Appendix B1

Drainage Report
1-Q24-063-Drainage Study

Canyon Peak Power Arapahoe County 1041/USR Application Q24-063

Stanley Consultants

Kindle Energy 1041 Drainage Report

Arapahoe County, Colorado

Prepared for: Kindle Energy
Prepared by: Stanley Consultants INC.

December 2024

Stanley Consultants INC.

Deliverable: Drainage Report
Project: Canyon Peak Power
Client: Kindle Energy LLC
Location: 5050 N County Rd 129, Bennett, CO 80102

Contract No:

Submittal: Draft Report
Date: December 20, 2024

Prepared by:
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Section 1 General Location and Description

1.1 Site Location

Canyon Peak Power LLC ("Canyon Peak") an affiliate of Kindle Energy LLC, is proposing a 150-170 MW power generation facility in Arapahoe County. The project site is located at 5050 N County RD 129, Bennett, CO 80102, 1 mile south of the intersection of County Road 129 and County Road 30. The property was developed in 2007 with a substation. This project will use vacant portions of the site to expand the substation to the east. The site is zoned as 'A-1' (Agricultural). The overall site is 20.0 acres.

Directly adjacent to the site in the north, east, and south is a solar farm. The development of this site included the addition of solar facility components, access driveways, and security fencing. The pre-existing drainage patterns of this site were maintained.

1.2 Report Purpose

This report presents the hydrologic and hydraulic analysis for development of the Canyon Peak Power site. Design would be in accordance with Arapahoe County requirements per the Arapahoe County Stormwater Management Manual, dated July 5, 2011.

The project is located in Section 9, Township 5 South, Range 63 West of the 6th Principal Meridian. See Figure 1.

Figure 1-1: Vicinity Map

1.3 Property Description

1.3.1 General

This project includes developing the east side of an existing substation site for expansion. The site is currently zoned 'A-1' (Agricultural). Existing ground cover of the east portion of the site includes native grasses and brush. The proposed development would maintain the overall drainage pattern and provide a detention pond in the southeast corner to attenuate flow and provide water quality contained volume. The proposed development requires removing the existing development's stormwater detention measures. The proposed development will include new detention facilities that maintain the existing outflow offsite.

The proposed expansion of the site includes gravel access roads and parking around the perimeter. The total proposed impervious area is 5.60 acres and the total disturbed area is 13.60 acres. Drainage will be provided by ditches storm sewer conveying runoff to a proposed extended detention basin.

1.3.2 General Topography

Existing slopes on site are between 0.5-3 percent. The existing substation slopes southeast and existing grading on the west part of the site will not be altered during the proposed development. There is currently a concrete channel on the south end of the site the directs runoff from west to east to an outlet on the SE corner of the site. The outlet structure maintains a 100-year outflow of 16.16 cfs. It also provides the sites water quality volume. There are two grass swales that convey runoff to the concrete channel from the north and from the west.

1.3.3 General Soil Conditions

The project site contains Hydrologic Soil Group (HSG) C. Type C soils have moderate infiltration rates and moderate to high runoff potential. Soil information was obtained from the NRCS Soils Map and are provided in Appendix A. The primary soil types at the project site are listed in Table 1-1.

Table 1-1: Hydrologic Soil Groups

Map Symbol	Description	HSG
WrB	Weld-Deertrail silt loams, 0 to 3 percent slopes	C
AdC	Adena-Colby silt loams, 1 to 5 percent slopes	C

Stanley Consultants is unaware of any groundwater present at the proposed development. No groundwater was found at the bore locations performed by H.P. Geotech at the proposed development.

1.3.3 Major Drainageways

The project site is not located near a major waterway. The project site is located in the South Platte River Watershed. Runoff from the site is received by Kiowa Creek.

The site is not located within a special flood hazard zone as shown per Flodd Insurance Rate Maps (Community Panel 08005C0265K, dated 12-17-2010 and Panel 08005C0575K, dated 12-17-2012) published by the Federal Emergency Management Agency (FEMA). The site is also outside of the Kiowa Creek Master Drainage Plan's Existing and Proposed100-year Flood Plain.

1.3.4 Irrigation Facilities

Stanley Consultants is unaware of any existing irrigation canals or ditches on site.

1.3.5 Utilities and Other Encumbrances

Stanley Consultants is unaware of any significant geological features or other encumbrances on site.

Due to the site being a substation, there are many overhead utilities. There are no known underground utilities impeding site design.

Section 2 Drainage Basins and Sub-Basins

2.1 Drainage Areas

Existing Drainage Areas

Existing drainage patterns on the site generally drain from north to south to roadside ditches along the southwest end of the project site. Water then flows to the west and into a concrete channel along the southeast edge of the site where it outlets to the southeast corner of the site. The concrete channel is used as a water quality volume BMP and for the 100-year storm flood control. Existing slopes on the site are between 0.5 to 3 percent. The current site's impervious area is 2.41 acres.

Directly adjacent to the site is a solar farm which maintained pre-existing drainage patterns.

Proposed Drainage Areas

The proposed design includes development on the east portion of the site. The site will be covered with gravel with concrete pads constructed to support the proposed equipment. The proposed total impervious area after expansion is 5.60 acres. Runoff will be conveyed to a detention pond by overland flow, conveyance ditches, and storm sewer. The existing concrete channel will be removed to accommodate the proposed design. The existing grass channel will convey runoff from the west of the site to a culvert under the west proposed access road. A secondary culvert will be installed under the east proposed access road. A vegetated channel will convey runoff from north to south and connect to the grass channel along the southern border of the site. The detention pond will continue use the same outfall location and elevation.

Section 3 Drainage Design Criteria

3.1 Development Criteria Reference

The design was based on the Arapahoe County Stormwater Management Manual, dated July 5, 2011, and the Mile High Flood District (MHFD) Criteria Manuals.

- "Water Quality Capture Volume (WQCV) and flood control detention must be provided for all new development, redevelopment, or expansion of a site."
- "The 100-year volume provided for full-spectrum detention facilities are equal to the 100-year detention volume calculated using the UDFCD simplified equation plus the WQCV."
- The maximum allowable 100-year release rate should not exceed 90% of the approved predevelopment release rate.
- Excess Urban Runoff Volume (EURV) is the difference between the developed and pre-developed runoff volume and must be included in the design criteria.

3.2 Hydrologic and Hydraulic Design

Rainfall data was obtained by NOAA Atlas 14 and is provided in Appendix B. The rational method was used for channel sizing and the UD-Detention workbook was used for the basin sizing. The peak runoff from the developed site was calculated using the rational method for the 100-year, 1-hour storm event. The percent impervious from the developed site is 27.40%.

The maximum allowable 100-year release rate based on predevelopment conditions is 16.16 cfs. The release rate of 16.16 cfs will be used for the 100-year release rate.

Detention calculations used the Modified FAA method tab from the Urban Drainage and Flood District workbook (ud-detention_v2.35), based on a 100-year, 1-hour storm event.

The provided major detention volume is 1.420 acre-feet based on a catchment drainage area of 20 acres. The proposed pond is a extended detention basin, 4.5' deep with 1-foot freeboard. Side slopes will be 4:1, and the pond bottom will be graded with a 0.5% slope. Release from the pond will use a 18-inch pipe with a restrictor plate attached. The overflow spillway will be designed to convey the 100-year inflow with a flow depth less than 0.5 feet.

The Water Quality Capture Volume (WQCV) was calculated as 0.251 ac-ft based on the MHFD Urban Storm Drainage Criteria Manuals. A water surface elevation of depth 1.87' will be required to provide this volume.

The outlet structure is designed for release of the WQCV as well as the EURV and 100-year storage volume. The outlet will have the WQCV orifice plate, and the outlet pipe restrictor plate attached.

The proposed ditches are sized based on a 10-year storm with calculations provided in Appendix D.

Section 4 Conclusions

The project complies with the standards and requirements of Arapahoe County and the drainage report is in conformation with Arapahoe County Stormwater Management Manual. The basic drainage concept is to convey all flows from the site to the stormwater detention pond located in the southeast corner. The detention pond will be sized to contain the 100-year, 1-hour storm.

Appendix A NRCS Soils Data

Map Scale: 1:2,530 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 35 70 140 210

Feet: 0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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: Arapahoe County, Colorado
Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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
AdC	Adena-Colby silt loams, 1 to 5 percent slopes	6.4	23.1%
WrB	Weld-Deertrail silt loams, 0 to 3 percent slopes	21.2	76.9%
Totals for Area of Interest		**27.5**	**100.0%**

Appendix B NOAA Rainfall Data

NOAA Atlas 14, Volume 8, Version 2
Location name: Brick Center, Colorado, USA*
Latitude: 39.6232°, Longitude: -104.4518°
Elevation: 5767 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.234** (0.193-0.287)	**0.292** (0.240-0.357)	**0.392** (0.321-0.481)	**0.483** (0.393-0.594)	**0.618** (0.487-0.796)	**0.730** (0.559-0.948)	**0.849** (0.625-1.13)	**0.977** (0.686-1.33)	**1.16** (0.778-1.61)	**1.30** (0.847-1.82)
10-min	**0.343** (0.282-0.420)	**0.427** (0.351-0.522)	**0.574** (0.470-0.704)	**0.707** (0.575-0.870)	**0.904** (0.714-1.16)	**1.07** (0.818-1.39)	**1.24** (0.915-1.65)	**1.43** (1.00-1.94)	**1.70** (1.14-2.36)	**1.91** (1.24-2.67)
15-min	**0.419** (0.344-0.512)	**0.521** (0.428-0.637)	**0.700** (0.573-0.859)	**0.862** (0.701-1.06)	**1.10** (0.870-1.42)	**1.30** (0.998-1.69)	**1.52** (1.12-2.01)	**1.74** (1.22-2.37)	**2.07** (1.39-2.88)	**2.33** (1.51-3.26)
30-min	**0.562** (0.463-0.687)	**0.697** (0.573-0.853)	**0.936** (0.766-1.15)	**1.15** (0.937-1.42)	**1.48** (1.16-1.90)	**1.75** (1.34-2.27)	**2.03** (1.50-2.70)	**2.34** (1.65-3.19)	**2.78** (1.87-3.88)	**3.14** (2.04-4.40)
60-min	**0.700** (0.576-0.855)	**0.859** (0.706-1.05)	**1.15** (0.939-1.41)	**1.41** (1.15-1.74)	**1.82** (1.44-2.35)	**2.16** (1.66-2.81)	**2.52** (1.86-3.36)	**2.92** (2.06-3.98)	**3.49** (2.35-4.87)	**3.95** (2.57-5.54)
2-hr	**0.837** (0.692-1.02)	**1.02** (0.844-1.24)	**1.36** (1.12-1.66)	**1.67** (1.37-2.05)	**2.16** (1.72-2.78)	**2.57** (1.98-3.33)	**3.01** (2.24-3.99)	**3.50** (2.48-4.74)	**4.20** (2.85-5.82)	**4.77** (3.13-6.63)
3-hr	**0.924** (0.766-1.12)	**1.12** (0.927-1.36)	**1.48** (1.22-1.80)	**1.82** (1.49-2.22)	**2.34** (1.88-3.01)	**2.79** (2.17-3.61)	**3.28** (2.45-4.33)	**3.82** (2.72-5.16)	**4.59** (3.13-6.34)	**5.23** (3.44-7.24)
6-hr	**1.11** (0.922-1.33)	**1.33** (1.11-1.60)	**1.74** (1.44-2.09)	**2.12** (1.75-2.57)	**2.71** (2.18-3.45)	**3.22** (2.51-4.13)	**3.77** (2.83-4.93)	**4.37** (3.14-5.86)	**5.24** (3.60-7.18)	**5.95** (3.95-8.18)
12-hr	**1.34** (1.13-1.60)	**1.61** (1.35-1.92)	**2.08** (1.74-2.49)	**2.52** (2.08-3.02)	**3.17** (2.56-3.98)	**3.71** (2.91-4.71)	**4.30** (3.25-5.57)	**4.94** (3.56-6.54)	**5.84** (4.04-7.92)	**6.56** (4.40-8.96)
24-hr	**1.62** (1.37-1.92)	**1.93** (1.63-2.29)	**2.47** (2.07-2.93)	**2.94** (2.45-3.51)	**3.64** (2.95-4.52)	**4.22** (3.32-5.29)	**4.82** (3.66-6.18)	**5.46** (3.97-7.17)	**6.36** (4.43-8.55)	**7.08** (4.78-9.60)
2-day	**1.92** (1.62-2.25)	**2.26** (1.91-2.66)	**2.84** (2.40-3.35)	**3.35** (2.81-3.97)	**4.08** (3.32-5.01)	**4.68** (3.70-5.80)	**5.29** (4.04-6.71)	**5.94** (4.34-7.72)	**6.84** (4.80-9.10)	**7.54** (5.14-10.2)
3-day	**2.09** (1.78-2.45)	**2.45** (2.08-2.87)	**3.06** (2.59-3.60)	**3.59** (3.02-4.23)	**4.34** (3.54-5.30)	**4.95** (3.93-6.11)	**5.58** (4.27-7.04)	**6.24** (4.58-8.07)	**7.14** (5.04-9.47)	**7.86** (5.38-10.5)
4-day	**2.23** (1.90-2.60)	**2.60** (2.21-3.04)	**3.23** (2.74-3.78)	**3.77** (3.18-4.44)	**4.55** (3.71-5.53)	**5.17** (4.11-6.36)	**5.81** (4.46-7.30)	**6.48** (4.77-8.35)	**7.40** (5.23-9.77)	**8.12** (5.58-10.8)
7-day	**2.54** (2.17-2.95)	**2.95** (2.52-3.43)	**3.64** (3.10-4.24)	**4.22** (3.57-4.94)	**5.05** (4.14-6.10)	**5.71** (4.56-6.97)	**6.38** (4.93-7.97)	**7.08** (5.24-9.06)	**8.03** (5.71-10.5)	**8.76** (6.07-11.6)
10-day	**2.82** (2.42-3.26)	**3.26** (2.80-3.78)	**4.00** (3.41-4.64)	**4.62** (3.92-5.38)	**5.49** (4.51-6.60)	**6.18** (4.96-7.51)	**6.88** (5.33-8.55)	**7.60** (5.65-9.68)	**8.58** (6.13-11.2)	**9.33** (6.49-12.3)
20-day	**3.66** (3.16-4.20)	**4.19** (3.61-4.82)	**5.06** (4.34-5.83)	**5.79** (4.94-6.69)	**6.79** (5.60-8.07)	**7.57** (6.10-9.11)	**8.35** (6.51-10.3)	**9.14** (6.84-11.5)	**10.2** (7.34-13.2)	**11.0** (7.72-14.5)
30-day	**4.38** (3.79-5.01)	**5.00** (4.32-5.73)	**6.01** (5.17-6.90)	**6.84** (5.85-7.88)	**7.96** (6.58-9.40)	**8.82** (7.14-10.6)	**9.67** (7.56-11.8)	**10.5** (7.90-13.2)	**11.6** (8.41-15.0)	**12.5** (8.80-16.3)
45-day	**5.31** (4.60-6.04)	**6.07** (5.26-6.92)	**7.28** (6.29-8.32)	**8.26** (7.10-9.48)	**9.56** (7.92-11.2)	**10.5** (8.54-12.5)	**11.5** (9.00-13.9)	**12.4** (9.33-15.4)	**13.6** (9.83-17.3)	**14.4** (10.2-18.8)
60-day	**6.10** (5.31-6.93)	**7.00** (6.08-7.96)	**8.42** (7.29-9.59)	**9.54** (8.22-10.9)	**11.0** (9.12-12.8)	**12.1** (9.80-14.3)	**13.1** (10.3-15.8)	**14.1** (10.6-17.4)	**15.3** (11.1-19.4)	**16.1** (11.5-20.9)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical

NOAA Atlas 14, Volume 8, Version 2
Location name: Parker, Colorado, USA*
Latitude: 39.5289°, Longitude: -104.6567°
Elevation: 6319 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**2.77** (2.29-3.37)	**3.49** (2.88-4.26)	**4.74** (3.90-5.78)	**5.82** (4.76-7.13)	**7.38** (5.84-9.35)	**8.64** (6.67-11.0)	**9.96** (7.40-12.9)	**11.3** (8.08-15.0)	**13.2** (9.06-17.9)	**14.8** (9.80-20.1)
10-min	**2.03** (1.67-2.47)	**2.56** (2.11-3.11)	**3.47** (2.86-4.24)	**4.26** (3.49-5.21)	**5.40** (4.28-6.85)	**6.32** (4.88-8.08)	**7.29** (5.42-9.48)	**8.30** (5.92-11.0)	**9.70** (6.63-13.1)	**10.8** (7.18-14.7)
15-min	**1.65** (1.36-2.00)	**2.08** (1.72-2.54)	**2.82** (2.32-3.44)	**3.46** (2.83-4.24)	**4.39** (3.48-5.57)	**5.14** (3.97-6.57)	**5.92** (4.41-7.71)	**6.75** (4.81-8.96)	**7.89** (5.39-10.7)	**8.78** (5.84-12.0)
30-min	**1.05** (0.866-1.28)	**1.33** (1.10-1.62)	**1.80** (1.48-2.20)	**2.22** (1.81-2.71)	**2.81** (2.23-3.56)	**3.29** (2.54-4.20)	**3.79** (2.82-4.93)	**4.32** (3.08-5.73)	**5.04** (3.45-6.83)	**5.61** (3.73-7.66)
60-min	**0.648** (0.536-0.789)	**0.813** (0.671-0.990)	**1.10** (0.903-1.34)	**1.35** (1.10-1.65)	**1.72** (1.36-2.18)	**2.02** (1.56-2.58)	**2.33** (1.74-3.04)	**2.67** (1.90-3.55)	**3.14** (2.15-4.26)	**3.51** (2.33-4.79)
2-hr	**0.386** (0.321-0.467)	**0.481** (0.399-0.582)	**0.647** (0.535-0.785)	**0.795** (0.653-0.967)	**1.01** (0.810-1.28)	**1.19** (0.929-1.52)	**1.39** (1.04-1.80)	**1.59** (1.14-2.10)	**1.88** (1.29-2.53)	**2.11** (1.41-2.86)
3-hr	**0.289** (0.241-0.348)	**0.356** (0.296-0.429)	**0.475** (0.393-0.573)	**0.582** (0.480-0.705)	**0.742** (0.596-0.937)	**0.876** (0.684-1.11)	**1.02** (0.767-1.32)	**1.17** (0.845-1.54)	**1.39** (0.962-1.87)	**1.56** (1.05-2.11)
6-hr	**0.178** (0.148-0.213)	**0.216** (0.180-0.259)	**0.284** (0.237-0.341)	**0.346** (0.286-0.416)	**0.438** (0.354-0.550)	**0.516** (0.405-0.651)	**0.599** (0.454-0.769)	**0.688** (0.499-0.901)	**0.815** (0.568-1.09)	**0.916** (0.619-1.23)
12-hr	**0.108** (0.091-0.129)	**0.131** (0.110-0.156)	**0.170** (0.142-0.203)	**0.205** (0.171-0.245)	**0.257** (0.208-0.319)	**0.299** (0.236-0.374)	**0.344** (0.262-0.438)	**0.392** (0.286-0.509)	**0.460** (0.322-0.609)	**0.514** (0.349-0.684)
24-hr	**0.066** (0.056-0.078)	**0.079** (0.066-0.093)	**0.101** (0.085-0.119)	**0.120** (0.100-0.143)	**0.148** (0.120-0.182)	**0.171** (0.135-0.211)	**0.194** (0.149-0.245)	**0.220** (0.161-0.282)	**0.254** (0.179-0.334)	**0.282** (0.193-0.373)
2-day	**0.039** (0.033-0.045)	**0.046** (0.039-0.054)	**0.057** (0.048-0.068)	**0.068** (0.057-0.080)	**0.082** (0.067-0.100)	**0.094** (0.075-0.116)	**0.106** (0.082-0.133)	**0.119** (0.088-0.152)	**0.137** (0.097-0.178)	**0.151** (0.104-0.198)
3-day	**0.028** (0.024-0.033)	**0.033** (0.028-0.038)	**0.041** (0.035-0.048)	**0.048** (0.041-0.057)	**0.058** (0.048-0.071)	**0.066** (0.053-0.081)	**0.075** (0.058-0.093)	**0.084** (0.062-0.106)	**0.095** (0.068-0.124)	**0.105** (0.072-0.137)
4-day	**0.022** (0.019-0.026)	**0.026** (0.022-0.030)	**0.032** (0.027-0.038)	**0.038** (0.032-0.044)	**0.046** (0.037-0.055)	**0.052** (0.041-0.063)	**0.058** (0.045-0.072)	**0.065** (0.048-0.082)	**0.074** (0.053-0.096)	**0.081** (0.056-0.106)
7-day	**0.014** (0.012-0.016)	**0.016** (0.014-0.019)	**0.020** (0.017-0.024)	**0.024** (0.020-0.028)	**0.029** (0.023-0.034)	**0.032** (0.026-0.039)	**0.036** (0.028-0.045)	**0.041** (0.030-0.051)	**0.046** (0.033-0.060)	**0.051** (0.035-0.066)
10-day	**0.011** (0.009-0.013)	**0.013** (0.011-0.015)	**0.015** (0.013-0.018)	**0.018** (0.015-0.021)	**0.022** (0.018-0.026)	**0.024** (0.020-0.030)	**0.027** (0.021-0.034)	**0.030** (0.023-0.038)	**0.035** (0.025-0.044)	**0.038** (0.026-0.049)
20-day	**0.007** (0.006-0.008)	**0.008** (0.007-0.009)	**0.010** (0.008-0.011)	**0.011** (0.009-0.013)	**0.013** (0.011-0.016)	**0.015** (0.012-0.018)	**0.016** (0.013-0.020)	**0.018** (0.013-0.023)	**0.020** (0.015-0.026)	**0.022** (0.016-0.029)
30-day	**0.005** (0.005-0.006)	**0.006** (0.005-0.007)	**0.008** (0.006-0.009)	**0.009** (0.007-0.010)	**0.010** (0.008-0.012)	**0.011** (0.009-0.014)	**0.013** (0.010-0.015)	**0.014** (0.010-0.017)	**0.016** (0.011-0.020)	**0.017** (0.012-0.022)
45-day	**0.004** (0.004-0.005)	**0.005** (0.004-0.006)	**0.006** (0.005-0.007)	**0.007** (0.006-0.008)	**0.008** (0.007-0.010)	**0.009** (0.007-0.011)	**0.010** (0.008-0.012)	**0.011** (0.008-0.014)	**0.012** (0.009-0.015)	**0.013** (0.009-0.017)
60-day	**0.004** (0.003-0.004)	**0.004** (0.004-0.005)	**0.005** (0.005-0.006)	**0.006** (0.005-0.007)	**0.007** (0.006-0.008)	**0.008** (0.006-0.009)	**0.009** (0.007-0.011)	**0.009** (0.007-0.012)	**0.010** (0.007-0.013)	**0.011** (0.008-0.014)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical

Appendix C Site Maps

Vicinity Map
Canyon Peak Power

Project Site

NOTES:

Stanley Consultants

0 580
Feet

November 11, 2024

Appendix D MHFD Design Workbook

Stanley Consultants INC.

