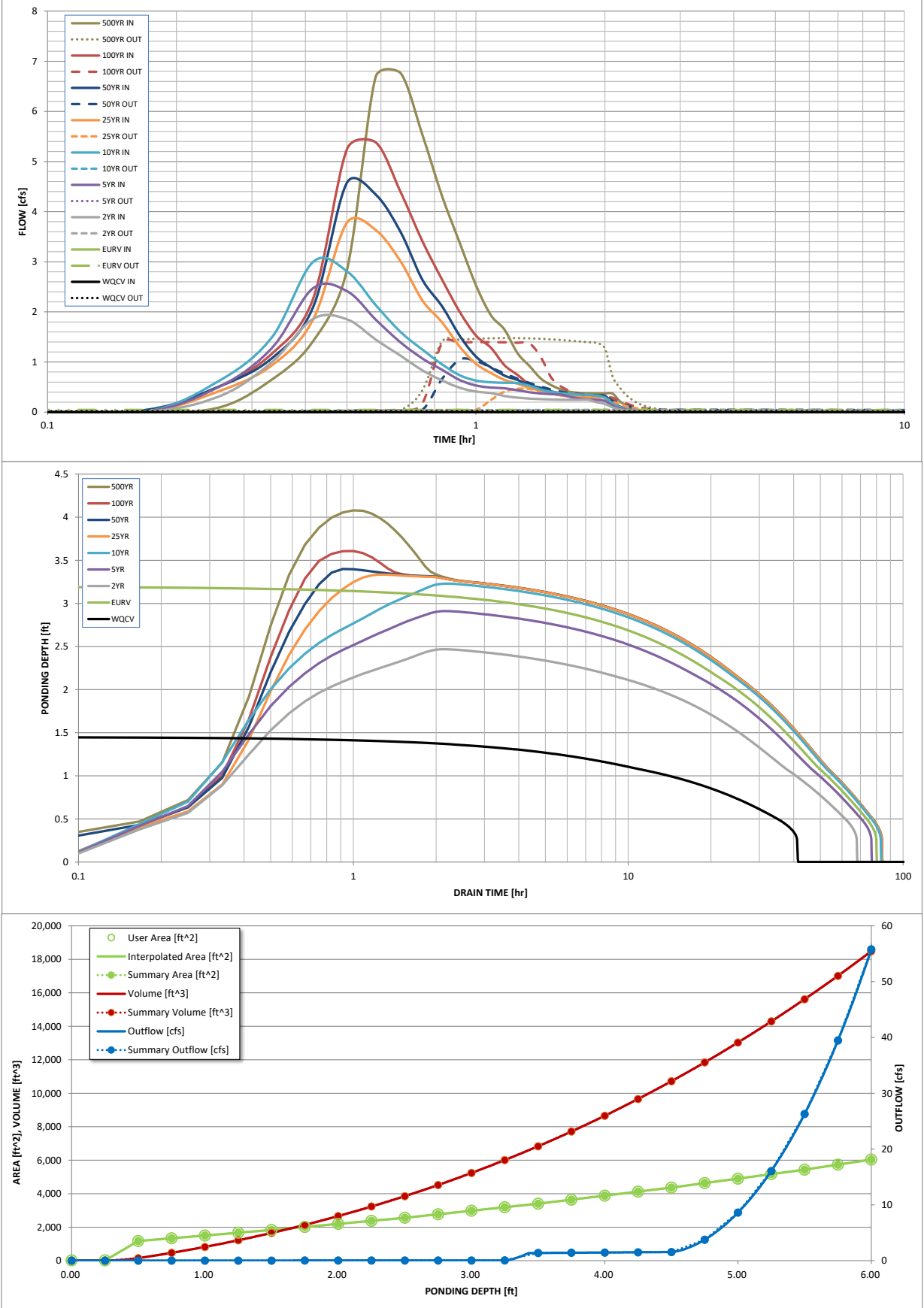
## Routed Hydrograph Results

The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.00
One-Hour Rainfall Depth (in) =	0.036	0.134	0.091	0.120	0.143	0.175	0.205	0.242	0.305
CUHP Runoff Volume (acre-ft) =	N/A	N/A	0.091	0.120	0.143	0.175	0.205	0.242	0.305
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.0	0.0	0.1	0.5	1.0	1.5	2.4
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A							
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.02	0.03	0.30	0.55	0.87	1.37
Peak Inflow Q (cfs) =	N/A	N/A	1.9	2.5	3.0	3.8	4.6	5.4	6.8
Peak Outflow Q (cfs) =	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.4	1.5
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.0	0.8	0.9	1.1	0.9	0.6
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	0.1	0.4	0.5	0.5
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) =	39	73	63	70	76	75	73	72	69
Time to Drain 99% of Inflow Volume (hours) =	41	78	66	75	80	81	80	79	78
Maximum Ponding Depth (ft) =	1.46	3.20	2.47	2.91	3.23	3.33	3.40	3.61	4.08
Area at Maximum Ponding Depth (acres) =	0.04	0.07	0.06	0.07	0.07	0.07	0.08	0.08	0.09
Maximum Volume Stored (acre-ft) =	0.036	0.134	0.086	0.114	0.136	0.144	0.148	0.165	0.205

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.00 (December 2019)



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

**FORBAY VOLUMES**

**FORBAY VOLUME**

Required Forbay Volume = 1% of WQCV  
WQCV = 0.035 ac-ft  
WQCV = 1,525 cu-ft  
1% of WQCV = 15 cu-ft

