From:	dane@tnesinc.com
Sent:	Monday, August 13, 2018 3:54 PM
To:	Marc Whorton
Cc:	'Luanne Ducett'
Subject:	Timberridge Estates - Revised Drainage Report and Comment Responses
Attachments:	173300 FDR.pdf

Marc,

Regarding the Timberridge Estates, attached is the revised drainage report. A fair number of revisions were made, and a number of the County's comments are best addressed with written responses (see below).

Comment Responses

C: On the 3-6'x12' box culverts calc sheet, there is a comments saying to address the freeboard requirements and a comment saying to use a FEMA flow rate.
R: The freeboard requirement has been addressed in the Hydraulic Calculations section of the text. On the FEMA flow rate, I updated the calculations and text to use the flow rate of 2,607 cfs (this change didn't require design changes to the culverts).

C: On the detention basin outlet structure design calc sheet, there is a comment saying high velocity = potential safety issue.
R: The discharge pipe on the outlet structure has an orifice control plate with an area ~ 30% of this inlet grate. The discharge velocity won't be as high as the values in this table.

C: On the proposed drainage plan, there is a comment saying label type and dimension of outfall stabilization.
R: See the extended detention basin detail in the top left corner of the sheet.

C: On the proposed drainage plan, this is a question of these are identified as no build areas, why are you disturbing these drainage ways?
R: The existing drainage channels flatten out in a number of places, which resulted in very wide drainage easements. The developer directed us to grade some of the existing channels so the easements weren't covering large portions of several of the lots.

C: On the proposed drainage plan, there is a comment saying stabilized spillway outfall needs to be entirely within the property.
R: This isn't possible since the drainage channel the spillway discharges into is mostly in the public ROW. I've added erosion protection to that section of the channel, but no matter where the spillway goes, it has to discharge water to the channel in the ROW.

C: On the proposed drainage plan, there is a comment saying PR Asphalt (after Arroya Lane, EX dirt road).
R: Paving Arroya Lane is not part of the Timberridge Estates development. Last I heard, Arroya Lane wasn't getting paved until phase 3 of the Retreat at TimberRidge, while Timberridge Estates is phase 1.

Please contact me if you have any questions.

Thank you,

Dane Frank
Project Engineer
Terra Nova Engineering, Inc.
dane@tnesinc.com
719.635.6422

PRELIMINARY/FINAL DRAINAGE REPORT
FOR
TIMBERRIDGE ESTATES, PRELIMINARY PLAN
PART OF THE RETREAT AT TIMBERRIDGE
(NORTH OF ARROYA LANE)

August 2018

Prepared For:
TIMBERRIDGE ESTATES, LLC
2760 Brogans Bluff Dr.
Colorado Springs, CO 80919

Prepared By:

TERRA NOVA ENGINEERING, INC.
721 S. 23RD STREET
Colorado Springs, CO 80904
(719) 635-6422

TNE Job No. 1733.00
County Job No. SP-18-002

PRELIMINARY/FINAL DRAINAGE REPORT
FOR
TIMBERRIDGE ESTATES, PRELIMINARY PLAN
PART OF THE RETREAT AT TIMBERRIDGE
(NORTH OF ARROYA LANE)

TABLE OF CONTENTS

REQUIRED MAPS AND DRAWINGS

VICINITY MAP

S.C.S. SOILS MAP

FEMA FIRM MAP

HYDROLOGIC CALCULATIONS

HYDRAULIC CALCULATIONS

DETENTION CALCULATIONS

DRAINAGE PLAN

CERTIFICATION STATEMENT:

Engineers Statement

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

____

L DUCETT, P.E. 32339 Seal

Developers Statements

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

TIMBERRIDGE ESTATES, LLC.
Business Name

By:____
Title:____
Address:____
____

El Paso County Approval:

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

____ ________________________

Jennifer Irvine, Date
County Engineer / ECM Administrator

Conditions:

PRELIMINARY/FINAL DRAINAGE REPORT
FOR
TIMBERRIDGE ESTATES, PRELIMINARY PLAN
PART OF THE RETREAT AT TIMBERRIDGE
(NORTH OF ARROYA LANE)

PURPOSE

The purpose of this Preliminary Drainage Report is to identify and analyze the proposed drainage patterns, determine proposed runoff quantities, size drainage structures for conveyance of developed runoff, and present solutions to drainage impacts on-site and off-site resulting from this development.

GENERAL DESCRIPTION

This Preliminary Drainage Report (PDR) is an analysis of approximately 35.30 acres of undeveloped land located in the northern part of El Paso County off of Volmer Road and Arroya Lane. This site is being developed by our client to include 10 single family lots consisting of 2.5 acre lots. The site is located in the south west quarter of Section 22, Township 12 South, Range 65 West of the 6th Principal Meridian currently within El Paso County, Colorado. The site is bounded to the north, and west by open space (rural residential), to the east by Vantage Point farm (rural residential) and to the south by Arroya Lane. The site is contained within the Sand Creek Basin.

Soils for this project are delineated by the map in the appendix as Kettle gravelly loamy sand (40), 3 to 8 percent slopes, Kettle gravelly loamy sand (41), 8 to 40 percent slopes and Pring Coarse sandy loam (71), 3 to 8 percent slopes. Soils in the study area are shown as mapped by S.C.S. in the “Soils Survey of El Paso County Area” and contains soils of Hydrologic Group B.

FLOODPLAIN STATEMENT

No portion of this site is within a designated F.E.M.A. floodplain, as determined by Flood Insurance Rate Map No. 08041C0535 F, dated March 17, 1997 (see appendix).

EXISTING DRAINAGE CONDITIONS

The site is currently undeveloped and is open space. The site consists mostly of natural vegetative grass and weeds, with some areas of trees. The site has been broken down into five existing basins, one onsite basin and four offsite basins tributary to the site. Below is a description of these basins.

Basin OS-4A's 2.98 acres is an offsite basin located along the eastern boundary consisting of undeveloped open space. This basin is part of a parcel currently in use as a residential property, with the basin area being largely in a natural state. Runoff (Q_5=0.9 cfs and Q_{100}=6.5 cfs) sheet flows onto the southern half of the site (Design Point OS-1) and then is transported west across the site in existing channels to Design Point EX-1.

Basin OS-4B's 7.76 acres is an offsite basin located along the eastern boundary. This basin is part of a parcel currently in use as a residential property, with the basin area being largely in a natural state. Runoff (Q_5=1.8 cfs and Q_{100}=12.7 cfs) sheet flows to the southeast corner of the site, before flowing across Arroya Lane to the south (Design Point OS-2). Some of the flow at Design Point OS-2 may flow west along Arroya Lane for a short distance (less than 150 feet) before flowing across Arroya Lane to the south.

Basin OS-4C's 8.17 acres is an offsite basin located along the northern boundary consisting of undeveloped open space. This basin is part of two parcels currently in use as residential properties, with the basin area being largely in a natural state. Runoff (Q_5=1.6 cfs and Q_{100}=11.4 cfs) sheet flows onto the northern half of the site (Design Point OS-3) and then is transported southwest across the site in existing channels to Design Point EX-1.

Basin OS-4D's 3.39 acres is an offsite basin located along the northern boundary consisting of undeveloped open space. This basin is part of a parcel currently in use as a residential property, with the basin area being largely in a natural state. Runoff (Q_5=0.7 cfs and Q_{100}=5.4 cfs) sheet flows onto the northern half of the site (Design Point OS-4) and then is transported southwest across the site in existing channels to Design Point EX-1.

Basin EX-E1's 35.30 acres consists of undeveloped open space. Runoff (Q_5=6.5 cfs and Q_{100}=46.1 cfs) sheet flows to existing onsite drainage channels and then is routed southwest across the site in an existing channel to Design Point EX-1. At Design Point EX-1 the combined flow Q_5=11.5 cfs and Q_{100}=82.1 cfs of all four existing basins is routed south under Arroya Lane via an existing 60" CMP culvert.

PROPOSED DRAINAGE CONDITIONS

Runoff in the developed conditions consists of 16 basins, 10 onsite basins (including along Arroya Lane) and six offsite basins. Below is a description of the runoff in the developed conditions and how it will be safely routed, treated and detained. See appendix for calculations.

As in the existing condition Runoff (Q_5=1.6 cfs and Q_{100}=11.2 cfs) from Basin OS-1's 7.76 acres sheet flows to the southeast corner of the site before flowing across Arroya Lane to the south (Design Point OS-1). No modifications to the drainage of this basin are proposed as part of this development. Modifications to this basin can be expected when Arroya Lane is upgraded to a paved road (not a part of this development). Possible modifications to Arroya Lane include the installation of a culvert crossing to prevent overtopping at Design Point OS-1. Installation of a culvert at this location is not expected to affect the site (would be offsite) and would likely be entirely in the right of way of Arroya Lane.

Runoff (Q_5=0.9 cfs and Q_{100}=7.0 cfs) from Basin OS-2's 2.98 acres sheet and channel flows onto the eastern edge of the site and onto Basin A's 12.38 acres. Basin A will be comprised of large lot development. Runoff (Q_5=3.9 cfs and Q_{100}=21.4 cfs) sheet flow to existing channels. The combined flow (Q_5=4.8 cfs and Q_{100}=28.4 cfs) is routed west across the site via existing channels and proposed ditch sections to a low point (Design Point 1). Dual 24" RCP culverts will route the flow under the new Nature Refuge Way road section and onto Basin C.

Runoff (Q_5=1.8 cfs and Q_{100}=12.9 cfs) from Basin OS-3's 8.17 acres sheet flows onto the northern half of the site and onto Basin C's 15.36 acres. Basin C will also be comprised of large lot development. Runoff (Q_5=4.8 cfs and Q_{100}=24.7 cfs) sheet flow to existing channels. The

and natural
channel/swale

and natural
channel/swale

combined flow is routed southwest across the site via existing channels and proposed ditch sections to a proposed Full Spectrum Extended Detention Basin (Design Point 3).

Runoff (Q_5=0.8 cfs and Q_{100}= 6.1cfs) from Basin OS-4's 3.39 acres sheet flows onto the northern half of the site and onto Basin C's 15.36 acres. Basin C will also be comprised of large lot development. Runoff (Q_5=4.8 cfs and Q_{100}=24.7 cfs) sheet flow to existing channels. The combined flow is routed southwest across the site via existing channels and proposed ditch sections to a proposed Full Spectrum Extended Detention Basin (Design Point 3).

Runoff (Q_5=0.7 cfs and Q_{100}=4.8 cfs) from Basin OS-5's 3.19 acres sheet and channel flows south onto Basin E before entering Sand Creek at Design Point 5. This basin is part of a parcel currently in use as a residential property, with the basin area being largely in a natural state.

Runoff (Q_5=1.2 cfs and Q_{100}=8.8 cfs) from Basin OS-6's 4.89 acres sheet and channel flows southeast onto Basin G before entering Sand Creek at Design Point 6. This basin is part of several parcels currently in use as a residential property or are undeveloped, with the basin area being largely in a natural state.

Basin A (12.38 acres) includes most of the eastern and southern portions of the site and is proposed for large residential lot development. Runoff (Q_5=3.9 cfs and Q_{100}=21.4 cfs) sheet and channels flows to a low point at the western side of the basin at Design Point 1. Dual 24" RCP culverts will route the flow under the new Nature Refuge Way road section and onto Basin C.

Basin A1 (1.83 acres) is an area consisting of the south and east side of the new Nature Refuge Way road and a small area off the road. Runoff (Q_5=2.7 cfs and Q_{100}=6.8 cfs) sheet and channels flows to a low point near the middle of the basin at Design Point 1. Dual 24" RCP culverts will route the flow under the new Nature Refuge Way road section and onto Basin C.

Basin B (1.66 acres) is an area consisting of the north and west side of the new Nature Refuge Way road and a small area off the road. Runoff (Q_5=2.1 cfs and Q_{100}=5.2 cfs) sheet and channels flows to a low point at the western side of the basin at Design Point 2, where it flows onto Basin C.

Basin C (15.36 acres) includes most of the western and northern portions of the site and is proposed for large residential lot development and the proposed Full Spectrum Extended Detention Basin. Runoff (Q_5=4.8 cfs and Q_{100}=24.7 cfs) sheet and channels flows to the detention basin in the southwest corner of the basin at Design Point 1. Outflow from the detention basin flows onto Basin E before flowing into Sand Creek.

Basin D (2.60 acres) is an area consisting of the north side of part of the existing Arroya Lane road and a small area north of the road. Runoff (Q_5=1.1 cfs and Q_{100}=4.7 cfs) sheet and channels flows to the west, where it crosses the new Nature Refuge Way road in a culvert and flows onto Basin E.

proposed 24-inch RCP

Basin E (1.04 acres) is an area consisting of the north side of part of the existing Arroya Lane road. Runoff (Q_5=1.8 cfs and Q_{100}=4.7 cfs) primarily channel flows to the west, where it enters Sand Creek at Design Point 5. Flows also enter Basin E from Basin D, the detention basin outfall, Basin F, and Basin OS-4 on their path to Sand Creek.

address WQCV for this area

Basin F (0.72 acres) is an area on the western edge of the site that includes some area in large residential lot development and some area around the detention basin. Runoff (Q_5=0.2 cfs and Q_{100}=1.7 cfs) sheet flows to the southwest and onto Basin E.

Basin G (1.16 acres) is an area consisting of the north side of part of the existing Arroya Lane road. Runoff (Q_5=2.0 cfs and Q_{100}=5.1 cfs) primarily channel flows to the east, where it enters Sand Creek at Design Point 6.

address WQCV for this area

Basin H (1.38 acres) is an area consisting of the south side of part of the existing Arroya Lane road. Runoff (Q_5=1.8 cfs and Q_{100}=4.7 cfs) primarily channel flows to the west, where it enters Sand Creek at Design Point 8.

address WQCV for this area

state whether this includes asphalt paving or not

Basin I (1.27 acres) is an area consisting of the south side of part of the existing Arroya Lane road. Runoff (Q_5=2.2 cfs and Q_{100}=5.6 cfs) primarily channel flows to the east, where it enters Sand Creek at Design Point 7.

address WQCV for this area

At Design Point 3 the combined flow (Q_5=17.0 cfs and Q_{100}=84.1 cfs) of Basins OS-2, OS-3, OS-4, A, A1, B, and C will be captured in a 1.359 acre-foot Extended Detention Basin. Runoff will be routed in the natural channel into a 192 cu-ft concrete lined forbay with a 1.6 feet high concrete cutoff wall. A 6 inch notch in the wall drains the flow to a 2' concrete trickle channel then the runoff is routed to the 2.5' deep micropool which has a 0.001 ac-ft Initial Surcharge Volume. The 46.70 acres tributary to the EDB are 5.63% impervious. Based upon this we need a WQCV of 0.158 ac-ft, an ERUV volume of 0.080 ac-ft and 100-year volume of 1.100 ac-ft for a total volume needed of 1339 ac-ft. The micropool elevation is at 7247.00 while the ISV elevation is at 7247.33. The WQCV orifice starts at 7247 with 3 1-inch diameter holes spaced 7.76 inches apart. A 4'x4' outlet structure is set at 7248.94, which corresponds to the EURV elevation. The 100-year elevation tops out at 7251.96. A 30" RCP outlet will release Q_5=0.1 cfs and Q_{100}=50.1 cfs discharge southwest to a riprap pad and then be routed to Design Point 5. The combined runoff at Design Point 5 is Q_5=21.9 cfs and Q_{100}=98.0. In "The Retreat at Timberridge Master Development Drainage Plan" it is proposed that three 6'x12' concrete box culvers will be installed to replace the existing 60' RCP.

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

1. Reduce Runoff- Runoff at the site will be collected in natural and grass swales before being directed into Sand Creek. The low Impervious area of the site and the use of pervious swales directly reduces runoff at the site. Additionally, the new improvements and impervious areas on the site will be routed to a proposed private Extended Detention Basin. These items will reduce the volume of runoff using ponding and infiltration.
2. Stabilize Drainageways- All of the proposed drainage channels are either existing natural channels or are grass swales. Additionally, the outflow of the Extended Detention Basin will be protected by riprap in the receiving channel. All of the proposed drainage channels that discharge into Sand Creek are grass swales.

3. Provide Water Quality Capture Volume (WQCV)- The Extended Detention Basin has been sized and designed to sufficiently capture the required WQCV and slowly release it though the three hole outlet, thereby allowing solids and contaminants to settle out.
4. Consider Need for Industrial and Commercial BMPs- As this is a residential development, industrial and commercial BMPs do not apply.

HYDROLOGIC CALCULATIONS

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

HYDRAULIC CALCULATIONS

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

A number of existing drainage channels are on the site, and a number of proposed drainage channels have been added along the roads. Proposed drainage easements for the existing drainage channels and cross sections of the proposed channels are shown on the Drainage Maps (see appendix). Channel flow calculations have been included for both the existing and proposed drainage channels.

Culverts are proposed at the crossing of Sand Creek, for the detention basin outfall, at the intersection of Arroya Lane and Nature Refuge Way, and at a low point on Nature Refuge Way. Culver design calculations have been included for the proposed drainage channels.

Box Culvert Bridge at Arroya Lane Crossing Sand Creek

The three 6'x12' box culverts at the Arroya Lane crossing of Sand Creek are classified as a bridge. These culverts have been design to flow at 66.3% capacity during a 100 year storm event, which results in an internal freeboard of 2.0 feet.

Proposed

is proposed

MAINTENANCE

The Extended Detention Basin and the storm drain systems are private and therefore must be maintained by the owner (TimberRidge Estates Home Owners Association). These should be cleaned and checked after any significant precipitation event and at least once every three months. The proposed erosion control measures will be repaired and maintained by the property owner or owner's representative as required.

Access to the Extended Detention Basin will be from Arroya Lane. Access to the proposed drainage easements will be from Nature Refuge Way and/or from Arroya Lane via the Extended Detention Basin.

further details will be required with the final drainage report and construction plans.

CONSTRUCTION COST OPINION

Public Reimbursable

1. 12'x6' Box Culverts	306 LF	$ 820	$ 250,920
			Total $ 250,920

Add a note describing the DBPS facilities and design storm.

Private Non Reimbursable

1. 24" RCP	180 LF	$ 50	$ 9,000
2. EDB	1 EA	$ 20,000	$ 20,000
			Total $ 20,900

DRAINAGE FEES

The existing site is in the Sand Creek Basin. 2018 Drainage fees due prior to final plat recordation are as follows:

FEE TYPE	% IMP.	PARCEL AREA	MOD.	FEE PER IMP. AC.	SUBTOTAL
DRAINAGE FEES:	11% x	35.3 acres x	75% x	$17,197 =	$50,082
BRIDGE FEES:	11% x	35.3 acres x	100% x	$ 5,210 =	$20,230
					TOTAL $70,312

SUMMARY

Development of this site will not adversely affect the surrounding development. Proposed flows, as detailed in this report, will follow the drainage patterns outlined in this report showing how runoff will be safely routed downstream. The Extended Detention Basin will control flow to historic levels and provide water quality for this site. These water features will need to be periodically maintained by the owner in order to maintain their effectiveness in cleaning the discharge form the site.

PREPARED BY:
TERRA NOVA ENGINEERING, INC.

L Ducett, P.E.
President
Jobs1733.00/drainage/drng report 1733fdr.doc

REFERENCE

"MDDP for the Retreat at TimberRidge" by Classic Consulting Engineers & Surveyors dated 2/22/18

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

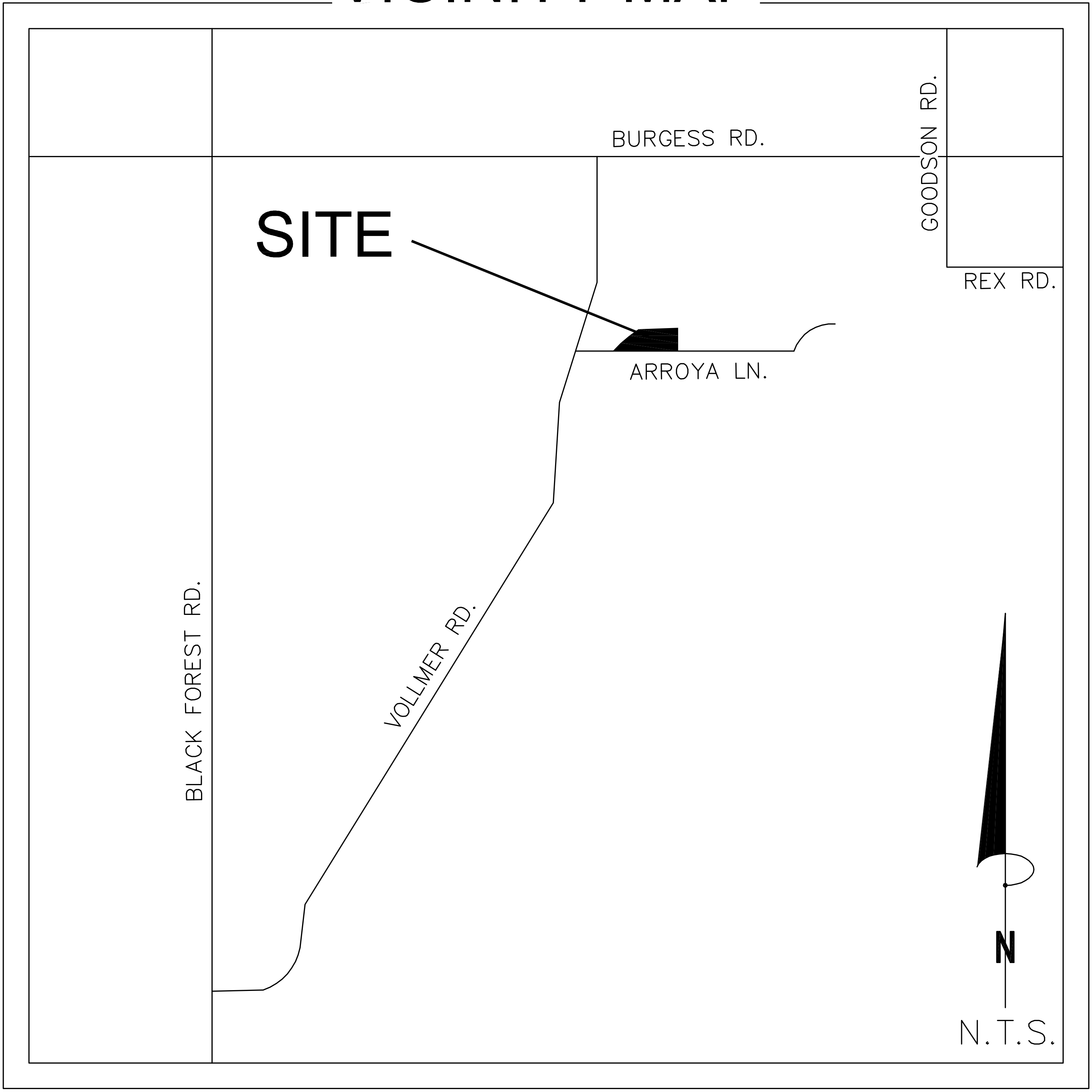
El Paso County Board Resolution No 15-042 (Adoption of Chapter 6 and Section 3.2.1 Chapter 13 of the City of Colorado Springs Drainage Criteria Manual dated May 2014, Hydrology and Full Spectrum Detention)

SCS Soils Map for El Paso County

Federal Emergency Management Agency (FEMA) flood maps

VICINITY MAP

VICINITY MAP



S.C.S. SOILS MAP

USDA United States Department of Agriculture Natural Resources Conservation Service

Web Soil Survey

Contact Us | Subscribe | Archived Soil Surveys | Soil Survey Status | Glossary | Preferences | Link | Logout | Help

Area of Interest (AOI) | **Soil Map** | Soil Data Explorer | Download Soils Data | Shopping Cart (Free)

Printable Version **Add to Shopping Cart**

Search

Map Unit Legend

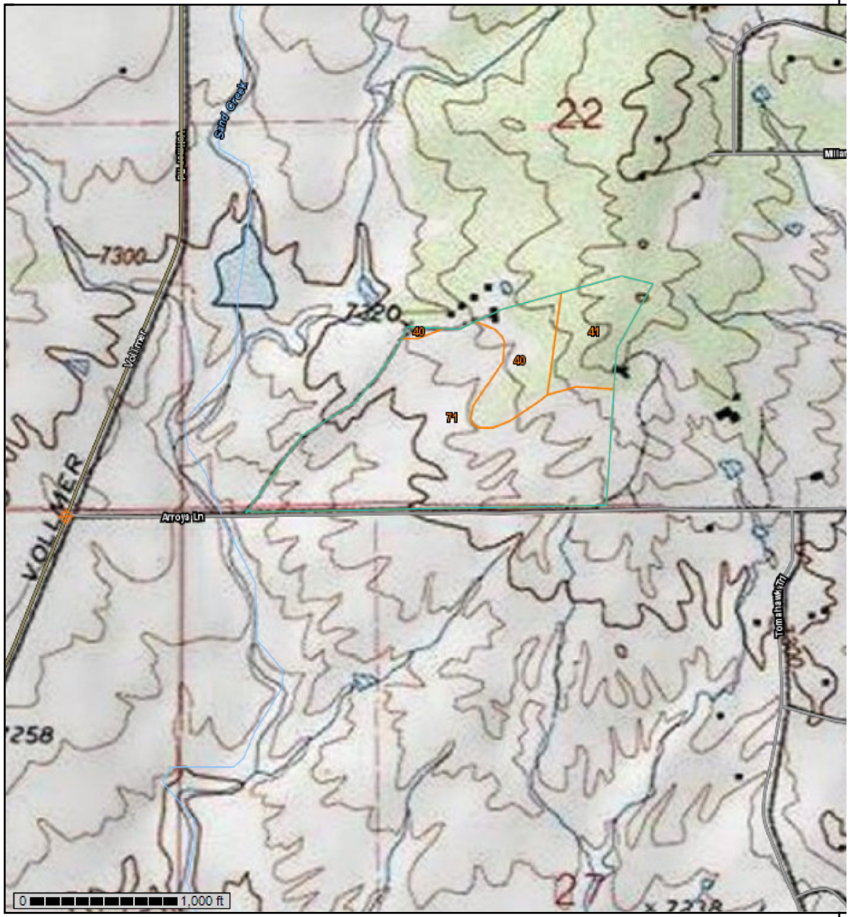
El Paso County Area, Colorado (CO625)

El Paso County Area, Colorado (CO625)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
40	Kettle gravelly loamy sand, 3 to 8 percent slopes	7.9	13.1%
41	Kettle gravelly loamy sand, 8 to 40 percent slopes	8.2	13.6%
71	Pring coarse sandy loam, 3 to 8 percent slopes	44.2	73.3%
Totals for Area of Interest		**60.2**	**100.0%**

Soil Map

Scale (not to scale)



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

You have zoomed in beyond the scale at which the soil map for this area is intended to be used. Mappi AOI were mapped at 1:24,000. The design of map units and the level of detail shown in the resulting

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapp of contrasting soils that could have been shown at a more detailed scale.