Computed by: M. Raymond 11/18/2024
Checked by: K. Cloherty 11/21/204
Approved by:

Project #: 31821.01
Subject: Riprap Sizing

PURPOSE:

The purpose of this calculation is to size drainage channels for the Kindle Energy Substation. Channels are sized based on the 10-year storm event using the rational method. Flow master for the hydraulic computations.

REFERENCES:

1.

ANALYSIS:

Stanley Consultants INC.

Computed by: M. Raymond 11/18/2024
Checked by: K. Cloherty 11/21/204
Approved by:

Project #: 31821.01
Subject: Riprap Sizing

Existing Percent Impervious

ID	Area (ac)	Gravel (High Traffic)	Gravel (Low Traffic)	Buildings	Pond	Concrete
E1	6.376	0.580	1.710	0.000	0.000	0.000
E2	5.356	0.000	0.000	0.000	0.000	0.052
E3	3.09	0.000	0.000	0.000	0.000	0.000
E4	2.674	0.420	0.430	0.000	0.000	0.000
U1	1.32	0	0	0	0	0
E6	0.57	0.215	0.000	0.000	0.000	0.000
E7	1.12	0	0	0	0	0

Imprvious Ratios

Surface Type	Imperviousness
Gravel Road	0.8
Gravel Yard	0.6
Buildings	0.95
Pond	0.45
Concrete	0.95

ID	Total Area (sq ft)	Total Impervious Area (sq ft)	Percent Impervious
E1	6.38	1.49	0.23
E2	5.36	0.05	0.01
E3	3.09	0.00	0.00
E4	2.67	0.59	0.22
U1	1.32	0.24	0.18
E6	0.57	0.17	0.30
E7	1.12	0.00	0.00

Stanley Consultants INC.

Computed by: M. Raymond 11/18/2024
Checked by: K. Cloherty 11/21/204
Approved by:

Project #: 31821.01
Subject: Riprap Sizing

Proposed Percent Impervious

ID	Area (sq ft)	Gravel (Low Traffic)	Buildings	Pond	Concrete
U1	57454	0	0	0	0
A	134513	0	0	0	0
B	139587	16443	0	0	0
C	155905	76035	0	0	0
E	24647	0	0	0	0
F	97397	1932			5334
G	31960	19657	0	0	0
I	194121	56884	0	12849	5740
H	26917	1297	0	0	0
j	69471	27620	0	0	10064

Imprvious Ratios

Surface Type	Imperviousness
Gravel Road	0.8
Gravel Yard	0.6
Buildings	0.95
Pond	0.45
Concrete	0.95

ID	Total Area (sq ft)	Total Impervious Area (sq ft)	Percent Impervious
U1	57454	#REF!	#REF!
A	134513	#REF!	#REF!
B	139587	#REF!	#REF!
C	155905	#REF!	#REF!
E	24647	#REF!	#REF!
F	97397	#REF!	#REF!
G	31960	#REF!	#REF!
I	194121	#REF!	#REF!
H	26917	#REF!	#REF!
j	69471	#REF!	#REF!

Stanley Consultants INC.

Computed by: M. Raymond 11/18/2024
Checked by: K. Cloherty 11/21/204
Approved by:

Project #: 31821.01
Subject: Riprap Sizing

PURPOSE:

The purpose of this calculation is to size riprap for the Kindle Energy Substation.

REFERENCES:

1. USDCM. Volume 2.
2. USDCM. Volume 1.

ANALYSIS:

1. Determine expansion factor using figure 9-35 from reference 1.
2. Calculate the length of protection.
3. Calculate the width of riprap and the furthest downstream point.
4. Size riprap for riprap apron.

1. Determine expansion factor using figure 9-35 from reference 1.

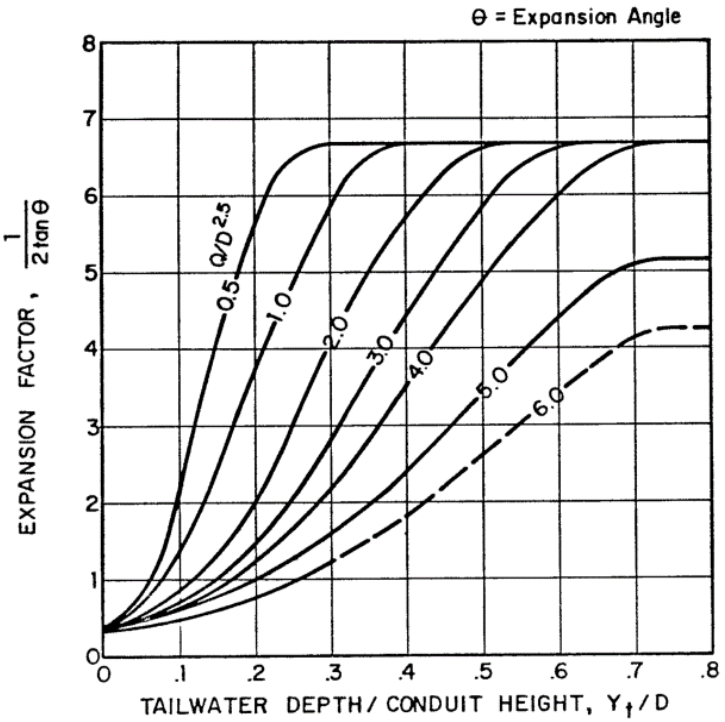

Figure 9-35. Expansion factor for circular conduits

Stanley Consultants INC.

Computed by: M. Raymond 11/18/2024
Checked by: K. Cloherty 11/21/204
Approved by:

Project #: 31821.01
Subject: Riprap Sizing

	W (ft)	Yt (ft)	Q10 (cfs)	Yt/W	Q/W^2.5	Expansion Factor
Culvert 1	1.5	0.6	4.73	0.4	1.72	6.1
Culvert 2	1.5	0.6	7.10	0.4	2.58	5.0
Pipe 1	1.5	0.6	3.51	0.4	1.27	6.4
Outfall	1.5	0.6	3.60	0.4	1.31	6.4

2. Calculate the length of protection.

$$A_t = \frac{Q}{V} \qquad L_p = \left(\frac{1}{2\tan\theta}\right)\left(\frac{A_t}{Y_t} - W\right)$$

	Q (cfs)	Velocity (fps)*	At (sq ft)	Lp** (ft)
Culvert 1	4.73	5.0	0.95	4.50
Culvert 2	7.10	5.0	1.42	4.50
Pipe 1	3.51	5.0	0.70	4.50
Outfall	3.60	5.0	0.72	4.50

*non-cohesive soils

**If Lp less than 3W, increase to minimum of 3W.

3. Calculate the width of riprap and the furthest downstream point.

$$\theta = \tan^{-1}\left(\frac{1}{2(\text{ExpansionFactor})}\right) \qquad T = 2\left(L_p \tan\theta\right) + W$$

	Θ	T (ft)
Culvert 1	0.082	2.24
Culvert 2	0.100	2.40
Pipe 1	0.078	2.20
Outfall	0.078	2.20

4. Size riprap for riprap apron.

When the length of protection is a distance of 3*W, use type L riprap (ref 1).

D50 (ft)	0.75
Min. Thickness (ft)	1.5

(ref 2)

Stanley Consultants INC.

Computed by: M. Raymond 11/18/2024
Checked by: K. Cloherty 11/21/204
Approved by:

Project #: 31821.01
Subject: Riprap Sizing

RESULTS

Type L ripirap should be used at all four outlets, the riprap apron should extend to a length of 4.5 feet downstream, and the apron thickness should be at least 1.5 feet. The width of the riprap apron is 2.24' for culvert 1, 2.4' for culvert 2, and 2.2' for pipe 1 and outfall.

Stanley Consultants INC.

Computed by: M. Raymond 11/18/2024
Checked by: K. Cloherty 11/21/204
Approved by:

Project #: 31821.01
Subject: Riprap Sizing

1. Size conveyance channels for 10-year event.

Channels

BasinID	Q	To Channel
A	0.98	B
B	1.97	B
C	3.81	B
F	0.78	F
G	1.1	G
H	0.45	H
J	2.1	B

Manning's n for concrete =	0.013
Manning's n with grass =	0.03

	B	F1	F2	G	H
Design Flow (cfs)	9.64	0.78	0.78	10.74	0.45
Upstream elevation (ft)	5763	5766	5769.7	5761.7	5767.25
Downstream elevation (ft	5761.86	5763	5766	5761.2	5766.21
Length (ft)	222.61	629.32	254.3	156.01	204.62
Slope (ft/ft)	0.005	0.005	0.015	0.003	0.005
Bottom width (ft)	3	3	0.5	3	0.5
Side slopes (H:V)	4	4	4	4	4
Water Depth (in)	8.9	2.4	3.3	9.4	3.3
Channel Depth w/ 1'	1.8	1.2	1.3	1.8	1.3
Velocity (ft/s)	2.2	1.0	1.8	1.7	1.0
Flow Type	Subcritical	Subcritical	Subcritical	Subcritical	Subcritical

1. Size storm sewer

Channel Slope (ft/ft)	0.016
Normal Depth (in).	2.6
Diamter (in)	12.0
Discharge (cfs)	0.450

Velocity (ft/s)	3.67
Flow Type	Supercritical

Stanley Consultants INC.

Computed by: M. Raymond 11/18/2024
Checked by: K. Cloherty 11/21/204
Approved by:

Project #: 31821.01
Subject: Riprap Sizing

Runoff Coefficents Table per Mile High Flood District Design Manual

TABLE 6-8. RUNOFF COEFFICIENTS, *C*, NRCS HSG C/D

TOTAL OR EFFECTIVE % IMPERVIOUS	NRCS HSG C/D						
	WQE & 2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.05	0.15	0.33	0.40	0.49	0.59
5%	0.03	0.08	0.17	0.35	0.42	0.50	0.60
10%	0.06	0.12	0.21	0.38	0.44	0.52	0.62
15%	0.10	0.16	0.24	0.40	0.47	0.55	0.64
20%	0.14	0.20	0.28	0.43	0.49	0.57	0.65
25%	0.18	0.24	0.32	0.46	0.52	0.59	0.67
30%	0.22	0.28	0.35	0.49	0.54	0.61	0.68
35%	0.26	0.32	0.39	0.52	0.57	0.63	0.70
40%	0.30	0.36	0.43	0.54	0.59	0.65	0.71
45%	0.34	0.40	0.46	0.57	0.62	0.67	0.73
50%	0.38	0.44	0.50	0.60	0.64	0.69	0.75
55%	0.43	0.48	0.54	0.63	0.66	0.71	0.76
60%	0.47	0.52	0.57	0.66	0.69	0.73	0.78
65%	0.51	0.56	0.61	0.68	0.71	0.75	0.79
70%	0.56	0.61	0.65	0.71	0.74	0.77	0.81
75%	0.60	0.65	0.68	0.74	0.76	0.79	0.82
80%	0.65	0.69	0.72	0.77	0.79	0.81	0.84
85%	0.69	0.73	0.76	0.80	0.81	0.83	0.86
90%	0.74	0.77	0.79	0.82	0.84	0.85	0.87
95%	0.79	0.81	0.83	0.85	0.86	0.87	0.89
100%	0.84	0.86	0.87	0.88	0.89	0.89	0.90

PEAK RUNOFF PREDICTION BY THE RATIONAL METHOD

Version 2.00 released May 2017

Urban Drainage and Flood Control District

Denver, Colorado

Purpose: **This workbook applies the Rational Method to estimate stormwater runoff and peak flows from small urban catchments (typically less than 90 acres)**

Function:

1. **To calculate the runoff coefficient, C for a catchment**
2. **To calculate the time of concentration, and then compare with the regional time of concentration limit used for the Denver region. The smaller one is recommended as the rainfall duration for use with the Rational Method.**
3. **To calculate the design rainfall intensity and resulting peak flow rate.**

Content: **The workbook consists of the following five sheets:**

Intro	Describes the purpose of each sheet in the workbook.
Rational Calcs	Performs Rational Method calculations, Q = CIA
Weighted C	Supporting tool to calculate area-weighted runoff coefficients from sub-areas.
Weighted Slope	Supporting tool to calculate length-weighted slope from multiple flow reaches.
Weighted Tc	Supporting tool to calculate reach-weighted time of concentration from multiple flow reaches.
Design Info	Provides background information from the USDCM

Acknowledgements:

Spreadsheet Development Team:

Derek N. Rapp, P.E.
Peak Stormwater Engineering, LLC
Holly Piza, P.E. and Ken MacKenzie, P.E.
Urban Drainage and Flood Control District

Comments?	Direct all comments regarding this spreadsheet workbook to:	UDFCD email
Revisions?	Check for revised versions of this or any other workbook at:	Downloads

EXISTING CONDITIONS

Calculation of Peak Runoff using Rational Method

Designer: K. Cloherty
Company: Stanley Consultants Inc
Date: 12/19/2024
Project: Canyon Peak Power
Location: 5050 N County Rd 129, Bennett, CO

Version 2.00 released May 2017

Cells of this color are for required user-input
Cells of this color are for optional override values
Cells of this color are for calculated results based on overrides

$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$

$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$

Computed $t_c = t_i + t_t$

Regional $t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$

$t_{minimum}$ = 5 (urban)
$t_{minimum}$ = 10 (non-urban)

Selected $t_c = \max\{t_{minimum}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$

Select UDFCD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website (click this link)

	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1-hour rainfall depth, P1 (in) =	0.86	1.15	1.41	1.82	2.16	2.52	3.49
	a	b	c				
Rainfall Intensity Equation Coefficients =	28.50	10.00	0.786				

$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$

$Q(cfs) = CIA$

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C							Overland (Initial) Flow Time					Channelized (Travel) Flow Time							Time of Concentration			Rainfall Intensity, I (in/hr)							Peak Flow, Q (cfs)						
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)	Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
E1	6.38	C	23.4	0.16	0.23	0.30	0.45	0.51	0.58	0.66	300.00	5770.00	5767.00	0.014	24.47	1006.92			0.010	7	0.70	23.97	48.44	35.69	35.69	1.22	1.63	1.99	2.57	3.05	3.56	4.93	1.27	2.34	3.86	7.38	9.90	13.17	20.82
E2	5.36	C	0.9	0.00	0.04	0.14	0.32	0.40	0.49	0.59	477.44	5770.00	5761.00	0.068	22.17	577.59			0.010	15	1.50	6.42	28.58	36.40	28.58	1.39	1.86	2.28	2.94	3.49	4.07	5.63	0.03	0.42	1.69	5.10	7.43	10.63	17.84
E4	2.67	C	22.2	0.15	0.22	0.30	0.44	0.50	0.57	0.66	300.00	5768.00	5764.00	0.006	32.72	60.00			0.010	7	0.70	1.43	34.15	23.05	23.05	1.57	2.10	2.57	3.32	3.94	4.59	6.36	0.64	1.21	2.03	3.93	5.28	7.05	11.18
U1	1.32	C	18.3	0.12	0.18	0.27	0.42	0.48	0.56	0.65	165.91	5769.00	5766.00	0.018	17.52	0.00			0.001	7	0.22	0.00	17.52	22.89	17.52	1.81	2.42	2.97	3.83	4.55	5.31	7.35	0.30	0.59	1.04	2.13	2.90	3.91	6.26
E6	0.57	C	27.3	0.19	0.26	0.33	0.47	0.53	0.60	0.67	32.37	5770.75	5770.01	0.023	6.58	360.55	5770.00	5768.25	0.005	7	0.49	12.32	18.90	28.09	18.90	1.74	2.33	2.86	3.69	4.38	5.11	7.07	0.19	0.34	0.54	0.98	1.31	1.72	2.70
E3	3.09	C	0.0	0.00	0.04	0.13	0.32	0.39	0.48	0.59	412.63	5768.00	5765.91	0.005	48.86	0.00			0.001	7	0.22	0.00	48.86	26.00	26.00	1.47	1.96	2.40	3.10	3.68	4.30	5.95	0.00	0.21	0.98	3.06	4.47	6.42	10.80
E7	1.18	C	0.0	0.00	0.04	0.13	0.32	0.39	0.48	0.59	300.00			0.006	39.42	60.00			0.006	7	0.54	1.84	41.26	27.43	27.43	1.42	1.90	2.33	3.01	3.57	4.17	5.77	0.00	0.08	0.36	1.13	1.66	2.38	4.00

PROPOSED CONDITIONS

Calculation of Peak Runoff using Rational Method

Designer: K. Cloherty
Company: Stanley Consultants Inc
Date: 12/19/2024
Project:
Location:

Version 2.00 released May 2017

Cells of this color are for required user-input
Cells of this color are for optional override values
Cells of this color are for calculated results based on overrides

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$$

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Select UDFCD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website (click this link)

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1-hour rainfall depth, P1 (in) =	0.86	1.15	1.41	1.82	2.16	2.52	3.49

Rainfall Intensity Equation Coefficients =	a	b	c
	28.50	10.00	0.786

$$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$$

$$Q(cfs) = CIA$$

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C							Overland (Initial) Flow Time					Channelized (Travel) Flow Time							Time of Concentration			Rainfall Intensity, I (in/hr)							Peak Flow, Q (cfs)						
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)	Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
U1	1.32	C	18.3	0.12	0.18	0.27	0.42	0.48	0.56	0.65	165.91	5769.00	5766.00	0.018	17.52	0.00			0.010	7	0.70	0.00	17.52	22.89	17.52	1.81	2.42	2.97	3.83	4.55	5.31	7.35	0.30	0.59	1.04	2.13	2.90	3.91	6.26
A	3.09	C	0.0	0.00	0.04	0.13	0.32	0.39	0.48	0.59	412.63	5768.00	5765.91	0.005	48.86	0.00			0.005	7	0.49	0.00	48.86	26.00	26.00	1.47	1.96	2.40	3.10	3.68	4.30	5.95	0.00	0.21	0.98	3.06	4.47	6.42	10.80
B	3.20	C	23.7	0.17	0.23	0.31	0.45	0.51	0.58	0.66	84.17	5770.50	5768.50	0.024	10.85	889.45	5768.50	5761.86	0.007	7	0.60	24.50	35.36	35.90	35.36	1.22	1.63	2.00	2.59	3.07	3.58	4.96	0.65	1.19	1.97	3.74	5.02	6.67	10.53
C	3.58	C	42.9	0.32	0.38	0.45	0.56	0.60	0.66	0.72	239.56	5770.00	5768.75	0.005	24.78	652.46	5768.75	5763.00	0.009	7	0.66	16.55	41.33	26.43	26.43	1.45	1.94	2.38	3.07	3.65	4.26	5.89	1.68	2.67	3.81	6.15	7.90	10.04	15.25
E	0.57	C	27.3	0.19	0.26	0.33	0.47	0.53	0.60	0.67	32.37	5770.75	5770.00	0.023	6.56	360.55	5770.00	5768.25	0.005	7	0.49	12.32	18.88	28.09	18.88	1.74	2.33	2.86	3.69	4.38	5.11	7.07	0.19	0.34	0.54	0.98	1.31	1.72	2.70
F	2.24	C	7.6	0.05	0.10	0.19	0.36	0.43	0.51	0.61	189.54	5769.70	5766.00	0.020	20.00	629.32	5766.00	5763.00	0.005	7	0.48	21.70	41.70	39.82	39.82	1.14	1.52	1.86	2.40	2.85	3.33	4.61	0.12	0.33	0.78	1.94	2.74	3.83	6.30
G	0.73	C	54.8	0.42	0.48	0.53	0.63	0.66	0.71	0.76	233.48	5767.00	5761.70	0.023	13.02	156.01	5761.70	5761.20	0.003	7	0.40	6.56	19.57	19.44	19.44	1.72	2.30	2.82	3.63	4.31	5.03	6.97	0.53	0.81	1.10	1.67	2.10	2.61	3.89
I	4.46	C	31.7	0.23	0.29	0.36	0.50	0.55	0.61	0.69	300.00	5770.00	5767.75	0.008	27.74	211.80	5767.75	5763.60	0.020	7	0.98	3.60	31.34	22.49	22.49	1.59	2.12	2.61	3.36	3.99	4.66	6.45	1.63	2.78	4.24	7.44	9.77	12.73	19.76
H	0.62	C	17.2	0.12	0.18	0.26	0.42	0.48	0.55	0.64	105.68	5770.00	5767.25	0.026	12.52	204.62	5767.25	5766.21	0.005	7	0.50	6.82	19.33	27.25	19.33	1.72	2.30	2.82	3.64	4.32	5.05	6.99	0.12	0.25	0.45	0.94	1.28	1.73	2.77
J	1.59	C	51.4	0.40	0.45	0.51	0.61	0.65	0.69	0.75	104.70	5769.75	5767.50	0.021	9.27	506.55	5767.50	5763.50	0.008	7	0.62	13.57	22.84	23.12	22.84	1.58	2.11	2.58	3.33	3.96	4.62	6.39	0.99	1.53	2.10	3.23	4.08	5.11	7.65

Table 6-1. Applicability of hydrologic methods

Watershed Size (acres)	Is the Rational Method Applicable?	Is CUHP Applicable?
0 to 90	Yes	Yes
90 to 160	No	Yes
160 to 3,000	No	Yes[1]
Greater than 3,000	No	Yes (subdividing into smaller catchments required)[1]

1. Subdividing into smaller subcatchments and routing the resultant hydrographs using SWMM may be needed to accurately model a catchment with areas of different soil types or percentages of imperviousness.