<i>ELEV</i>	<i>AREA</i>	<i>AREA AVG.</i>	<i>DELTA ELEV.</i>	<i>VOLUME</i>	<i>VOLUME TOTAL</i>
6483.00	39	39	1	39	
6484.00	39				39

Design Volume: 39 cu-ft  
0.001 ac-ft

# MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

By: **Dane Frank**

Chk By:

Location: **Forebay Notch - Q=13.9 cfs \* 2% = 0.28 cfs**

Date: **8/31/2020**

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

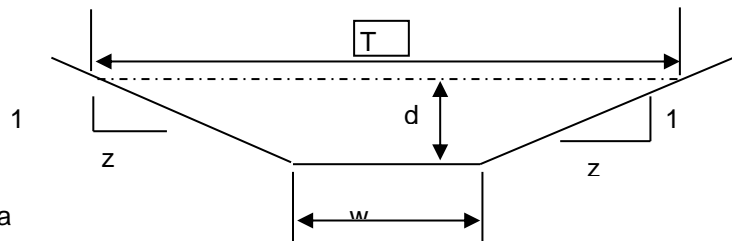
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 0  
z (sideslope)= 0  
b (btm width, ft)= 0.19  
d (depth, ft)= 1  
S (slope, ft/ft) 0.005  
n low = 0.013  
n high = 0.013

Clear Data  
Entry Cells

Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Low N		High N		
				Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs	
1	0.19	2.19	0.09	1.58391326	0.30094	1.583913	0.30094	T = 0.19
								Dm = 1.000
				Sc low = 0.0641		Sc high = 0.0641		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc	
				0.0448	0.0833	0.0448	0.0833	

s<sub>c</sub> = critical slope ft / ft

T = top width of the stream

d<sub>m</sub> = a/T = mean depth of flow

Created by: Mike O'Shea

# MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **EDB Trickle Channels (need Q= 0.28 cfs)**

By: **Dane Frank**

Date: **8/31/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

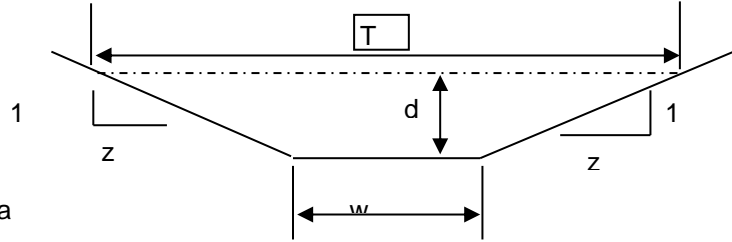
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 0  
z (sideslope)= 0  
b (btm width, ft)= 0.3  
d (depth, ft)= 0.5  
S (slope, ft/ft) 0.005  
n low = 0.013  
n high = 0.013