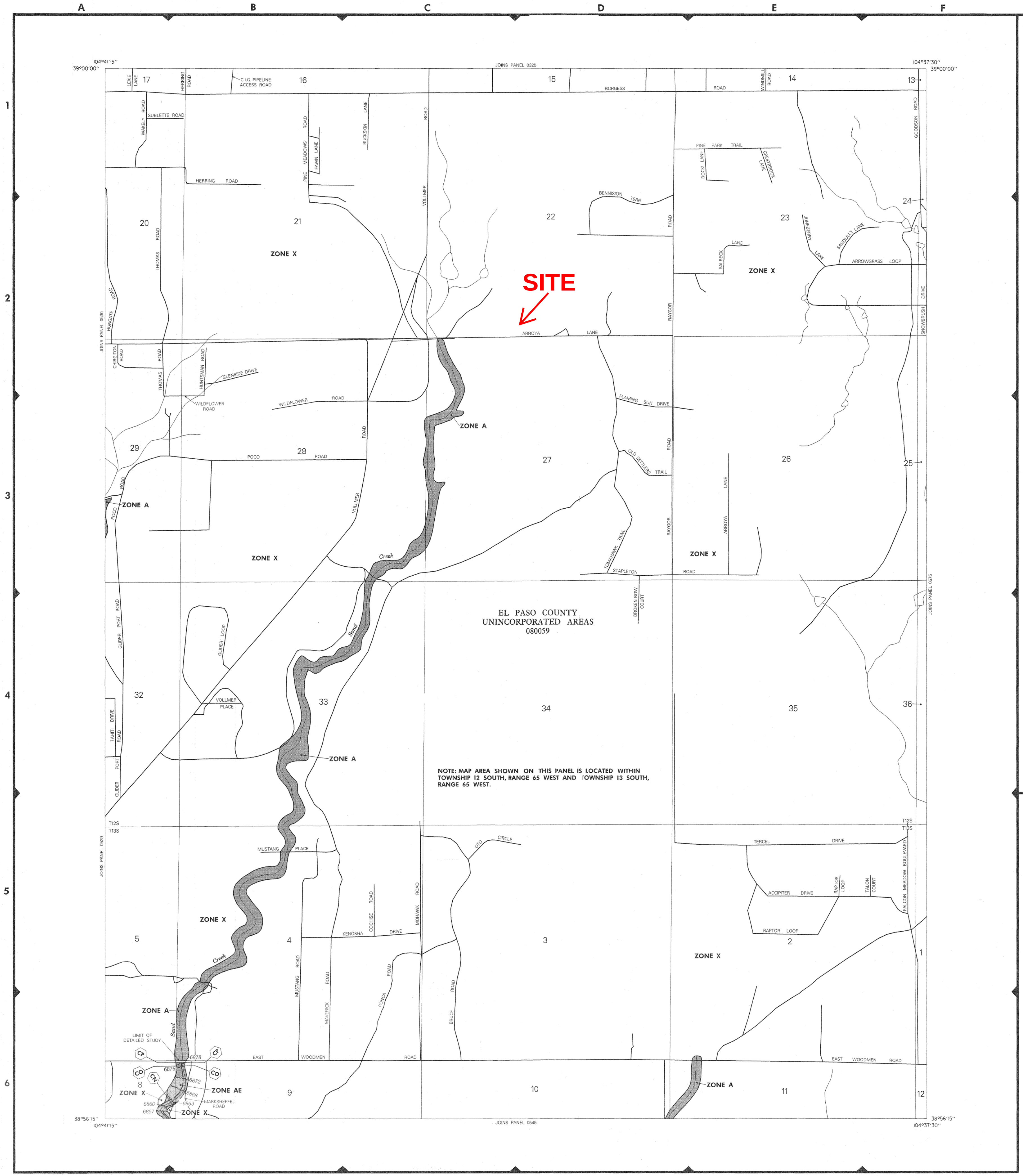
Measure ☒

Segment	Distance (Feet/Miles)	Distance (Meters/Kilometers)
Segment 1	1.02 miles	1.64 kilometers
Total Distance	1.02 miles	1.64 kilometers

FOIA | Accessibility Statement | Privacy Policy | Non-Discrimination Statement | Information Quality | USA.gov | White House

Hydrologic Soil Group: B

FEMA FIRM MAP



NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 12 SOUTH, RANGE 65 WEST AND TOWNSHIP 13 SOUTH, RANGE 65 WEST.

LEGEND

▨ SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

ZONE A	No base flood elevations determined.
ZONE AE	Base flood elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE A99	To be protected from 100-year flood by Federal flood protection system under construction; no base elevations determined.
ZONE V	Coastal flood with velocity hazard (wave action); no base flood elevations determined.
ZONE VE	Coastal flood with velocity hazard (wave action); base flood elevations determined.

▨ FLOODWAY AREAS IN ZONE AE

▨ OTHER FLOOD AREAS

ZONE X	Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.

□ OTHER AREAS

ZONE X	Areas determined to be outside 500-year floodplain.
ZONE D	Areas in which flood hazards are undetermined.

UNDEVELOPED COASTAL BARRIERS

▨	▨	▨
Identified 1983	Identified 1990	Otherwise Protected Areas

Coastal barrier areas are normally located within or adjacent to Special Flood Hazard Areas.

———	Flood Boundary
— — —	Floodway Boundary
- —— —— -	Zone D Boundary
▨	Boundary Dividing Special Flood Hazard Zones, and Boundary Dividing Areas of Different Coastal Base Flood Elevations Within Special Flood Hazard Zones.
~~513~~~	Base Flood Elevation Line; Elevation in Feet. See Map Index for Elevation Datum.
(D)——(D)	Cross Section Line
(EL 987)	Base Flood Elevation in Feet Where Uniform Within Zone. See Map Index for Elevation Datum.
RM7 ×	Elevation Reference Mark
● M2	River Mile
97°07'30'', 32°22'30''	Horizontal Coordinates Based on North American Datum of 1927 (NAD 27) Projection.

NOTES

This map is for use in administering the National Flood Insurance Program; it does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size, or all planimetric features outside Special Flood Hazard Areas.

Coastal base flood elevations apply only landward of 0.0 NGVD, and include the effects of wave action; these elevations may also differ significantly from those developed by the National Weather Service for hurricane evacuation planning.

Areas of Special Flood Hazard (100-year flood) include Zones A, AE, AH, AO, A99, V, and VE.

Certain areas not in Special Flood Hazard Areas may be protected by flood control structures.

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the Federal Emergency Management Agency.

Floodway widths in some areas may be too narrow to show to scale. Floodway widths are provided in the Flood Insurance Study Report.

This map may incorporate approximate boundaries of Coastal Barrier Resource System Units and /or Otherwise Protected Areas established under the Coastal Barrier Improvement Act of 1990 (PL 101-591).

Corporate limits shown are current as of the date of this map. The user should contact appropriate community officials to determine if corporate limits have changed subsequent to the issuance of this map.

For community map revision history prior to countywide mapping, see Section 6.0 of the Flood Insurance Study Report.

For adjoining map panels and base map source see separately printed Map Index.

MAP REPOSITORY
Refer to Repository Listing on Map Index

EFFECTIVE DATE OF
COUNTYWIDE FLOOD INSURANCE RATE MAP:

MARCH 17, 1997

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL:

Refer to the FLOOD INSURANCE RATE MAP EFFECTIVE DATE shown on this map to determine when actuarial rates apply to structures in zones where elevations or depths have been established.

To determine if flood insurance is available, contact an insurance agent or call the National Flood Insurance Program at (800) 638-6620.

APPROXIMATE SCALE IN FEET
1000 0 1000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 535 OF 1300
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS: COMMUNITY	NUMBER	PANEL	SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0535	F

MAP NUMBER
08041C0535 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency

HYDROLOGIC CALCULATIONS

TIMBERRIDGE ESTATES
(Area Runoff Coefficient Summary)

EXISTING CONDITIONS

		STREETS / DEVELOPED			***OVERLAND / UNDEVELOPED***			***WEIGHTED***	
BASIN	**TOTAL AREA** *(Acres)*	**AREA** *(Acres)*	**C_5**	**C_{100}**	**AREA** *(Acres)*	**C_5**	**C_{100}**	**C_5**	**C_{100}**
EX-E1	35.30	0.00	0.90	0.96	35.30	0.08	0.35	0.08	0.35
OS-4	12.99	0.00	0.90	0.96	12.99	0.08	0.35	0.08	0.35
OS-4A	2.98	0.00	0.90	0.96	2.98	0.08	0.35	0.08	0.35
OS-4B	7.76	0.00	0.90	0.96	7.76	0.08	0.35	0.08	0.35

Calculated by: DLF
Date: 6/4/2018
Checked by: ________

Provide all basins, routing and design points.

revise to
match the
plan

TIMBERRIDGE ESTATES
(Area Runoff Coefficient Summary)

DEVELOPED CONDITIONS

		STREETS / DEVELOPED			***OVERLAND / UNDEVELOPED***			***WEIGHTED***	
BASIN	**TOTAL AREA** *(Acres)*	**AREA** *(Acres)*	C_5	C_{100}	**AREA** *(Acres)*	C_5	C_{100}	C_5	C_{100}
OS-1	12.50	0.00	0.90	0.96	12.50	0.08	0.35	0.08	0.35
OS-2	2.98	0.00	0.90	0.96	2.98	0.08	0.35	0.08	0.35
OS-3	7.76	0.00	0.90	0.96	7.76	0.08	0.35	0.08	0.35
OS-4	3.19	0.00	0.90	0.96	3.19	0.08	0.35	0.08	0.35
OS-5	4.89	0.00	0.90	0.96	4.89	0.08	0.35	0.08	0.35
A	12.38	0.51	0.90	0.96	11.87	0.08	0.35	0.11	0.37
A1	1.83	0.73	0.90	0.96	1.10	0.08	0.35	0.41	0.59
B	1.66	0.66	0.90	0.96	0.99	0.08	0.35	0.41	0.59
C	15.36	0.76	0.90	0.96	14.60	0.08	0.35	0.12	0.38
D	2.60	0.26	0.90	0.96	2.34	0.08	0.35	0.16	0.41
E	1.04	0.42	0.90	0.96	0.62	0.08	0.35	0.41	0.59
F	0.72	0.00	0.90	0.96	0.72	0.08	0.35	0.08	0.35
G	1.16	0.46	0.90	0.96	0.70	0.08	0.35	0.41	0.59
H	1.38	0.55	0.90	0.96	0.83	0.08	0.35	0.41	0.59
I	1.27	0.51	0.90	0.96	0.76	0.08	0.35	0.41	0.59

Calculated by: DLF
Date: 6/4/2018
Checked by: ______

Revise values that don't match previous tables and plans.

TIMBERRIDGE ESTATES
AREA DRAINAGE SUMMARY

EXISTING CONDITIONS

		WEIGHTED		*OVERLAND*				*STREET / CHANNEL FLOW*				*T_t*	*INTENSITY*		*TOTAL FLOWS*	
BASIN	**AREA TOTAL** *(Acres)*	**C_5**	**C_{100}**	**C_5**	**Length** *(ft)*	**Height** *(ft)*	**T_C** *(min)*	**Length** *(ft)*	**Slope** *(%)*	**Velocity** *(fps)*	**T_t** *(min)*	**TOTAL** *(min)*	**I_5** *(in/hr)*	**I_{100}** *(in/hr)*	**Q_5** *(c.f.s.)*	**Q_{100}** *(c.f.s.)*
		** For Calcs See Runoff Summary*														
EX-E1	35.30	0.08	0.35	0.08	300	16.0	10.5	2148	5.0%	1.5	23.9	34.3	2.3	3.7	**6.5**	**46.1**
OS-4	12.99	0.08	0.35	0.08	300	20.0	9.7	1460	5.7%	1.8	13.5	23.2	2.8	4.7	**2.9**	**21.3**
OS-4A	2.98	0.08	0.35	0.08	300	25.0	9.0	390	5.0%	1.5	4.3	13.4	3.6	6.2	**0.9**	**6.5**
OS-4B	7.76	0.08	0.35	0.08	300	20.0	9.7	1220	5.0%	1.5	13.6	23.3	2.8	4.7	**1.8**	**12.7**

DEVELOPED CONDITIONS

		WEIGHTED		*OVERLAND*				*STREET / CHANNEL FLOW*				*T_t*	*INTENSITY*		*TOTAL FLOWS*	
BASIN	**AREA TOTAL** *(Acres)*	**C_5**	**C_{100}**	**C_5**	**Length** *(ft)*	**Height** *(ft)*	**T_C** *(min)*	**Length** *(ft)*	**Slope** *(%)*	**Velocity** *(fps)*	**T_t** *(min)*	**TOTAL** *(min)*	**I_5** *(in/hr)*	**I_{100}** *(in/hr)*	**Q_5** *(c.f.s.)*	**Q_{100}** *(c.f.s.)*
		** For Calcs See Runoff Summary*														
OS-1	12.50	0.08	0.35	0.09	300	16.0	10.4	2148	5.0%	1.1	32.0	42.4	2.0	3.3	**2.0**	**14.3**
OS-2	2.98	0.08	0.35	0.09	100	5.0	6.8	243	5.0%	1.1	3.6	10.4	4.0	6.9	**1.0**	**7.2**
OS-3	7.76	0.08	0.35	0.09	300	20.0	9.6	1460	5.7%	1.2	20.4	30.0	2.5	4.0	**1.5**	**11.0**
OS-4	3.19	0.08	0.35	0.09	300	16.0	10.4	783	4.9%	1.1	11.8	22.2	2.9	4.8	**0.7**	**5.4**
OS-5	4.89	0.08	0.35	0.09	300	15.0	10.6	416	5.1%	1.1	6.1	16.7	3.3	5.6	**1.3**	**9.6**
A	12.38	0.11	0.37	0.09	284	16.0	10.0	1226	4.4%	1.5	13.9	23.9	2.8	4.6	**3.9**	**21.4**
A1	1.83	0.41	0.59	0.09	50	4.0	4.4	844	5.2%	1.6	8.8	13.2	3.7	6.3	**2.7**	**6.8**
B	1.66	0.41	0.59	0.09	129	9.0	6.8	1098	5.1%	1.6	11.6	18.3	3.2	5.3	**2.1**	**5.2**
C	15.36	0.12	0.38	0.09	226	20.0	7.8	1780	4.5%	1.5	20.0	27.8	2.6	4.2	**4.8**	**24.7**
D	2.60	0.16	0.41	0.09	108	6.0	6.8	1448	3.1%	1.2	19.6	26.4	2.7	4.4	**1.1**	**4.7**
E	1.04	0.41	0.59	0.09	30	2.0	3.8	825	4.6%	3.2	4.3	8.1	4.4	7.7	**1.8**	**4.7**
F	0.72	0.08	0.35	0.09	150	10.0	7.3	335	6.0%	1.7	3.3	10.6	4.0	6.9	**0.2**	**1.7**
G	1.16	0.41	0.59	0.09	30	2.0	3.8	934	3.9%	3.0	5.3	9.1	4.2	7.4	**2.0**	**5.1**
H	1.38	0.41	0.59	0.09	58	2.0	6.2	904	5.3%	3.5	4.4	10.6	4.0	6.9	**2.2**	**5.7**
I	1.27	0.41	0.59	0.09	30	2.0	3.8	934	3.9%	3.0	5.3	9.1	4.2	7.4	**2.2**	**5.6**

Calculated by: DLF

Date: 6/4/2018

Checked by: ______

TIMBERRIDGE ESTATES
PROPOSED SURFACE ROUTING SUMMARY

Design Point(s)	*Contributing Basins*	*Area Ac*	*Flow*	
			Q_5	*Q_{100}*
1	**OS-2, A & A1**	17.18	*7.6*	*35.5*
2	**OS-2, A, A1 & B**	18.84	*9.8*	*40.7*
3	**OS-1, OS-2, A, A1, B, & C**	46.70	*16.6*	*79.8*
4	**D**	2.60	*1.1*	*4.7*
5	**OS-1, OS-2, OS-4, A, A1, B, C, D, E, & F**	54.25	*20.5*	*96.3*
6	**OS-5 & G**	8.80	*3.3*	*14.6*
7	**I**	1.27	*2.2*	*5.6*
8	**H**	1.38	*2.2*	*5.7*
OS-3	**OS-3**	7.76	*1.5*	*11.0*

Calculated by: DLF
Date: 6/4/2018
Checked by: ____

Revise as appropriate. Provide calculations for channel flow values.

Table 6-6. Runoff Coefficients for Rational Method

(Source: UDFCD 2001)

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

3.2 Time of Concentration

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

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

HYDRAULIC CALCULATIONS

MANNING'S EQUATION for OPEN CHANNEL FLOW

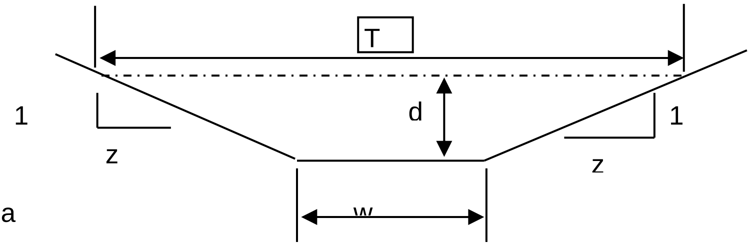
Project: **Timber Rider Estates** Location: Point EX1 - Min 100 Yr Channel Size (Q=1.2 cfs)
By: Dane Frank Date: 5/31/2018
Chk By: Date:

version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

	INPUT
z (sideslope)=	11.3
z (sideslope)=	17.5
b (btm width, ft)=	0
d (depth, ft)=	0.4
S (slope, ft/ft)	0.026
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
0.4	2.30	11.55	0.20	0.54535695	1.2565	0.545357	1.2565	T =	11.52
								Dm =	0.200

Sc low =	0.5620	Sc high =	0.5620
.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.3934	0.7307	0.3934	0.7307

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

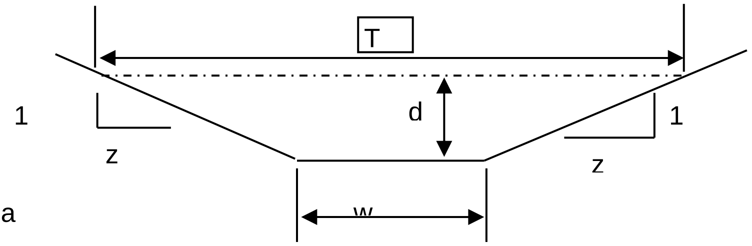
Project: **Timber Rider Estates** Location: Point EX2 - Min 100 Yr Channel Size (Q=7.1 cfs)
By: Dane Frank Date: 5/31/2018
Chk By: Date:

version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

INPUT	
z (sideslope)=	11.5
z (sideslope)=	12
b (btm width, ft)=	8
d (depth, ft)=	0.47
S (slope, ft/ft)	0.056
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N	
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs
0.47	6.36	19.08	0.33	1.12628489	7.15819	1.126285	7.15819

T = 19.045
Dm = 0.334

Sc low =	0.4736	Sc high =	0.4736
.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.3315	0.6157	0.3315	0.6157

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

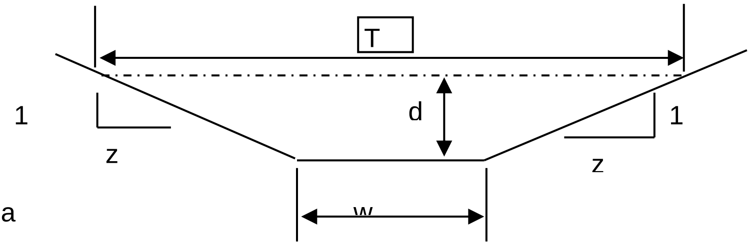
MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX3 - Min 100 Yr Channel Size (Q=18.5 cfs)

By: Dane Frank Date: 5/31/2018

Chk By: Date:

version 12-2004



INPUT

z (sideslope)= 7.2

z (sideslope)= 7.9

b (btm width, ft)= 0

d (depth, ft)= 1.27

S (slope, ft/ft) 0.044

n_{low} = 0.15

n_{high} = 0.15

Clear Data Entry Cells

Mannings Formula

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

R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient

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

Q = V x A

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
1.27	12.18	19.34	0.63	1.52630076	18.5864	1.526301	18.5864	T =	19.177
								Dm =	0.635
				Sc low =	0.3856	Sc high =	0.3856		

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.2699	0.5013	0.2699	0.5013

Created by: Mike O'Shea

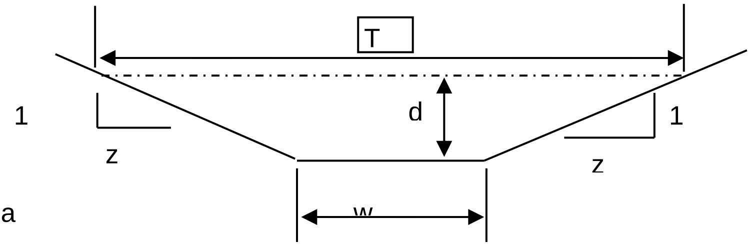
MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX4 - Min 100 Yr Channel Size (Q=23.9 cfs)
By: Dane Frank Date: 5/31/2018
Chk By: Date:
version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

	INPUT
z (sideslope)=	7.5
z (sideslope)=	6.5
b (btm width, ft)=	0
d (depth, ft)=	1.41
S (slope, ft/ft)	0.049
n_{low} =	0.15
n $_{high}$ =	0.15

Clear Data Entry Cells

				Low N		High N	
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs
1.41	13.92	19.94	0.70	1.72533701	24.011	1.725337	24.011

T = 19.74
Dm = 0.705

Sc low = 0.3731 Sc high = 0.3731

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.2612	0.4850	0.2612	0.4850

Created by: Mike O'Shea

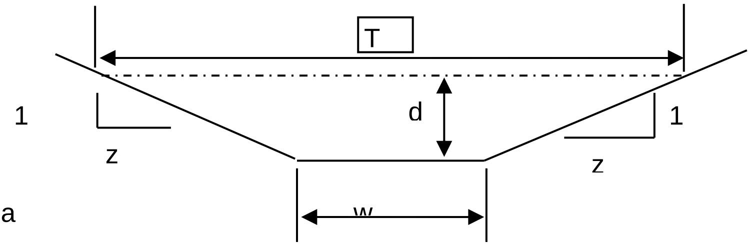
MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX5 - Min 100 Yr Channel Size (Q=26.3 cfs)
By: Dane Frank Date: 6/6/2018
Chk By: Date:
version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

	INPUT
z (sideslope)=	4
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	1.99
S (slope, ft/ft)	0.03
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
1.99	15.84	16.41	0.97	1.6759462	26.5477	1.675946	26.5477	T =	15.92
								Dm =	0.995

Sc low =	0.3417	Sc high =	0.3417
.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.2392	0.4442	0.2392	0.4442

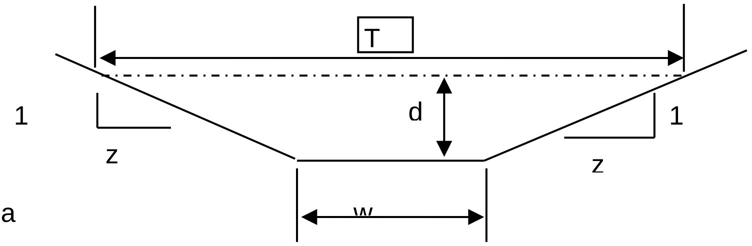
s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX6 - Min 100 Yr Channel Size (Q=35.5 cfs)
By: Dane Frank Date: 6/6/2018
Chk By: Date:

version 12-2004



	INPUT
z (sideslope)=	4
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	2.21
S (slope, ft/ft)	0.031
n_{low} =	0.15
n_{high} =	0.15

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient

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

Clear Data
Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
2.21	19.54	18.22	1.07	1.82701148	35.6932	1.827011	35.6932	T =	17.68
								Dm =	1.105
				Sc low =	0.3299	Sc high =	0.3299		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.2310	0.4289	0.2310	0.4289		

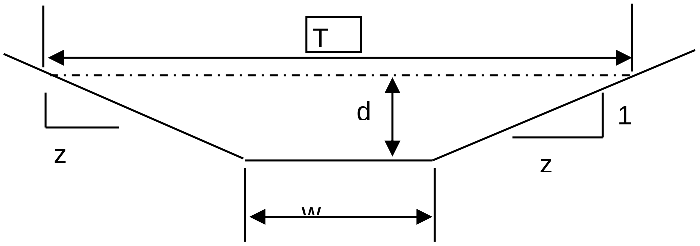
s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX7 - Min 100 Yr Channel Size (Q=7.6 cfs)
By: Dane Frank Date: 5/31/2018
Chk By: Date:

version 12-2004



INPUT	
z (sideslope)=	6.7
z (sideslope)=	16.8
b (btm width, ft)=	0
d (depth, ft)=	0.73
S (slope, ft/ft)	0.061
n_{low} =	0.15
n_{high} =	0.15

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient

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

Clear Data Entry Cells

				Low N		High N	
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs
0.73	6.26	17.23	0.36	1.24593434	7.80151	1.245934	7.80151