The general procedure for Rational Method calculations for a single catchment is as follows:

1. Delineate the catchment boundary and determine its area.
2. Define the flow path from the upper-most portion of the catchment to the design point. Divide the flow path into reaches of similar flow type (e.g., overland flow, shallow swale flow, gutter flow, etc.). Determine the length and slope of each reach.
3. Determine the time of concentration, t_c, for the selected waterway.
4. Find the rainfall intensity, I, for the design storm using the calculated t_c and the rainfall intensity-duration-frequency curve (see *Rainfall* chapter).
5. Determine the runoff coefficient, C.
6. Calculate the peak flow rate, Q, from the catchment using Equation 6-1.

The basic assumptions for the application of the Rational Method include:

1. The computed maximum rate of runoff to the design point is a function of the average rainfall rate during the time of concentration to that point.
2. The hydrologic losses in the catchment are homogeneous and uniform. The runoff coefficients vary with respect to type of soils, imperviousness percentage, and rainfall frequencies. These coefficients represent the average antecedent soil moisture condition.
3. The depth of rainfall used is one that occurs from the start of the storm to the time of concentration. The design rainfall depth during that period is converted to the average rainfall intensity for that period.
4. The maximum runoff rate occurs when the entire area is contributing flow. This assumption is not valid where a more intensely developed portion of the catchment with a shorter time of concentration produces a higher rate of runoff than the entire catchment with a longer time of concentration.

Table 6-4. Runoff coefficient equations based on NRCS soil group and storm return period

NRCS Soil Group	Storm Return Period						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
A	$C_A = 0.84i^{1.302}$	$C_A = 0.86i^{1.276}$	$C_A = 0.87i^{1.232}$	$C_A = 0.84i^{1.124}$	$C_A = 0.85i+0.025$	$C_A = 0.78i+0.110$	$C_A = 0.65i+0.254$
B	$C_B = 0.84i^{1.169}$	$C_B = 0.86i^{1.088}$	$C_B = 0.81i+0.057$	$C_B = 0.63i+0.249$	$C_B = 0.56i+0.328$	$C_B = 0.47i+0.426$	$C_B = 0.37i+0.536$
C/D	$C_{C/D} = 0.83i^{1.122}$	$C_{C/D} = 0.82i+0.035$	$C_{C/D} = 0.74i+0.132$	$C_{C/D} = 0.56i+0.319$	$C_{C/D} = 0.49i+0.393$	$C_{C/D} = 0.41i+0.484$	$C_{C/D} = 0.32i+0.588$

Where:

i = % imperviousness (expressed as a decimal)

C_A = Runoff coefficient for Natural Resources Conservation Service (NRCS) HSG A soils

C_B = Runoff coefficient for NRCS HSG B soils

$C_{C/D}$ = Runoff coefficient for NRCS HSG C and D soils.

Table 6-2. NRCS Conveyance factors, K

Type of Land Surface	Conveyance Factor, K
Heavy meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

Table 6-3. Recommended percentage imperviousness values

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential lots (lot area only):	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	10
Playgrounds	25
Schools	55
Railroad yard areas	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

Table 6-5. Runoff coefficients, *c*

Total or Effective % Impervious	NRCS Hydrologic Soil Group A						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.01	0.01	0.01	0.04	0.13	0.27
5%	0.02	0.02	0.02	0.03	0.07	0.15	0.29
10%	0.04	0.05	0.05	0.07	0.11	0.19	0.32
15%	0.07	0.08	0.08	0.1	0.15	0.23	0.35
20%	0.1	0.11	0.12	0.14	0.2	0.27	0.38
25%	0.14	0.15	0.16	0.19	0.24	0.3	0.42
30%	0.18	0.19	0.2	0.23	0.28	0.34	0.45
35%	0.21	0.23	0.24	0.27	0.32	0.38	0.48
40%	0.25	0.27	0.28	0.32	0.37	0.42	0.51
45%	0.3	0.31	0.33	0.36	0.41	0.46	0.54
50%	0.34	0.36	0.37	0.41	0.45	0.5	0.58
55%	0.39	0.4	0.42	0.45	0.49	0.54	0.61
60%	0.43	0.45	0.47	0.5	0.54	0.58	0.64
65%	0.48	0.5	0.51	0.54	0.58	0.62	0.67
70%	0.53	0.55	0.56	0.59	0.62	0.65	0.71
75%	0.58	0.6	0.61	0.64	0.66	0.69	0.74
80%	0.63	0.65	0.66	0.69	0.71	0.73	0.77
85%	0.68	0.7	0.71	0.74	0.75	0.77	0.8
90%	0.73	0.75	0.77	0.79	0.79	0.81	0.84
95%	0.79	0.81	0.82	0.83	0.84	0.85	0.87
100%	0.84	0.86	0.87	0.88	0.88	0.89	0.9
Total or Effective % Impervious	**NRCS Hydrologic Soil Group B**						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.01	0.07	0.26	0.34	0.44	0.54
5%	0.03	0.03	0.1	0.28	0.36	0.45	0.55
10%	0.06	0.07	0.14	0.31	0.38	0.47	0.57
15%	0.09	0.11	0.18	0.34	0.41	0.5	0.59
20%	0.13	0.15	0.22	0.38	0.44	0.52	0.61
25%	0.17	0.19	0.26	0.41	0.47	0.54	0.63
30%	0.2	0.23	0.3	0.44	0.49	0.57	0.65
35%	0.24	0.27	0.34	0.47	0.52	0.59	0.66
40%	0.29	0.32	0.38	0.5	0.55	0.61	0.68
45%	0.33	0.36	0.42	0.53	0.58	0.64	0.7
50%	0.37	0.4	0.46	0.56	0.61	0.66	0.72
55%	0.42	0.45	0.5	0.6	0.63	0.68	0.74
60%	0.46	0.49	0.54	0.63	0.66	0.71	0.76
65%	0.5	0.54	0.58	0.66	0.69	0.73	0.77
70%	0.55	0.58	0.62	0.69	0.72	0.75	0.79
75%	0.6	0.63	0.66	0.72	0.75	0.78	0.81
80%	0.64	0.67	0.7	0.75	0.77	0.8	0.83
85%	0.69	0.72	0.74	0.78	0.8	0.82	0.85
90%	0.74	0.76	0.78	0.81	0.83	0.84	0.87
95%	0.79	0.81	0.82	0.85	0.86	0.87	0.88
100%	0.84	0.86	0.86	0.88	0.89	0.89	0.9
Total or Effective % Impervious	**NRCS Hydrologic Soil Group C**						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.05	0.15	0.33	0.40	0.49	0.59
5%	0.03	0.08	0.17	0.35	0.42	0.5	0.6
10%	0.06	0.12	0.21	0.37	0.44	0.52	0.62
15%	0.1	0.16	0.24	0.4	0.47	0.55	0.64
20%	0.14	0.2	0.28	0.43	0.49	0.57	0.65
25%	0.18	0.24	0.32	0.46	0.52	0.59	0.67
30%	0.22	0.28	0.35	0.49	0.54	0.61	0.68
35%	0.26	0.32	0.39	0.51	0.57	0.63	0.7
40%	0.3	0.36	0.43	0.54	0.59	0.65	0.71
45%	0.34	0.4	0.46	0.57	0.62	0.67	0.73
50%	0.38	0.44	0.5	0.6	0.64	0.69	0.75
55%	0.43	0.48	0.54	0.63	0.66	0.71	0.76
60%	0.47	0.52	0.57	0.65	0.69	0.73	0.78
65%	0.51	0.56	0.61	0.68	0.71	0.75	0.79
70%	0.56	0.61	0.65	0.71	0.74	0.77	0.81
75%	0.6	0.65	0.68	0.74	0.76	0.79	0.82
80%	0.65	0.69	0.72	0.77	0.79	0.81	0.84
85%	0.7	0.73	0.76	0.79	0.81	0.83	0.86
90%	0.74	0.77	0.79	0.82	0.84	0.85	0.87
95%	0.79	0.81	0.83	0.85	0.86	0.87	0.89
100%	0.83	0.85	0.87	0.88	0.89	0.89	0.9

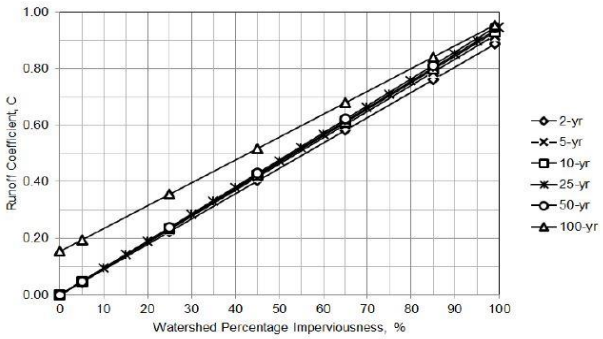

Figure 6-1. Runoff coefficient vs. watershed imperviousness NRCS HSG A

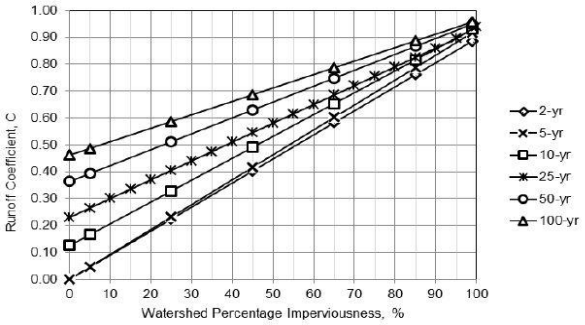

Figure 6-2. Runoff coefficient vs. watershed imperviousness NRCS HSG B

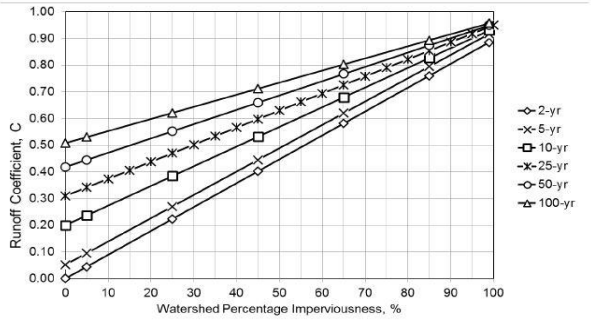

Figure 6-3. Runoff coefficient vs. watershed imperviousness NRCS HSG C and D

MILE HIGH FLOOD DISTRICT

DETENTION BASIN DESIGN WORKBOOK

MHFD-Detention, Version 4.06 (July 2022)
Mile High Flood District
Denver, Colorado
www.mhfd.org

Purpose:

This workbook aids in the estimation of stormwater detention basin sizing and outlet routing based on the modified puls routing method for urban watersheds. Several different BMP types and various outlet configurations can be sized.

Function:

1. Approximates the stage-area-volume relationship for a detention basin based on watershed parameters and basin geometry parameters. Also evaluates existing user-defined basin stage-area relationships.

2. Sizes filtration media orifice, outlet orifices, elliptical slots, weirs, trash racks, and develops stage-discharge relationships. Uses the Modified Puls method to route a series of hydrographs (i.e., 2-, 5-, 10-, 25-, 50-, 100- and 500-year) and calibrates the peak discharge out of the basin to match the pre-development peak discharges for the watershed.

Content: **This workbook consists of the following sheets:**

Basin	Tabulates stage-area-volume relationship estimates based on watershed parameters
Outlet Structure	Tabulates a stage-discharge relationship for the user-defined outlet structure (inlet control).
Reference	Provides reference equations and figures.
User Tips and Tools	Provides instructions and video links to assist in using this workbook. Includes a stage-area calculator.
BMP Zone Images	Provides images of typical BMP zone confirgurations corresponding with Zone pulldown selections.

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Professor, Department of Civil Engineering, University of Colorado at Denver

Comments?
Revisions?

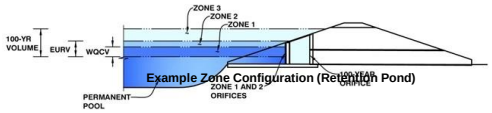
Direct all comments regarding this spreadsheet workbook to: **MHFD E-Mail**
Check for revised versions of this or any other workbook at: **Downloads**

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

Project: _____

Basin ID: _____



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	EDB	
Watershed Area =	21.08	acres
Watershed Length =	1,137	ft
Watershed Length to Centroid =	825	ft
Watershed Slope =	0.010	ft/ft
Watershed Imperviousness =	27.40%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	

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

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.251	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.521	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 0.86 in.) =	0.000	acre-feet	0.86	inches
5-yr Runoff Volume (P1 = 1.15 in.) =	0.000	acre-feet	1.15	inches
10-yr Runoff Volume (P1 = 1.41 in.) =	0.000	acre-feet	1.41	inches
25-yr Runoff Volume (P1 = 1.82 in.) =	0.000	acre-feet	1.82	inches
50-yr Runoff Volume (P1 = 2.16 in.) =	0.000	acre-feet	2.16	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.000	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.49 in.) =	0.000	acre-feet	3.49	inches
Approximate 2-yr Detention Volume =	0.321	acre-feet		
Approximate 5-yr Detention Volume =	0.583	acre-feet		
Approximate 10-yr Detention Volume =	0.716	acre-feet		
Approximate 25-yr Detention Volume =	0.916	acre-feet		
Approximate 50-yr Detention Volume =	1.011	acre-feet		
Approximate 100-yr Detention Volume =	1.306	acre-feet		

Define Zones and Basin Geometry

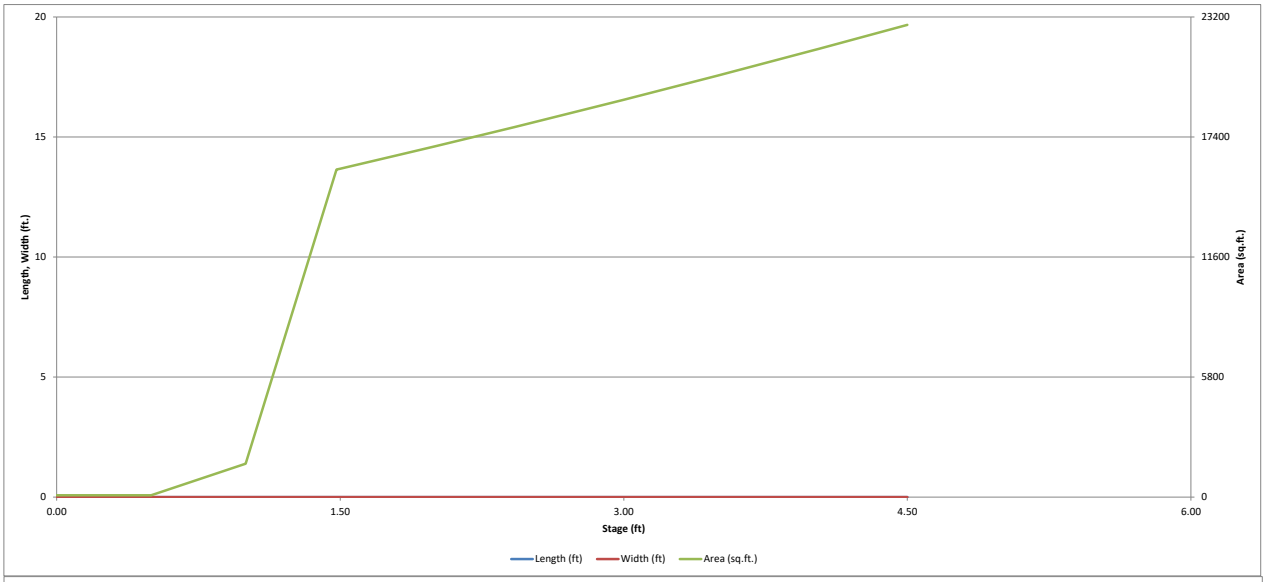
Zone 1 Volume (WQCV) =	0.251	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.269	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.785	acre-feet
Total Detention Basin Volume =	1.306	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
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^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
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^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

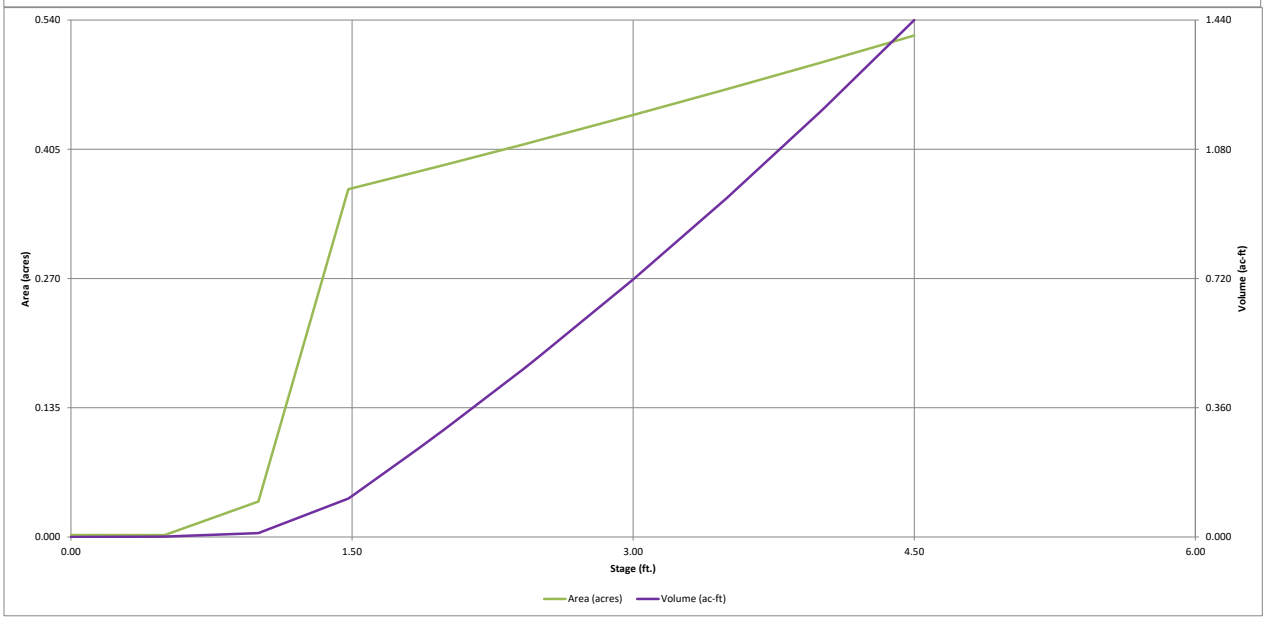
Depth Increment = 0.50 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	89	0.002		
ISV	--	0.33	--	--	--	89	0.002	29	0.001
	--	0.50	--	--	--	89	0.002	45	0.001
	--	1.00	--	--	--	1,614	0.037	470	0.011
Floor	--	1.48	--	--	--	15,827	0.363	4,656	0.107
WQCV	--	1.50	--	--	--	15,870	0.364	4,973	0.114
	--	1.85	--	--	--	16,621	0.382	10,659	0.245
	--	2.00	--	--	--	16,948	0.389	13,176	0.302
	--	2.42	--	--	--	17,878	0.410	20,490	0.470
	--	2.50	--	--	--	18,058	0.415	21,927	0.503
	--	3.00	--	--	--	19,200	0.441	31,242	0.717
	--	3.50	--	--	--	20,374	0.468	41,135	0.944
	--	4.00	--	--	--	21,581	0.495	51,624	1.185
	--	4.03	--	--	--	21,654	0.497	52,273	1.200
	--	4.50	--	--	--	22,819	0.524	62,724	1.440

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)



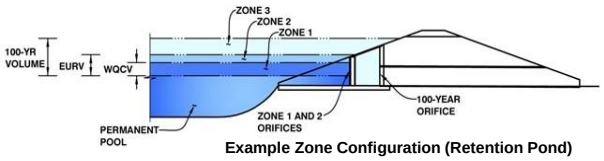


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project:

Basin ID:



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.87	0.251	Orifice Plate
Zone 2 (EURV)	2.55	0.269	Orifice Plate
Zone 3 (100-year)	4.25	0.785	Weir&Pipe (Restrict)
Total (all zones)		1.306	

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft²
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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)

Centroid of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	7.500E-03	ft²
Depth at top of Zone using Orifice Plate =	2.42	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	9.70	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	1.08	sq. inches (diameter = 1-3/16 inches)	Elliptical Slot Area =	N/A	ft²

Calculated Parameters for Plate

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	0.81	1.61					
Orifice Area (sq. inches)	1.08	1.08	1.08					

	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			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft²
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

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

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	2.42	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.42	N/A	feet
Overflow Weir Front Edge Length =	3.00	N/A	feet	Overflow Weir Slope Length =	4.12	N/A	feet
Overflow Weir Grate Slope =	4.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	5.84	N/A	
Horiz. Length of Weir Sides =	4.00	N/A	feet	Overflow Grate Open Area w/o Debris =	8.61	N/A	ft²
Overflow Grate Type =	Type C Grate	N/A		Overflow Grate Open Area w/ Debris =	8.61	N/A	ft²
Debris Clogging % =	0%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	1.00	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	1.47	N/A	ft²
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.64	N/A	feet
Restrictor Plate Height Above Pipe Invert =	14.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	2.16	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	7.10	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.84	feet
Spillway Crest Length =	10.00	feet	Stage at Top of Freeboard =	8.94	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.52	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	1.44	acre-ft

Calculated Parameters for Spillway

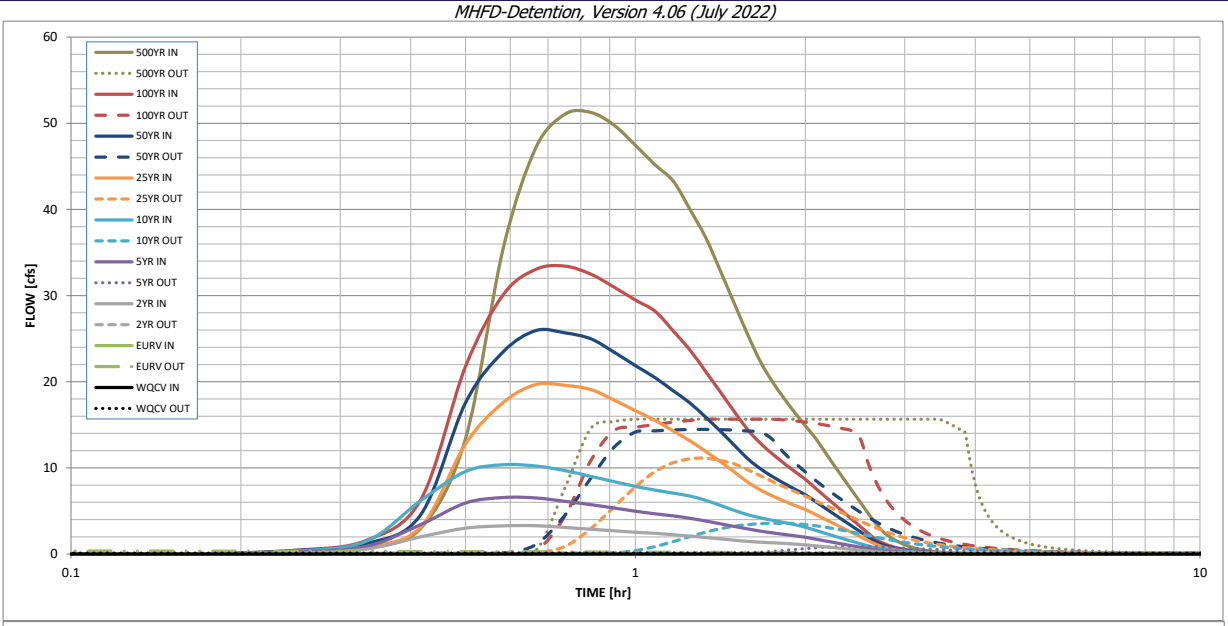
Routed Hydrograph Results

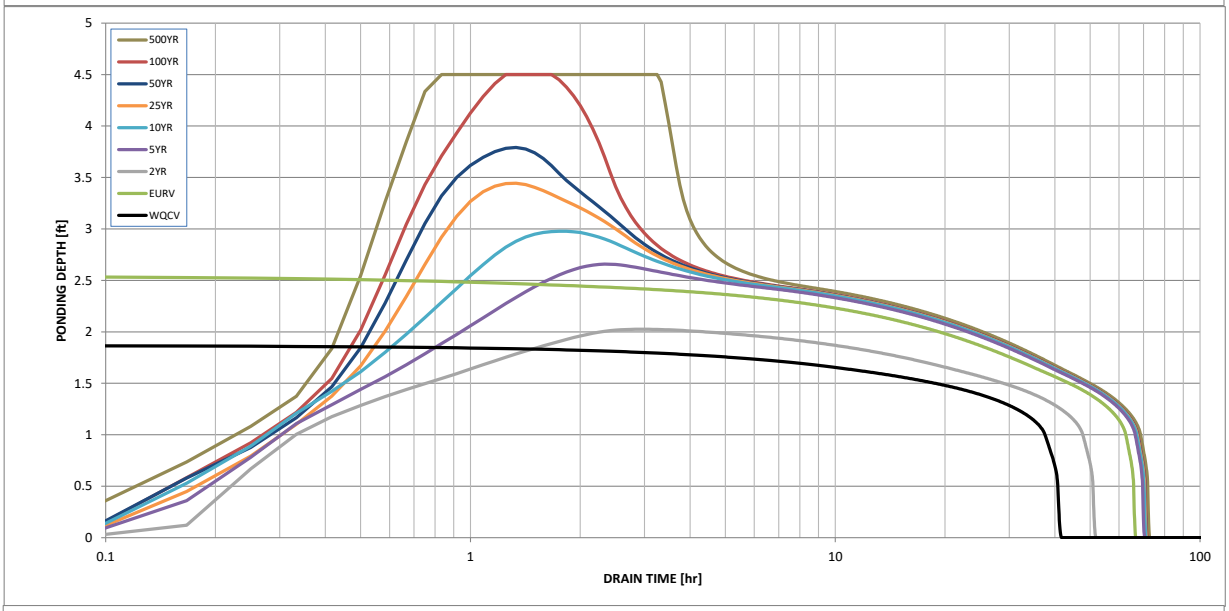
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

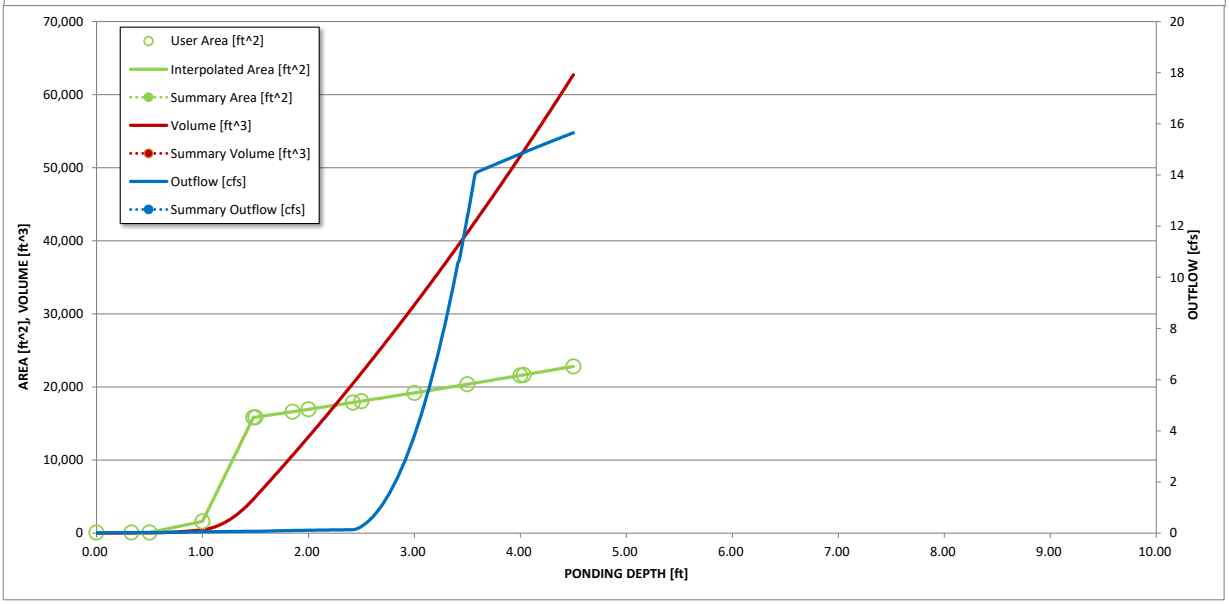
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.86	1.15	1.41	1.82	2.16	2.52	3.49
CUHP Runoff Volume (acre-ft) =	0.251	0.521	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.338	0.650	1.036	1.844	2.446	3.186	4.958
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A						16.6	
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.00	0.00	0.00	0.00	0.00	0.79	0.00
Peak Inflow Q (cfs) =	N/A	N/A	3.3	6.6	10.4	19.7	25.9	33.4	51.3
Peak Outflow Q (cfs) =	0.1	0.4	0.1	0.9	3.6	11.1	14.5	15.7	15.7
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.9	#DIV/0!
Structure Controlling Flow =	Plate	Overflow Weir 1	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	N/A	N/A
Max Velocity through Grate 1 (fps) =	N/A	0.03	N/A	0.1	0.4	1.3	1.7	1.8	1.8
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) =	38	62	48	65	63	59	56	52	44
Time to Drain 99% of Inflow Volume (hours) =	**40**	64	50	68	67	66	65	63	61
Maximum Ponding Depth (ft) =	1.87	2.55	2.03	2.66	2.98	3.44	3.79	4.50	4.50
Area at Maximum Ponding Depth (acres) =	0.38	0.42	0.39	0.42	0.44	0.46	0.48	0.52	0.52
Maximum Volume Stored (acre-ft) =	0.252	0.524	0.310	0.566	0.704	0.916	1.082	1.440	1.440

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)







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

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.15
	0:15:00	0.00	0.00	0.08	0.24	0.35	0.29	0.42	0.44	0.77
	0:20:00	0.00	0.00	0.58	0.88	1.48	0.84	1.21	1.58	3.00
	0:25:00	0.00	0.00	2.00	3.43	6.22	3.15	4.58	6.32	13.39
	0:30:00	0.00	0.00	3.00	5.92	9.58	12.77	17.56	21.76	35.52
	0:35:00	0.00	0.00	3.27	6.56	10.36	17.59	23.48	30.11	47.21
	0:40:00	0.00	0.00	3.29	6.51	10.22	19.69	25.94	33.06	51.06
	0:45:00	0.00	0.00	3.08	6.12	9.69	19.58	25.68	33.42	51.26
	0:50:00	0.00	0.00	2.88	5.73	9.02	19.10	24.99	32.49	49.78
	0:55:00	0.00	0.00	2.70	5.34	8.41	17.87	23.43	30.98	47.45
	1:00:00	0.00	0.00	2.53	4.97	7.85	16.64	21.87	29.48	45.18
	1:05:00	0.00	0.00	2.41	4.67	7.42	15.52	20.48	28.19	43.29
	1:10:00	0.00	0.00	2.24	4.43	7.07	14.28	18.95	25.90	39.97
	1:15:00	0.00	0.00	2.08	4.15	6.73	13.13	17.52	23.66	36.69
	1:20:00	0.00	0.00	1.92	3.83	6.23	11.90	15.85	21.15	32.76
	1:25:00	0.00	0.00	1.76	3.50	5.63	10.70	14.22	18.74	28.95
	1:30:00	0.00	0.00	1.60	3.19	5.05	9.48	12.57	16.46	25.38
	1:35:00	0.00	0.00	1.47	2.91	4.55	8.32	11.03	14.38	22.28
	1:40:00	0.00	0.00	1.37	2.66	4.20	7.43	9.89	12.84	19.97
	1:45:00	0.00	0.00	1.30	2.46	3.92	6.74	8.98	11.61	18.08
	1:50:00	0.00	0.00	1.24	2.28	3.67	6.16	8.21	10.54	16.41
	1:55:00	0.00	0.00	1.16	2.11	3.41	5.64	7.52	9.57	14.89
	2:00:00	0.00	0.00	1.07	1.95	3.12	5.17	6.88	8.67	13.48
	2:05:00	0.00	0.00	0.95	1.74	2.77	4.60	6.11	7.66	11.85
	2:10:00	0.00	0.00	0.84	1.53	2.42	4.04	5.35	6.69	10.29
	2:15:00	0.00	0.00	0.74	1.33	2.09	3.51	4.62	5.78	8.83
	2:20:00	0.00	0.00	0.64	1.15	1.78	3.00	3.93	4.90	7.42
	2:25:00	0.00	0.00	0.54	0.97	1.49	2.51	3.26	4.05	6.06
	2:30:00	0.00	0.00	0.45	0.80	1.21	2.03	2.62	3.22	4.75
	2:35:00	0.00	0.00	0.36	0.63	0.95	1.57	2.00	2.42	3.53
	2:40:00	0.00	0.00	0.28	0.48	0.72	1.14	1.44	1.71	2.57
	2:45:00	0.00	0.00	0.22	0.37	0.57	0.82	1.06	1.25	1.92
	2:50:00	0.00	0.00	0.18	0.29	0.46	0.61	0.80	0.94	1.45
	2:55:00	0.00	0.00	0.14	0.24	0.38	0.46	0.62	0.69	1.09
	3:00:00	0.00	0.00	0.12	0.20	0.31	0.35	0.47	0.51	0.81
	3:05:00	0.00	0.00	0.10	0.16	0.26	0.27	0.37	0.38	0.60
	3:10:00	0.00	0.00	0.08	0.13	0.21	0.21	0.29	0.27	0.44
	3:15:00	0.00	0.00	0.07	0.11	0.17	0.17	0.22	0.20	0.33
	3:20:00	0.00	0.00	0.06	0.09	0.13	0.13	0.17	0.16	0.26
	3:25:00	0.00	0.00	0.05	0.07	0.11	0.10	0.14	0.13	0.20
	3:30:00	0.00	0.00	0.04	0.05	0.08	0.08	0.11	0.10	0.16
	3:35:00	0.00	0.00	0.03	0.04	0.06	0.06	0.08	0.08	0.13
	3:40:00	0.00	0.00	0.02	0.03	0.05	0.05	0.06	0.06	0.09
	3:45:00	0.00	0.00	0.02	0.02	0.03	0.03	0.04	0.04	0.06
	3:50:00	0.00	0.00	0.01	0.02	0.02	0.02	0.03	0.03	0.04
	3:55:00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02
	4:00:00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

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.

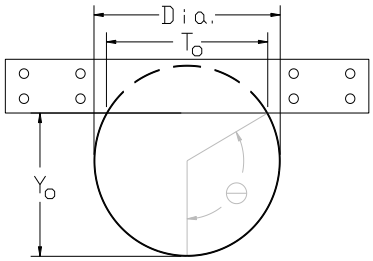
Stage - Storage Description	Stage [ft]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]

For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

REFERENCE FIGURES AND EQUATIONS

Circular Pipe with Restrictor Plate



WQ Elliptical Slot Weir (Alternative to WQ Orifice Plate for Large Watersheds)

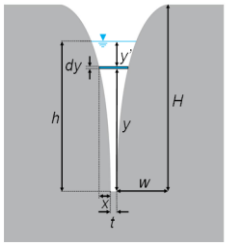
$$f(y)=\sqrt{2g(h-y)}\left[2\frac{H}{R}\left(1-1\sqrt{1-\frac{y^2}{H^2}}\right)+t\right]$$

$$Q_{app}=0.3015h\left[f(0)+f(0.603h)\right]+0.1415h\left[f(0.603h)+f(0.886h)\right]+0.0570W\left[f(0.886h)\right]$$

Orifice Equations

$$Q=C_dA_i\sqrt{2g(h-C_y)}$$

$$A_i=H(2W+t)-\frac{\pi HW}{2}\qquad C_y=\frac{\frac{H}{2}(2W+t)-\frac{2HW}{3}}{2W+t-\frac{\pi W}{2}}$$



- dy = elementary flow vertical distance [L];
- h = total flow depth [L];
- H = total weir height and semi-major ellipse axis [L];
- t = weir gap thickness [L];
- W = semi-minor ellipse axis [L];
- x = horizontal distance along the ellipse shape [L];
- y = vertical depth measured from the weir crest to the elementary flow strip [L]; and
- y' = vertical distance measured from the water surface to the elementary flow strip [L].

WQCV and EURV Equations

$$WQCV=\frac{A}{12}*a[0.91I^3-1.19I^2+0.78I]$$

$$EURV=Area*[0.140(IMP)^{1.28}*A\%+0.113(IMP)^{1.08}*B\%+0.100(IMP)^{1.08}*C/D\%]$$

Where *WQCV* is the water quality capture volume (acre-ft), EURV is the excess urban runoff volume (acre-ft), *a* is a coefficient corresponding to WQCV drain time (1.0 for 40 hours, 0.9 for 24 hours, and 0.8 for 12 hours), *A* is the contributing watershed area (acres), *I* is the percentage imperviousness (expressed as a decimal), *A%*, *B%*, and *CD%* are the percent of each hydraulic soil group (expressed as a decimal).

Approximate Storage Volume Equations

$$V_{Storage\_2yr}(ac-ft)=P_1A[(0.078I^{1.324})A\%+(0.077I^{1.184})B\%+(0.077I^{1.134})CD\%]$$

$$V_{Storage\_5yr}(ac-ft)=P_1A[(0.080I^{1.298})A\%+(0.079I^{1.100})B\%+(0.077I^{1.001}+0.003I^{0.001})CD\%]$$

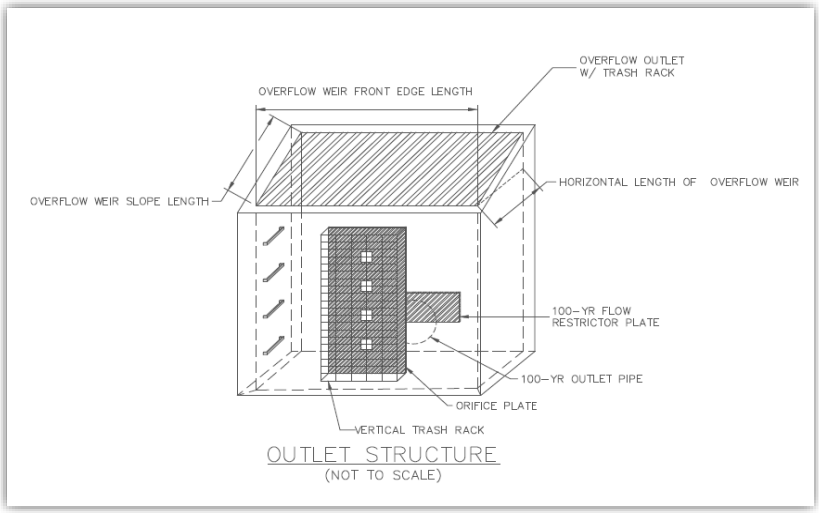
$$V_{Storage\_10yr}(acft)=P_1A[(0.081I^{1.251})A\%+(0.077I^{1.056}+0.005I^{0.056})B\%+(0.069I^{1.167}+0.011I^{0.167})CD\%]$$

$$V_{Storage\_25yr}(ac-ft)=P_1A[(0.083I^{1.188})A\%+(0.056I^{1.290}+0.021I^{0.290})B\%+(0.048I^{1.382}+0.026I^{0.382})CD\%]$$

$$V_{Storage\_50yr}(ac-ft)=P_1A[(0.078I^{1.182}+0.002I^{0.182})A\%+(0.045I^{1.381}+0.026I^{0.381})B\%+(0.037I^{1.457}+0.030I^{0.457})CD\%]$$

$$V_{Storage\_100yr}(ac-ft)=P_1A[(0.067I^{1.225}+0.009I^{0.225})A\%+(0.034I^{1.371}+0.031I^{0.371})B\%+(0.028I^{1.389}+0.033I^{0.389})CD\%]$$

Where $V_{STORAGE\_yr}$ is the estimated storage volume for the given return period (acre-ft), P_1 is the one-hour rainfall depth (in), *A* is the contributing watershed area (acres), *I* is the percentage imperviousness (expressed as a decimal), *A%*, *B%*, and *CD%* are the percent of each hydraulic soil group (expressed as a decimal).



Basin Volume Calculations

Initial Surcharge Volume:

$$ISV=0.003WQCV \qquad L_{ISV}=\sqrt{A_{ISV}}$$

$$A_{ISV}=\frac{ISV}{ISD} \qquad W_{ISV}=\sqrt{A_{ISV}}$$

Where *ISV* is the initial surcharge volume (ft^3), A_{ISV} is *ISV* surface area (ft^2), *ISD* is the initial surcharge depth (ft, typically 0.33 to 0.50), and L_{ISV} and W_{ISV} are the length and width of the *ISV* (ft).