Clear Data  
Entry Cells

Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Low N		High N		
				Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs	
0.5	0.15	1.30	0.12	1.91555431	0.28733	1.915554	0.28733	T = 0.3
				Sc low = 0.0219		Sc high = 0.0219		Dm = 0.500
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc	
				0.0153	0.0285	0.0153	0.0285	

$s_c$  = critical slope ft / ft

T = top width of the stream

$d_m = a/T$  = mean depth of flow










Created by: Mike O'Shea

## **DRAINAGE MAPS**

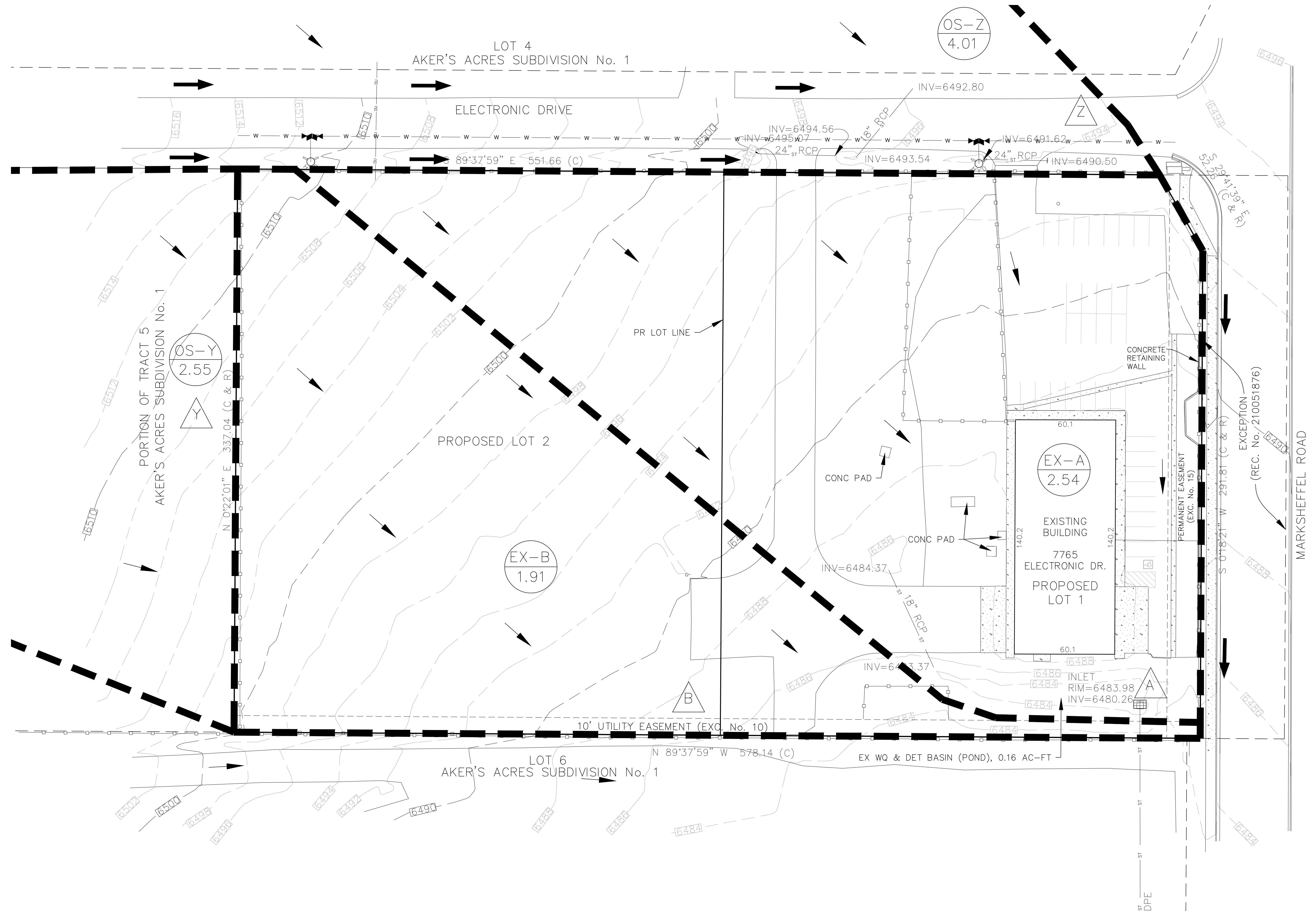
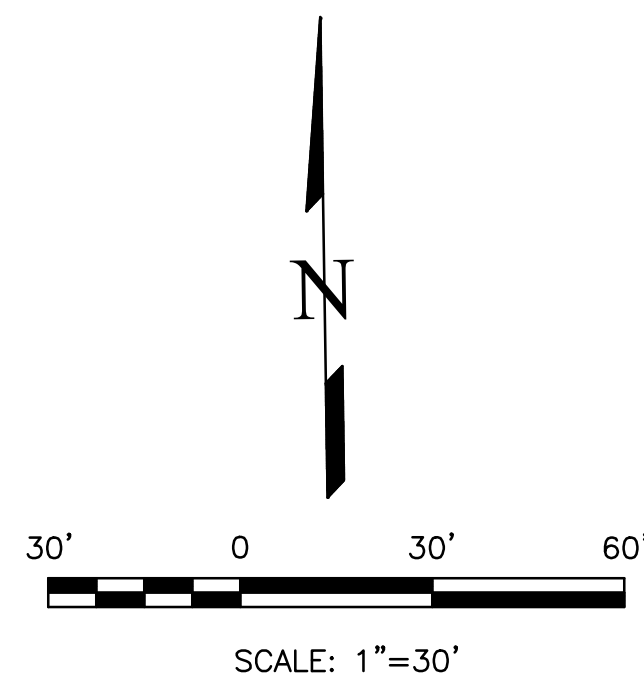
**ELECTRONIC STORAGE**  
SITE DEVELOPMENT PLAN  
**EXISTING DRAINAGE MAP**  
DECEMBER 2020