T = 17.155
Dm = 0.365

Sc low = 0.4611 Sc high = 0.4611

.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.3228	0.5994	0.3228	0.5994

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX8 - Min 100 Yr Channel Size (Q=19.8 cfs)

By: Dane Frank Date: 5/31/2018

Chk By: Date:

version 12-2004

Mannings Formula

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

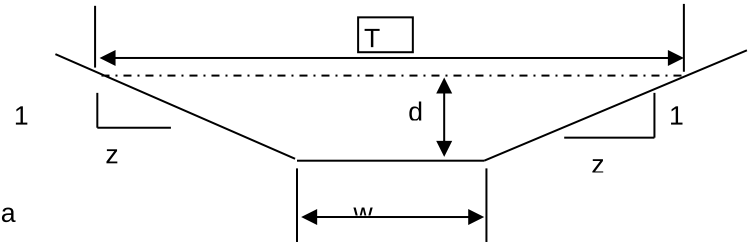
R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



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

Q = V x A

	INPUT
z (sideslope)=	7.5
z (sideslope)=	11.5
b (btm width, ft)=	0
d (depth, ft)=	1.27
S (slope, ft/ft)	0.032
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
1.27	15.32	24.27	0.63	1.30419882	19.9837	1.304199	19.9837	T =	24.13
								Dm =	0.635
				Sc low =	0.3841	Sc high =	0.3841		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.2689	0.4993	0.2689	0.4993		

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

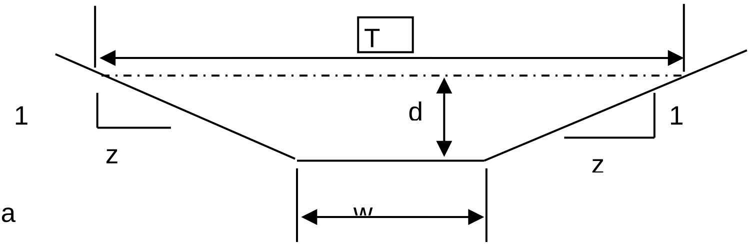
MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX9 - Min 100 Yr Channel Size (Q=26.3 cfs)
By: Dane Frank Date: 6/6/2018
Chk By: Date:

version 12-2004

Mannings Formula

$Q = (1.486/n)AR_h^{2/3}S^{1/2}$
R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

	INPUT
z (sideslope)=	4
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	1.89
S (slope, ft/ft)	0.039
n_{low} =	0.15
n $_{high}$ =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
1.89	14.29	15.59	0.92	1.84630518	26.3807	1.846305	26.3807	T =	15.12
								Dm =	0.945
				Sc low =	0.3476	Sc high =	0.3476		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.2433	0.4519	0.2433	0.4519		

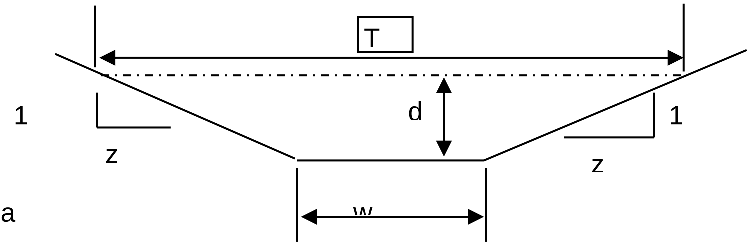
s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX10 - Min 100 Yr Channel Size (Q=32.0 cfs)
By: Dane Frank Date: 6/6/2018
Chk By: Date:

version 12-2004



	INPUT
z (sideslope)=	4
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	2.09
S (slope, ft/ft)	0.034
n_{low} =	0.15
n_{high} =	0.15

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient

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

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
2.09	17.47	17.23	1.01	1.84346581	32.2098	1.843466	32.2098	T =	16.72
								Dm =	1.045

Sc low =	0.3361	Sc high =	0.3361

.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.2353	0.4370	0.2353	0.4370

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

see comment letter

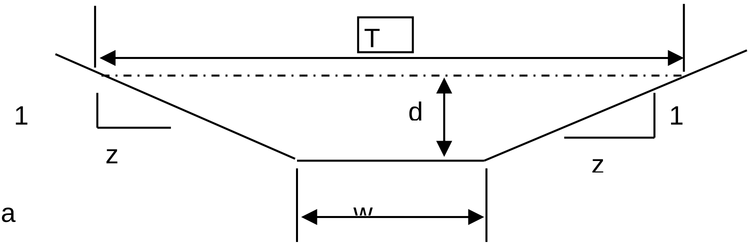
MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point EX11 - Min 100 Yr Channel Size (Q=76.0 cfs)
By: Dane Frank Date: 6/6/2018
Chk By: Date:
version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

INPUT
z (sideslope)= 4
z (sideslope)= 4
b (btm width, ft)= 0
d (depth, ft)= 2.94
S (slope, ft/ft) 0.031
n_{low} = 0.15
n $_{high}$ = 0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
2.94	34.57	24.24	1.43	2.20994829	76.4076	2.209948	76.4076	T =	23.52
								Dm =	1.470

Sc low =	0.3000	Sc high =	0.3000
.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.2100	0.3900	0.2100	0.3900

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

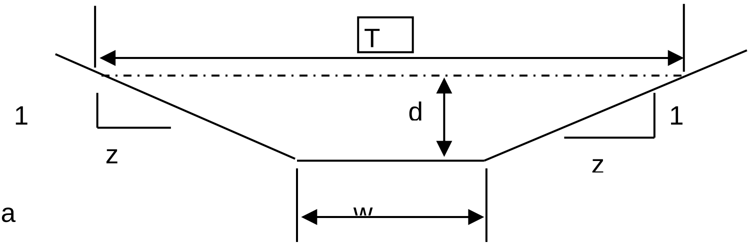
Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project:	**Timber Rider Estates**	Location:	Point PR1 - Min 100 Yr Channel Size (Q=40.7 cfs)
By:	Dane Frank	Date:	6/6/2018
Chk By:		Date:	

version 12-2004

Mannings Formula



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

R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient

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

Q = V x A

	INPUT
z (sideslope)=	5
z (sideslope)=	6
b (btm width, ft)=	20
d (depth, ft)=	1.31
S (slope, ft/ft)	0.013
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
1.31	35.64	34.65	1.03	1.15095872	41.0185	1.150959	41.0185	T =	34.41
								Dm =	1.036
				Sc low =	0.3268	Sc high =	0.3268		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.2287	0.4248	0.2287	0.4248		

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

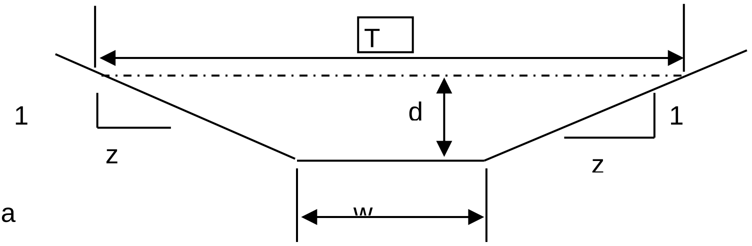
Project: **Timber Rider Estates** Location: Point PR2 - Min 100 Yr Channel Size (Q=79.8 cfs)
By: Dane Frank Date: 6/6/2018
Chk By: Date:

version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

	INPUT
z (sideslope)=	4
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	2.73
S (slope, ft/ft)	0.051
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
2.73	29.81	22.51	1.32	2.6979185	80.4293	2.697918	80.4293	T =	21.84
								Dm =	1.365

Sc low =	0.3075	Sc high =	0.3075
.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.2153	0.3998	0.2153	0.3998

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project:	**Timber Rider Estates**	Location:	Point PR3 - Min 100 Yr Channel Size (Q=4.7 cfs)
By:	Dane Frank	Date:	5/31/2018
Chk By:		Date:	

version 12-2004

Mannings Formula

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

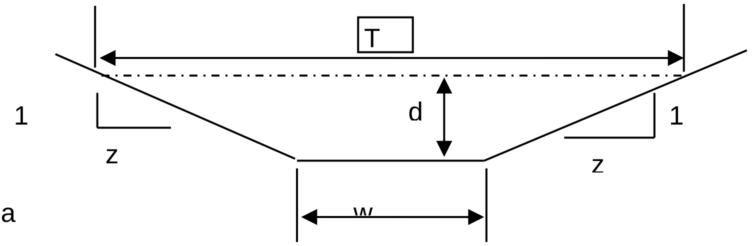
R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



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

Q = V x A

INPUT	
z (sideslope)=	4
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	1
S (slope, ft/ft)	0.037
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
1	4.00	8.25	0.49	1.17639986	4.7056	1.1764	4.7056	T =	8
								Dm =	0.500

Sc low =	0.4298	Sc high =	0.4298
.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.3008	0.5587	0.3008	0.5587

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project:	**Timber Rider Estates**	Location:	Point PR4 - Min 100 Yr Channel Size (Q=3.2 cfs)
By:	Dane Frank	Date:	5/31/2018
Chk By:		Date:	

version 12-2004

Mannings Formula

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

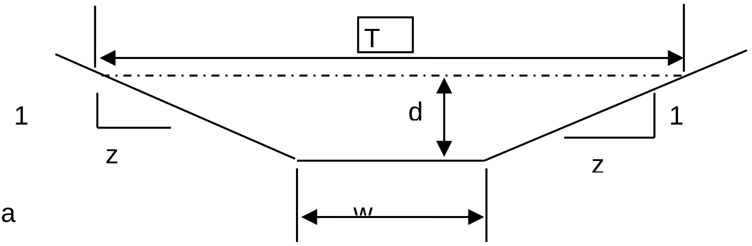
R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



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

Q = V x A

	INPUT
z (sideslope)=	4.5
z (sideslope)=	3.6
b (btm width, ft)=	0
d (depth, ft)=	0.78
S (slope, ft/ft)	0.063
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
0.78	2.46	6.51	0.38	1.30105342	3.20582	1.301053	3.20582	T =	6.318
								Dm =	0.390
				Sc low =	0.4666	Sc high =	0.4666		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.3266	0.6066	0.3266	0.6066		

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

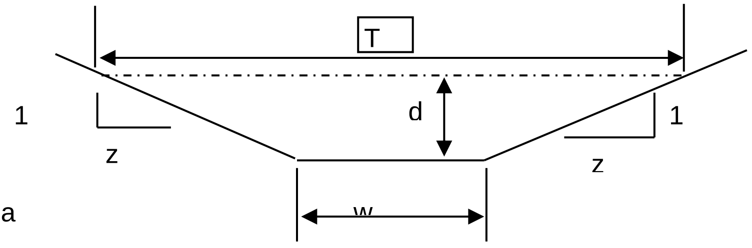
Project: **Timber Rider Estates** Location: Point PR5 - Min 100 Yr Channel Size (Q=0.9 cfs)
By: Dane Frank Date: 5/31/2018
Chk By: Date:

version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

Q = V x A

	INPUT
z (sideslope)=	3.8
z (sideslope)=	3.8
b (btm width, ft)=	0
d (depth, ft)=	0.67
S (slope, ft/ft)	0.013
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N	
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs
0.67	1.71	5.27	0.32	0.53278593	0.90884	0.532786	0.90884

T = 5.092
Dm = 0.335

Sc low = 0.4932 Sc high = 0.4932

.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.3452	0.6412	0.3452	0.6412

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point PR6 - Min 100 Yr Channel Size (Q=3.6 cfs)

By: Dane Frank Date: 5/31/2018

Chk By: Date:

version 12-2004

INPUT

z (sideslope)= 4

z (sideslope)= 3.5

b (btm width, ft)= 0

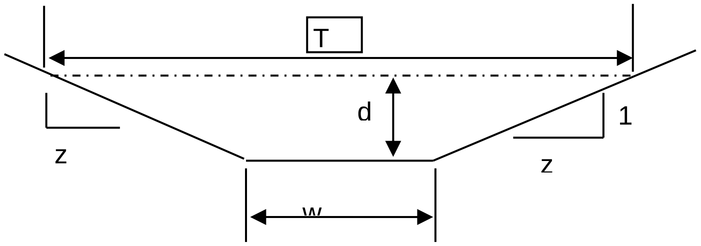
d (depth, ft)= 1.13

S (slope, ft/ft) 0.013

n_{low} = 0.15

n_{high} = 0.15

Mannings Formula



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

R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient

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

Q = V x A

Clear Data Entry Cells

				Low N		High N	
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs
1.13	4.79	8.77	0.55	0.754405	3.61237	0.754405	3.61237

T = 8.475

Dm = 0.565

Sc low = 0.4149 Sc high = 0.4149

.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.2904	0.5394	0.2904	0.5394

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

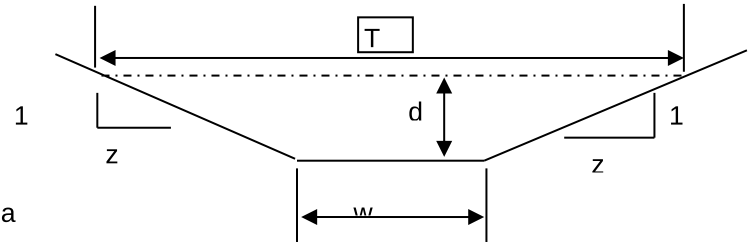
Project: **Timber Rider Estates** Location: Point PR7 - Min 100 Yr Channel Size (Q=8.2 cfs)
By: Dane Frank Date: 5/31/2018
Chk By: Date:

version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

INPUT
z (sideslope)= 4
z (sideslope)= 3
b (btm width, ft)= 0
d (depth, ft)= 1.22
S (slope, ft/ft) 0.052
n_{low} = 0.15
n_{high} = 0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
1.22	5.21	8.89	0.59	1.58211653	8.24188	1.582117	8.24188	T =	8.54
								Dm =	0.610
				Sc low =	0.4074	Sc high =	0.4074		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.2852	0.5296	0.2852	0.5296		

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

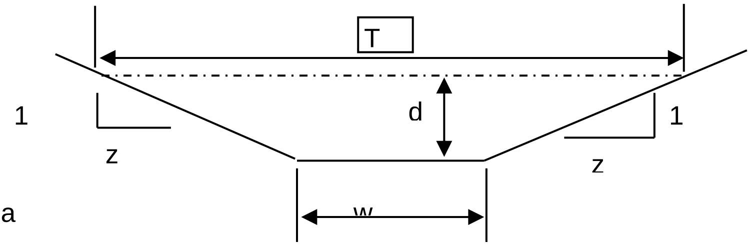
MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point PR8 - Min 100 Yr Channel Size (Q=96.3 cfs)
By: Dane Frank Date: 5/31/2018
Chk By: Date:
version 12-2004

Mannings Formula

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

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient



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

	INPUT
z (sideslope)=	4
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	2.97
S (slope, ft/ft)	0.05
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
2.97	35.28	24.49	1.44	2.82569854	99.7008	2.825699	99.7008	T =	23.76
								Dm =	1.485

Sc low =	0.2990	Sc high =	0.2990
.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.2093	0.3887	0.2093	0.3887

s_c = critical slope ft / ft
T = top width of the stream
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point PR9 - Min 100 Yr Channel Size (Q=5.7 cfs)

By: Dane Frank Date: 5/31/2018

Chk By: Date:

version 12-2004

Mannings Formula

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

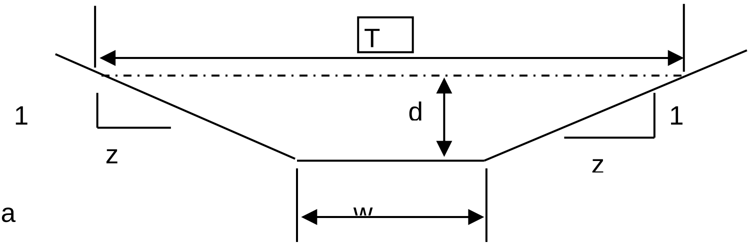
R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



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

Q = V x A

	INPUT
z (sideslope)=	4
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	0.99
S (slope, ft/ft)	0.06
n_{low} =	0.15
n_{high} =	0.15

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
0.99	3.92	8.16	0.48	1.48805749	5.83378	1.488057	5.83378	T =	7.92
								Dm =	0.495
				Sc low =	0.4312	Sc high =	0.4312		

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

.7 Sc	1.3 Sc	.7 Sc	1.3 Sc
0.3018	0.5606	0.3018	0.5606

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point PR10 - Min 100 Yr Channel Size (Q=10.5 cfs)

By: Dane Frank Date: 5/31/2018

Chk By: Date:

version 12-2004

Mannings Formula

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

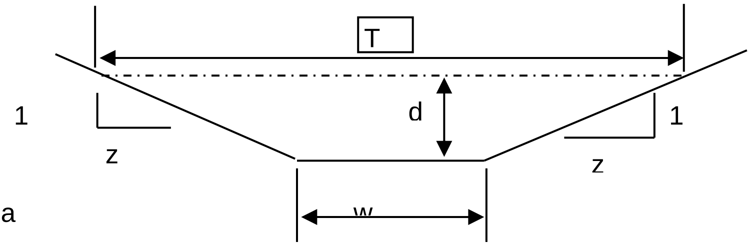
R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



INPUT	
z (sideslope)=	3.5
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	1.27
S (slope, ft/ft)	0.059
n_{low} =	0.15
n $_{high}$ =	0.15

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

Q = V x A

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
1.27	6.05	9.86	0.61	1.73731044	10.5079	1.73731	10.5079	T =	9.525
								Dm =	0.635
				Sc low =	0.3991	Sc high =	0.3991		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.2793	0.5188	0.2793	0.5188		

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Timber Rider Estates** Location: Point PR11 - Min 100 Yr Channel Size (Q=5.6 cfs)

By: Dane Frank Date: 5/31/2018

Chk By: Date:

version 12-2004

Mannings Formula

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

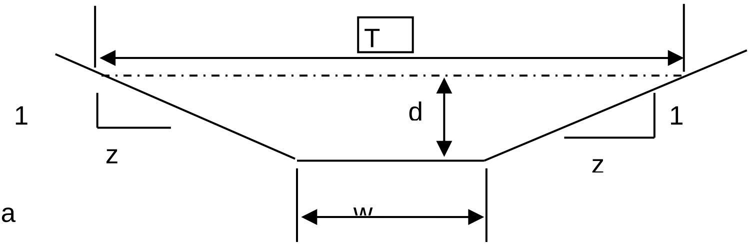
R = A/P

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



	INPUT
z (sideslope)=	3.5
z (sideslope)=	4
b (btm width, ft)=	0
d (depth, ft)=	0.96
S (slope, ft/ft)	0.078
n_{low} =	0.15
n_{high} =	0.15

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

Q = V x A

Clear Data Entry Cells

				Low N		High N			
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs		
0.96	3.46	7.45	0.46	1.65757434	5.72858	1.657574	5.72858	T =	7.2
								Dm =	0.480
				Sc low =	0.4381	Sc high =	0.4381		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.3067	0.5695	0.3067	0.5695		

s_c = critical slope ft / ft

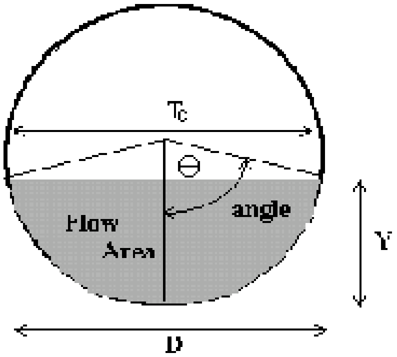
T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

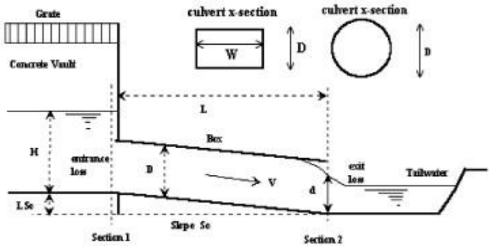
Project: **TIMBERRIDGE ESTATES**
Pipe ID: **Design Point 1 (35.5 cfs) - Dual 24" RCP Culverts**



Design Information (Input)			
Pipe Invert Slope	So =	0.0100	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	24.00	inches
Design discharge	**Q =**	**17.75**	**cfs**
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 =	22.68	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.91	radians
Flow area	An =	2.22	sq ft
Top width	Tn =	1.89	ft
Wetted perimeter	Pn =	3.82	ft
Flow depth	Yn =	1.33	ft
Flow velocity	Vn =	7.99	fps
Discharge	Qn =	17.75	cfs
Percent Full Flow	Flow =	78.3%	of full flow
Normal Depth Froude Number	Fr_n =	1.30	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.12	radians
Critical flow area	Ac =	2.56	sq ft
Critical top width	Tc =	1.71	ft
Critical flow depth	Yc =	1.52	ft
Critical flow velocity	Vc =	6.94	fps
Critical Depth Froude Number	Fr_c =	1.00	

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

Project: Timberridge Estates
Basin ID: Design Point 1 (35.5 cfs) - Dual 24" RCP Culverts
Status:



Design Information (Input):

Circular Culvert:	Barrel Diameter in Inches	D =	24	inches
	Inlet Edge Type (choose from pull-down list)		Grooved End Projection	
OR:				
Box Culvert:	Barrel Height (Rise) in Feet	Height (Rise) =		ft.
	Barrel Width (Span) in Feet	Width (Span) =		ft.
	Inlet Edge Type (choose from pull-down list)		Square Edge w/ 90-15 Deg. Headwall	
	Number of Barrels	No =	2	
	Inlet Elevation at Culvert Invert	Inlet Elev =	7270.37	ft. elev.
	Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Outlet Elev =	7269.7	ft. elev.
	Culvert Length in Feet	L =	80	ft.
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	K_b =	0	
	Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.20
Friction Loss Coefficient	K_f =	0.84
Sum of All Loss Coefficients	K_s =	2.04
Orifice Inlet Condition Coefficient	C_d =	0.95
Minimum Energy Condition Coefficient	KE_{low} =	-0.0342

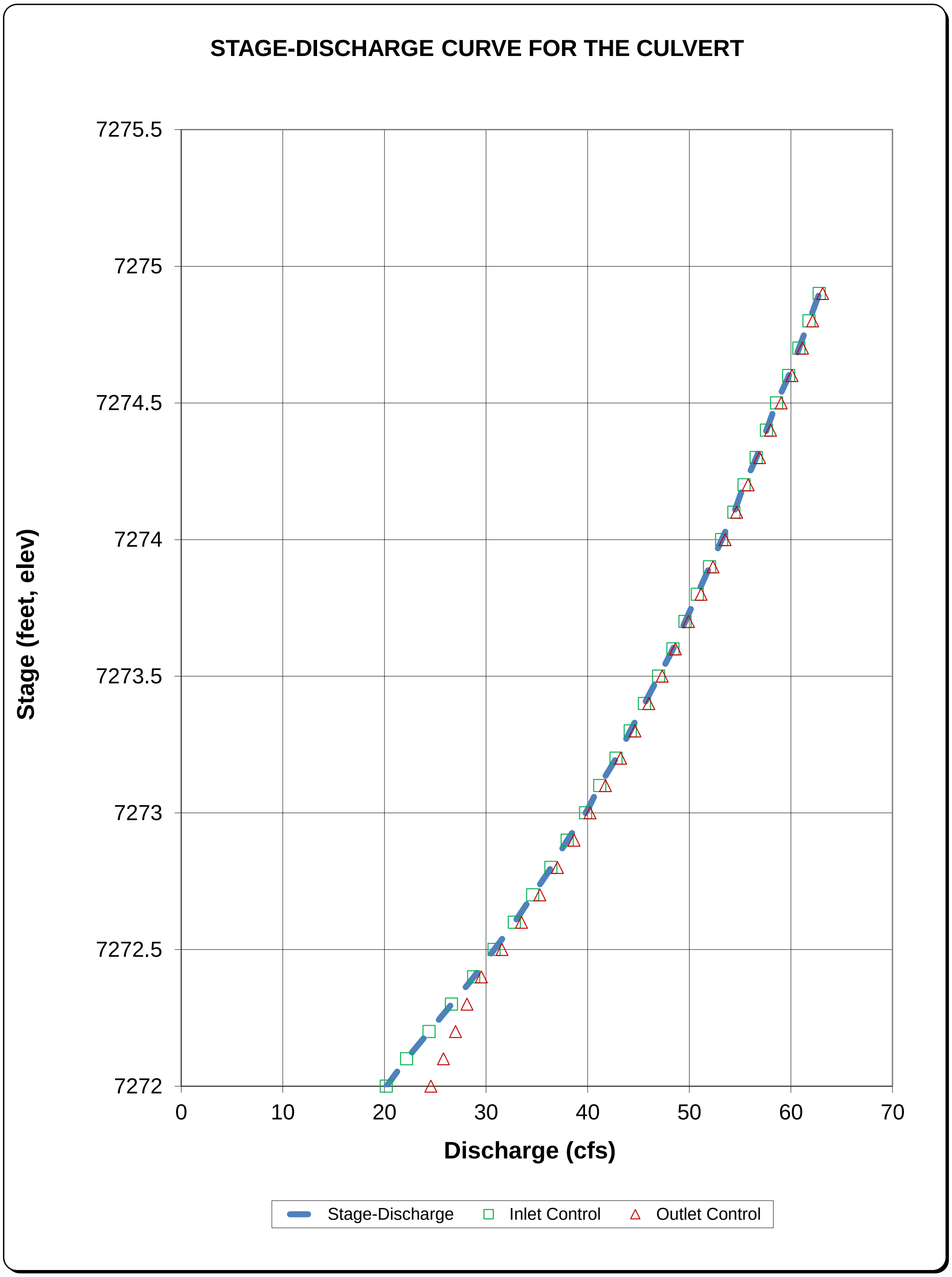
Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
7272.00		20.20	24.58	**20.20**	Regression Eqn.	INLET
7272.10		22.20	25.81	**22.20**	Regression Eqn.	INLET
7272.20		24.40	27.00	**24.40**	Regression Eqn.	INLET
7272.30		26.60	28.13	**26.60**	Regression Eqn.	INLET
7272.40		28.80	29.54	**28.80**	Regression Eqn.	INLET
7272.50		30.80	31.58	**30.80**	Regression Eqn.	INLET
7272.60		32.80	33.49	**32.80**	Regression Eqn.	INLET
7272.70		34.60	35.30	**34.60**	Regression Eqn.	INLET
7272.80		36.40	37.03	**36.40**	Regression Eqn.	INLET
7272.90		38.00	38.67	**38.00**	Regression Eqn.	INLET
7273.00		39.80	40.24	**39.80**	Regression Eqn.	INLET
7273.10		41.20	41.76	**41.20**	Regression Eqn.	INLET
7273.20		42.80	43.24	**42.80**	Regression Eqn.	INLET
7273.30		44.20	44.65	**44.20**	Regression Eqn.	INLET
7273.40		45.60	46.02	**45.60**	Regression Eqn.	INLET
7273.50		47.00	47.35	**47.00**	Regression Eqn.	INLET
7273.60		48.40	48.65	**48.40**	Regression Eqn.	INLET
7273.70		49.60	49.93	**49.60**	Regression Eqn.	INLET
7273.80		50.80	51.16	**50.80**	Regression Eqn.	INLET
7273.90		52.00	52.35	**52.00**	Regression Eqn.	INLET
7274.00		53.20	53.54	**53.20**	Regression Eqn.	INLET
7274.10		54.40	54.68	**54.40**	Regression Eqn.	INLET
7274.20		55.40	55.80	**55.40**	Regression Eqn.	INLET
7274.30		56.60	56.92	**56.60**	Regression Eqn.	INLET
7274.40		57.60	58.00	**57.60**	Regression Eqn.	INLET
7274.50		58.60	59.05	**58.60**	Regression Eqn.	INLET
7274.60		59.80	60.11	**59.80**	Regression Eqn.	INLET
7274.70		60.80	61.14	**60.80**	Regression Eqn.	INLET
7274.80		61.80	62.15	**61.80**	Regression Eqn.	INLET
7274.90		62.80	63.14	**62.80**	Regression Eqn.	INLET

Processing Time: 00.87 Seconds

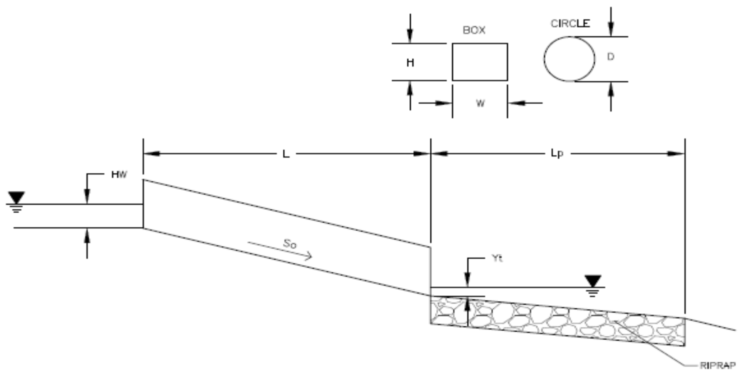
CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Timberridge Estates
Basin ID: Design Point 1 (35.5 cfs) - Dual 24" RCP Culverts



Determination of Culvert Headwater and Outlet Protection

Project: Timberridge Estates
Basin ID: Design Point 1 (35.5 cfs) - Dual 24" RCP Culverts



Soil Type:
Choose One:
● Sandy
○ Non-Sandy

Supercritical Flow! Using Da to calculate protection type.