Basin Floor Volume:

$$L_{floor}=L_{ISV}+\frac{H_{floor}}{S_{TC}}+H_{floor}(S_{main}) \qquad W_{floor}=W_{ISV}+\frac{H_{floor}}{R_{LW}(S_{TC})}$$

$$A_{floor}=L_{floor}(W_{floor})$$

$$V_{floor}=\frac{H_{floor}}{3}\left(A_{ISV}+A_{floor}+\sqrt{A_{ISV}(A_{floor})}\right)$$

Where L_{floor} and W_{floor} (ft) are the length and width of the basin floor section at the point where the top of the basin floor section meets the toe of the basin main section, H_{floor} is the depth of the basin floor section (ft), S_{TC} is the trickle channel slope (ft/ft), S_{main} is the side slope of the basin main section (H:V; e.g., 4 if the horizontal:vertical ratio is 4:1), $R_{L:W}$ is the basin length:width ratio (e.g., 2 if the basin length is twice the basin width), A_{floor} is top area of the basin floor section (ft^2), and V_{floor} is volume of the basin floor section (ft^3).

Main Basin Volume:

$$L_{main}=L_{floor}+2H_{main}(S_{main}) \qquad A_{main}=L_{main}(W_{main})$$

$$W_{main}=W_{floor}+2H_{main}(S_{main})$$

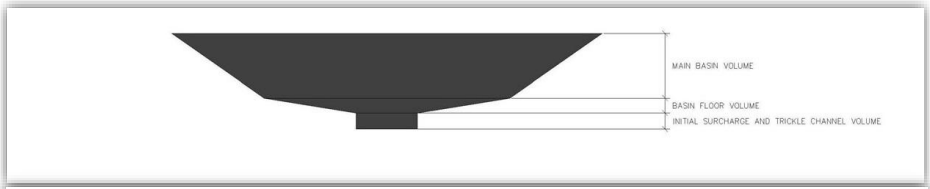
$$V_{main}=\frac{H_{main}}{3}\left(A_{main}+A_{floor}+\sqrt{A_{main}(A_{floor})}\right)$$

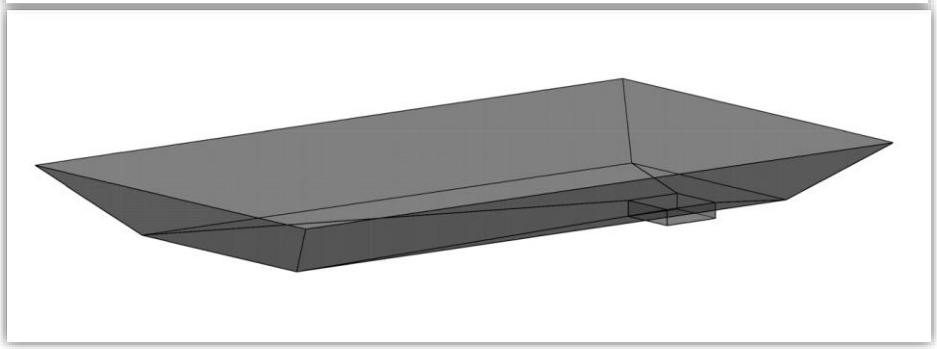
Where L_{main} and W_{main} (ft) are the length and width of the main basin section at the point at the top of the basin, H_{main} is the depth of the main basin section (ft), A_{main} is top area of the main basin section (ft^2), and V_{main} is volume of the main basin section (ft^3).

Total Basin Volume:

$$V_{total}=ISV+A_{ISV}\cdot D_{TC}+V_{floor}+V_{main}$$

Where V_{total} is the volume of the total basin (ft^3) and D_{TC} is the depth of the trickle channel (ft).





Default Horton's Equation Parameters			
NRCS Hydrologic Group	Infiltration (inches per hour)		Decay Coefficient (1/sec)
	Initial - f_i	Final - f_o	
A	5.0	1.0	0.0007
B	4.5	0.6	0.0018
C/D	3.0	0.5	0.0018

Default Depression Storage	
Impervious (in)	Pervious (in)
0.10	0.35

USER TIPS AND TOOLS

MHFD-Detention, Version 4.06 (July 2022)

Video Links: Click the link below to visit the MHFD YouTube Channel where you can access instructional videos for this and other workbooks.
MHFD Workbook Instructional Videos

Manual: **Click here** to download the **Technical Reference Manual** for the MHFD-Detention workbook. The manual provides background information on methods and equations used in this workbook.

User Tips:

Basin Sheet

- To evaluate a Detention Basin without a water quality component, select "**Flood Control Only**" from the BMP Type selection box.

- **Rainfall depths** can be overridden by entering user-defined values in cells D28:D34. Not all values have to be overriden, some can remain consistent with the pulldown selection.

- **Required Storage Volumes** can be overriden for each zone by selecting "**User Defined**" from the pulldown lists for each zone. This allows the user to adjust the required storage volume to better match local requirements. The user-defined storage values can be input as an equations which references other cells on the worksheet. For example, if the user wants to set the Zone 2 storage equal to the 100-year storage volume plus half of the WQCV minus Zone 1, an equation such as "=B40 + 0.5*(B26) - B43" can be entered in the cell. This will allow the volume to update automatically if other inputs change.

- **User Defined Stage-Area inputs** can be entered one row at a time or by entering all stages and then going back and entering all the areas. It is recommended that the latter approach be used in order to speed up the input process. This is because every time there are an equal number of stage and area values, the code will update calculations.

Outlet Structure Sheet

- If an outlet is not being used for one of the zone pulldowns, selecting "**Not Utilized**" from the pulldown list will assist in populating the unused inputs with "N/A".

- There is only one outlet type pulldown per zone. However, **additional outlets** can be added by providing the additional inputs and the effects will be accounted for in the stage-discharge table and routing results. However, some of the automatic sizing routines will no longer be available if additional outlets are utilized.

- When sizing an **orifice plate for WQCV and EURV**, the uppermost orifice can be manually changed to better satisfy 72 hour drain time requirements.

- The **Stage-Area-Volume-Discharge chart** can be manipulated automatically by changing the min/max scale values below the chart. This allows the user to zoom in on areas of interest and helps to ensure that summary tables include all critical stages.

- **Inflow hydrographs** can be overridden by simplying copying over the default values with values from another model or with exported outflow hydrographs from an upstream MHFD-Detention workbook. Please note that when using exported hydrographs from another MHFD-Detention workbook, there is no accounting for travel time or attenuation between detention basins. If there is additional runoff between the detention basins or complex routing, a more sophisticated program like EPA-SWMM is recommended.

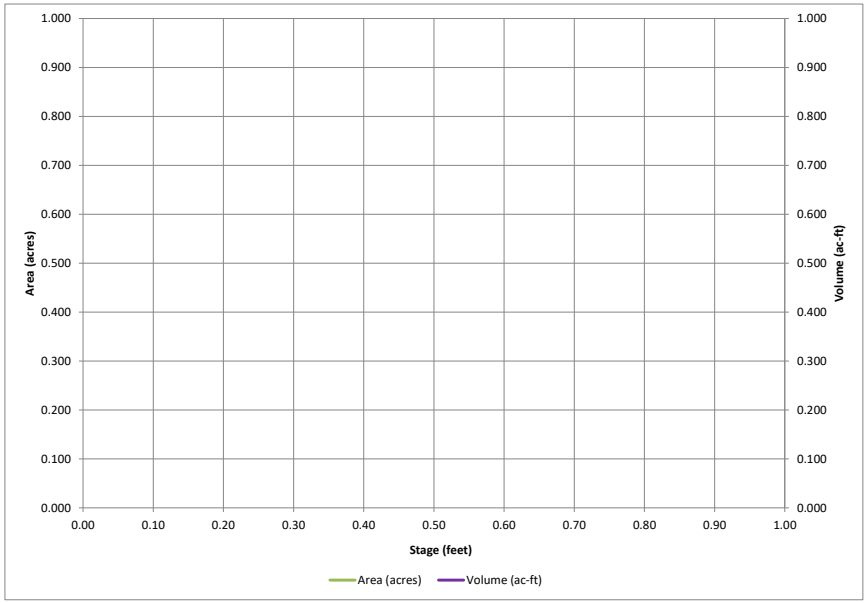
Calculate Stage-Area relationship from known Stage-Volume Relationship

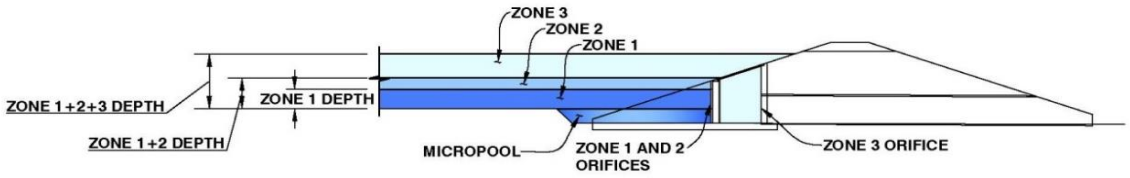
								SSD 0.00E+00
Stage - Storage Description	User Stage (ft)	User Volume (ac-ft)	User Volume (ft^3)	Calculated Volume (ft^3)	Calculated Area (ft^2)	Calculated Area (acre)	Volume % Diff (ft^3)	Squared Difference in Area (ft^2)
Bottom of Basin	0.00	0.000	0	0			0%	

- The Stage-Area Tool is designed to help the user develop a Stage-Area relationship from a known Stage-volume relationship.
- The calculated volume is determined using the conic approximation method and is consistent with the method used on the Basin worksheet.

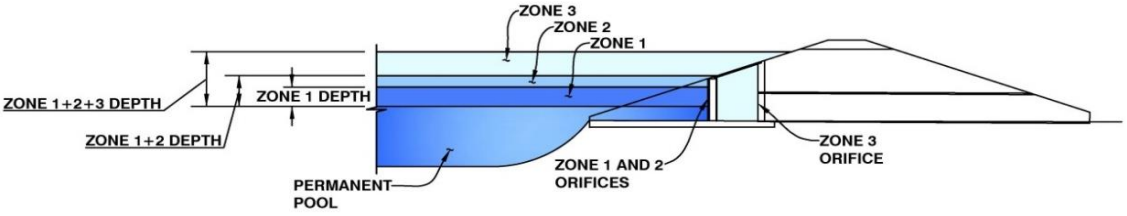
- The tool requires the user to provide a stage-volume relationship as the minimum input. The basin bottom area is an optional input.
  - If the user provides the bottom area, the program will automatically run the sizing routine to determine the area at each depth increment.
  - If the user clicks the "Minimize SSD" button, the program will iteratively solve for the bottom area that provides the best overall fit.

- If the program returns the message that the program could not find a solution, try the following:
  - Check the user inputs for stage and volume to determine if they are reasonable and try to identify any potential input mistakes.
  - Try manually changing the bottom area to see if you can get a closer fit.
  - Identify the row where the program failed and look closely at the volumes to determine what may be causing the routine to fail.

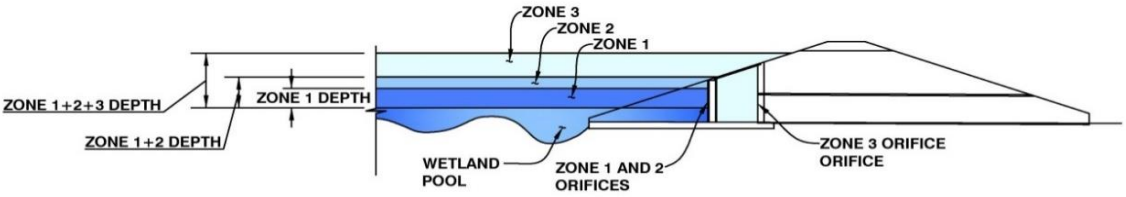




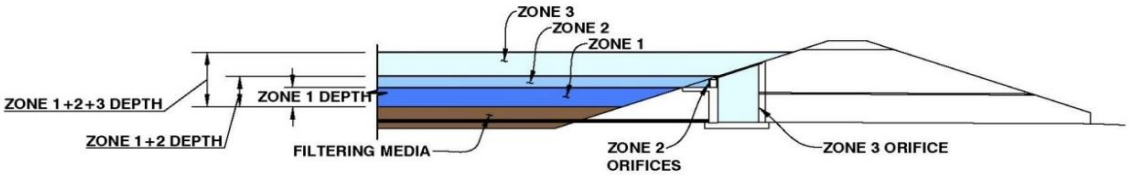
EXTENDED DETENTION BASIN WITH 3 ZONES



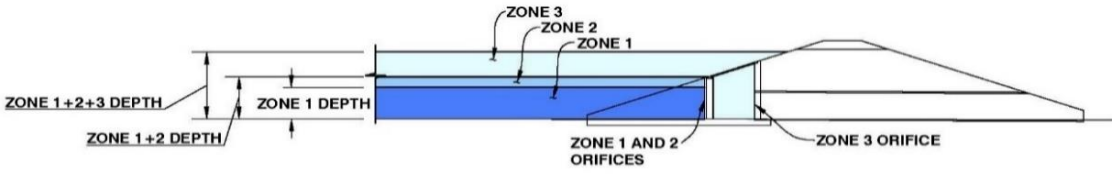
RETENTION POND WITH 3 ZONES



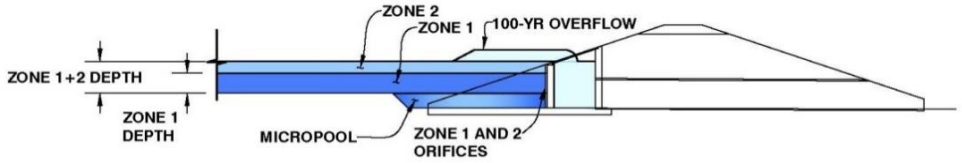
CONSTRUCTED WETLAND POND WITH 3 ZONES



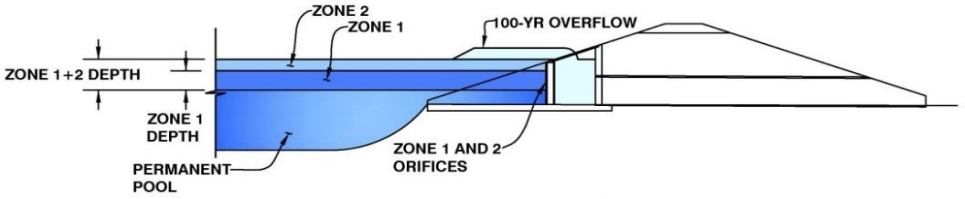
FILTERING BMP WITH 3 ZONES



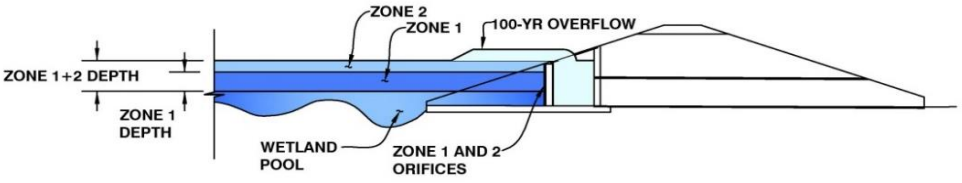
FLOOD CONTROL WITH THREE ZONES



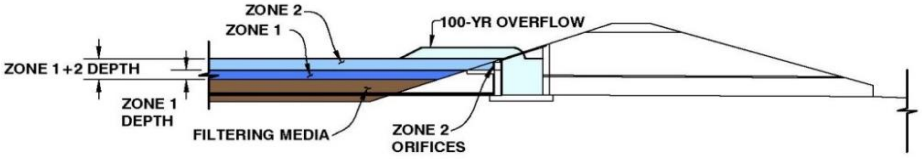
EXTENDED DETENTION BASIN WITH ZONE 1 AND ZONE 2



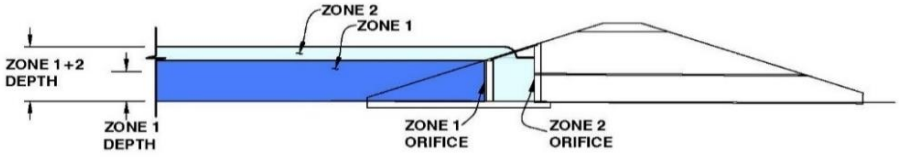
RETENTION POND WITH ZONE 1 AND ZONE 2



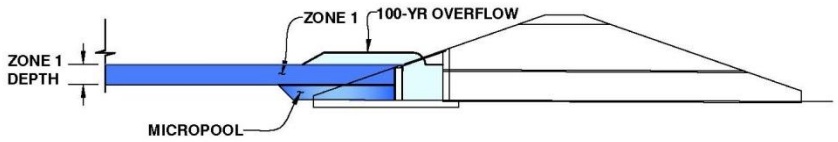
CONSTRUCTED WETLAND POND WITH ZONE 1 AND ZONE 2



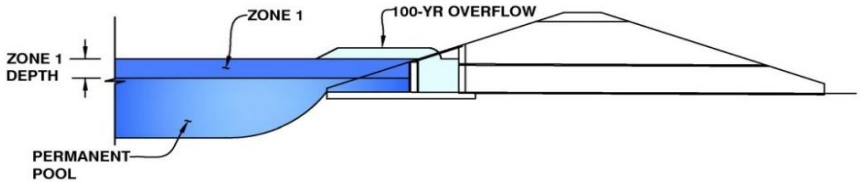
FILTERING BMP ZONE 1 AND ZONE 2



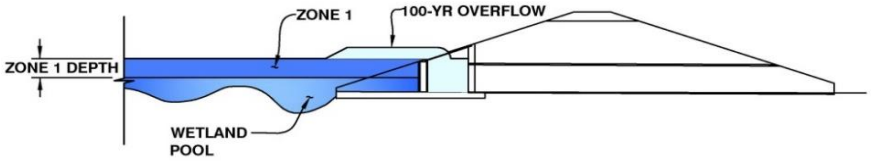
FLOOD CONTROL WITH TWO ZONES



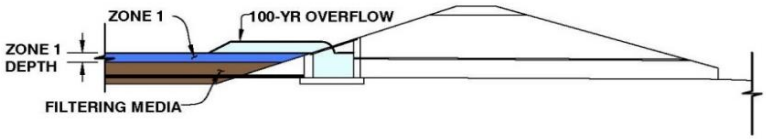
EXTENDED DETENTION BASIN WITH ZONE 1 ONLY



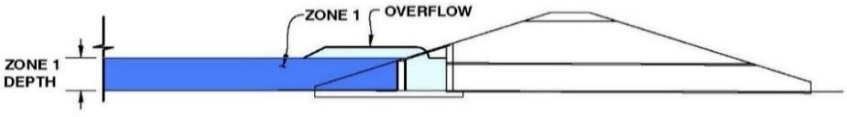
RETENTION POND WITH ZONE 1 ONLY



CONSTRUCTED WETLAND POND WITH ZONE 1 ONLY



FILTERING BMP WITH ZONE 1 ONLY



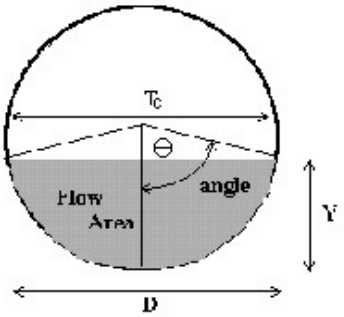
FLOOD CONTROL WITH ONE ZONE

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: Canyon Peak Power

Pipe ID: Culvert 1



Design Information (Input)			
Pipe Invert Slope	So =	0.0050	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	24.00	inches
Design discharge	Q =	14.92	cfs

10-year storm

Full-Flow Capacity (Calculated)			
Full-flow area	Af =	3.14	sq ft
Full-flow wetted perimeter	Pf =	6.28	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	16.04	cfs

Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	2.13	radians
Flow area	An =	2.57	sq ft
Top width	Tn =	1.70	ft
Wetted perimeter	Pn =	4.25	ft
Flow depth	Yn =	1.53	ft
Flow velocity	Vn =	5.80	fps
Discharge	Qn =	14.92	cfs
Percent of Full Flow	Flow =	93.0%	of full flow
Normal Depth Froude Number	Fr_n =	0.83	subcritical

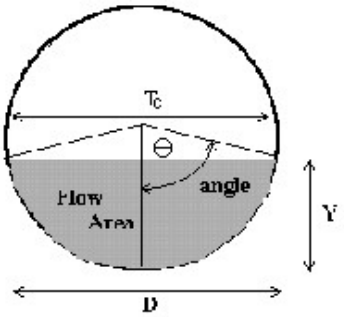
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	1.97	radians
Critical flow area	Ac =	2.33	sq ft
Critical top width	Tc =	1.84	ft
Critical flow depth	Yc =	1.39	ft
Critical flow velocity	Vc =	6.39	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: Canyon Peak Power

Pipe ID: Pipe 2



Design Information (Input)			
Pipe Invert Slope	So =	0.0050	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	24.00	inches
Design discharge	Q =	16.02	cfs

10-year storm

Full-Flow Capacity (Calculated)			
Full-flow area	Af =	3.14	sq ft
Full-flow wetted perimeter	Pf =	6.28	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	16.04	cfs

Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	2.26	radians
Flow area	An =	2.75	sq ft
Top width	Tn =	1.54	ft
Wetted perimeter	Pn =	4.52	ft
Flow depth	Yn =	1.64	ft
Flow velocity	Vn =	5.82	fps
Discharge	Qn =	16.02	cfs
Percent of Full Flow	Flow =	99.9%	of full flow
Normal Depth Froude Number	Fr_n =	0.77	subcritical

Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.03	radians
Critical flow area	Ac =	2.43	sq ft
Critical top width	Tc =	1.79	ft
Critical flow depth	Yc =	1.44	ft
Critical flow velocity	Vc =	6.60	fps
Critical Depth Froude Number	Fr_c =	1.00	

Appendix E FEMA Maps

104°30'1.75"W 39°39'51.01"N

104°22'28.32"W 39°31'28.3"N

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR DRAFT FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS

- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD

- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS

- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES

- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES

- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by USDA, Farm Service Agency (FSA). This information was derived from NAIP, dated April 11, 2018.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **11/22/2024 6:25 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at https://www.fema.gov/media-library/assets/documents/118418

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards. This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date.

SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: No elevation features on this FIRM
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at https://msc.fema.gov

N

1 inch = 2,000 feet 1:24,000

0 1,000 2,000 4,000 6,000 8,000 Feet

0 210 420 840 1,260 1,680 Meters

NATIONAL FLOOD INSURANCE PROGRAM

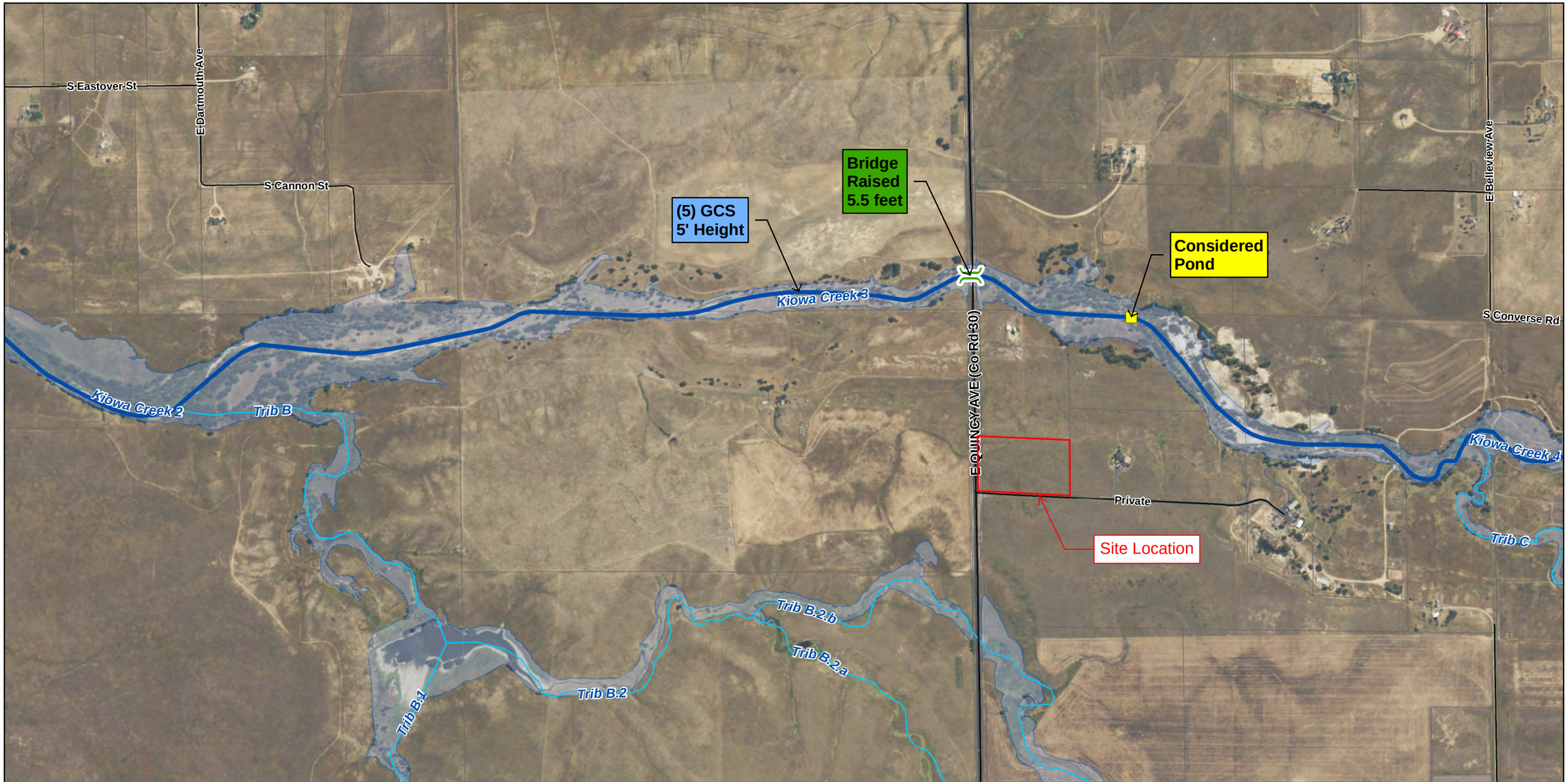
FLOOD INSURANCE RATE MAP

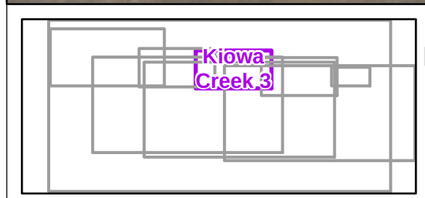
PANEL 575 OF 675

Panel Contains:

COMMUNITY	NUMBER	PANEL
ELBERT COUNTY	080058	0575
ARAPAHOE COUNTY	080011	0575

MAP NUMBER
08005C0575K
EFFECTIVE DATE
December 17, 2010





Legend

- Bridge
- CBC
- Pond
- RCP
- Areas of Observed Erosion
- Local Streets
- Kiowa Creek
- Kiowa Tributaries
- 100 year Existing Floodplain
- Assessor Parcels

Alternatives

Crossing Structure Improvements

- Bridge
- CBC
- RCP

Detention Ponds

- Pond

Floodplain Preservation

- Bank Stabilization
- GCS

N

0 1,000 2,000 ft

1 in = 1,000 ft

Bohannan Huston
www.bhinc.com 800.877.5332

ARAPAHOE COUNTY
COLORADO'S FIRST

Kiowa Creek
Master Drainage Plan

Figure 18
Kiowa Creek 3 Alternatives

P:\20170164\WR\Reports\Final\Figures\MXDs\Figure15-23_KiowaTributaries.mxd
Author: gmaynard

September 2017

Appendix F 2007 Construction Drawings

PARCEL 8
MAX LENIASKI
REC NO A6049428

SECTION LINE

EXST 60' ROW

75' UTIL ESMT

JOHN H HYATT
3 NAVASOTA CIR
WICHITA FALLS, TX 76309
PARCEL #2067-00-0-00-297

E1

E3

E4

H3
1.232 | 0.15 / 0.50

H4
0.462 | 0.25 / 0.55

H1
12.850 | 0.15 / 0.50

S BRICK CENTER ROAD

27' UTIL ESMT

INTERMOUNTAIN RURAL
ELECTRIC ASSOCIATION
10.004 ACRES

EXISTING OVERHEAD
ELECTRIC POWER LINE

INTERMOUNTAIN RURAL
ELECTRIC ASSOCIATION
10.004 ACRES

H2
6.809 | 0.17 / 0.51

E2

PARCEL 9
CHRIS KING
REC NO B4039221

STATE OF COLORADO
200 E. COLFAX AVE.
DENVER, CO 80203
PARCEL #2067-00-0-00-012

FUTURE ROW FOR
E BELLEVIEW AVE

SECTION LINE

EXISTING OVERHEAD
ELECTRIC POWER LINE

FUTURE 57' ROW

EXST 225' UTIL ESMT BK 2782 PG 547

EXST 30' ROW

EXISTING OVERHEAD ELECTRIC
TRANSMISSION LINES

LEGEND

- PROPERTY LINE
- EX ROADWAY
- EX FIELD FENCE
- EX ELECTRIC LINE
- 5765 EX MAJOR CONTOUR
- 5766 EX MINOR CONTOUR

A — BASIN ID
1.00 | 0.50 / 0.90 — 5 YR RUNOFF COEFF. / 100 YR RUNOFF COEFF.
BASIN AREA (AC.)

1 — DESIGN POINT

NOTES:

1. EXISTING CONTOURS SHOWN FOR REFERENCE ONLY. CONTRACTOR SHALL NOTIFY ENGINEER IF DISCREPANCIES ARE FOUND.

NORTH

60 0 30 60 120

(IN FEET)
SCALE: 1 in = 60 ft

ISSUED FOR PERMITTING
05/31/07

NO.	REVISIONS	DSGN	CHKD	APVD	DATE
A	ISSUED FOR PERMITTING	JLV			05/30/07

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9200 East Mineral Avenue, Suite 400, Englewood, Colorado 80112-3416
www.stanleyconsultants.com

INTERMOUNTAIN RURAL ELECTRIC ASSOCIATION
COLORADO – 16 – JEFFERSON
SEDALIA, COLORADO

BRICK CENTER TRANSMISSION SUBSTATION (406)
EXISTING DRAINAGE PLAN

DESIGNED	N.L. DURAN
DRAWN	G.P. PIEHL
CHECKED	J.L. VARONE
APPROVED	
APPROVED	
DATE	05/31/07

SCALE: 1" = 60'-0"
NO. 19907.01.00
REV.
CD01
A

CADD D1-R4

PARCEL 8
MAX LENAISKI
REC NO A6049428

SECTION LINE

EXST 60' ROW | 75' UTIL ESMT

JOHN H HYATT
3 NAVASOTA CIR
WICHITA FALLS, TX 76309
PARCEL #2067-00-0-00-297

RETAINING WALL
SEE CONSTRUCTION DOCUMENTS
SHEET CG04 FOR DETAILS

40 LF-12" RCP
W/ FES @ 0.5%
TYPE M RIP RAP
10'X5'X21" (BOTH ENDS)

U1
0.985 | 0.15 | 0.50

U2
1.232 | 0.15 | 0.50

CHAIN LINK FENCE

INTERMOUNTAIN RURAL
ELECTRIC ASSOCIATION
10.004 ACRES

INTERMOUNTAIN RURAL
ELECTRIC ASSOCIATION
10.004 ACRES

27' UTIL ESMT

A
3.292 | 0.16 | 0.51

C
6.295 | 0.31 | 0.57

D
5.357 | 0.15 | 0.50

E
0.437 | 0.23 | 0.54

B
2.872 | 0.27 | 0.56

S BRICK CENTER ROAD

EXISTING OVERHEAD
ELECTRIC POWER LINE

20 LF-DRAINAGE PAN @ 2.0%
SEE DETAILS SHEET CU03

GRADE SWALE TO DRAIN @ 0.7% MIN.

18" RCP FES
10'x10'x21'
TYPE M RIP RAP

DRAINAGE ESMT

600 LF-LOW FLOW CHANNEL @ 0.5%
SEE DETAILS SHEET CU03

24.4 LF-24" RCP @ 1.0%

PRE-SEDIMENTATION FOREBAY
SEE DETAILS SHEET CU03

4-CU03
50.00

DETENTION FACILITY OUTLET STRUCTURE
SEE DETAILS SHEET CU02

TYPE M RIP RAP
10'X10'X21"

TYPE M RIP RAP
42.7 SY, 21" MIN. DEPTH

FIELD FENCE

SECTION LINE

GRADE SWALE TO DRAIN @ 0.5% MIN.

EMERGENCY OVERFLOW
69.3 SY, 21" MIN. DEPTH
TYPE M RIP RAP
SEE DETAIL SHEET CU03

PARCEL 9
CHRIS KING
REC NO B4039221

FUTURE ROW FOR
E BELLEVIEW AVE

EXISTING OVERHEAD
ELECTRIC POWER LINE

FUTURE 57' ROW

EXST 225' UTIL ESMT BK 2782 PG 647

EXST 30' ROW

EXISTING OVERHEAD ELECTRIC
TRANSMISSION LINES

STATE OF COLORADO
200 E. COLFAX AVE
DENVER, CO 80203
PARCEL #2067-00-0-00-012

LEGEND

- PROPERTY LINE
- EX ROADWAY
- PR ROADWAY
- EX FIELD FENCE
- PR FIELD FENCE
- PR CHAIN LINK FENCE
- EX ELECTRIC LINE
- PR ELECTRIC LINE
- 5765 EX MAJOR CONTOUR
- 5766 EX MINOR CONTOUR
- 5765 PR MAJOR CONTOUR
- 5764 PR MINOR CONTOUR

A | 1.00 | 0.50 / 0.90
- BASIN ID
- 5 YR RUNOFF COEFF.
- 100 YR RUNOFF COEFF.
- BASIN AREA (AC.)

1 DESIGN POINT

NOTES:

1. FOUNDATIONS SHOWN FOR ORIENTATION PURPOSES ONLY. FOR FOUNDATIONS BEING CONSTRUCTED SEE FOUNDATION PLAN.
2. SUBSTATION AND TRANSMISSION EQUIPMENT SHOWN FOR ORIENTATION PURPOSES ONLY. FOR EQUIPMENT BEING CONSTRUCTED SEE EQUIPMENT PLAN.
4. EXISTING CONTOURS SHOWN FOR REFERENCE ONLY. CONTRACTOR SHALL NOTIFY ENGINEER IF DISCREPANCIES ARE FOUND.
5. SEE CONSTRUCTION DOCUMENTS GRADING PLAN SHEET FOR SITE GRADING AND RETAINING WALL DETAILS.
6. SEE CONSTRUCTION DOCUMENTS HORIZONTAL CONTROL PLAN FOR SPECIFIC LOCATION FOR ALL DRAINAGE STRUCTURES.
7. SEE CONSTRUCTION DOCUMENTS FOR SUBSTATION YARD AND FIELD FENCE DETAILS.
8. RCP SHALL BE CLASS III UNLESS OTHERWISE SPECIFIED. ALL RCP AND RCP FES SHALL BE RINKER MATERIALS PRECAST PIPE, OR APPROVED EQUAL, INSTALLED PER MANUFACTURER GUIDELINES.
9. ALL ROCK RIP RAP SHALL BE BURIED UNLESS OTHERWISE SPECIFIED. SEE SHEET CU03 FOR RIP RAP GRADIATIONS.

NORTH

50 0 25 50 100
(IN FEET)
SCALE: 1 in = 50 ft

ISSUED FOR PERMITTING
05/31/07

NO.	REVISIONS	DSGN	CHKD	APVD	DATE
A	ISSUED FOR PERMITTING	JLV			05/31/07

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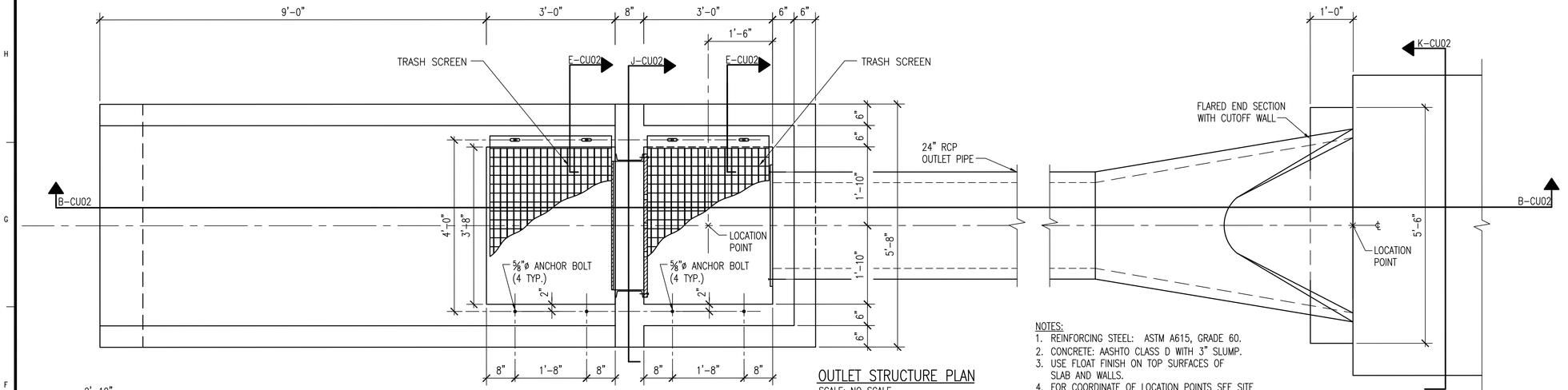
INTERMOUNTAIN RURAL ELECTRIC ASSOCIATION
COLORADO - 16 - JEFFERSON
SEDALIA, COLORADO

BRICK CENTER TRANSMISSION SUBSTATION (406) DRAINAGE IMPROVEMENTS PLAN

DESIGNED	N.L. DURAN
DRAWN	G.P. PIEHL
CHECKED	J.L. VARONE
APPROVED	
APPROVED	
DATE	05/31/07

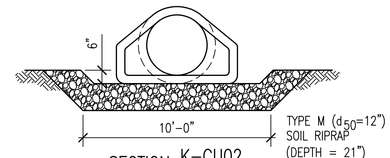
SCALE: 1" = 50'-0"
NO. 19907.01.00
REV.
CU01
A

CADD D1-R4

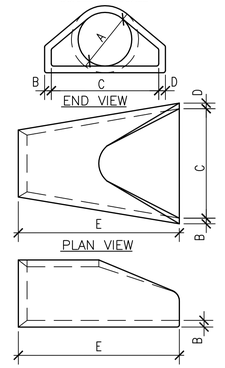


OUTLET STRUCTURE PLAN
SCALE: NO SCALE

NOTES:
1. REINFORCING STEEL: ASTM A615, GRADE 60.
2. CONCRETE: AASHTO CLASS D WITH 3" SLUMP.
3. USE FLOAT FINISH ON TOP SURFACES OF SLAB AND WALLS.
4. FOR COORDINATE OF LOCATION POINTS SEE SITE PLAN SHEET CG01.



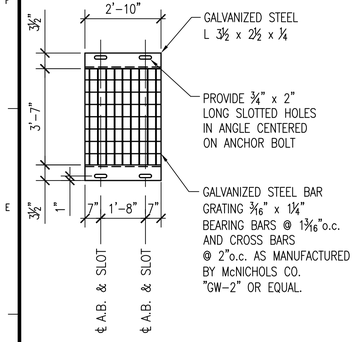
SECTION K-CU02 / CU02
SCALE: NO SCALE



	24" F.E.S.
A	24"
B	3"
C	58.8"
D	3"
E	72"

NOTES:
1. USE O-RING GASKETS (R-4 JOINTS) FOR ALL RCP.
2. JOINT RESTRAINTS ARE REQUIRED FOR A MINIMUM OF THE LAST THREE JOINTS OF RCP OUTFALL.