DESIGN POINT	BASIN	AREA (ACRES)	FLOW	
			5 YR (cfs)	100 YR (cfs)
Z	OS-Z	4.01	7.3	16.5
Y	OS-Y	2.55	2.1	8.2
A	EX-A	2.54	3.2	9.5
B	EX-B	1.91	0.9	5.4

**Legend**

-  BASIN DESIGNATION
-  AREA IN BASIN (AC)
-  DESIGN POINT
-  BASIN BOUNDARY
-  EXISTING 1' CONTOUR
-  EXISTING 10' CONTOUR
-  GROUND SURFACE FLOW DIRECTION
-  ROAD AND DITCH FLOW DIRECTION
-  CHAIN-LINK FENCE

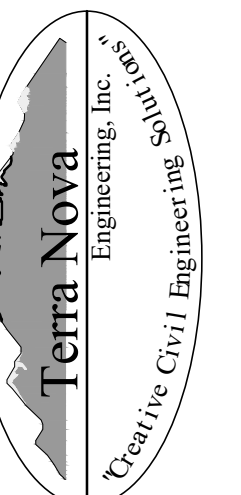
1. ALL FEATURE SHOWN ARE EXISTING.
2. NO GRADING CHANGES ARE INCLUDED IN THIS PLAN
3. THE OFFSITE BASINS ARE BASED ON FIMS GROUND SURFACE CONTOURS. FIMS DATA IS FROM 2012.



NUMBERS	DESCRIPTION	DATE
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		
57		
58		
59		
60		
61		
62		
63		
64		
65		
66		
67		
68		
69		
70		
71		
72		
73		
74		
75		
76		
77		
78		
79		
80		
81		
82		
83		
84		
85		
86		
87		
88		
89		
90		
91		
92		
93		
94		
95		
96		
97		
98		
99		
100		

UNTIL SUCH TIME AS THESE  
DRAWINGS ARE APPROVED  
BY THE APPROPRIATE  
REVIEWING AGENCIES,  
TERRA NOVA ENGINEERING,  
INC. APPROVES THEIR USE  
ONLY FOR THE  
PURPOSES DESIGNATED BY  
WRITTEN AUTHORIZATION.