Design Information (Input):

Design Discharge	Q =	17.75	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	24	inches
Inlet Edge Type (Choose from pull-down list)	Grooved End Projection		
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	Height (Rise) =		ft
Barrel Width (Span) in Feet	Width (Span) =		ft
Inlet Edge Type (Choose from pull-down list)			
Number of Barrels	No =	2	
Inlet Elevation	Elev IN =	7270.37	ft
Outlet Elevation **OR** Slope	Elev OUT =	7269.7	ft
Culvert Length	L =	80	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	Elev Y_t =		ft
Max Allowable Channel Velocity	V =	5	ft/s

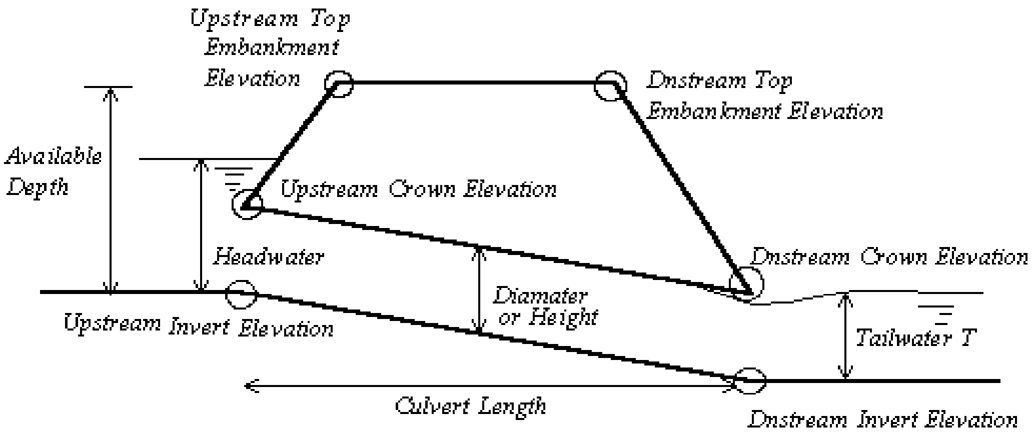
Required Protection (Output):

Tailwater Surface Height	Y_t =	0.80	ft
Flow Area at Max Channel Velocity	A_t =	1.77	ft^2
Culvert Cross Sectional Area Available	A =	3.14	ft^2
Entrance Loss Coefficient	k_e =	0.20	
Friction Loss Coefficient	k_f =	0.99	
Sum of All Losses Coefficients	k_s =	2.19	ft
Culvert Normal Depth	Y_n =	0.91	ft
Culvert Critical Depth	Y_c =	1.06	ft
Tailwater Depth for Design	d =	1.53	ft
Adjusted Diameter **OR** Adjusted Rise	D_a =	1.46	ft
Expansion Factor	1/(2*tan(Θ)) =	6.70	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/D^2.5 =	1.57	$ft^{0.5}/s$
Froude Number	Fr =	1.34	**Supercritical!**
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/D =	0.55	
Inlet Control Headwater	HW_I =	1.52	ft
Outlet Control Headwater	HW_O =	1.13	
Design Headwater Elevation	**HW =**	**7,271.89**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**0.76**	
Minimum Theoretical Riprap Size	d_{50} =	3	in
Nominal Riprap Size	d_{50} =	6	in
UDFCD Riprap Type	**Type =**	**VL**	
Length of Protection	**L_p =**	**6**	**ft**
Width of Protection	**T =**	**3**	**ft**

Vertical Profile for the Culvert

Project = **Timberridge Estates**

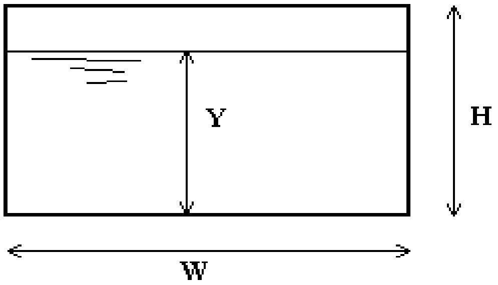
Box ID = **Design Point 1 (35.5 cfs) - Dual 24" RCP Culverts**



Culvert Information (Input)			
Barrel Diameter or Height	D or H =	24.00	inches
Barrel Length	L =	80.00	ft
Barrel Invert Slope	So =	0.0084	ft/ft
Downstream Invert Elevation	EDI =	7269.70	ft
Downstream Top Embankment Elevation	EDT =	7272.70	ft
Upstream Top Embankment Elevation	EUT =	7273.40	ft
Design Headwater Depth (not elev.)	Hw =	1.53	ft
Tailwater Depth (not elev.)	Yt =	0.56	ft
Culvert Hydraulics (Calculated)			
Available Headwater Depth	HW-a =	3.03	ft
Design Hw/D ratio	Hw/D =	0.77	
Culvert Vertical Profile			
Upstream Invert Elevation	EUI =	7270.37	ft
Upstream Crown Elevation	EUC =	7272.37	ft
Upstream Soil Cover Depth	Upsoil =	1.03	ft
Downstream Invert Elevation	EDI =	7269.70	ft
Downstream Crown Elevation	EDC =	7271.70	ft
Downstream Soil Cover Depth	Dnsoil =	1.00	ft

BOX CONDUIT FLOW (Normal & Critical Depth Computation)

Project: Timberridge Estates
Box ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts



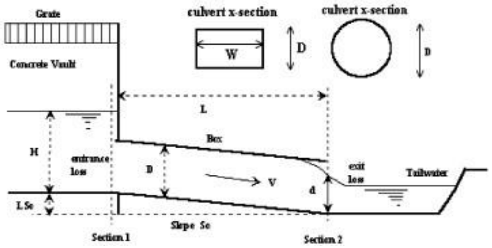
South report shows 6'x16'. See comment letter.

Design Information (Input)			
Box conduit invert slope	So =	0.0100	ft/ft
Box Manning's n-value	n =	0.0130	
Box Width	W =	12.00	ft
Box Height	H =	6.00	ft
Design discharge	**Q =**	**869.00**	**cfs**

Full-flow capacity (Calculated)			
Full-flow area	Af =	72.00	sq ft
Full-flow wetted perimeter	Pf =	36.00	ft
Full-flow capacity	Qf =	1309.97	cfs
Calculations of Normal Flow Condition			
Normal flow depth (<H)	Yn =	3.66	ft
Flow area	An =	43.87	sq ft
Wetted perimeter	Pn =	19.31	ft
Flow velocity	Vn =	19.81	fps
Discharge	Qn =	869.00	cfs
Percent Full	Flow =	66.3%	of full flow
Normal Depth Froude Number	Fr_n =	1.83	supercritical
Calculation of Critical Flow Condition			
Critical flow depth	Yc =	5.46	ft
Critical flow area	Ac =	65.53	sq ft
Critical flow velocity	Vc =	13.26	fps
Critical Depth Froude Number	Fr_c =	1.00	

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

Project: Timberridge Estates
Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches D = inches
Inlet Edge Type (choose from pull-down list) Grooved End Projection
OR:
Box Culvert: Barrel Height (Rise) in Feet Height (Rise) = 6.00 ft.
Barrel Width (Span) in Feet Width (Span) = 12.00 ft.
Inlet Edge Type (choose from pull-down list) Square Edge w/ 90-15 Deg. Headwall

Number of Barrels No = 3
Inlet Elevation at Culvert Invert Inlet Elev = 7233 ft. elev.
Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.) Outlet Elev = 7232 ft. elev.
Culvert Length in Feet L = 100 ft.
Manning's Roughness n = 0.013
Bend Loss Coefficient K_b = 0
Exit Loss Coefficient K_x = 1

Design Information (calculated):

Entrance Loss Coefficient K_e = 0.50
Friction Loss Coefficient K_f = 0.29
Sum of All Loss Coefficients K_s = 1.79
Orifice Inlet Condition Coefficient C_d = 0.82
Minimum Energy Condition Coefficient KE_{low} = 0.4004

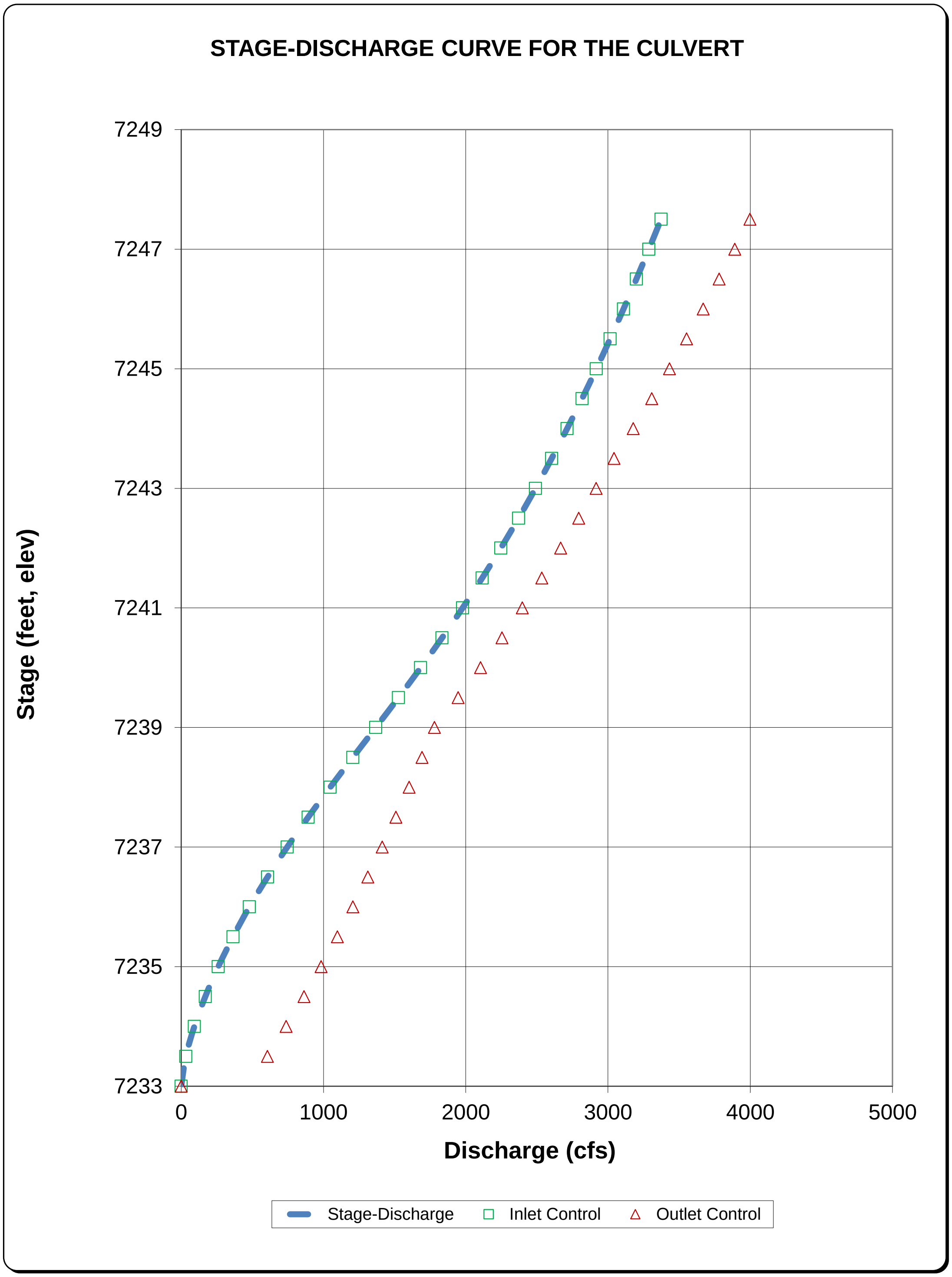
Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
7233.00		0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
7233.50		32.70	605.74	**32.70**	Min. Energy. Eqn.	INLET
7234.00		92.40	737.63	**92.40**	Min. Energy. Eqn.	INLET
7234.50		169.50	863.44	**169.50**	Min. Energy. Eqn.	INLET
7235.00		260.70	983.37	**260.70**	Min. Energy. Eqn.	INLET
7235.50		364.50	1,097.81	**364.50**	Min. Energy. Eqn.	INLET
7236.00		479.10	1,207.17	**479.10**	Min. Energy. Eqn.	INLET
7236.50		607.50	1,312.01	**607.50**	Regression Eqn.	INLET
7237.00		745.50	1,412.54	**745.50**	Regression Eqn.	INLET
7237.50		892.80	1,509.35	**892.80**	Regression Eqn.	INLET
7238.00		1,047.30	1,602.63	**1,047.30**	Regression Eqn.	INLET
7238.50		1,206.60	1,692.77	**1,206.60**	Regression Eqn.	INLET
7239.00		1,367.70	1,780.18	**1,367.70**	Regression Eqn.	INLET
7239.50		1,527.30	1,947.14	**1,527.30**	Regression Eqn.	INLET
7240.00		1,683.30	2,104.90	**1,683.30**	Regression Eqn.	INLET
7240.50		1,833.90	2,255.01	**1,833.90**	Regression Eqn.	INLET
7241.00		1,978.20	2,398.26	**1,978.20**	Regression Eqn.	INLET
7241.50		2,115.60	2,535.44	**2,115.60**	Regression Eqn.	INLET
7242.00		2,246.70	2,667.52	**2,246.70**	Regression Eqn.	INLET
7242.50		2,371.50	2,794.51	**2,371.50**	Regression Eqn.	INLET
7243.00		2,490.60	2,917.38	**2,490.60**	Regression Eqn.	INLET
7243.50		2,604.30	3,042.41	**2,604.30**	Regression Eqn.	INLET
7244.00		2,713.20	3,177.82	**2,713.20**	Regression Eqn.	INLET
7244.50		2,817.90	3,307.55	**2,817.90**	Regression Eqn.	INLET
7245.00		2,918.40	3,432.39	**2,918.40**	Regression Eqn.	INLET
7245.50		3,015.30	3,552.91	**3,015.30**	Regression Eqn.	INLET
7246.00		3,109.20	3,669.31	**3,109.20**	Regression Eqn.	INLET
7246.50		3,199.80	3,782.19	**3,199.80**	Regression Eqn.	INLET
7247.00		3,287.70	3,891.93	**3,287.70**	Regression Eqn.	INLET
7247.50		3,373.20	3,998.54	**3,373.20**	Regression Eqn.	INLET

Processing Time: 00.70 Seconds

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

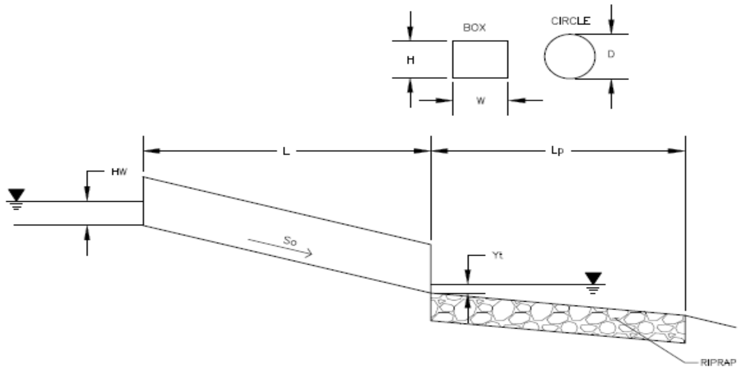
Project: Timberridge Estates
Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts



Determination of Culvert Headwater and Outlet Protection

Project: Timberridge Estates

Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts



Soil Type:

Choose One:
● Sandy
○ Non-Sandy

Supercritical Flow! Using Ha to calculate protection type.

Design Information (Input):

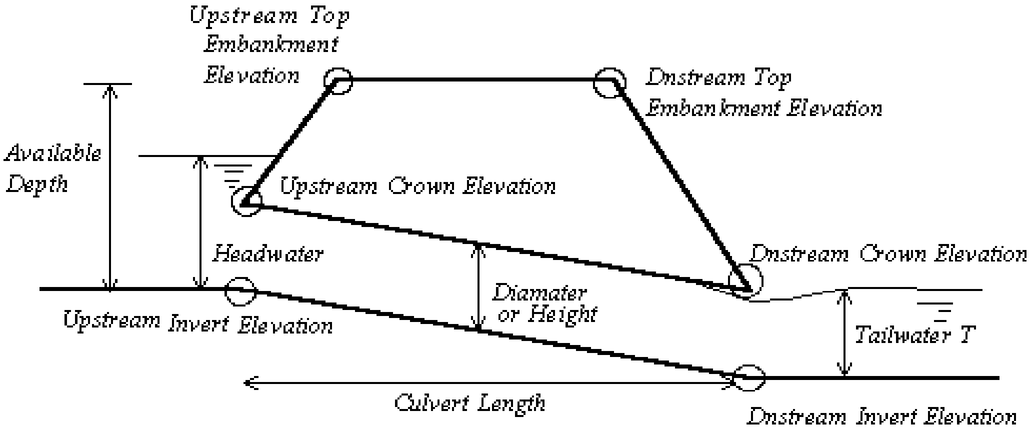
Design Discharge	Q =	2607	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =		inches
Inlet Edge Type (Choose from pull-down list)			
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	Height (Rise) =	6	ft
Barrel Width (Span) in Feet	Width (Span) =	12	ft
Inlet Edge Type (Choose from pull-down list)	Square Edge w/ 90-15 Deg. Headwall		
Number of Barrels	No =	3	
Inlet Elevation	Elev IN =	7233	ft
Outlet Elevation **OR** Slope	Elev OUT =	7232	ft
Culvert Length	L =	100	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	Elev Y_t =		ft
Max Allowable Channel Velocity	V =	5	ft/s

Required Protection (Output):

Tailwater Surface Height	Y_t =	2.40	ft
Flow Area at Max Channel Velocity	A_t =	173.80	ft^2
Culvert Cross Sectional Area Available	A =	72.00	ft^2
Entrance Loss Coefficient	k_e =	0.50	
Friction Loss Coefficient	k_f =	0.29	
Sum of All Losses Coefficients	k_s =	1.79	ft
Culvert Normal Depth	Y_n =	3.66	ft
Culvert Critical Depth	Y_c =	5.46	ft
Tailwater Depth for Design	d =	5.73	ft
Adjusted Diameter **OR** Adjusted Rise	H_a =	4.83	ft
Expansion Factor	1/(2*tan(Θ)) =	2.85	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/WH^1.5 =	4.93	$ft^{0.5}/s$
Froude Number	Fr =	1.83	Supercritical!
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/H =	0.50	
Inlet Control Headwater	HW_I =	10.51	ft
Outlet Control Headwater	HW_O =	8.77	
Design Headwater Elevation	**HW =**	**7,243.51**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/H =**	**1.75**	**HW/H > 1.5!**
Minimum Theoretical Riprap Size	d_{50} =	11	in
Nominal Riprap Size	d_{50} =	12	in
UDFCD Riprap Type	**Type =**	**M**	
Length of Protection	**L_p =**	**60**	**ft**
Width of Protection	**T =**	**34**	**ft**

Vertical Profile for the Culvert

Project = **Timberridge Estates**
Box ID = **Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts**



Culvert Information (Input)

Barrel Diameter or Height	D or H =	72.00	inches
Barrel Length	L =	100.00	ft
Barrel Invert Slope	So =	0.0100	ft/ft
Downstream Invert Elevation	EDI =	7232.00	ft
Downstream Top Embankment Elevation	EDT =	7244.00	ft
Upstream Top Embankment Elevation	EUT =	7244.00	ft
Design Headwater Depth (not elev.)	Hw =	8.70	ft
Tailwater Depth (not elev.)	Yt =	0.52	ft

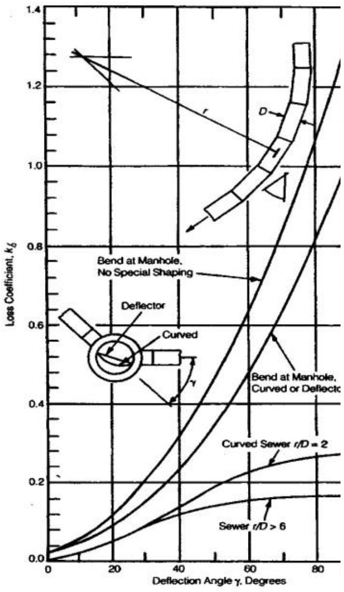
Culvert Hydraulics (Calculated)

Available Headwater Depth	HW-a =	11.00	ft
Design Hw/D ratio	Hw/D =	1.45	

Culvert Vertical Profile

Upstream Invert Elevation	EUI =	7233.00	ft
Upstream Crown Elevation	EUC =	7239.00	ft
Upstream Soil Cover Depth	Upsoil =	5.00	ft
Downstream Invert Elevation	EDI =	7232.00	ft
Downstream Crown Elevation	EDC =	7238.00	ft
Downstream Soil Cover Depth	Dnsoil =	6.00	ft

```
       CIRCULAR (SHAPE = 1) SUMMARY OF SHAPES, MATERIALS, SIZES, & "n"

Matl   SPANS  NO. OF   DEFAULT  DEF. ENTRANCE   INLET     EQUATION    HDS 5
CODE   (in.)  CULVERTS CORRUG.  "n"  (ITYPE)   EDGE (CI)  NUMBER-IC CHT#-SCALE

1-RCP  8-144  29,p96ac         .012  1-Conv   1-sq. proj.      8  (not used)
                                              3-headwall       9        1-1
                                              4-groove         4        1-3
                                              5-groove,hd      5        1-2
                                              6-1:1 bevel      6        3-A
                                              7-1.5 bev.       7        3-B

2-CSP  12-96   17,p49ai 2.7x.5 .024  1-Conv   1-thin           1        2-3
       54-144  16,p50ai 3x1    .028           2-mitered        2        2-2
       54-144  16,p50ai 5x1    .026           3-headwall       3        2-1
       60-312  43,p58ai 6x2    .035           6-1.1 bevel      6        3-A
                                              7-1.5 bevel      7        3-B

3-CAP  12-84   16,p39ka 2.7x.5 .024  1-Conv   (Same as CSP)
       30-120  16,p39ka 3x1    .028
       48-120  13,p39ka 6x1    .025
       60-252  33,p39ka 9x2.5  .035

 ALL   See Inlet Control Procedures  2-Side   1-thin      face, side   56-3
           For Equations               (Cir)  2-square                 56-2
                                              3-bevel                  56-1
                                     3-Side   see box     face, side   58-1/2
                                     4-slope  see box     face, slope  59-1/2
```



Values of Kb

```
ai = AISI, Handbook of Steel Drainage & Highway Construction Products, 1983
ka = Kaiser Aluminum, Hydraulic Design Detail, DP-131, Edition 2, 1984
```