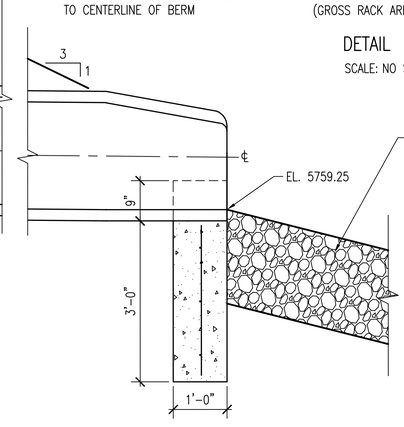
FLARED END SECTION DETAIL
3/8"=1'-0"

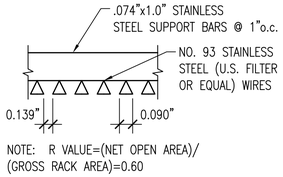


TRASH SCREEN PLAN
3/8"=1'-0"

SECTION B-CU02 / CU02
SCALE: NO SCALE

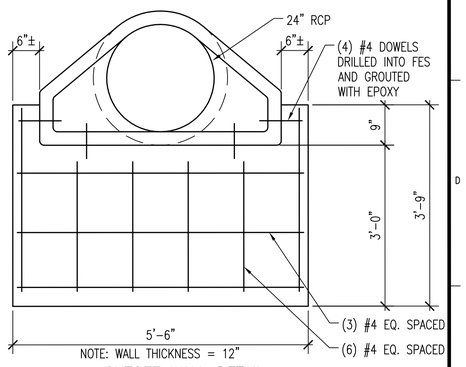
NOTE:
RCP DIMENSIONS SHOWN ARE ALONG CENTERLINE OF PIPE PERPENDICULAR TO CENTERLINE OF BERM



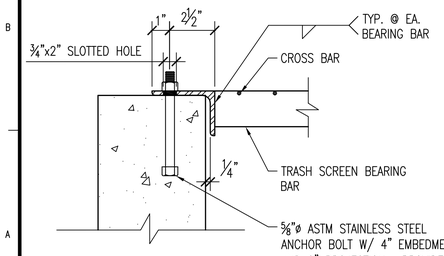


NOTE: R VALUE=(NET OPEN AREA)/(GROSS RACK AREA)=0.60

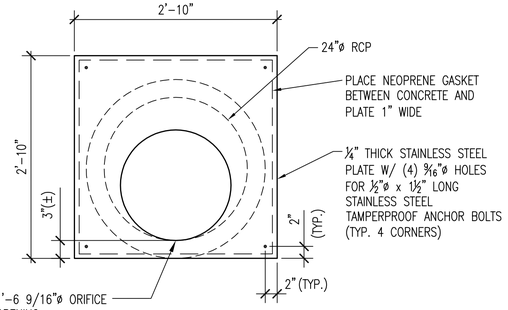
DETAIL H-CU02 / CU02
SCALE: NO SCALE



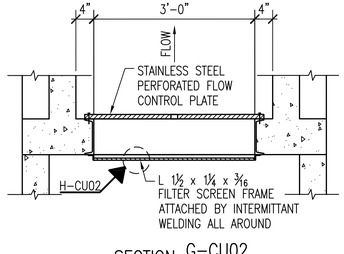
CUTOFF WALL DETAIL
3/4"=1'-0"



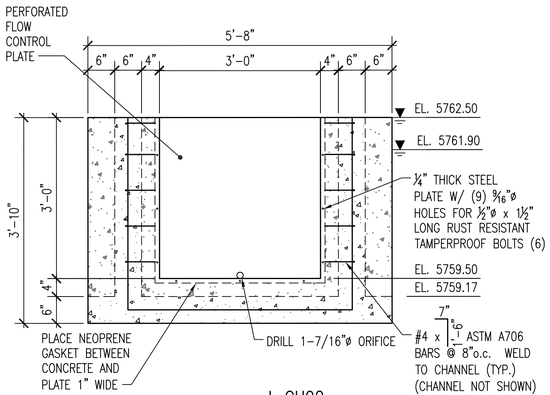
SECTION E-CU02 / CU02
SCALE: 3"=1'-0"



100 YR ORIFICE PLATE DETAIL
1"=1'-0"



SECTION G-CU02 / CU02
SCALE: 3/4"=1'-0"



SECTION J-CU02 / CU02
SCALE: NO SCALE

ISSUED FOR PERMITTING
05/31/07

NO.	REVISIONS	DSGN	CHKD	APVD	DATE
A	ISSUED FOR PERMITTING	JLV			05/31/07

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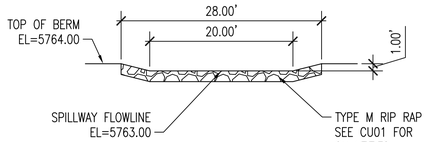
INTERMOUNTAIN RURAL ELECTRIC ASSOCIATION
COLORADO – 16 – JEFFERSON
SEDALIA, COLORADO

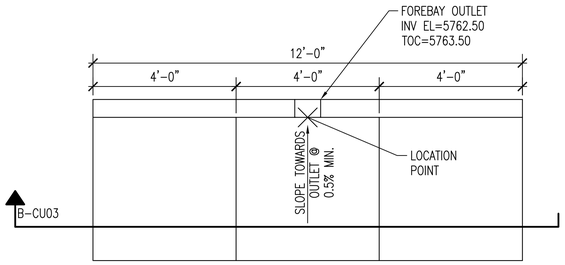
BRICK CENTER TRANSMISSION SUBSTATION (406)
DRAINAGE DETAILS
SHEET 1 OF 2

DESIGNED	N.L. DURAN	SCALE: AS NOTED	
DRAWN	G.P. PIEHL	NO. 19907.01.00	REV.
CHECKED	J.L. VARONE	CU02	A
APPROVED			
APPROVED			
DATE	05/31/07		

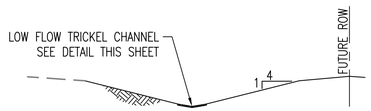
CADD D1-R4



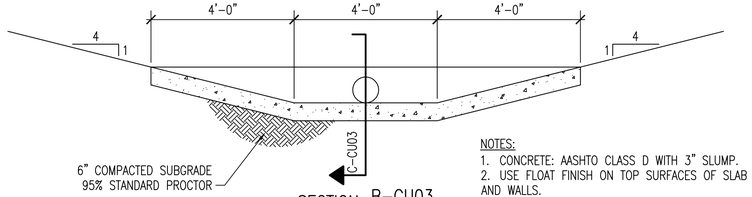
EMERGENCY OVERFLOW SPILLWAY
SCALE: 1"=10'



PRE-SEDIMENTATION FOREBAY STRUCTURE PLAN
SCALE: 1/2" = 1'-0"

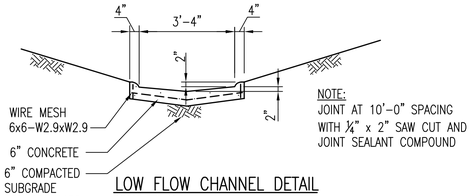


SECTION A-CU03
CU01
SCALE: 1"=10'



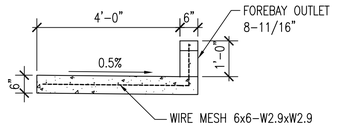
SECTION B-CU03
CU03
SCALE: 1/2" = 1'-0"

NOTES:
1. CONCRETE: AASHTO CLASS D WITH 3" SLUMP.
2. USE FLOAT FINISH ON TOP SURFACES OF SLAB AND WALLS.
3. FOR COORDINATE OF LOCATION POINTS SEE SITE PLAN SHEET CG01.



NOTE:
JOINT AT 10'-0" SPACING WITH ¼" x 2" SAW CUT AND JOINT SEALANT COMPOUND

LOW FLOW CHANNEL DETAIL
SCALE: NTS



SECTION C-CU03
CU03
SCALE: 1/2" = 1'-0"

RIPRAP GRADATIONS

Riprap Designation	% Smaller Than Given Size By Weight	Intermediate Rock Dimension (inches)	Approximate Min-Rock Weight (pounds)	D_{50}* (inches)
Type VL	70-100	12	85	
	50-70	9	36	
	35-50	6	11	6
	2-10	2	0.4	
Type L	70-100	15	166	
	50-70	12	85	
	35-50	9	36	9
	2-10	3	1.3	
Type M	70-100	21	455	
	50-70	18	287	
	35-50	12	85	12
	2-10	4	3	
Type H	100	30	1327	
	50-70	24	680	
	35-50	18	287	18
	2-10	6	11	
Type VH	100	42	3642	
	50-70	33	1767	
	35-50	24	680	24
	2-10	9	36	

*D50 = Means particle size (intermediate dimension) by weight

Mix VL and L rip rap with 30% (by volume) topsoil and bury with 6 inches of topsoil, all vibration compacted, and re-vegetated.

ISSUED FOR PERMITTING
05/31/07

NO.	REVISIONS	DSGN	CHKD	APVD	DATE
A	ISSUED FOR PERMITTING	JLV			05/31/07

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INTERMOUNTAIN RURAL ELECTRIC ASSOCIATION
COLORADO – 16 – JEFFERSON
SEDALIA, COLORADO

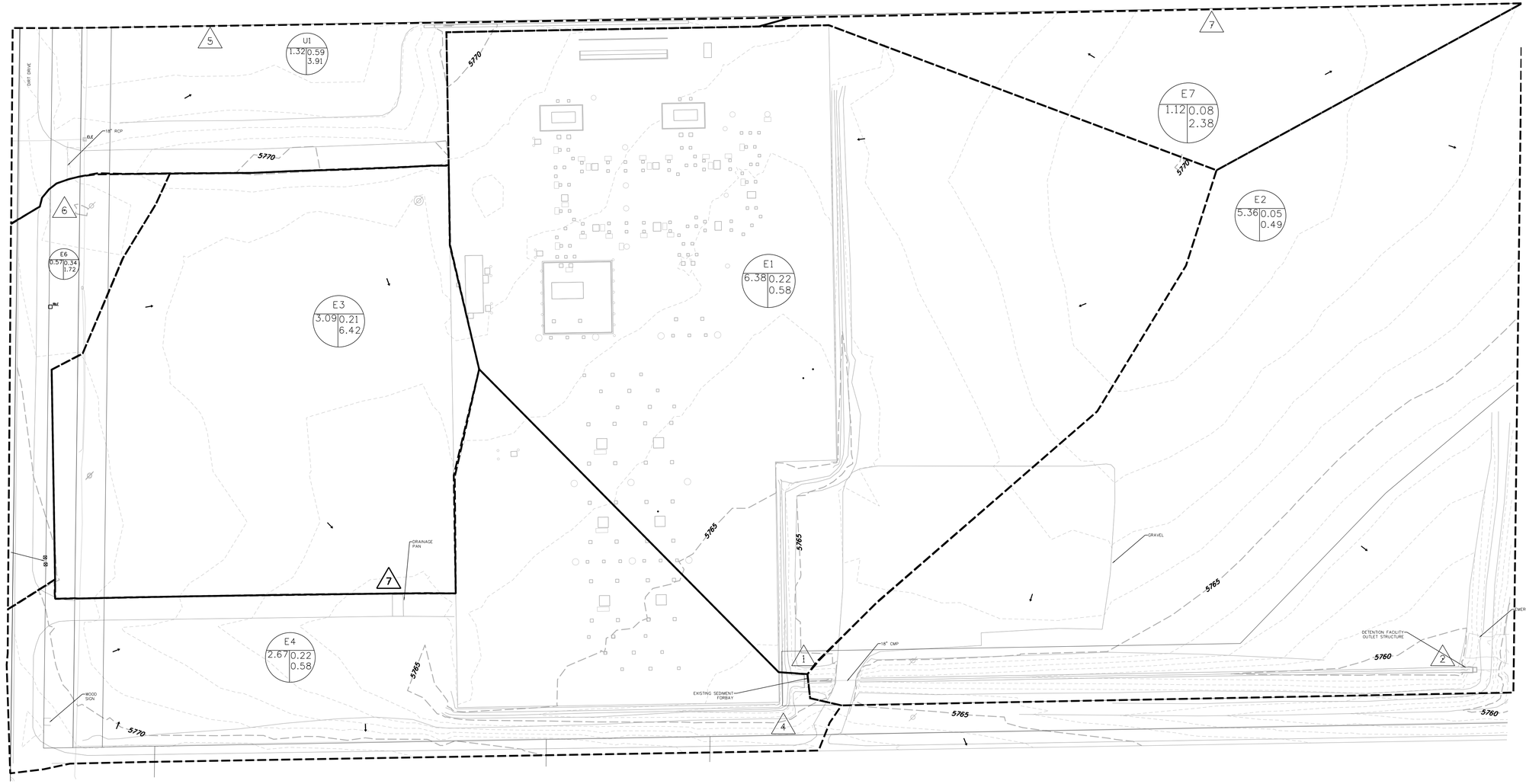
BRICK CENTER TRANSMISSION SUBSTATION (406)
DRAINAGE DETAILS
SHEET 2 OF 2

DESIGNED	N.L. DURAN
DRAWN	G.P. PIEHL
CHECKED	J.L. VARONE
APPROVED	
APPROVED	
DATE	05/31/07

SCALE: AS NOTED
NO. 19907.01.00
REV. A
CU03

CADD D1-R4

Appendix G Construction Drawings

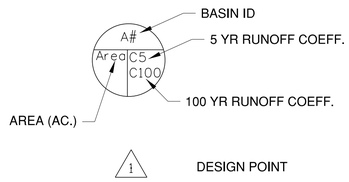


LEGEND

- PR MAJOR CONTOUR
- PR MINOR CONTOUR
- EX MAJOR CONTOUR
- EX MINOR CONTOUR
- PROPERTY LINE
- PR ROADWAY
- EX ROADWAY
- EX FENCE
- DRAINAGE BASIN

SUMMARY RUNOFF TABLE

BASIN ID	AREA (AC)	% IMPERVIOUS	RUNOFF COEFFICIENT 100-yr STORM	PEAK FLOW 100-yr STORM (CFS)	DESIGN POINT
E1	6.38	23.4	0.58	13.17	1
E2	5.36	0.9	0.59	10.63	2
E3	3.09	0	0.48	6.42	3
E4	2.67	22.2	0.57	7.05	4
U1	1.32	18.3	0.56	3.91	5
E6	0.57	27.3	0.60	1.72	6
E7	1.18	0	0.48	2.38	7



NO.	REVISIONS	DSGN	CHKD	APVD	DATE

Stanley Consultants INC.

8000 South Chester Street, Suite 400, Centennial, Colorado 80112-3516
www.stanleyconsultants.com

CANYON PEAK POWER, LLC
CANYON PEAK POWER STATION
ARAPAHOE COUNTY, COLORADO

CIVIL EXISTING DRAINAGE PLAN

DESIGNED K. CLOHERTY
DRAWN K. CLOHERTY
CHECKED W. ESHENAUR
APPROVED --
APPROVED --
DATE 12/20/2024

SCALE: AS NOTED
NO. 31324.07
REV. A
CG120

ARAPAHOE COUNTY CASE NO. XX-XXX

CADD D3-R5

LEGEND

- PR MAJOR CONTOUR
- PR MINOR CONTOUR
- EX MAJOR CONTOUR
- EX MINOR CONTOUR
- PROPERTY LINE
- PR ROADWAY
- EX ROADWAY
- EX FENCE
- DRAINAGE BASIN

SUMMARY RUNOFF TABLE

BASIN ID	AREA (AC)	% IMPERVIOUS	RUNOFF COEFFICENT 100-yr STORM	PEAK FLOW 100-yr STORM (CFS)	DESIGN POINT
U1	1.32	18.3	0.56	3.91	1
A	3.09	0.0	0.48	6.42	2
B	3.20	23.7	0.58	6.67	3
C	3.58	42.9	0.66	10.04	4
E	0.57	27.3	0.60	1.72	9
F	2.24	7.6	0.51	3.83	5
G	0.73	54.8	0.71	2.61	8
I	4.46	0.23	0.61	12.73	6
H	0.62	0.12	0.55	1.73	7
J	1.59	51.4	0.69	5.11	10

BASIN ID
5 YR RUNOFF COEFF.
100 YR RUNOFF COEFF.
AREA (AC.)
DESIGN POINT

U1 1.32 0.59 3.91
A 3.09 0.21 6.42
B 3.20 1.19 6.67
C 3.58 2.67 10.04
E 0.57 0.34 1.72
F 2.24 0.33 3.83
G 0.73 0.81 2.61
H 0.62 0.25 1.73
I 4.46 2.78 12.73
J 1.59 1.53 5.11

18" CMP
12" FES
12" RCP
48" MANHOLE
DRAINAGE EASEMENT
DRAINAGE PAN
BURIED UTILITY BOX
WOOD SIGN
PROPOSED DETENTION POND
OUTLET STRUCTURE
CULVERT 2 RIPRAP
18" RCP
OUTFALL TO EXISTING DITCH
OUTFALL RIPRAP
24" FES
24" RCP
CULVERT 1 RIPRAP
Feature With Name Feature Num

NO.	REVISIONS	DSGN	CHKD	APVD	DATE

Stanley Consultants INC.

8000 South Chester Street, Suite 400, Centennial, Colorado 80112-3516
www.stanleyconsultants.com

CANYON PEAK POWER, LLC
CANYON PEAK POWER STATION
ARAPAHOE COUNTY, COLORADO

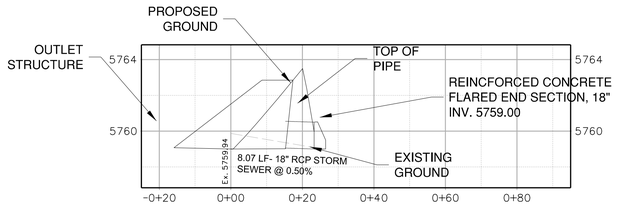
CIVIL PROPOSED DRAINAGE PLAN

DESIGNED	K. CLOHERTY
DRAWN	K. CLOHERTY
CHECKED	W. ESHENAUR
APPROVED	--
APPROVED	--
DATE	12/20/2024

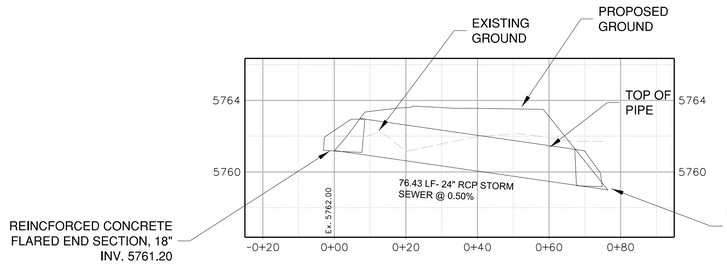
SCALE: AS NOTED
NO. 31324.07
REV. A
CG121

ARAPAHOE COUNTY CASE NO. XX-XXX

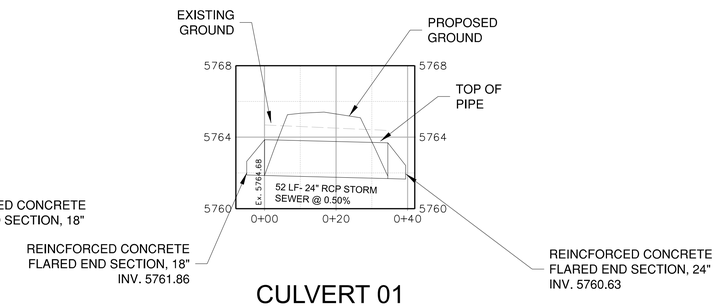
CADD D3-R5



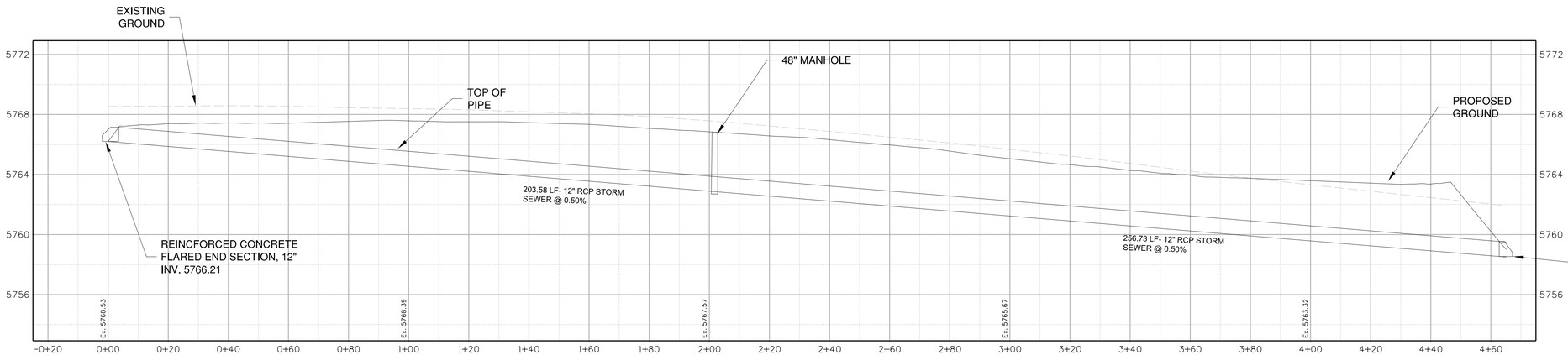
PIPE 02- OUTLET PIPE



Culvert 2



CULVERT 01



PIPE 01

NO.	REVISIONS	DSGN	CHKD	APVD	DATE

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8000 South Chester Street, Suite 400, Centennial, Colorado 80112-3516
www.stanleyconsultants.com

CANYON PEAK POWER, LLC
CANYON PEAK POWER STATION
ARAPAHOE COUNTY, COLORADO

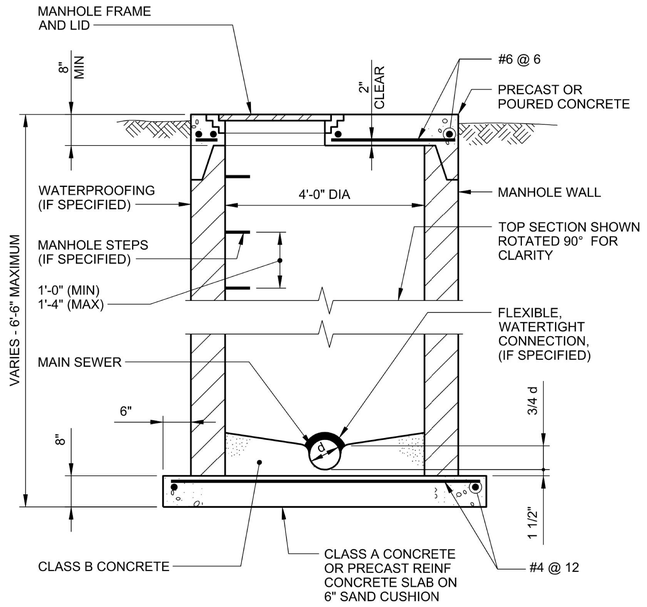
CIVIL STORM SEWER PROFILES

DESIGNED K. CLOHERTY
DRAWN K. CLOHERTY
CHECKED W. ESHENAUR
APPROVED --
APPROVED --
DATE 12/20/2024

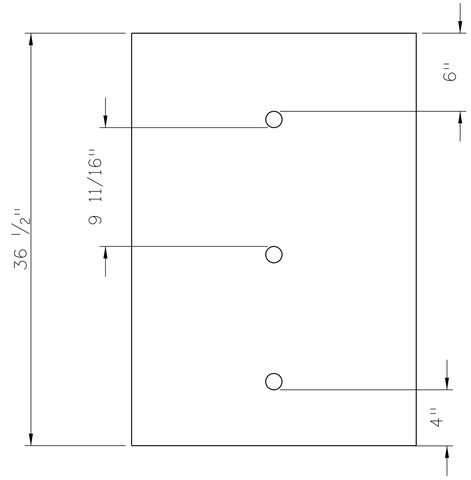
SCALE: AS NOTED
NO. 31324.07
REV. A
CG130

ARAPAHOE COUNTY CASE NO. XX-XXX

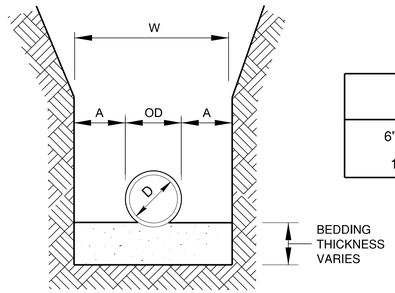
CADD D3-R5



SHALLOW MANHOLE DETAIL



ORIFICE PLATE DETAIL



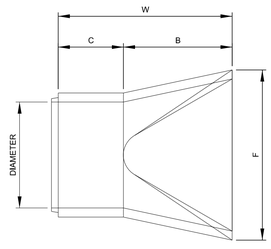
PIPE DIA "D"	MAXIMUM "A"
6" TO 15"	8"
16" TO 21"	10"

MAXIMUM TRENCH WIDTH
"W" TAKEN AT TOP OF PIPE

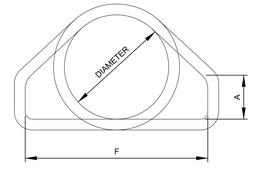
NOTE:
PROVIDE BEDDING IN ACCORDANCE WITH THE SPECIFICATIONS.