PREPARED FOR:  
**D. STEFANO-BUILDING &...**  
ATTN: DAVID STEFANO  
520 W 21ST ST, G-2 #710  
NORFOLK, CA 93517  
757.333.3144



721 S. 23RD STREET  
COLORADO SPRINGS, CO 80904

---

OFFICE: 719-635-6422  
FAX: 719-635-6426  
[www.tnesinc.com](http://www.tnesinc.com)

## ELECTRONIC STORAGE

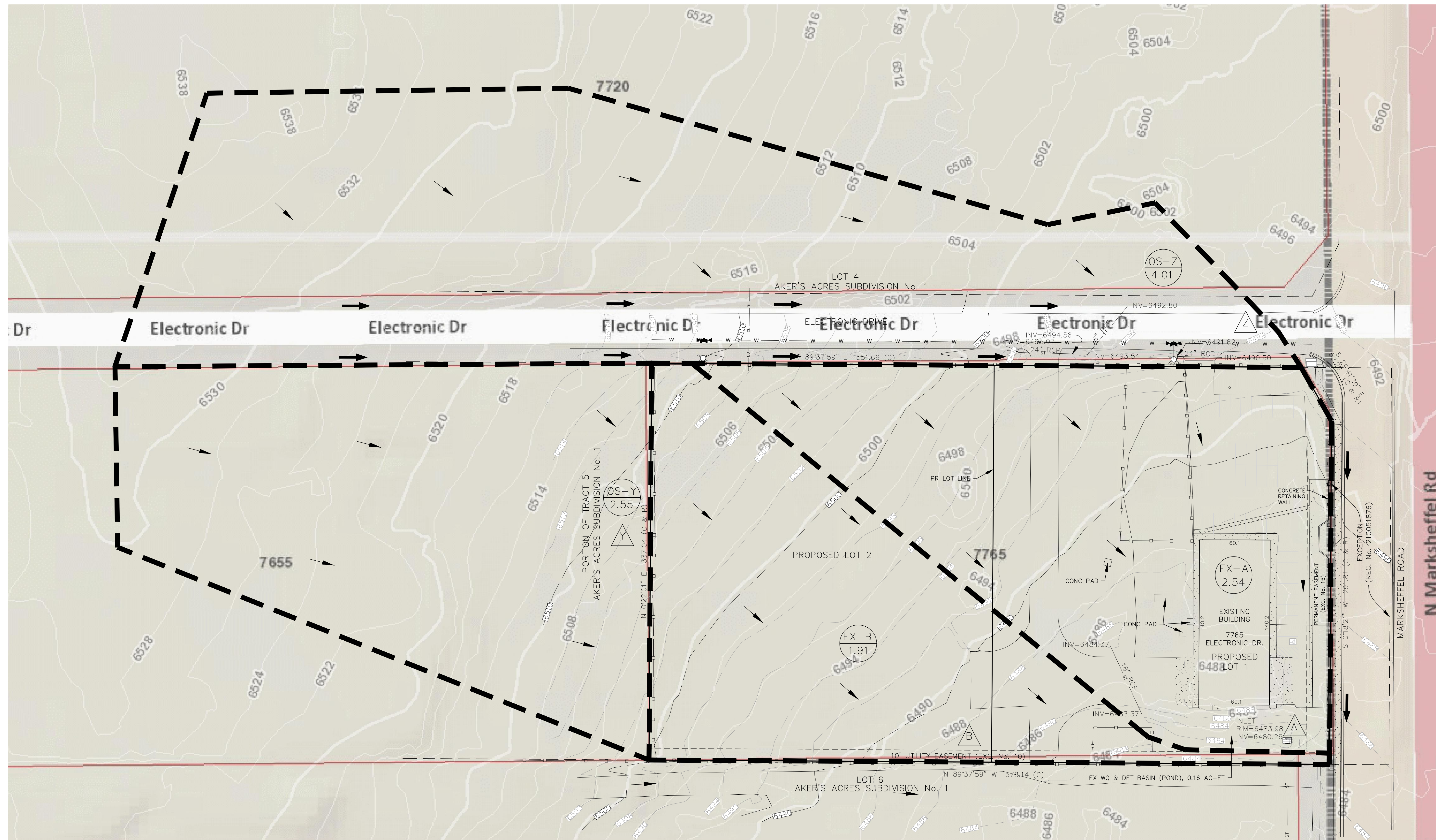
FOR THE RECORD

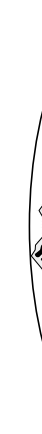
SIGNED BY DLF
DRAWN BY DLF
CHECKED BY LD
SCALE AS SHOWN
SCALE N/A
DB NO. 1971.00
DATE ISSUED 12/14/20
SHEET NO. 1 OF 4



**NOTES**

1. ALL FEATURE SHOWN ARE EXISTING.
2. NO GRADING CHANGES ARE INCLUDED IN THIS PLAN.
3. THE OFFSITE BASINS ARE BASED ON FIMS GROUND SURFACE CONTOURS. FIMS DATA IS FROM 2012.