EQ	EDGE	KE	SR	A	BS	C	DIP	EE	F
1	thin	0.9	0.5	0.187321	0.56771	-0.156544	0.0447052	-0.00343602	8.97E-05
2	mitered	0.7	0	0.107137	0.757789	-0.361462	0.1233932	-0.01606422	7.67E-04
3	headwall	0.5	0.5	0.167433	0.538595	-0.149374	0.0391543	-0.00343974	1.16E-04
4	groove	0.2	0.5	0.108786	0.662381	-0.233801	0.0579585	-0.0055789	2.05E-04
5	grv.hdw.	0.2	0.5	0.114099	0.653562	-0.233615	0.0597723	-0.00616338	2.43E-04
6	1.1-bev.	0.2	0.5	0.063343	0.766512	-0.316097	0.0876701	-0.009836951	4.17E-04
7	1.5-bev.	0.2	0.5	0.08173	0.698353	-0.253683	0.065125	-0.0071975	3.12E-04
8	sq.-proj.	0.2	0.5	0.167287	0.558766	-0.159813	0.0420069	-0.00369252	1.25E-04
9	headwall	0.5	0.5	0.087483	0.706578	-0.253295	0.0667001	-0.00661651	2.51E-04
10	end-sect.	0.4	0.5	0.120659	0.630768	-0.218423	0.0591815	-0.00599169	2.29E-04

```
EQ #'s: REFERENCE
  1-9 : Calculator Design Series (CDS) 3 for TI-59, FHWA, 198O, page 60
  1-10: Hydraulic Computer Program (HY) 1, FHWA, 1969, page 18
```

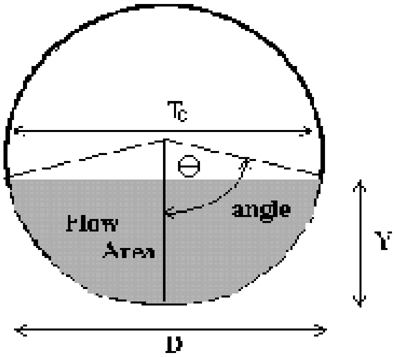
```
       BOX (SHAPE = 2) SUMMARY OF SHAPES, MATERIALS, SIZES, & "n"

Matl   SPAN   RISE    DEF.  ENTRANCE   INLET     EQUATION     HDS 5
CODE   RANGE  RANGE   "n"   (ITYPE)   EDGE (CI)  NUMBER-IC  CHT#-SCALE

1-RCB  4'-15' 4'-20' .012   1-Conv    1-square       1        10-1
                                      2-1.5 bev      2        10-3
                                      3-1.1 bev      3        10-2
                                      4-30-75sq      4         8-1
                                      5-90-15sq      1         8-2
                                      6-0 sq         5         8-3
                                      7-1.5 bev      6         9-2
                                      8-bevel        6         9-1

  All  See Inlet Control    2-Side    1&2-square  face, side  58-1
       Procedures For                 3&4-bevel               58-2
       Equations            4-Slope   1&2-square  face, slope 59-1
                                      3&4-bevel               59-2

ac = ACPA, Concrete Pipe Design Manual, February 1985
```

EQ	EDGE	KE	SR	A	BS	C	DIP	EE	F
1	square	0.5	0.5	0.122117	0.505435	-0.10856	0.0207809	-1.37E-03	3.46E-05
2	1.5-bev.	0.2	0.5	0.0967588	0.4551575	-0.08128951	0.01215577	-6.78E-04	0.0000148
3	1.1-bev.	0.2	0.5	0.1566086	0.3989353	-0.06403921	0.01120135	-0.0006449	1.46E-05
4	sq-30/75	0.4	0.5	0.0724927	0.507087	-0.117474	0.0221702	-1.49E-03	0.000038
5	square	0.7	0.5	0.144133	0.461363	-0.0921507	0.0200028	-1.36E-03	0.0000358
6	bevel	0.2	0.5	0.0895633	0.4412465	-0.07434981	0.01273183	-0.0007588	1.77E-05

```
 EQ #'s: REFERENCE
    1-6: Hydraulic Computer Program (HY) 6, FHWA, 1969, subroutine BEQUA
  1,4,5: Hydraulic Computer Program (HY) 3, FHWA, 1969, page 16
1,3,4,6: Calculator Design Series (CDS) 3 for TI-59, FHWA, 198O, page 16
```

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

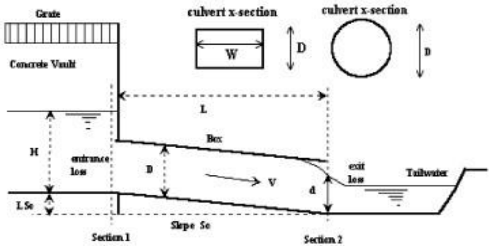
Project: **TIMBERRIDGE ESTATES**
Pipe ID: **Design Point 4 (4.7 cfs) - 24" RCP**



Design Information (Input)			
Pipe Invert Slope	So =	0.0100	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	24.00	inches
Design discharge	**Q =**	**4.70**	**cfs**
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 =	22.68	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.18	radians
Flow area	An =	0.83	sq ft
Top width	Tn =	1.85	ft
Wetted perimeter	Pn =	2.36	ft
Flow depth	Yn =	0.62	ft
Flow velocity	Vn =	5.69	fps
Discharge	Qn =	4.70	cfs
Percent Full Flow	Flow =	20.7%	of full flow
Normal Depth Froude Number	Fr_n =	1.50	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	1.33	radians
Critical flow area	Ac =	1.10	sq ft
Critical top width	Tc =	1.94	ft
Critical flow depth	Yc =	0.76	ft
Critical flow velocity	Vc =	4.27	fps
Critical Depth Froude Number	Fr_c =	1.00	

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

Project: Timberridge Estates
Basin ID: Design Point 4 (4.7 cfs) - 24" RCP
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches D = 24 inches
Inlet Edge Type (choose from pull-down list) Grooved End Projection

OR:

Box Culvert: Barrel Height (Rise) in Feet Height (Rise) = ft.
Barrel Width (Span) in Feet Width (Span) = ft.
Inlet Edge Type (choose from pull-down list) Square Edge w/ 90-15 Deg. Headwall

Number of Barrels No = 1
Inlet Elevation at Culvert Invert Inlet Elev = 7272 ft. elev.
Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.) Outlet Elev = 7271.39 ft. elev.
Culvert Length in Feet L = 61 ft.
Manning's Roughness n = 0.013
Bend Loss Coefficient K_b = 0
Exit Loss Coefficient K_x = 1

Design Information (calculated):

Entrance Loss Coefficient K_e = 0.20
Friction Loss Coefficient K_f = 0.75
Sum of All Loss Coefficients K_s = 1.95
Orifice Inlet Condition Coefficient C_d = 0.95
Minimum Energy Condition Coefficient KE_{low} = -0.0342

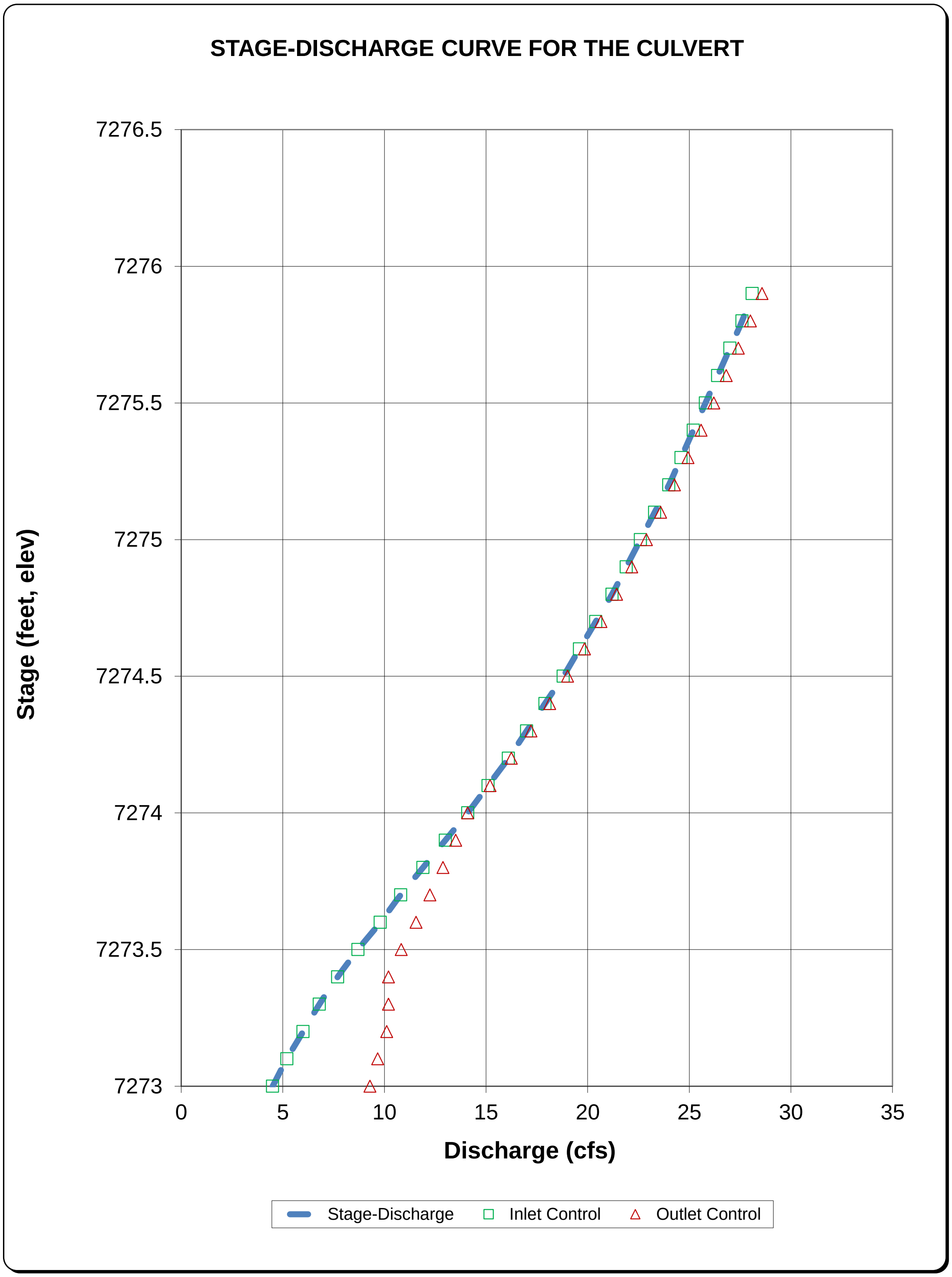
Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
7273.00		4.50	9.29	**4.50**	Min. Energy. Eqn.	INLET
7273.10		5.20	9.67	**5.20**	Regression Eqn.	INLET
7273.20		6.00	10.11	**6.00**	Regression Eqn.	INLET
7273.30		6.80	10.20	**6.80**	Regression Eqn.	INLET
7273.40		7.70	10.20	**7.70**	Regression Eqn.	INLET
7273.50		8.70	10.82	**8.70**	Regression Eqn.	INLET
7273.60		9.80	11.56	**9.80**	Regression Eqn.	INLET
7273.70		10.80	12.24	**10.80**	Regression Eqn.	INLET
7273.80		11.90	12.88	**11.90**	Regression Eqn.	INLET
7273.90		13.00	13.51	**13.00**	Regression Eqn.	INLET
7274.00		14.10	14.09	**14.09**	Regression Eqn.	OUTLET
7274.10		15.10	15.20	**15.10**	Regression Eqn.	INLET
7274.20		16.10	16.24	**16.10**	Regression Eqn.	INLET
7274.30		17.00	17.22	**17.00**	Regression Eqn.	INLET
7274.40		17.90	18.13	**17.90**	Regression Eqn.	INLET
7274.50		18.80	19.01	**18.80**	Regression Eqn.	INLET
7274.60		19.60	19.85	**19.60**	Regression Eqn.	INLET
7274.70		20.40	20.65	**20.40**	Regression Eqn.	INLET
7274.80		21.20	21.42	**21.20**	Regression Eqn.	INLET
7274.90		21.90	22.17	**21.90**	Regression Eqn.	INLET
7275.00		22.60	22.89	**22.60**	Regression Eqn.	INLET
7275.10		23.30	23.60	**23.30**	Regression Eqn.	INLET
7275.20		24.00	24.27	**24.00**	Regression Eqn.	INLET
7275.30		24.60	24.94	**24.60**	Regression Eqn.	INLET
7275.40		25.20	25.59	**25.20**	Regression Eqn.	INLET
7275.50		25.80	26.21	**25.80**	Regression Eqn.	INLET
7275.60		26.40	26.82	**26.40**	Regression Eqn.	INLET
7275.70		27.00	27.42	**27.00**	Regression Eqn.	INLET
7275.80		27.60	28.01	**27.60**	Regression Eqn.	INLET
7275.90		28.10	28.58	**28.10**	Regression Eqn.	INLET

Processing Time: 00.64 Seconds

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

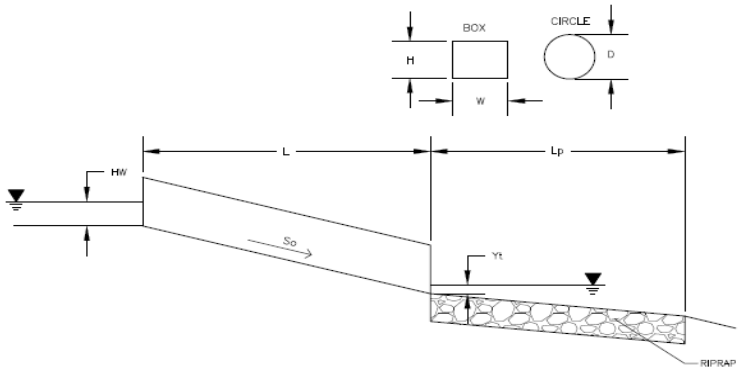
Project: Timberridge Estates
Basin ID: Design Point 4 (4.7 cfs) - 24" RCP



Determination of Culvert Headwater and Outlet Protection

Project: Timberridge Estates

Basin ID: Design Point 4 (4.7 cfs) - 24" RCP



Soil Type:

Choose One:
● Sandy
○ Non-Sandy

Supercritical Flow! Using Da to calculate protection type.

Design Information (Input):

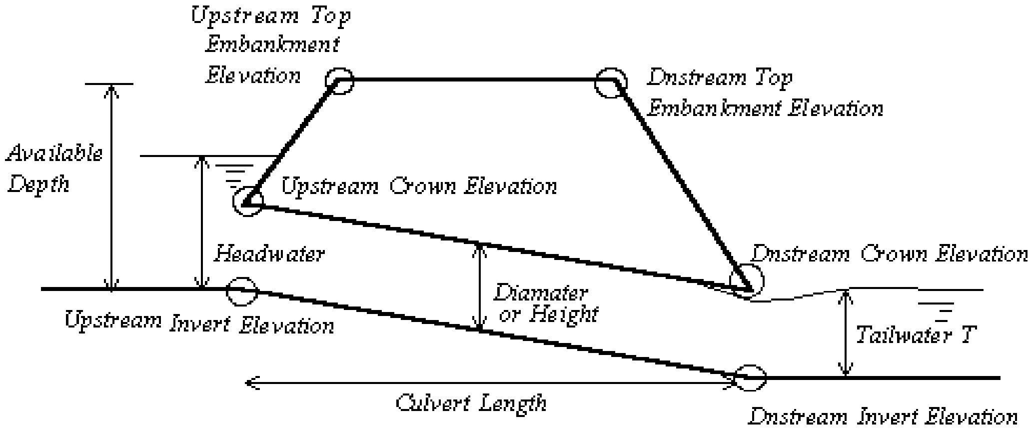
Design Discharge	Q =	4.7	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	24	inches
Inlet Edge Type (Choose from pull-down list)		Grooved End Projection	
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	Height (Rise) =		ft
Barrel Width (Span) in Feet	Width (Span) =		ft
Inlet Edge Type (Choose from pull-down list)			
Number of Barrels	No =	1	
Inlet Elevation	Elev IN =	7272	ft
Outlet Elevation **OR** Slope	Elev OUT =	7271.39	ft
Culvert Length	L =	61	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	Elev Y_t =		ft
Max Allowable Channel Velocity	V =	5	ft/s

Required Protection (Output):

Tailwater Surface Height	Y_t =	0.80	ft
Flow Area at Max Channel Velocity	A_t =	0.94	ft^2
Culvert Cross Sectional Area Available	A =	3.14	ft^2
Entrance Loss Coefficient	k_e =	0.20	
Friction Loss Coefficient	k_f =	0.75	
Sum of All Losses Coefficients	k_s =	1.95	ft
Culvert Normal Depth	Y_n =	0.62	ft
Culvert Critical Depth	Y_c =	0.76	ft
Tailwater Depth for Design	d =	1.38	ft
Adjusted Diameter **OR** Adjusted Rise	D_a =	1.31	ft
Expansion Factor	1/(2*tan(Θ)) =	6.70	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/D^2.5 =	0.83	$ft^{0.5}/s$
Froude Number	Fr =	1.50	**Supercritical!**
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/D =	0.61	
Inlet Control Headwater	HW_I =	1.05	ft
Outlet Control Headwater	HW_O =	0.84	
Design Headwater Elevation	**HW =**	**7,273.05**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**0.52**	
Minimum Theoretical Riprap Size	d_{50} =	2	in
Nominal Riprap Size	d_{50} =	6	in
UDFCD Riprap Type	**Type =**	**VL**	
Length of Protection	**L_p =**	**6**	**ft**
Width of Protection	**T =**	**3**	**ft**

Vertical Profile for the Culvert

Project = **Timberridge Estates**
Box ID = **Design Point 4 (4.7 cfs) - 24" RCP**



Culvert Information (Input)

Barrel Diameter or Height	D or H =	24.00	inches
Barrel Length	L =	61.00	ft
Barrel Invert Slope	So =	0.0100	ft/ft
Downstream Invert Elevation	EDI =	7271.39	ft
Downstream Top Embankment Elevation	EDT =	7275.00	ft
Upstream Top Embankment Elevation	EUT =	7275.00	ft
Design Headwater Depth (not elev.)	Hw =	1.05	ft
Tailwater Depth (not elev.)	Yt =	0.61	ft

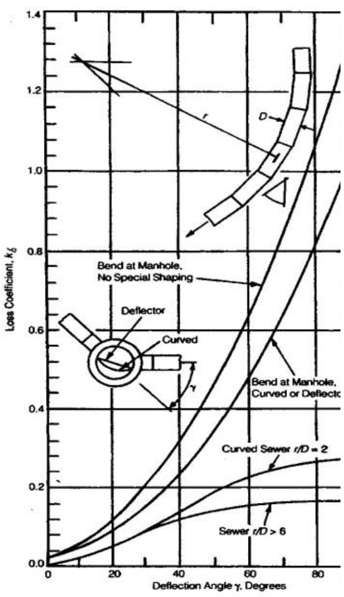
Culvert Hydraulics (Calculated)

Available Headwater Depth	HW-a =	3.00	ft
Design Hw/D ratio	Hw/D =	0.53	

Culvert Vertical Profile

Upstream Invert Elevation	EUI =	7272.00	ft
Upstream Crown Elevation	EUC =	7274.00	ft
Upstream Soil Cover Depth	Upsoil =	1.00	ft
Downstream Invert Elevation	EDI =	7271.39	ft
Downstream Crown Elevation	EDC =	7273.39	ft
Downstream Soil Cover Depth	Dnsoil =	1.61	ft

```
        CIRCULAR (SHAPE = 1) SUMMARY OF SHAPES, MATERIALS, SIZES, & "n"

Matl   SPANS  NO. OF   DEFAULT  DEF. ENTRANCE   INLET     EQUATION    HDS 5
CODE   (in.)  CULVERTS CORRUG.  "n"  (ITYPE)   EDGE (CI)  NUMBER-IC CHT#-SCALE

1-RCP  8-144  29,p96ac         .012  1-Conv   1-sq. proj.     8  (not used)
                                              3-headwall      9        1-1
                                              4-groove        4        1-3
                                              5-groove,hd     5        1-2
                                              6-1:1 bevel     6        3-A
                                              7-1.5 bev.      7        3-B

2-CSP  12-96   17,p49ai 2.7x.5 .024  1-Conv   1-thin          1        2-3
       54-144  16,p50ai 3x1    .028           2-mitered       2        2-2
       54-144  16,p50ai 5x1    .026           3-headwall      3        2-1
       60-312  43,p58ai 6x2    .035           6-1.1 bevel     6        3-A
                                              7-1.5 bevel     7        3-B

3-CAP  12-84   16,p39ka 2.7x.5 .024  1-Conv   (Same as CSP)
       30-120  16,p39ka 3x1    .028
       48-120  13,p39ka 6x1    .025
       60-252  33,p39ka 9x2.5  .035

 ALL   See Inlet Control Procedures  2-Side   1-thin      face, side   56-3
           For Equations               (Cir)  2-square                 56-2
                                              3-bevel                  56-1
                                     3-Side   see box     face, side   58-1/2
                                     4-slope  see box     face, slope  59-1/2

ai = AISI, Handbook of Steel Drainage & Highway Construction Products, 1983
ka = Kaiser Aluminum, Hydraulic Design Detail, DP-131, Edition 2, 1984
```



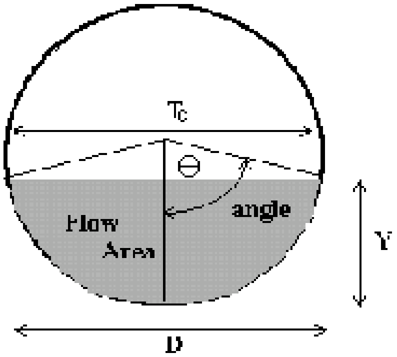
Values of Kb

```
   EQ      EDGE    KE  SR     A         BS          C          DIP          EE          F
    1       thin    0.9 0.5 0.187321   0.56771    -0.156544   0.0447052  -0.00343602  8.97E-05
    2     mitered   0.7  0  0.107137   0.757789   -0.361462   0.1233932  -0.01606422  7.67E-04
    3     headwall  0.5 0.5 0.167433   0.538595   -0.149374   0.0391543  -0.00343974  1.16E-04
    4      groove   0.2 0.5 0.108786   0.662381   -0.233801   0.0579585   -0.0055789   2.05E-04
    5     grv.hdw.  0.2 0.5 0.114099   0.653562   -0.233615   0.0597723  -0.00616338  2.43E-04
    6     1.1-bev.  0.2 0.5 0.063343   0.766512   -0.316097   0.0876701 -0.009836951  4.17E-04
    7     1.5-bev.  0.2 0.5  0.08173   0.698353   -0.253683    0.065125   -0.0071975   3.12E-04
    8    sq.-proj.  0.2 0.5 0.167287   0.558766   -0.159813   0.0420069  -0.00369252  1.25E-04
    9     headwall  0.5 0.5 0.087483   0.706578   -0.253295   0.0667001  -0.00661651  2.51E-04
   10    end-sect.  0.4 0.5 0.120659   0.630768   -0.218423   0.0591815  -0.00599169  2.29E-04

EQ #'s: REFERENCE
  1-9 : Calculator Design Series (CDS) 3 for TI-59, FHWA, 198O, page 60
  1-10: Hydraulic Computer Program (HY) 1, FHWA, 1969, page 18
```

```
       BOX (SHAPE = 2) SUMMARY OF SHAPES, MATERIALS, SIZES, & "n"

Matl   SPAN   RISE    DEF.  ENTRANCE   INLET     EQUATION     HDS 5
CODE   RANGE  RANGE   "n"   (ITYPE)   EDGE (CI)  NUMBER-IC  CHT#-SCALE

1-RCB  4'-15' 4'-20' .012   1-Conv    1-square       1        10-1
                                      2-1.5 bev      2        10-3
                                      3-1.1 bev      3        10-2
                                      4-30-75sq      4         8-1
                                      5-90-15sq      1         8-2
                                      6-0 sq         5         8-3
                                      7-1.5 bev      6         9-2
                                      8-bevel        6         9-1

  All  See Inlet Control    2-Side    1&2-square  face, side  58-1
       Procedures For                 3&4-bevel               58-2
       Equations            4-Slope   1&2-square  face, slope 59-1
                                      3&4-bevel               59-2

ac = ACPA, Concrete Pipe Design Manual, February 1985
   EQ      EDGE    KE  SR     A         BS          C          DIP          EE          F
    1      square   0.5 0.5  0.122117  0.505435    -0.10856    0.0207809    -1.37E-03    3.46E-05
    2     1.5-bev.  0.2 0.5 0.0967588 0.4551575 -0.08128951  0.01215577    -6.78E-04   0.0000148
    3     1.1-bev.  0.2 0.5 0.1566086 0.3989353 -0.06403921  0.01120135   -0.0006449    1.46E-05
    4     sq-30/75  0.4 0.5 0.0724927  0.507087   -0.117474    0.0221702    -1.49E-03    0.000038
    5      square   0.7 0.5  0.144133  0.461363   -0.0921507   0.0200028    -1.36E-03   0.0000358
    6      bevel    0.2 0.5 0.0895633 0.4412465 -0.07434981  0.01273183   -0.0007588    1.77E-05

 EQ #'s: REFERENCE
    1-6: Hydraulic Computer Program (HY) 6, FHWA, 1969, subroutine BEQUA
  1,4,5: Hydraulic Computer Program (HY) 3, FHWA, 1969, page 16
1,3,4,6: Calculator Design Series (CDS) 3 for TI-59, FHWA, 198O, page 16
```

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

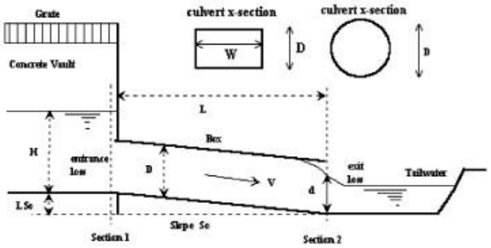
Project: TIMBERRIDGE ESTATES
Pipe ID: Detention Basin Outlet (50.1 cfs) - 30" RCP