TRENCH DETAIL

TYPE 2 APRON						
DIAM.	SLOPE	A	B	MINIMUM C	MINIMUM E	F
12"	2.4:1	4"	2'-0"	4'-2 3/4"	6'-2 7/8"	2'-0"
15"	2.4:1	6"	2'-3"	3'-10"	6'-1"	2'-6"
18"	2.3:1	9"	2'-3"	3'-10"	6'-1"	3'-0"
21"	2.4:1	9"	3'-0"	3'-1 1/2"	6'-1 1/2"	3'-5"
24"	2.5:1	9 1/2"	3'-7 1/2"	2'-6"	6'-1 1/2"	4'-0"

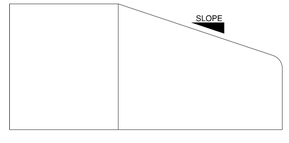


(TYPE 2 APRON) PLAN



(TYPE 2 APRON) END VIEW

GROOVE END DETAIL



SIDE VIEW

CONCRETE FLARED END SECTION DETAIL

NO.	REVISIONS	DSGN	CHKD	APVD	DATE

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ARAPAHOE COUNTY, COLORADO

CIVIL DRAINAGE DETAILS
(1 OF 4)

DESIGNED K. CLOHERTY
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CHECKED W. ESHENAUR
APPROVED --
APPROVED --
DATE 12/20/2024

SCALE: AS NOTED
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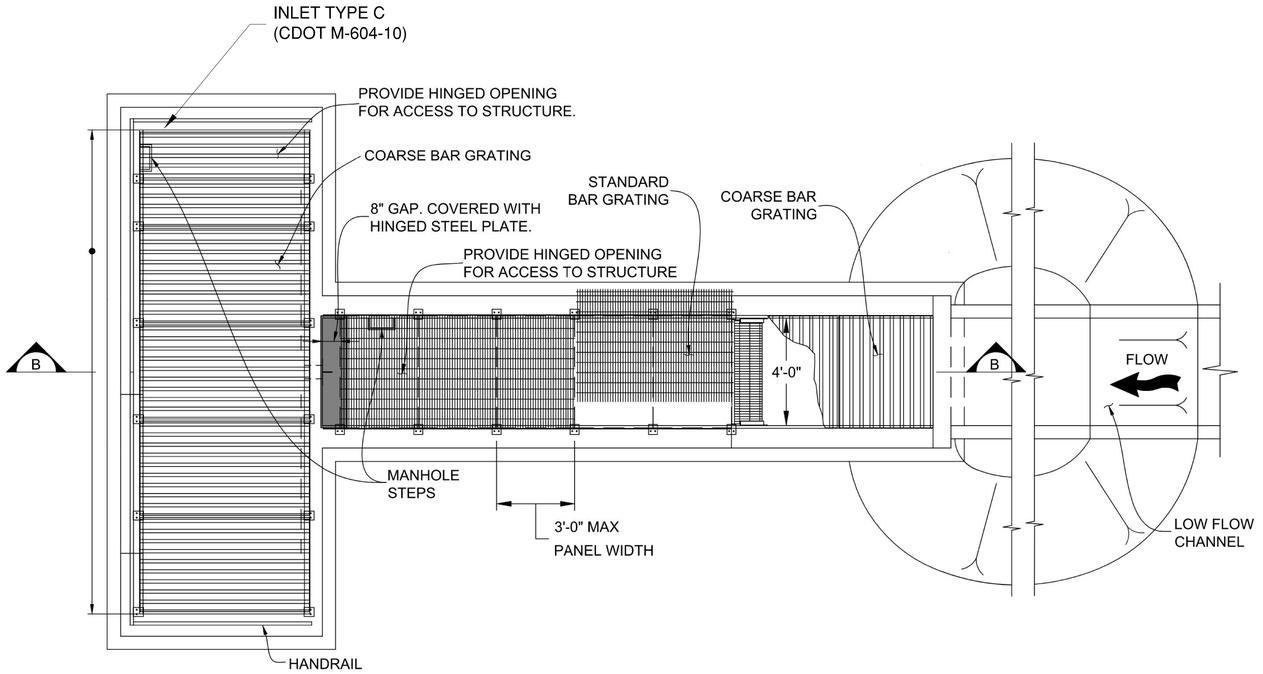
REV. A
CG521

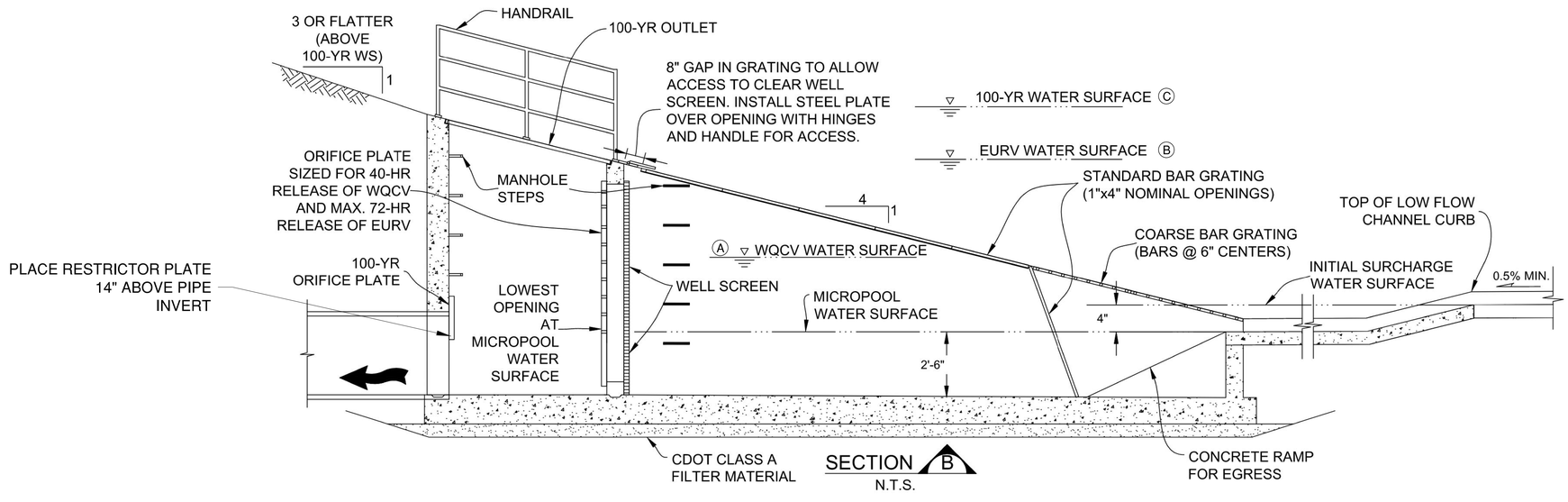
ARAPAHOE COUNTY CASE NO. XX-XXX

CADD D3-R5



Ⓐ 5760.85 FT
Ⓑ 5761.48 FT
Ⓒ 5763.25 FT

OUTLET STRUCTURE PLAN
N.T.S.



N.T.S.

EDB OUTLET STRUCTURE
N.T.S.

ARAPAHOE COUNTY CASE NO. XX-XXX

NO.	REVISIONS	DSGN	CHKD	APVD	DATE

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ARAPAHOE COUNTY, COLORADO

CIVIL DRAINAGE DETAILS (2 OF 4)

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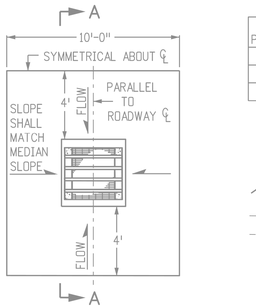
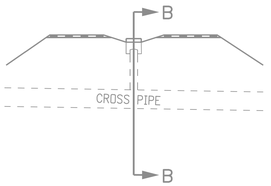


INLET WITH DITCH PAVING

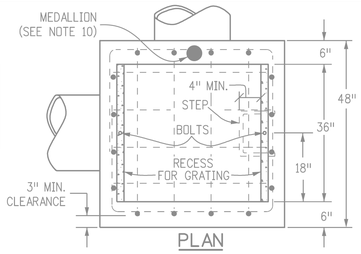
STEEL GRATE QUANTITIES

NO. PIECES	DESCRIPTION	LENGTH	LBS PER FT.	WEIGHT (LBS.)
4	S4 x 7.7 BEAM	41"	7.90	106
2	3½" x ¼" FLAT	26⅝"	2.98	13
2	3" x ¼" FLAT	26⅝"	2.55	12

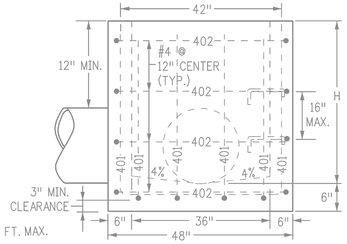
TOTAL LBS. - 131



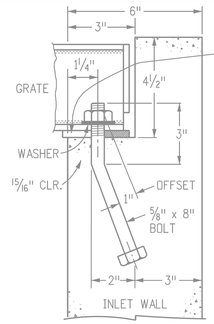
SECTION VIEW



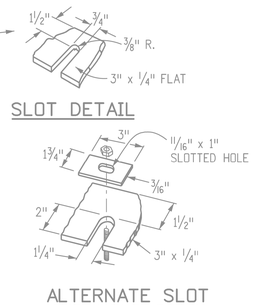
PLAN



ELEVATION
CONCRETE INLET



GRATE INSTALLATION DETAIL



ALTERNATE SLOT AND HOLD DOWN PLATE DETAIL

QUANTITIES FOR ONE INLET

H	CONCRETE (CU. YDS.)	STEEL (LBS.)	NO. STEPS REQ'D.
2'-6"	1.0	76	0
3'-0"	1.1	81	0
3'-6"	1.2	97	0
4'-0"	1.3	102	1
4'-6"	1.5	117	2
5'-0"	1.6	123	2
5'-6"	1.7	138	2
6'-0"	1.9	143	3
6'-6"	2.0	159	3
7'-0"	2.1	164	3
7'-6"	2.2	180	4
8'-0"	2.4	185	4
8'-6"	2.5	200	4
9'-0"	2.6	206	5
9'-6"	2.8	221	5
10'-0"	2.9	236	6
11'-6"	3.3	252	6

▼ PIPE INSIDE DIAMETER SHALL BE 30 IN. OR LESS. CONCRETE AND STEEL QUANTITIES ARE FOR ONE ENTIRE INLET BEFORE DEDUCTION FOR VOLUME OCCUPIED BY PIPE. WEIGHT OF STEEL INCLUDES A RING FOR THE MAXIMUM PIPE DIAMETER.

GENERAL NOTES

1. INLET TYPE C IS NOT HS-20 RATED AND SHALL NOT BE PLACED IN PAVED ROADWAYS. THIS INLET SHALL BE USED ONLY OUTSIDE PAVED ROADWAYS.
2. CONCRETE SHALL BE CLASS B. INLET MAY BE CAST-IN-PLACE OR PRECAST.
3. REINFORCING BARS SHALL BE GRADE 60, EPOXY COATED, AND DEFORMED #4, AND SHALL HAVE A MIN. 2 INCH CLEARANCE. CUT OR BEND AROUND PIPES AS REQUIRED.
4. CONCRETE SLOPE AND DITCH PAVING SHALL BE IN ACCORDANCE WITH SECTION 507. REINFORCEMENT FOR CONCRETE SLOPE PAVING SHALL BE 6 X 6 - W1.4 X W1.4 OR 6 X 6 - W2.1 X W2.1.
5. STRUCTURAL STEEL FOR GRATES AND GRATE INSTALLATION HARDWARE SHALL BE GALVANIZED, AND SHALL BE IN ACCORDANCE WITH SUBSECTION 712.06.
6. THE STANDARD INLET GRATES SHALL BE USED ON ALL TYPE C INLETS UNLESS CLOSE MESH INLET GRATES ARE SPECIFIED ON THE PLANS.
7. CLOSE MESH GRATES ARE RECOMMENDED WHERE FOOT TRAFFIC OR BICYCLE ROUTES ARE IN CLOSE PROXIMITY TO GRATE. THIS GRATE IS NOT ADA COMPLIANT OR BICYCLE FRIENDLY AND SHALL NOT BE PLACED DIRECTLY IN SIDEWALKS, CROSSWALKS OR BIKE PATHS.
8. STEPS SHALL BE PROVIDED WHEN INLET DIMENSION "H" IS EQUAL TO OR GREATER THAN 3 FEET - 6 INCHES AND SHALL CONFORM TO AASHTO M 199.
9. SEE STANDARD PLAN M-604-11, FOR REINFORCEMENT AROUND THE PIPE OPENING.
10. ALL INLETS SHALL HAVE A 4 INCH DIA. METAL MEDALLION WITH A "NO DUMPING DRAINS TO STREAM" MESSAGE ON IT. THE MEDALLION SHALL HAVE A FISH SYMBOL WITH A BLUE BACKGROUND. IT SHALL BE FIRMLY ATTACHED TO THE TOP OF THE INLET WITH A PERMANENT FASTENER.
11. SEE PLANS FOR SIZE AND LOCATION OF PIPE.

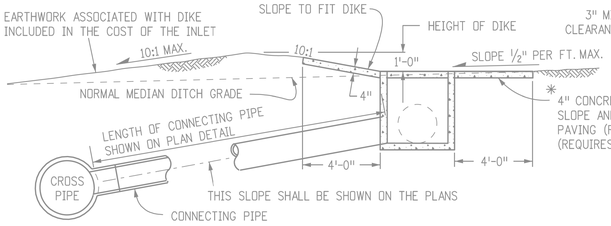
BAR LIST FOR H = 2 FT.-6 IN. AND BENDING DIAGRAM

MARK	NO. REQ'D.	HEIGHT	LENGTH
401	2	2'-2½"	8'-0"
401	6	2'-7"	8'-8"
402	4	"U"	15'-4"

"U" INCREASE DIMENSION 6 IN. FOR EACH 6 IN. INCREASE OF "H" ABOVE 2 FT.-6 IN.

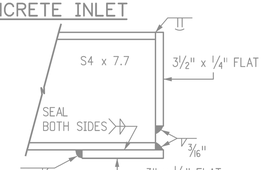
ADD ONE BAR FOR EACH FT. INCREASE OF "H" ABOVE 2 FT. - 6 IN.

402 BARS SHALL BE EQUALLY SPACED FROM EACH OTHER.

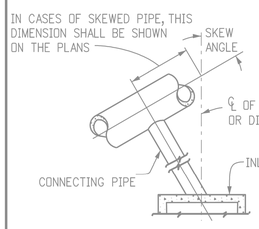


SECTION B-B
INLET CONNECTED TO A CROSS PIPE

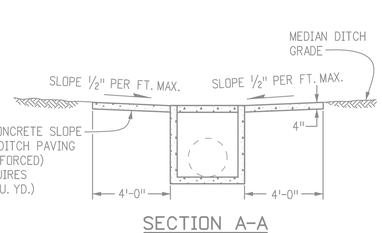
SECTION A-A
INLET ON GRADE (FLOW FROM ONE DIRECTION)



SECTION D-D



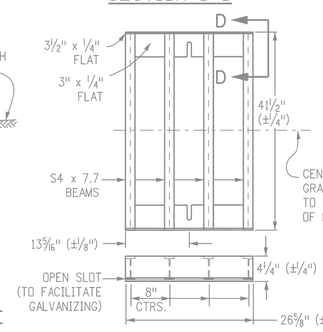
INLET CONNECTED TO A SKEWED CROSS PIPE



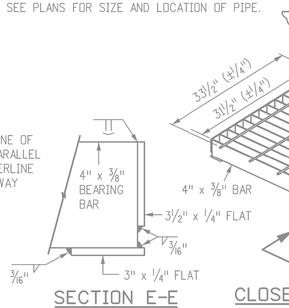
SECTION A-A

*CONCRETE SLOPE AND DITCH PAVING WILL BE REQUIRED WHEN SHOWN ON THE PLANS.

INLET AT BOTTOM OF VERTICAL CURVE (FLOW FROM TWO DIRECTIONS)



STANDARD INLET GRATE



SECTION E-E

CLOSE MESH INLET GRATE

SLOT DETAIL IN 3½" x ¼" FLATS SAME AS IN STANDARD INLET GRATE

NO.	REVISIONS	DSGN	CHKD	APVD	DATE

Computer File Information		Sheet Revisions	
Creation Date: 07/31/19		Date:	Comments
Designer Initials: JBK	(R-X)		
Last Modification Date: 07/31/19	(R-X)		
Detailer Initials: LTA	(R-X)		
CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English	(R-X)		

Colorado Department of Transportation
2829 West Howard Place
CDOT HQ, 3rd Floor
Denver, CO 80204
Phone: 303-757-9021 FAX: 303-757-9868
Project Development Branch JBK

INLET, TYPE C

Issued by the Project Development Branch: July 31, 2019

STANDARD PLAN NO.
M-604-10
Standard Sheet No. 1 of 1
Project Sheet Number:

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CIVIL DRAINAGE DETAILS
(3 OF 4)

DESIGNED	K. CLOHERTY
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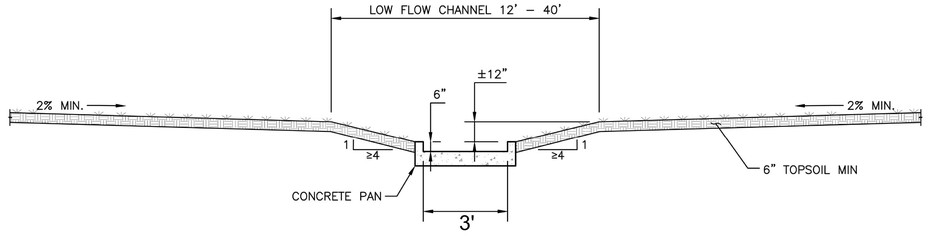
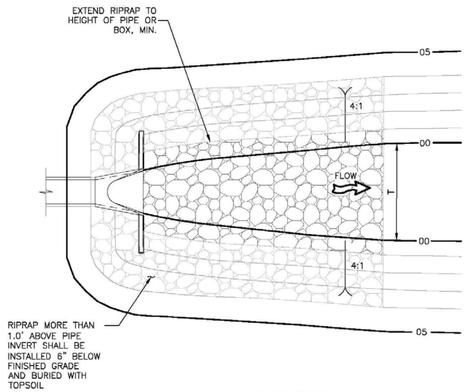
CADD D3-R5

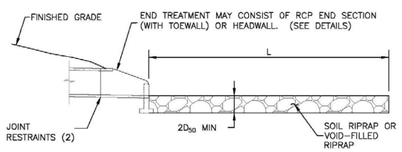


LOW FLOW CHANNEL WITH CONCRETE PAN

LOW FLOW CHANNEL DETAIL

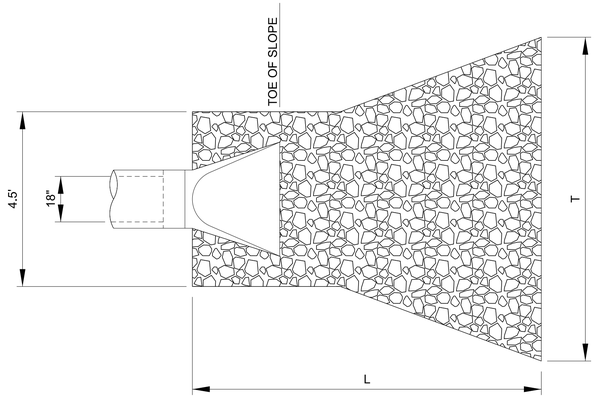


PLAN VIEW
NTS

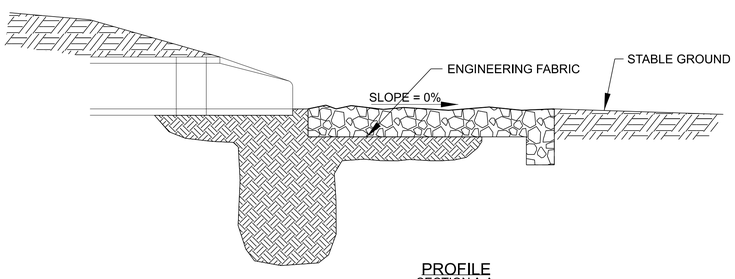


PROFILE
NTS

CHANNEL RIPRAP DETAIL



PLAN



PROFILE
SECTION A-A

RIPRAP TO FLAT GROUND DETAIL

PIPE NAME	DIAM.	T	L
CULVERT 1	24"	2.2'	4.5'
CULVERT 2	24"	2.4'	4.5'
OUTLET	18"	2.2'	4.5'

NOTE: ALL RIPRAP TO BE OF CLASS L

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