<h2 style="margin: 0;">ELECTRONIC STORAGE</h2>	<h2 style="margin: 0;">EXISTING OFFSITE BASINS</h2>	<div style="text-align: center;">  </div> <p style="text-align: center;">             721 S. 23RD STREET              COLORADO SPRINGS, CO 80904              OFFICE: 719-635-6422              FAX: 719-635-6426  <a href="http://www.tnseinc.com">www.tnseinc.com</a> </p>
<p>DESIGNED BY DLF</p> <p>DRAWN BY DLF</p> <p>CHECKED BY LD</p> <p>H-SCALE AS SHOWN</p> <p>V-SCALE N/A</p> <p>JOB NO. 1971.00</p> <p>DATE ISSUED 12/14/20</p> <p>SHEET NO. 2 OF 20</p>		



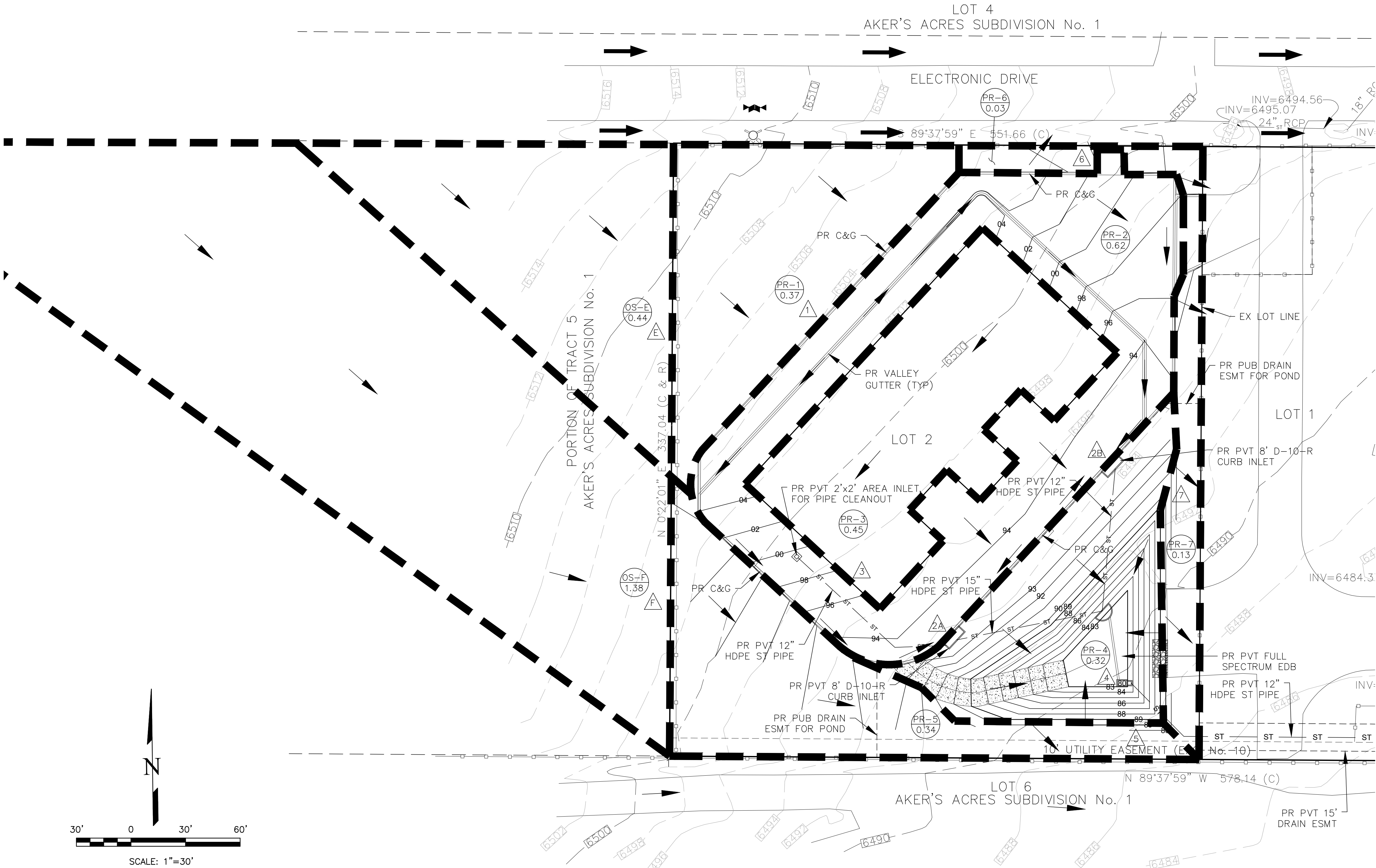
N:\jobs\1971.00\Drawings\197100 SDP.dwg, 2/4/2021 10:00:27 AM