Design Information (Input)			
Pipe Invert Slope	So =	0.0180	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	30.00	inches
Design discharge	**Q =**	**50.10**	**cfs**
Full-flow Capacity (Calculated)			
Full-flow area	Af =	4.91	sq ft
Full-flow wetted perimeter	Pf =	7.85	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	55.18	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	2.09	radians
Flow area	An =	3.93	sq ft
Top width	Tn =	2.17	ft
Wetted perimeter	Pn =	5.22	ft
Flow depth	Yn =	1.87	ft
Flow velocity	Vn =	12.73	fps
Discharge	Qn =	50.10	cfs
Percent Full Flow	Flow =	90.8%	of full flow
Normal Depth Froude Number	Fr_n =	1.67	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.57	radians
Critical flow area	Ac =	4.73	sq ft
Critical top width	Tc =	1.35	ft
Critical flow depth	Yc =	2.30	ft
Critical flow velocity	Vc =	10.60	fps
Critical Depth Froude Number	Fr_c =	1.00	

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

Project: Timberridge Estates
Basin ID: Detention Basin Outlet (50.1 cfs) - 30" RCP
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches D = 30 inches
Inlet Edge Type (choose from pull-down list) Grooved End Projection

OR:

Box Culvert: Barrel Height (Rise) in Feet Height (Rise) = ft.
Barrel Width (Span) in Feet Width (Span) = ft.
Inlet Edge Type (choose from pull-down list) Square Edge w/ 90-15 Deg. Headwall

Number of Barrels No = 1
Inlet Elevation at Culvert Invert Inlet Elev = 7246.5 ft. elev.
Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.) Outlet Elev = 7243.9 ft. elev.
Culvert Length in Feet L = 145 ft.
Manning's Roughness n = 0.013
Bend Loss Coefficient K_b = 0
Exit Loss Coefficient K_x = 1

Design Information (calculated):

Entrance Loss Coefficient K_e = 0.20
Friction Loss Coefficient K_f = 1.33
Sum of All Loss Coefficients K_s = 2.53
Orifice Inlet Condition Coefficient C_d = 0.95
Minimum Energy Condition Coefficient KE_{low} = -0.0628

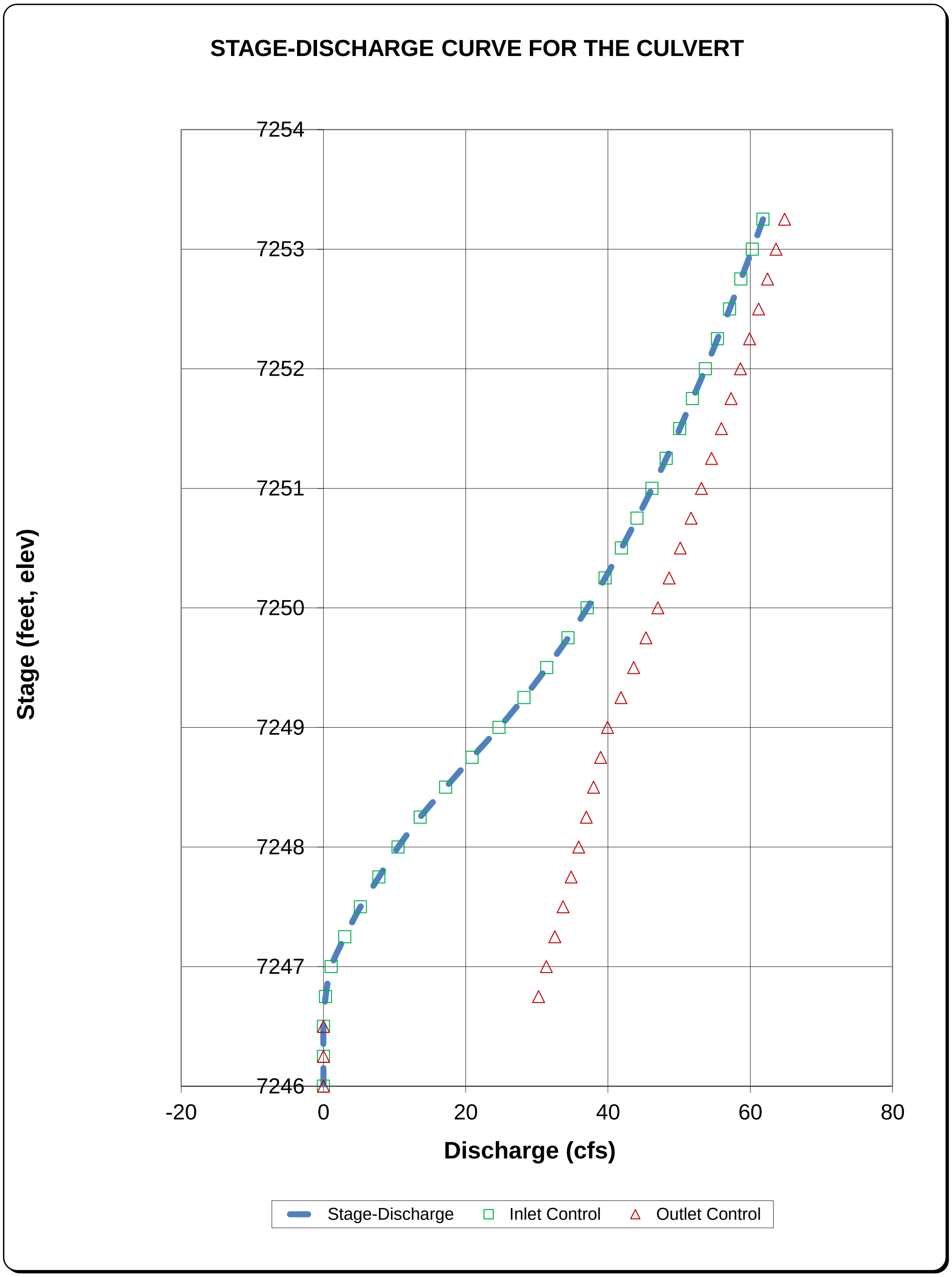
Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
7246.00		0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
7246.25		0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
7246.50		0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
7246.75		0.30	30.24	**0.30**	Min. Energy. Eqn.	INLET
7247.00		1.10	31.33	**1.10**	Min. Energy. Eqn.	INLET
7247.25		3.00	32.54	**3.00**	Min. Energy. Eqn.	INLET
7247.50		5.20	33.70	**5.20**	Min. Energy. Eqn.	INLET
7247.75		7.80	34.82	**7.80**	Min. Energy. Eqn.	INLET
7248.00		10.50	35.89	**10.50**	Regression Eqn.	INLET
7248.25		13.60	36.96	**13.60**	Regression Eqn.	INLET
7248.50		17.20	37.98	**17.20**	Regression Eqn.	INLET
7248.75		20.90	38.97	**20.90**	Regression Eqn.	INLET
7249.00		24.70	39.96	**24.70**	Regression Eqn.	INLET
7249.25		28.20	41.83	**28.20**	Regression Eqn.	INLET
7249.50		31.40	43.61	**31.40**	Regression Eqn.	INLET
7249.75		34.40	45.34	**34.40**	Regression Eqn.	INLET
7250.00		37.10	47.02	**37.10**	Regression Eqn.	INLET
7250.25		39.60	48.61	**39.60**	Regression Eqn.	INLET
7250.50		41.90	50.17	**41.90**	Regression Eqn.	INLET
7250.75		44.10	51.68	**44.10**	Regression Eqn.	INLET
7251.00		46.20	53.14	**46.20**	Regression Eqn.	INLET
7251.25		48.20	54.57	**48.20**	Regression Eqn.	INLET
7251.50		50.10	55.94	**50.10**	Regression Eqn.	INLET
7251.75		51.90	57.31	**51.90**	Regression Eqn.	INLET
7252.00		53.70	58.63	**53.70**	Regression Eqn.	INLET
7252.25		55.40	59.92	**55.40**	Regression Eqn.	INLET
7252.50		57.10	61.19	**57.10**	Regression Eqn.	INLET
7252.75		58.70	62.42	**58.70**	Regression Eqn.	INLET
7253.00		60.30	63.63	**60.30**	Regression Eqn.	INLET
7253.25		61.80	64.84	**61.80**	Regression Eqn.	INLET

Processing Time: 00.71 Seconds

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

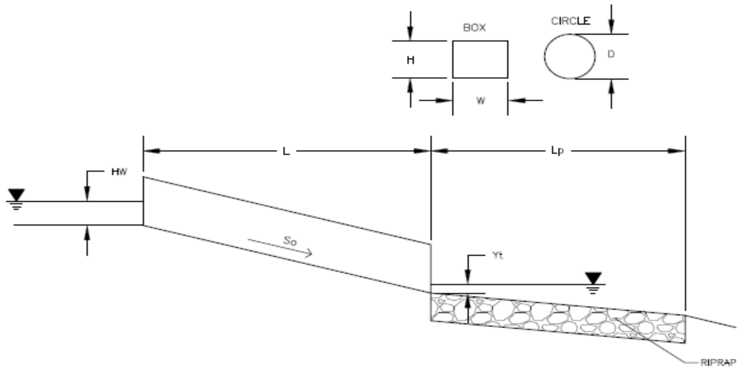
Project: Timberridge Estates
Basin ID: Detention Basin Outlet (50.1 cfs) - 30" RCP



Determination of Culvert Headwater and Outlet Protection

Project: Timberridge Estates

Basin ID: Detention Basin Outlet (50.1 cfs) - 30" RCP



Soil Type:

Choose One:
● Sandy
○ Non-Sandy

Supercritical Flow! Using Da to calculate protection type.

Design Information (Input):

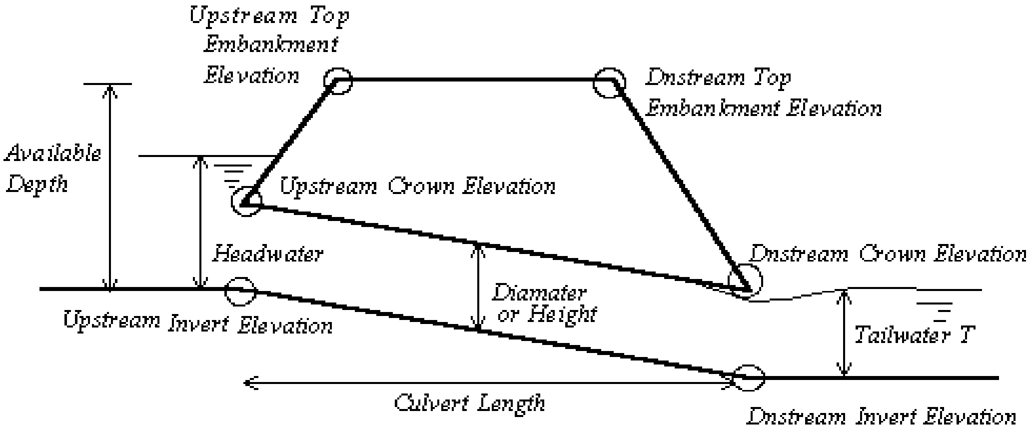
Design Discharge	Q =	50.1	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	30	inches
Inlet Edge Type (Choose from pull-down list)	Grooved End Projection		
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	Height (Rise) =		ft
Barrel Width (Span) in Feet	Width (Span) =		ft
Inlet Edge Type (Choose from pull-down list)			
Number of Barrels	No =	1	
Inlet Elevation	Elev IN =	7246.5	ft
Outlet Elevation **OR** Slope	Elev OUT =	7243.9	ft
Culvert Length	L =	145	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	Elev Y_t =		ft
Max Allowable Channel Velocity	V =	5	ft/s

Required Protection (Output):

Tailwater Surface Height	Y_t =	1.00	ft
Flow Area at Max Channel Velocity	A_t =	10.02	ft^2
Culvert Cross Sectional Area Available	A =	4.91	ft^2
Entrance Loss Coefficient	k_e =	0.20	
Friction Loss Coefficient	k_f =	1.33	
Sum of All Losses Coefficients	k_s =	2.53	ft
Culvert Normal Depth	Y_n =	1.87	ft
Culvert Critical Depth	Y_c =	2.30	ft
Tailwater Depth for Design	d =	2.40	ft
Adjusted Diameter **OR** Adjusted Rise	D_a =	2.19	ft
Expansion Factor	1/(2*tan(Θ)) =	2.93	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/D^2.5 =	5.07	ft$^{0.5}$/s
Froude Number	Fr =	1.66	**Supercritical!**
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/D =	0.46	
Inlet Control Headwater	HW_I =	5.01	ft
Outlet Control Headwater	HW_O =	3.89	
Design Headwater Elevation	**HW =**	**7,251.51**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**2.00**	**HW/D > 1.5!**
Minimum Theoretical Riprap Size	d_{50} =	11	in
Nominal Riprap Size	d_{50} =	12	in
UDFCD Riprap Type	**Type =**	**M**	
Length of Protection	**L_p =**	**23**	**ft**
Width of Protection	**T =**	**11**	**ft**

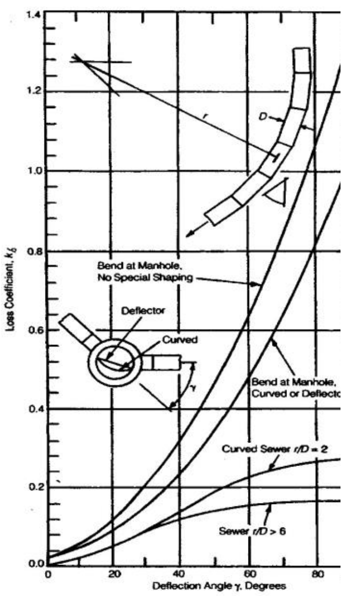
Vertical Profile for the Culvert

Project = **Timberridge Estates**
Box ID = **Detention Basin Outlet (50.1 cfs) - 30" RCP**



Culvert Information (Input)			
Barrel Diameter or Height	D or H =	30.00	inches
Barrel Length	L =	145.00	ft
Barrel Invert Slope	So =	0.0180	ft/ft
Downstream Invert Elevation	EDI =	7243.90	ft
Downstream Top Embankment Elevation	EDT =	7244.00	ft
Upstream Top Embankment Elevation	EUT =	7252.30	ft
Design Headwater Depth (not elev.)	Hw =	5.01	ft
Tailwater Depth (not elev.)	Yt =	0.46	ft
Culvert Hydraulics (Calculated)			
Available Headwater Depth	HW-a =	5.79	ft
Design Hw/D ratio	Hw/D =	2.00	
Culvert Vertical Profile			
Upstream Invert Elevation	EUI =	7246.51	ft
Upstream Crown Elevation	EUC =	7249.01	ft
Upstream Soil Cover Depth	Upsoil =	3.29	ft
Downstream Invert Elevation	EDI =	7243.90	ft
Downstream Crown Elevation	EDC =	7246.40	ft
Downstream Soil Cover Depth	Dnsoil =	-2.40	ft

```
       CIRCULAR (SHAPE = 1) SUMMARY OF SHAPES, MATERIALS, SIZES, & "n"

Matl   SPANS  NO. OF   DEFAULT  DEF. ENTRANCE   INLET     EQUATION    HDS 5
CODE   (in.)  CULVERTS CORRUG.  "n"  (ITYPE)   EDGE (CI)  NUMBER-IC CHT#-SCALE

1-RCP  8-144  29,p96ac         .012  1-Conv   1-sq. proj.     8  (not used)
                                              3-headwall      9        1-1
                                              4-groove        4        1-3
                                              5-groove,hd     5        1-2
                                              6-1:1 bevel     6        3-A
                                              7-1.5 bev.      7        3-B

2-CSP  12-96   17,p49ai 2.7x.5 .024  1-Conv   1-thin          1        2-3
       54-144  16,p50ai 3x1    .028           2-mitered       2        2-2
       54-144  16,p50ai 5x1    .026           3-headwall      3        2-1
       60-312  43,p58ai 6x2    .035           6-1.1 bevel     6        3-A
                                              7-1.5 bevel     7        3-B

3-CAP  12-84   16,p39ka 2.7x.5 .024  1-Conv   (Same as CSP)
       30-120  16,p39ka 3x1    .028
       48-120  13,p39ka 6x1    .025
       60-252  33,p39ka 9x2.5  .035

 ALL   See Inlet Control Procedures  2-Side   1-thin      face, side   56-3
           For Equations               (Cir)  2-square                 56-2
                                              3-bevel                  56-1
                                     3-Side   see box     face, side   58-1/2
                                     4-slope  see box     face, slope  59-1/2

ai = AISI, Handbook of Steel Drainage & Highway Construction Products, 1983
ka = Kaiser Aluminum, Hydraulic Design Detail, DP-131, Edition 2, 1984
```



Values of Kb

EQ	EDGE	KE	SR	A	BS	C	DIP	EE	F
1	thin	0.9	0.5	0.187321	0.56771	-0.156544	0.0447052	-0.00343602	8.97E-05
2	mitered	0.7	0	0.107137	0.757789	-0.361462	0.1233932	-0.01606422	7.67E-04
3	headwall	0.5	0.5	0.167433	0.538595	-0.149374	0.0391543	-0.00343974	1.16E-04
4	groove	0.2	0.5	0.108786	0.662381	-0.233801	0.0579585	-0.0055789	2.05E-04
5	grv.hdw.	0.2	0.5	0.114099	0.653562	-0.233615	0.0597723	-0.00616338	2.43E-04
6	1.1-bev.	0.2	0.5	0.063343	0.766512	-0.316097	0.0876701	-0.009836951	4.17E-04
7	1.5-bev.	0.2	0.5	0.08173	0.698353	-0.253683	0.065125	-0.0071975	3.12E-04
8	sq.-proj.	0.2	0.5	0.167287	0.558766	-0.159813	0.0420069	-0.00369252	1.25E-04
9	headwall	0.5	0.5	0.087483	0.706578	-0.253295	0.0667001	-0.00661651	2.51E-04
10	end-sect.	0.4	0.5	0.120659	0.630768	-0.218423	0.0591815	-0.00599169	2.29E-04

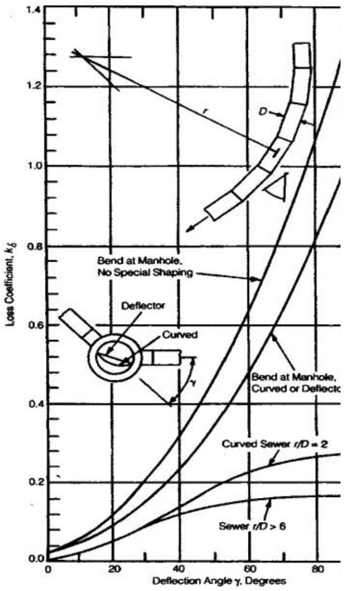
```
EQ #'s: REFERENCE
  1-9 : Calculator Design Series (CDS) 3 for TI-59, FHWA, 198O, page 60
  1-10: Hydraulic Computer Program (HY) 1, FHWA, 1969, page 18
```

```
      BOX (SHAPE = 2) SUMMARY OF SHAPES, MATERIALS, SIZES, & "n"

Matl   SPAN   RISE    DEF.  ENTRANCE   INLET     EQUATION     HDS 5
CODE   RANGE  RANGE   "n"   (ITYPE)   EDGE (CI)  NUMBER-IC  CHT#-SCALE

1-RCB  4'-15' 4'-20' .012   1-Conv    1-square       1        10-1
                                      2-1.5 bev      2        10-3
                                      3-1.1 bev      3        10-2
                                      4-30-75sq      4         8-1
                                      5-90-15sq      1         8-2
                                      6-0 sq         5         8-3
                                      7-1.5 bev      6         9-2
                                      8-bevel        6         9-1

  All  See Inlet Control    2-Side    1&2-square  face, side  58-1
       Procedures For                 3&4-bevel               58-2
       Equations            4-Slope   1&2-square  face, slope 59-1
                                      3&4-bevel               59-2

ac = ACPA, Concrete Pipe Design Manual, February 1985
```

EQ	EDGE	KE	SR	A	BS	C	DIP	EE	F
1	square	0.5	0.5	0.122117	0.505435	-0.10856	0.0207809	-1.37E-03	3.46E-05
2	1.5-bev.	0.2	0.5	0.0967588	0.4551575	-0.08128951	0.01215577	-6.78E-04	0.0000148
3	1.1-bev.	0.2	0.5	0.1566086	0.3989353	-0.06403921	0.01120135	-0.0006449	1.46E-05
4	sq-30/75	0.4	0.5	0.0724927	0.507087	-0.117474	0.0221702	-1.49E-03	0.000038
5	square	0.7	0.5	0.144133	0.461363	-0.0921507	0.0200028	-1.36E-03	0.0000358
6	bevel	0.2	0.5	0.0895633	0.4412465	-0.07434981	0.01273183	-0.0007588	1.77E-05

```
 EQ #'s: REFERENCE
    1-6: Hydraulic Computer Program (HY) 6, FHWA, 1969, subroutine BEQUA
  1,4,5: Hydraulic Computer Program (HY) 3, FHWA, 1969, page 16
1,3,4,6: Calculator Design Series (CDS) 3 for TI-59, FHWA, 198O, page 16
```

```
       CIRCULAR (SHAPE = 1) SUMMARY OF SHAPES, MATERIALS, SIZES, & "n"

Matl   SPANS  NO. OF   DEFAULT  DEF. ENTRANCE   INLET     EQUATION    HDS 5
CODE   (in.)  CULVERTS CORRUG.  "n"  (ITYPE)   EDGE (CI)  NUMBER-IC CHT#-SCALE

1-RCP  8-144  29,p96ac         .012  1-Conv   1-sq. proj.      8  (not used)
                                              3-headwall       9        1-1
                                              4-groove         4        1-3
                                              5-groove,hd      5        1-2
                                              6-1:1 bevel      6        3-A
                                              7-1.5 bev.       7        3-B

2-CSP  12-96   17,p49ai 2.7x.5 .024  1-Conv   1-thin           1        2-3
       54-144  16,p50ai 3x1    .028           2-mitered        2        2-2
       54-144  16,p50ai 5x1    .026           3-headwall       3        2-1
       60-312  43,p58ai 6x2    .035           6-1.1 bevel      6        3-A
                                              7-1.5 bevel      7        3-B

3-CAP  12-84   16,p39ka 2.7x.5 .024  1-Conv   (Same as CSP)
       30-120  16,p39ka 3x1    .028
       48-120  13,p39ka 6x1    .025
       60-252  33,p39ka 9x2.5  .035

 ALL   See Inlet Control Procedures  2-Side   1-thin      face, side   56-3
           For Equations               (Cir)  2-square                 56-2
                                              3-bevel                  56-1
                                     3-Side   see box     face, side   58-1/2
                                     4-slope  see box     face, slope  59-1/2

ai = AISI, Handbook of Steel Drainage & Highway Construction Products, 1983
ka = Kaiser Aluminum, Hydraulic Design Detail, DP-131, Edition 2, 1984
```



Values of Kb

EQ	EDGE	KE	SR	A	BS	C	DIP	EE	F
1	thin	0.9	0.5	0.187321	0.56771	-0.156544	0.0447052	-0.00343602	8.97E-05
2	mitered	0.7	0	0.107137	0.757789	-0.361462	0.1233932	-0.01606422	7.67E-04
3	headwall	0.5	0.5	0.167433	0.538595	-0.149374	0.0391543	-0.00343974	1.16E-04
4	groove	0.2	0.5	0.108786	0.662381	-0.233801	0.0579585	-0.0055789	2.05E-04
5	grv.hdw.	0.2	0.5	0.114099	0.653562	-0.233615	0.0597723	-0.00616338	2.43E-04
6	1.1-bev.	0.2	0.5	0.063343	0.766512	-0.316097	0.0876701	-0.009836951	4.17E-04
7	1.5-bev.	0.2	0.5	0.08173	0.698353	-0.253683	0.065125	-0.0071975	3.12E-04
8	sq.-proj.	0.2	0.5	0.167287	0.558766	-0.159813	0.0420069	-0.00369252	1.25E-04
9	headwall	0.5	0.5	0.087483	0.706578	-0.253295	0.0667001	-0.00661651	2.51E-04
10	end-sect.	0.4	0.5	0.120659	0.630768	-0.218423	0.0591815	-0.00599169	2.29E-04

```
EQ #'s: REFERENCE
  1-9 : Calculator Design Series (CDS) 3 for TI-59, FHWA, 198O, page 60
  1-10: Hydraulic Computer Program (HY) 1, FHWA, 1969, page 18
```

```
      BOX (SHAPE = 2) SUMMARY OF SHAPES, MATERIALS, SIZES, & "n"

Matl   SPAN   RISE    DEF.  ENTRANCE   INLET     EQUATION     HDS 5
CODE   RANGE  RANGE   "n"   (ITYPE)   EDGE (CI)  NUMBER-IC  CHT#-SCALE

1-RCB  4'-15' 4'-20' .012   1-Conv    1-square       1        10-1
                                      2-1.5 bev      2        10-3
                                      3-1.1 bev      3        10-2
                                      4-30-75sq      4         8-1
                                      5-90-15sq      1         8-2
                                      6-0 sq         5         8-3
                                      7-1.5 bev      6         9-2
                                      8-bevel        6         9-1

  All  See Inlet Control    2-Side    1&2-square  face, side  58-1
       Procedures For                 3&4-bevel               58-2
       Equations            4-Slope   1&2-square  face, slope 59-1
                                      3&4-bevel               59-2

ac = ACPA, Concrete Pipe Design Manual, February 1985
```

EQ	EDGE	KE	SR	A	BS	C	DIP	EE	F
1	square	0.5	0.5	0.122117	0.505435	-0.10856	0.0207809	-1.37E-03	3.46E-05
2	1.5-bev.	0.2	0.5	0.0967588	0.4551575	-0.08128951	0.01215577	-6.78E-04	0.0000148
3	1.1-bev.	0.2	0.5	0.1566086	0.3989353	-0.06403921	0.01120135	-0.0006449	1.46E-05
4	sq-30/75	0.4	0.5	0.0724927	0.507087	-0.117474	0.0221702	-1.49E-03	0.000038
5	square	0.7	0.5	0.144133	0.461363	-0.0921507	0.0200028	-1.36E-03	0.0000358
6	bevel	0.2	0.5	0.0895633	0.4412465	-0.07434981	0.01273183	-0.0007588	1.77E-05

```
 EQ #'s: REFERENCE
    1-6: Hydraulic Computer Program (HY) 6, FHWA, 1969, subroutine BEQUA
  1,4,5: Hydraulic Computer Program (HY) 3, FHWA, 1969, page 16
1,3,4,6: Calculator Design Series (CDS) 3 for TI-59, FHWA, 198O, page 16
```

TIMBERRIDGE ESTATES
NORTHEAST AND SOUTHWEST FORBAY WALL NOTCH

Wall Notch

Notch to releae 3% of the undetained 100-year peak discharge

100-y peak discharge = 82.161 cfs
2% = 1.64 cfs

The general form of the equation for horizontal crested weirs is Q = CLH3/2 where:

Q = Weir flow discharge (cfs)	**1.64**	
C = Weir flow coefficient	3.4	
H = Depth of flow over the weir (ft)	1.00	Opening Height
L = Length of the weir (ft)	**0.48**	Length
L = Length of the weir (in)	**6**	

Notch to releae 2% of the undetained 100-year peak discharge is 6" wide by 12" high

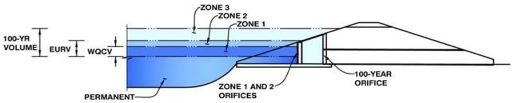
DETENTION CALCULATIONS

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: TIMBERRIDGE ESTATES

Basin ID: ONSITE CALCULATIONS FOR WATER QULAITY CAPTURE VOLUME ONLY



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	46.70	acres		
Watershed Length =	2,040	ft		
Watershed Slope =	0.020	ft/ft		
Watershed Imperviousness =	5.69%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	100.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.158	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.239	acre-feet		
2-yr Runoff Volume (P1 = 1.19 in.) =	0.155	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.253	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.785	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	2.577	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	3.686	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	5.134	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3 in.) =	7.573	acre-feet	3.00	inches
Approximate 2-yr Detention Volume =	0.144	acre-feet		
Approximate 5-yr Detention Volume =	0.237	acre-feet		
Approximate 10-yr Detention Volume =	0.653	acre-feet		
Approximate 25-yr Detention Volume =	0.984	acre-feet		
Approximate 50-yr Detention Volume =	1.007	acre-feet		
Approximate 100-yr Detention Volume =	1.339	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.158	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.080	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	1.100	acre-feet
Total Detention Basin Volume =	1.339	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 = 1 ft

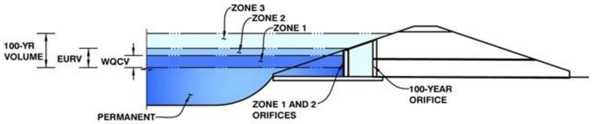
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	405	0.009		
	--	0.33	--	--	--	521	0.012	148	0.003
	--	1.00	--	--	--	6,408	0.147	2,410	0.055
	--	3.00	--	--	--	15,296	0.351	24,178	0.555
	--	5.00	--	--	--	19,725	0.453	59,199	1.359
	--	7.00	--	--	--	23,887	0.548	103,657	2.380
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				
	--		--	--	--				

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: TIMBERRIDGE ESTATES

Basin ID: ONSITE CALCULATIONS FOR WATER QULAITY CAPTURE VOLUME ONLY



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.58	0.158	Orifice Plate
Zone 2 (EURV)	1.94	0.080	Orifice Plate
Zone 3 (100-year)	4.96	1.100	Weir&Pipe (Restrict)
		1.339	Total

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 Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	1.94	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	7.76	inches
Orifice Plate: Orifice Area per Row =	0.81	sq. inches (diameter = 1 inch)

Calculated Parameters for Plate

WQ Orifice Area per Row =	5.625E-03	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

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	0.50	1.00					
Orifice Area (sq. inches)	0.81	0.81	0.81					

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

User Input: Vertical Orifice (Circular or Rectangular)

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

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

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

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	1.94	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	4.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	4.00	N/A	feet
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	1.94	N/A	feet
Over Flow Weir Slope Length =	4.00	N/A	feet
Grate Open Area / 100-yr Orifice Area =	2.28	N/A	should be $\geq$ 4
Overflow Grate Open Area w/o Debris =	11.20	N/A	ft^2
Overflow Grate Open Area w/ Debris =	5.60	N/A	ft^2

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

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.50	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	30.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	30.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	4.91	N/A	ft^2
Outlet Orifice Centroid =	1.25	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	3.14	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	5.30	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	40.00	feet
Spillway End Slopes =	8.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.70	feet
Stage at Top of Freeboard =	7.00	feet
Basin Area at Top of Freeboard =	0.57	acres

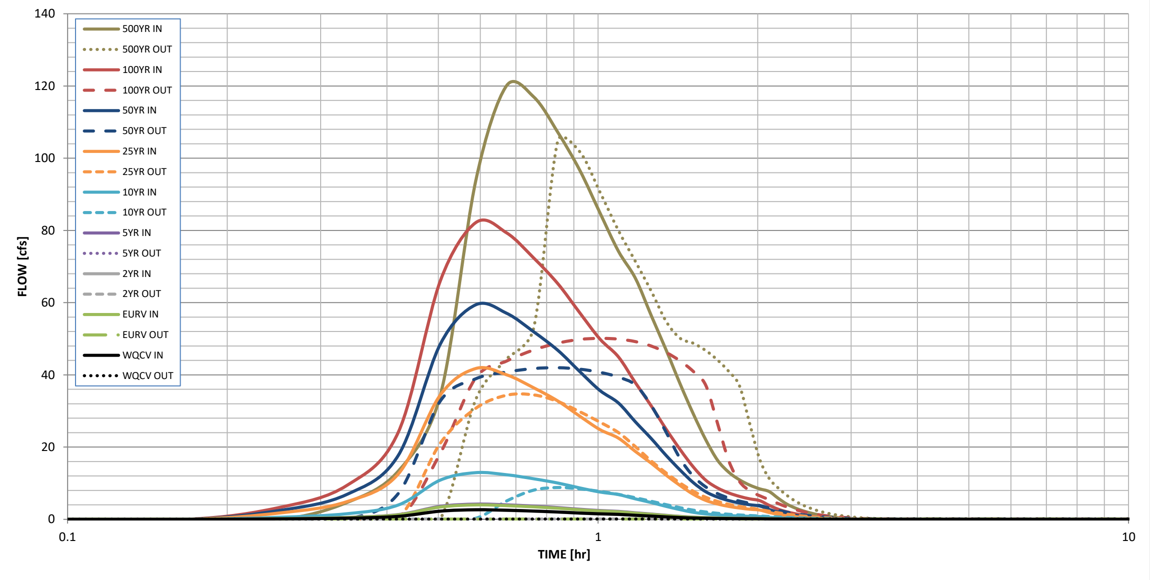
Routed Hydrograph Results

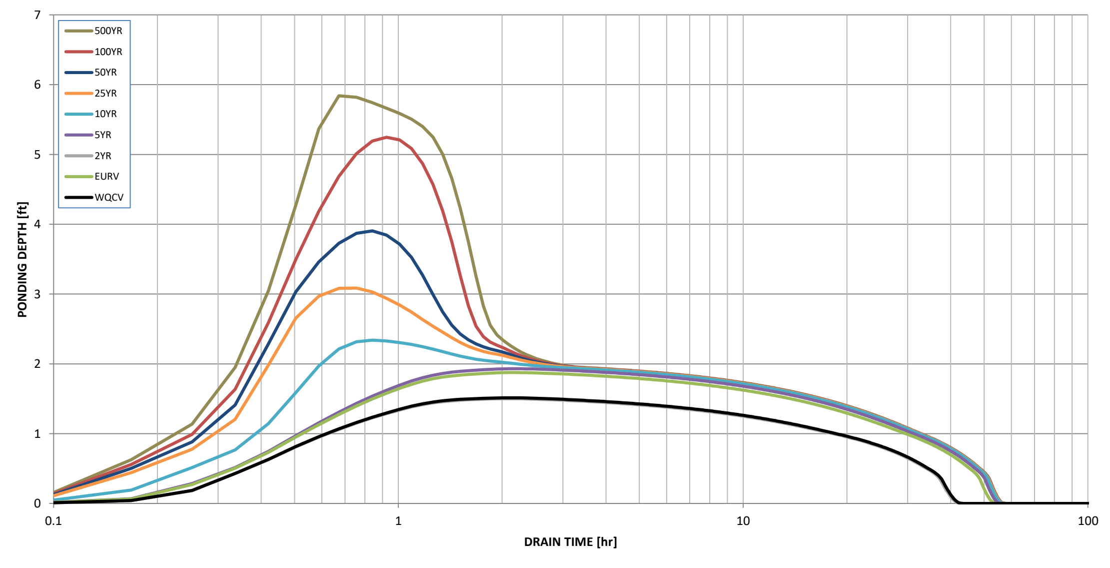
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.00
Calculated Runoff Volume (acre-ft) =	0.158	0.239	0.155	0.253	0.785	2.577	3.686	5.134	7.573
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.158	0.239	0.155	0.252	0.786	2.578	3.687	5.134	7.576
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.02	0.20	0.66	0.91	1.23	1.73
Predevelopment Peak Q (cfs) =	0.0	0.0	0.6	1.0	9.3	30.8	42.6	57.3	80.9
Peak Inflow Q (cfs) =	2.6	4.0	2.6	4.2	12.9	41.8	59.4	82.2	120.1
Peak Outflow Q (cfs) =	0.1	0.1	0.1	0.1	8.8	34.5	42.0	50.1	104.9
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.1	0.9	1.1	1.0	0.9	1.3
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.8	3.1	3.7	4.5	4.7
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) =	37	46	37	48	42	28	22	15	5
Time to Drain 99% of Inflow Volume (hours) =	**40**	50	39	51	49	42	38	34	29
Maximum Ponding Depth (ft) =	1.51	1.88	1.50	1.93	2.34	3.09	3.90	5.25	5.84
Area at Maximum Ponding Depth (acres) =	0.20	0.24	0.20	0.24	0.28	0.36	0.40	0.47	0.50
Maximum Volume Stored (acre-ft) =	0.145	0.223	0.143	0.238	0.343	0.583	0.892	1.469	1.755

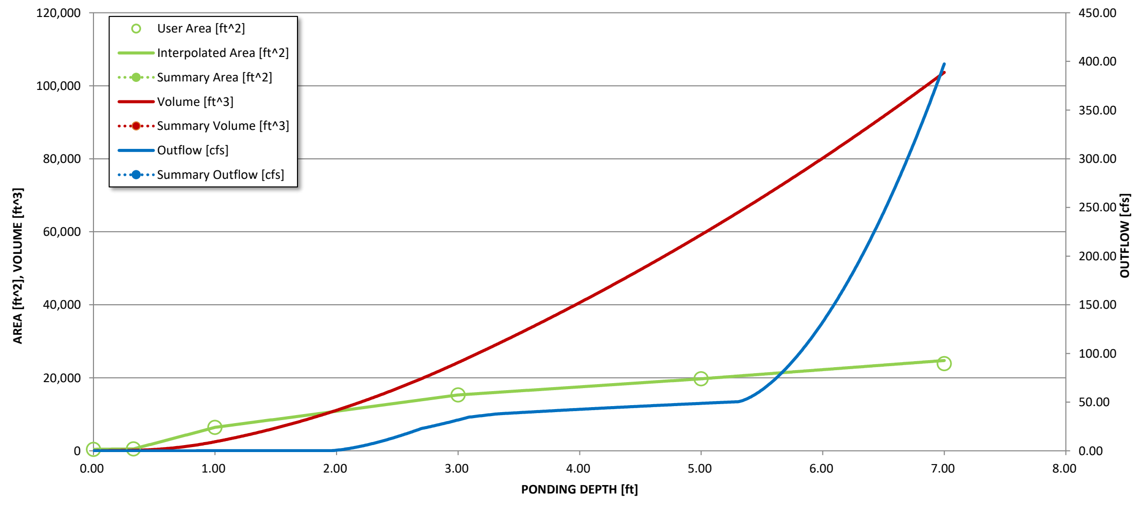
High velocity
= potential
safety issue.

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)



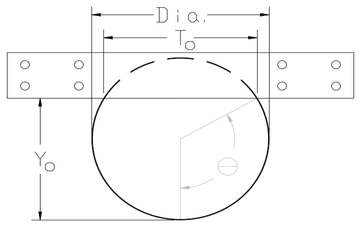




S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

Reference Figures and Equations

Circular Pipe with Restrictor Plate



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

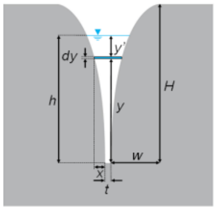
$$f(y)=\sqrt{2g(h-y)}\left[2\frac{H}{R}\left(1-1\sqrt{1-\frac{y^2}{H^2}}\right)+t\right]$$

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

Orifice Equations

$$Q=C_d A_t\sqrt{2g\left(h-C_y\right)}$$

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



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].

Watershed Runoff Volume Calculations

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

$$EURV=A[0.140I^{1.28}*A\%+0.113I^{1.08}*B\%+0.100I^{1.08}]$$

$$V_{Runoff\_2yr}=P_1A[(0.084I^{1.440})A\%+(0.084I^{1.173})B\%+(0.084I^{1.094})CD\%]$$

$$V_{Runoff\_5yr}=P_1A[(0.084I^{1.350})A\%+(0.077I+0.007)B\%+(0.070I+0.014)CD\%]$$

$$V_{Runoff\_10yr}=P_1A[(0.085I^{1.220})A\%+(0.069I+0.016)B\%+(0.061I+0.024)CD\%]$$

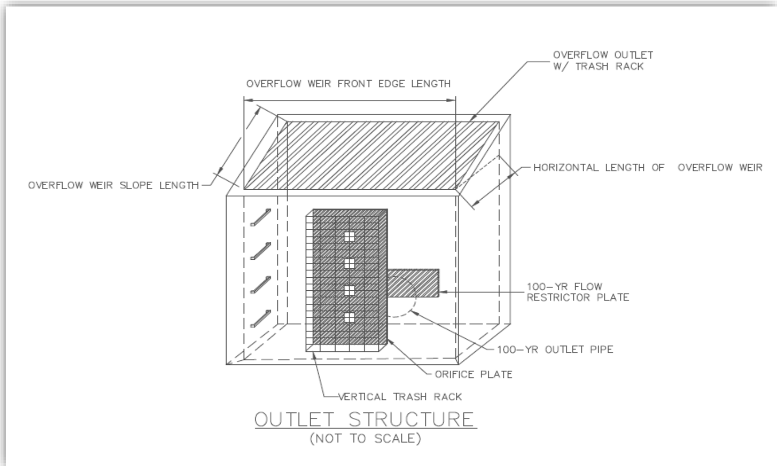
$$V_{\_Runoff\_25yr}=P_1A[(0.082I+0.004)A\%+(0.055I+0.031)B\%+(0.048I+0.038)CD\%]$$

$$V_{Runoff\_50yr}=P_1A[(0.078I+0.009)A\%+(0.049I+0.038)B\%+(0.044I+0.043)CD\%]$$

$$V_{Runoff\_100yr}=P_1A[(0.073I+0.015)A\%+(0.043I+0.045)B\%+(0.038I+0.050)CD\%]$$

$$V_{Runoff\_500yr}=P_1A[(0.064I+0.025)A\%+(0.036I+0.053)B\%+(0.031I+0.058)CD\%]$$

Where *WQCV* is the water quality capture volume (acre-ft), EURV is the excess urban runoff volume (acre-ft), $V_{\#yr}$ is the volume for the given return period (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), 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).



OUTLET STRUCTURE
(NOT TO SCALE)

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:

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

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

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

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:

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

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

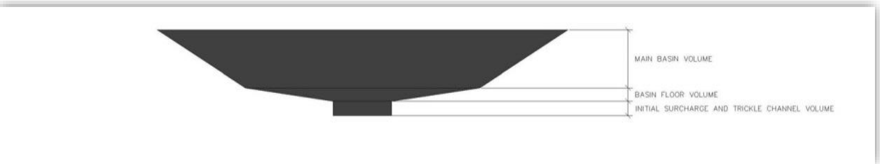
$$V_{main}=\frac{H_{main}}{3}\left(A_{main}+A_{floor}+\sqrt{A_{main}(A_{floor})}\right)$$

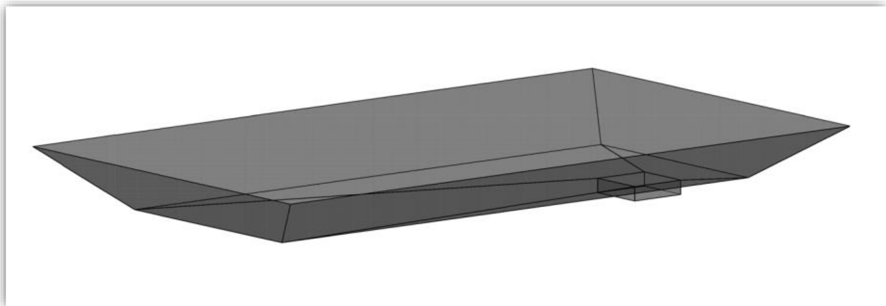
Where L_{main} and W_{main} (ft) are the length and width of the main basin section at the point at the top of the basin, H_{main} is the depth of the main basin section (ft), A_{main} is top area of the main basin section (ft^2), and V_{main} is volume of the main basin section (ft^3).

Total Basin Volume:

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

Where $V\text{-}_{total}$ is the volume of the total basin (ft^3) and D_{TC} is the depth of the trickle channel (ft).





DRAINAGE MAPS

TIMBERRIDGE ESTATES
EXISTING DRAINAGE PLAN

AUGUST 2018

EXISTING CONDITIONS

BASIN	ACRES	Q5 CFS	Q100 CFS
EX-E1	35.30	6.5	46.1
OS-4A	2.98	0.9	6.5
OS-4B	7.76	1.8	12.7
OS-4C	8.17	1.6	11.4
OS-4D	3.39	0.7	5.4

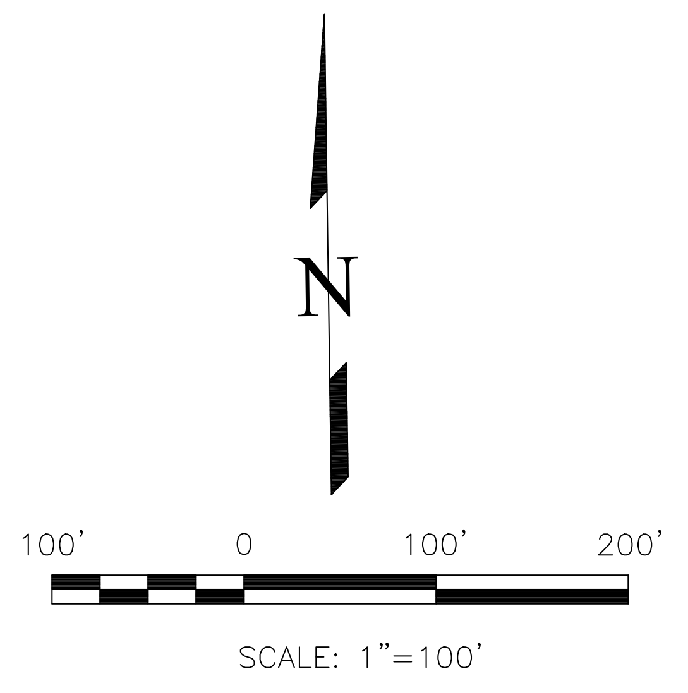
DESIGN POINT SUMMARY

DP	CONTRIBUTING BASINS	AREA AC.	Q5 CFS	Q10 CFS	Q100 CFS
OS-1	OS-4A	3.00	0.9	---	6.5
OS-2	OS-4B	7.50	1.7	---	12.3
OS-3	OS-4C	8.17	1.6	---	11.4
OS-4	OS-4D	3.39	0.7	---	5.4
EX-1	EX-E1, OS-4A, OS-4B, OS-4C, & OS-4D	57.60	11.5	---	82.1
SC-1*	SAND CREEK DRAINAGE BASIN	---	---	630	2,170

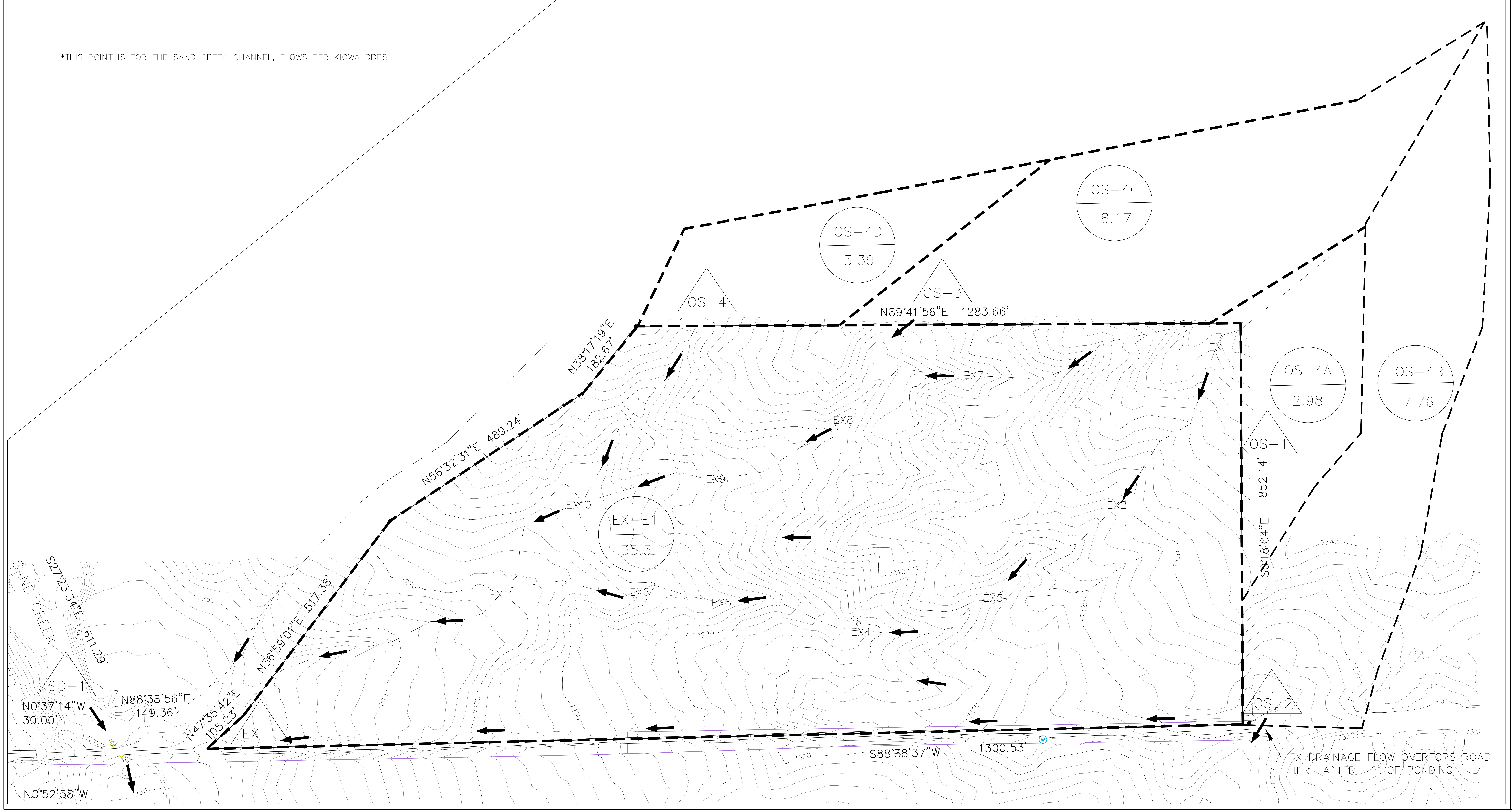
*THIS POINT IS FOR THE SAND CREEK CHANNEL, FLOWS PER KIOWA DBPS

LEGEND

P-7 / 12.22	BASIN DESIGNATION AREA IN BASIN (AC)
△ D	DESIGN POINT
— — —	BASIN BOUNDARY
———	EXISTING 2' CONTOUR
—7260—	EXISTING 10' CONTOUR
←	FLOW DIRECTION
— · — · —	SURFACE FLOW CHANNEL



SCALE: 1"=100'



EX DRAINAGE FLOW OVERTOPS ROAD HERE AFTER ~2' OF PONDING

N:\jobs\1733.00\Drawings\SDP\173300 FDM.dwg, EX-DR, 8/13/2018 3:48:31 PM

REVISIONS

NO.	DESCRIPTION	DATE

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

PREPARED FOR:
TIMBERRIDGE ESTATES, LLC
ATTN:
2760 BROGANS BLUFF
COLORADO SPRINGS, CO 80919

Terra Nova Engineering, Inc.
"Creative Civil Engineering Solutions"

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

TIMBERRIDGE ESTATES

EXISTING DRAINAGE PLAN

DESIGNED BY DLM
DRAWN BY DLM
CHECKED BY LD

H-SCALE 1"=100'
V-SCALE N/A

JOB NO. 1733.00
DATE ISSUED 08/10/18
SHEET NO. 1 OF 4

TIMBERRIDGE ESTATES
PROPOSED DRAINAGE PLAN

AUGUST 2018

PROPOSED CONDITIONS

BASIN	ACRES	Q5 CFS	Q100 CFS
OS–1	7.76	1.6	11.2
OS–2	2.98	0.9	7.0
OS–3	8.17	1.8	12.9
OS–4	3.39	0.8	6.1
OS–5	3.19	0.7	8.8
OS–6	4.89	1.2	9.6
A	12.38	3.9	21.4
A1	1.83	2.7	6.8
B	1.66	2.1	5.2
C	15.36	4.8	24.7
D	2.60	1.1	4.7
E	1.04	1.8	4.7
F	0.72	0.2	1.7
G	1.16	2.0	5.1
H	1.38	2.2	5.7
I	1.27	2.2	5.6

Ensure that these values match calculation tables.