BASIN SUMMARY				
DESIGN POINT	BASIN	AREA (ACRES)	FLOW	
			5 YR (cfs)	100 YR (cfs)
E	OS-E	0.44	0.4	1.7
F	OS-F	1.38	1.2	4.6
1	PR-1	0.37	0.2	1.1
2	PR-2	0.62	3.2	6.5
3	PR-3	0.45	2.3	4.5
4	PR-4	0.32	0.2	1.2
5	PR-5	0.34	0.1	1.0
6	PR-6	0.03	0.0	0.1
7	PR-7	0.13	0.1	0.6

DESIGN POINT SUMMARY				
DESIGN POINT	CONTRIBUTING BASINS	AREA (ACRES)	FLOW	
			5 YR (cfs)	100 YR (cfs)
E	OS-E	0.44	0.4	1.7
F	OS-F	1.38	1.2	4.6
1	OS-E,PR-1	0.81	0.6	2.8
2	OS-E,PR-1,PR-2	1.44	3.8	9.3
2A	HALF OF BASIN TOTAL	---	1.9	4.7
2B	HALF OF BASIN TOTAL	---	1.9	4.7
3	PR-3	0.45	2.3	4.5
4	OS-E,PR-1,PR-2,PR-3,PR-4	2.20	6.3	15.1
5	OS-F,PR-5	1.72	1.3	5.6
6	PR-6	0.03	0.0	0.1
7	PR-7	0.13	0.1	0.6

LEGEND

- BASIN DESIGNATION
- AREA IN BASIN (AC)
- DESIGN POINT
- BASIN BOUNDARY
- EXISTING 1' CONTOUR
- EXISTING 10' CONTOUR
- GROUND SURFACE FLOW DIRECTION
- ROAD AND DITCH FLOW DIRECTION
- CHAIN-LINK FENCE



ELECTRONIC STORAGE  
SITE DEVELOPMENT PLAN  
PROPOSED DRAINAGE MAP  
DECEMBER 2020

REVISIONS

NO.	DESCRIPTION	DATE

UNTIL SUCH TIME AS THESE DRAWINGS ARE APPROVED FOR THE PROJECT BY THE REVIEWING AGENCIES, TERRA NOVA ENGINEERING, INC. APPROVES THEIR USE ONLY FOR THE PROJECT AND ANY MODIFICATIONS WITHOUT WRITTEN AUTHORIZATION.

PREPARED FOR:  
**D. STEFANO-BUILDING &...**  
ATTN: DAVID STEFANO  
520 W 21ST ST, G-2 #710  
NORFOLK, CA 23517  
757.333.3144

721 S. 23RD STREET  
COLORADO SPRINGS, CO 80904  
OFFICE: 719-635-6422  
FAX: 719-635-6426  
www.tnecinc.com

ELECTRONIC STORAGE

PROPOSED DRAINAGE MAP

DESIGNED BY DLF

DRAWN BY DLF

CHECKED BY LD

H-SCALE AS SHOWN

V-SCALE N/A

JOB NO. 1971.00

DATE ISSUED 12/14/20

SHEET NO. 3 OF 4