DESIGN POINT SUMMARY

DP	CONTRIBUTING BASINS	AREA AC.	Q5 CFS	Q10 CFS	Q100 CFS
1	OS–2, A & A1	17.19	7.5	–––	35.2
2	OS–2, A, A1 & B	18.85	9.6	–––	40.4
3	OS–2, OS–3, OS–4, A, A1, B & C	45.77	17.0	–––	84.1
4	D	2.60	1.1	–––	4.7
5	OS–2, OS–3,OS–4, OS–5, A, A1, B, C, D, E & F	53.32	20.8	–––	100
6	OS–6 & G	6.05	3.2	–––	13.9
7	I	1.27	2.2	–––	5.6
8	H	1.38	2.2	–––	5.7
OS–1	OS–1	7.76	1.6	–––	11.2
OS–2	OS–2	2.98	0.9	–––	7.0
OS–3	OS–3	8.17	1.8	–––	12.9
OS–4	OS–4	3.39	0.8	–––	6.1
OS–5	OS–5	3.19	0.7	–––	4.8
OS–6	OS–6	4.89	1.2	–––	8.8
SC–1*	SAND CREEK DRAINAGE BASIN	–––	–––	630	2,170

*THIS POINT IS FOR THE SAND CREEK CHANNEL, FLOWS PER KIOWA DBPS

Label FEMA flows

DRAINAGE NOTES

1. EXTENDED DETENTION BASIN ACCESS IS FROM ARROYA LANE OR THE SOUTHERN END OF NATURE REFUGE WAY.
2. DRAINAGE EASEMENT MAINTENANCE ACCESS IF FROM NATURE REFUGE WAY AND/OR FROM ARROYA LANE.

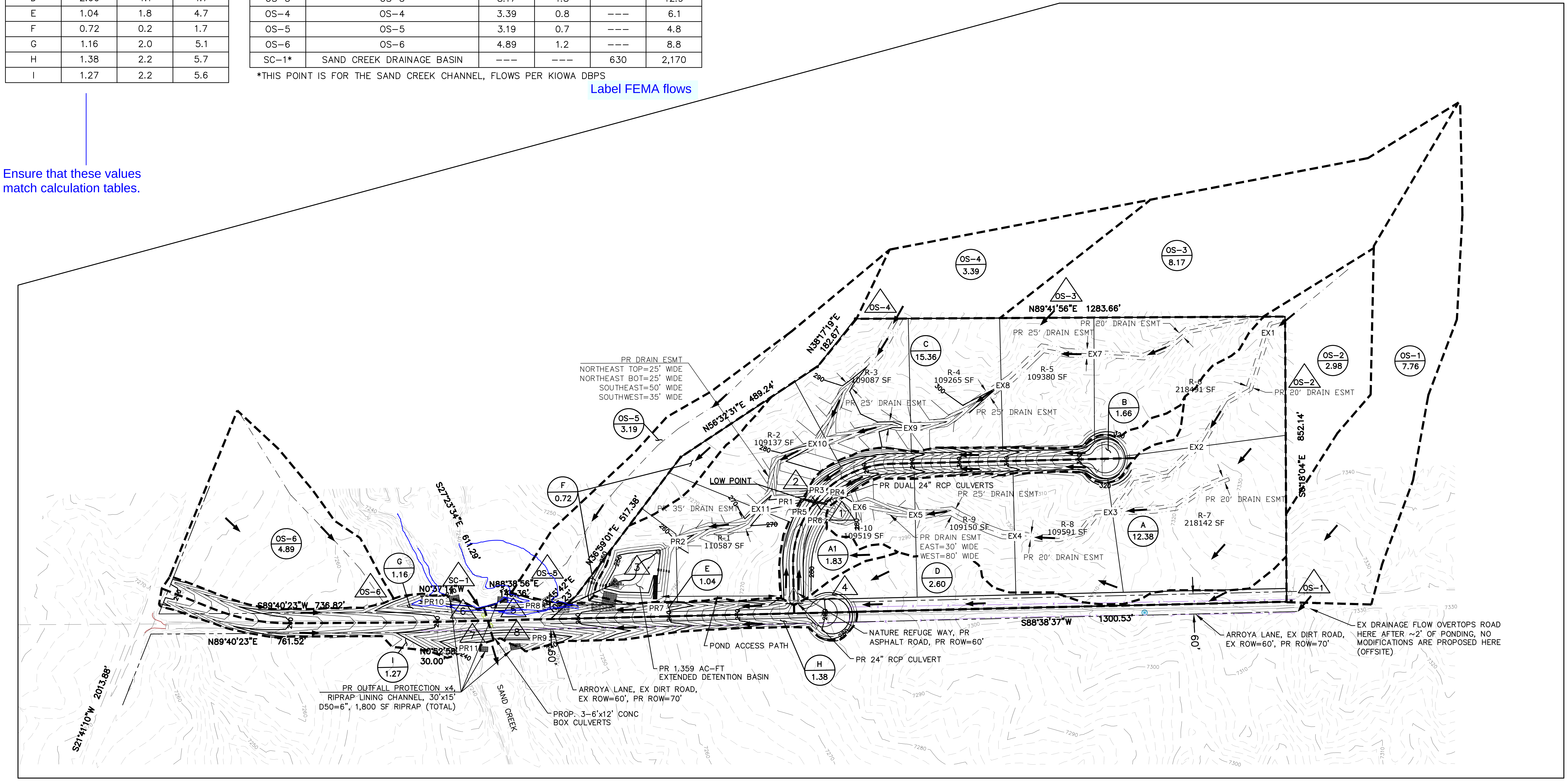
LEGEND

P–7 / 12.22	BASIN DESIGNATION AREA IN BASIN (AC)
△ D	DESIGN POINT
– – –	BASIN BOUNDARY
	EXISTING 2' CONTOUR
7260	EXISTING 10' CONTOUR
	PROPOSED 2' CONTOUR
260	PROPOSED 10' CONTOUR
←	FLOW DIRECTION
– · –	SURFACE FLOW CHANNEL
– –	PROPOSED DRAINAGE EASEMENT
EX# / PR#	OPEN CHANNEL FLOW CALC POINT

N

150' 0 150' 300'

SCALE: 1"=150'



N:\jobs\1733.00\Drawings\SDP\173300 FDM.dwg, PR-DR, 8/13/2018 3:48:39 PM

REVISIONS

NO.	DESCRIPTION	DATE
1	REV'D PER 6/2/16 CTY COMMENTS	8/22/16

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

PREPARED FOR:
TIMBERRIDGE ESTATES, LLC
ATTN:
2760 BROGANS BLUFF
COLORADO SPRINGS, CO 80919

Terra Nova Engineering, Inc.
"Creative Civil Engineering Solutions"

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

TIMBERRIDGE ESTATES

PROPOSED DRAINAGE PLAN

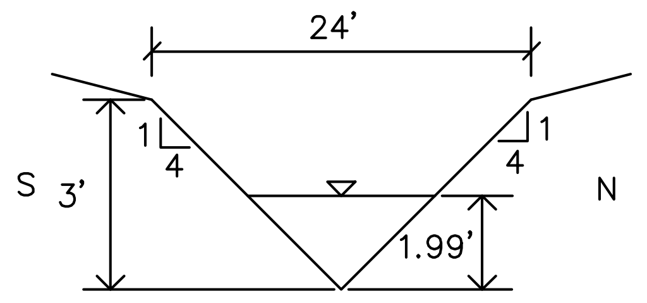
DESIGNED BY DLM
DRAWN BY DLM
CHECKED BY LD
H–SCALE 1"=150'
V–SCALE N/A
JOB NO. 1733.00
DATE ISSUED 08/10/18
SHEET NO. 2 OF 4

TIMBERRIDGE ESTATES

PROPOSED DRAINAGE PLAN

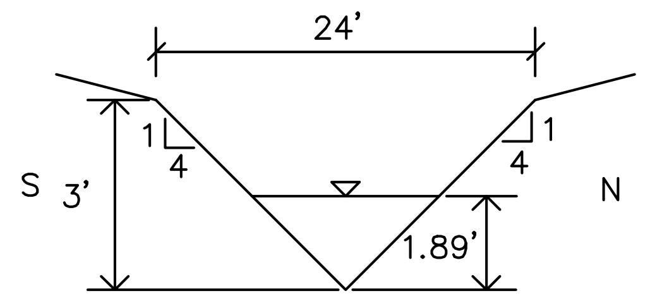
AUGUST 2018

PRELIMINARY DRAWING NOT FOR CONSTRUCION



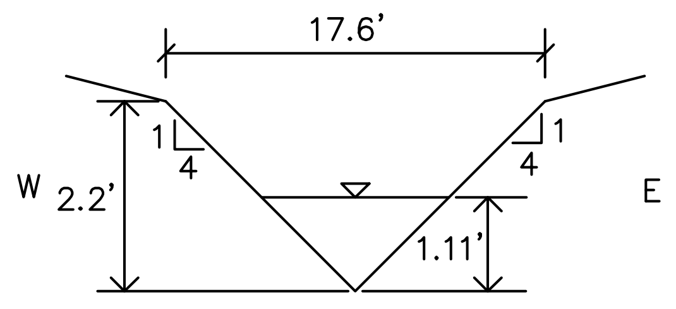
Q = 26.3 CFS
SLOPE = 3.0%
n VALUE = 0.15
DEPTH = 1.99'
VELOCITY = 1.68 FT/S

SWALE CROSS SECTION – EX5



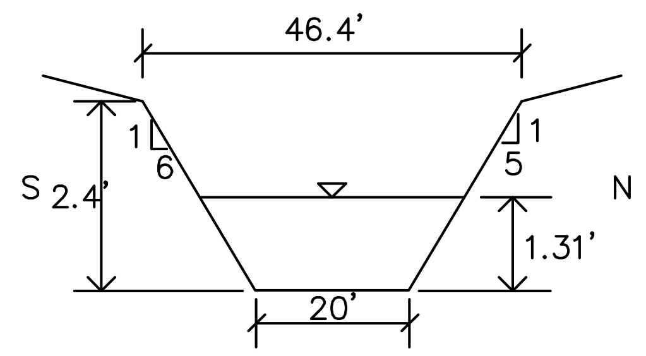
Q = 26.4 CFS
SLOPE = 3.9%
n VALUE = 0.15
DEPTH = 1.89'
VELOCITY = 1.85 FT/S

SWALE CROSS SECTION – EX9



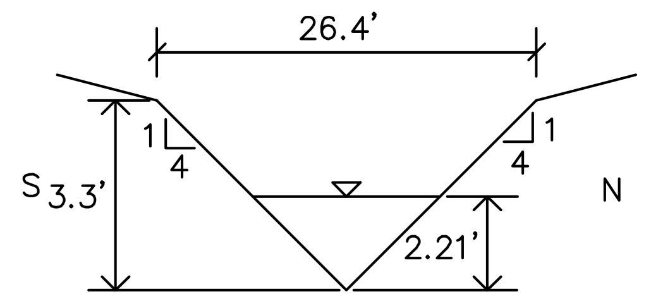
Q = 3.6 CFS
SLOPE = 1.3%
n VALUE = 0.15
DEPTH = 1.11'
VELOCITY = 0.75 FT/S

SWALE CROSS SECTION – PR6



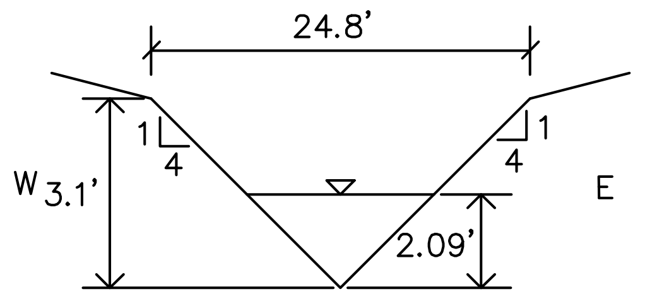
Q = 41.0 CFS
SLOPE = 1.3%
n VALUE = 0.15
DEPTH = 1.31'
VELOCITY = 1.15 FT/S

SWALE CROSS SECTION – PR1



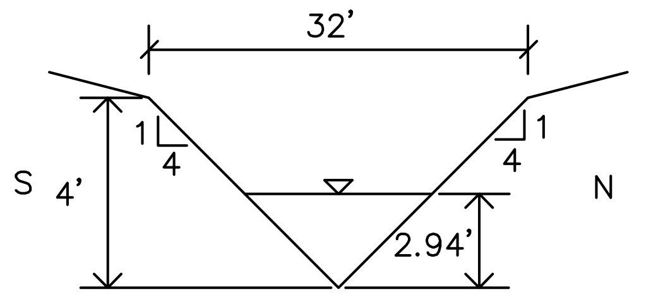
Q = 35.7 CFS
SLOPE = 3.1%
n VALUE = 0.15
DEPTH = 2.21'
VELOCITY = 1.83 FT/S

SWALE CROSS SECTION – EX6



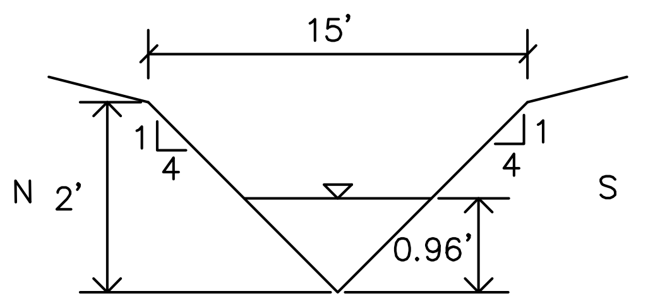
Q = 32.2 CFS
SLOPE = 3.4%
n VALUE = 0.15
DEPTH = 2.09'
VELOCITY = 1.84 FT/S

SWALE CROSS SECTION – EX10



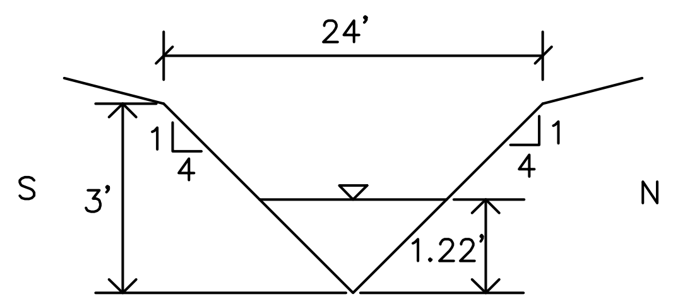
Q = 76.4 CFS
SLOPE = 3.1%
n VALUE = 0.15
DEPTH = 2.94'
VELOCITY = 2.21 FT/S

SWALE CROSS SECTION – EX11



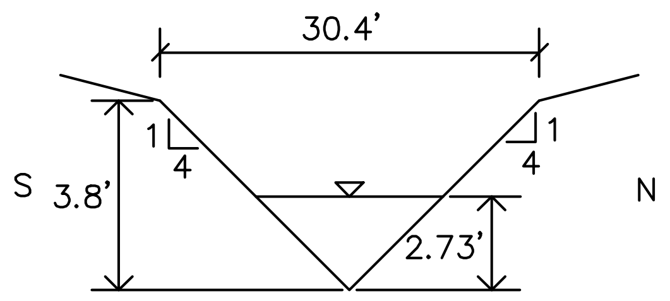
Q = 5.6 CFS
SLOPE = 7.8%
n VALUE = 0.15
DEPTH = 0.96'
VELOCITY = 1.66 FT/S

SWALE CROSS SECTION – PR11



Q = 8.2 CFS
SLOPE = 5.2%
n VALUE = 0.15
DEPTH = 1.16'
VELOCITY = 1.54 FT/S
*EXPANDED TO ALLOW FOR POSSIBLE FUTURE FLOW INCREASES

SWALE CROSS SECTION – PR7

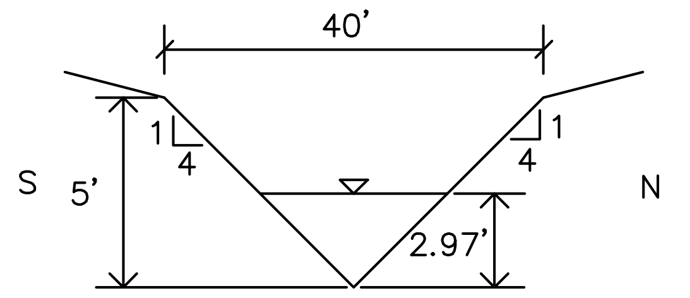


Q = 80.4 CFS
SLOPE = 5.1%
n VALUE = 0.15
DEPTH = 2.73'
VELOCITY = 2.70 FT/S

SWALE CROSS SECTION – PR2

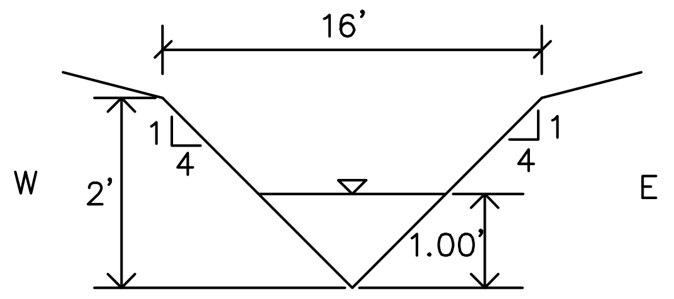
See comment letter regarding regrading of the existing natural swales.

These values are for a ditch full of shrubbery and vegetation (okay for depth check). See comment letter regarding velocity and stability calculations.



Q = 99.7 CFS
SLOPE = 5.0%
n VALUE = 0.15
DEPTH = 2.97'
VELOCITY = 2.83 FT/S
*EXPANDED TO ALLOW FOR POSSIBLE FUTURE FLOW INCREASES

SWALE CROSS SECTION – PR8

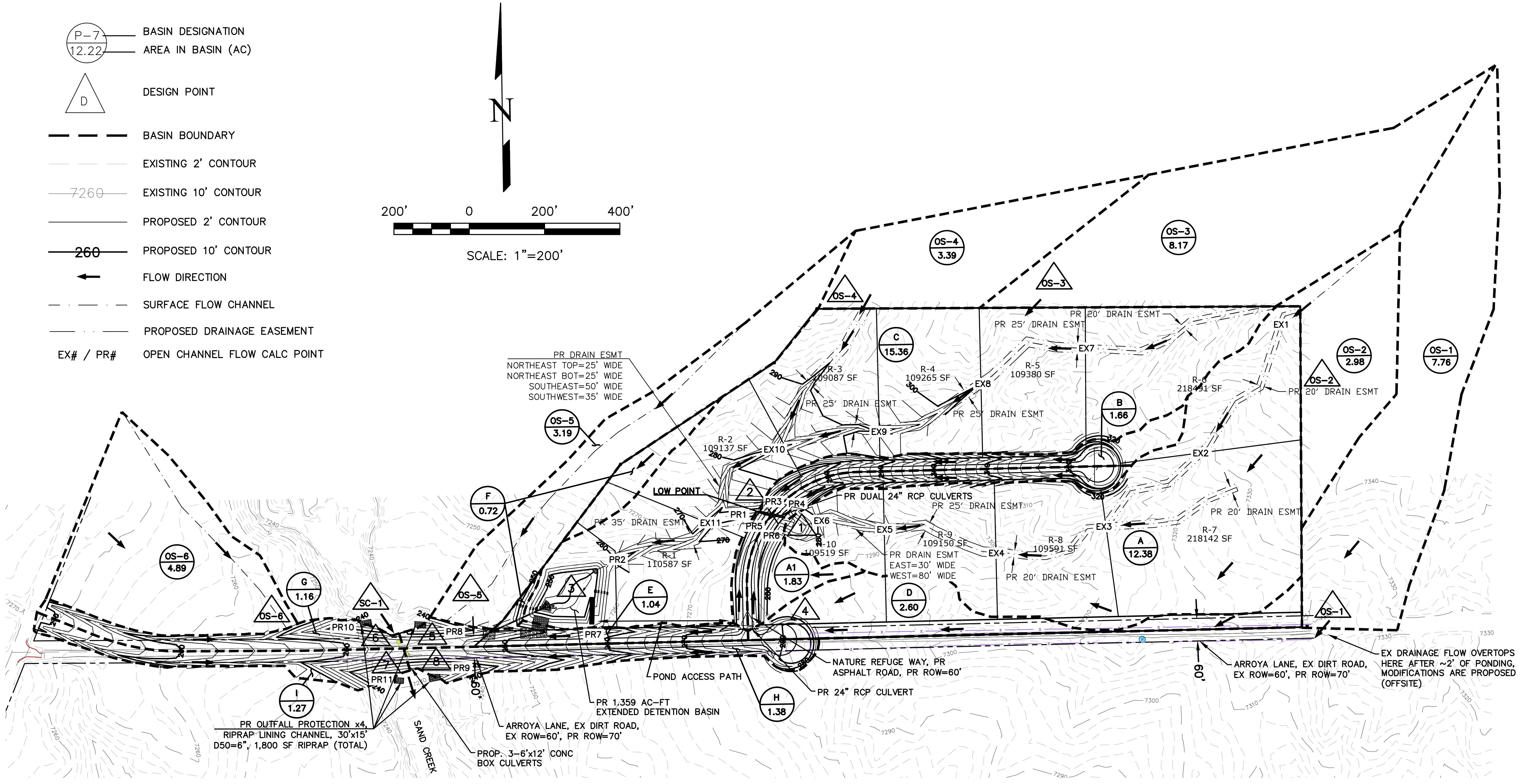


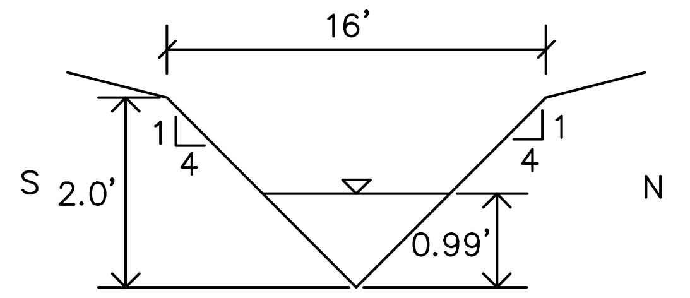
Q = 4.7 CFS
SLOPE = 3.7%
n VALUE = 0.15
DEPTH = 1.00'
VELOCITY = 1.18 FT/S

SWALE CROSS SECTION – PR3

LEGEND

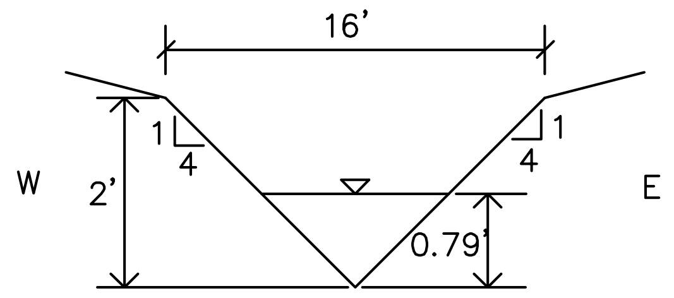
P-7 / 12.22	BASIN DESIGNATION AREA IN BASIN (AC)
△ D	DESIGN POINT
— — —	BASIN BOUNDARY
- - - -	EXISTING 2' CONTOUR
—7260—	EXISTING 10' CONTOUR
———	PROPOSED 2' CONTOUR
—260—	PROPOSED 10' CONTOUR
←	FLOW DIRECTION
— · — · —	SURFACE FLOW CHANNEL
—— · · ——	PROPOSED DRAINAGE EASEMENT
EX# / PR#	OPEN CHANNEL FLOW CALC POINT





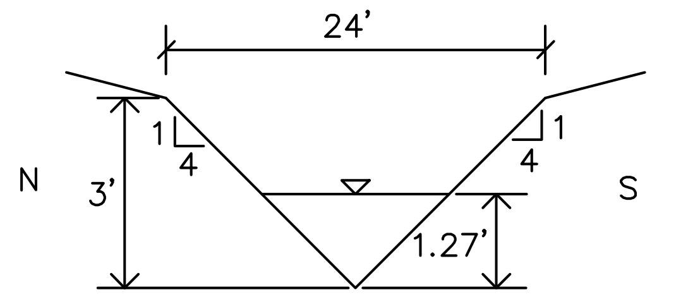
Q = 5.8 CFS
SLOPE = 6.0%
n VALUE = 0.15
DEPTH = 0.99'
VELOCITY = 1.49 FT/S

SWALE CROSS SECTION – PR9



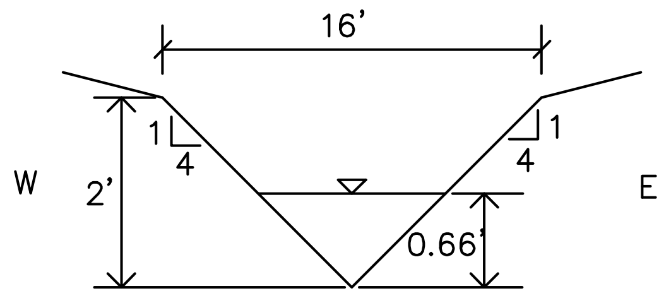
Q = 3.2 CFS
SLOPE = 6.3%
n VALUE = 0.15
DEPTH = 0.79'
VELOCITY = 1.31 FT/S

SWALE CROSS SECTION – PR4



Q = 10.5 CFS
SLOPE = 5.9%
n VALUE = 0.15
DEPTH = 1.27'
VELOCITY = 1.74 FT/S
*EXPANDED TO ALLOW FOR POSSIBLE FUTURE FLOW INCREASES

SWALE CROSS SECTION – PR10



Q = 0.9 CFS
SLOPE = 1.3%
n VALUE = 0.15
DEPTH = 0.66'
VELOCITY = 0.53 FT/S

SWALE CROSS SECTION – PR5

REVISIONS

NO.	DESCRIPTION	DATE

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

PREPARED FOR:
TIMBERRIDGE ESTATES, LLC
ATTN:
2760 BROGANS BLUFF
COLORADO SPRINGS, CO 80919

Terra Nova Engineering, Inc.
"Creative Civil Engineering Solutions"

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

TIMBERRIDGE ESTATES

PROPOSED DRAINAGE DETAILS

DESIGNED BY DLM
DRAWN BY DLM
CHECKED BY LD
H-SCALE 1"=200'
V-SCALE N/A
JOB NO. 1733.00
DATE ISSUED 08/10/18
SHEET NO. 3 OF 4

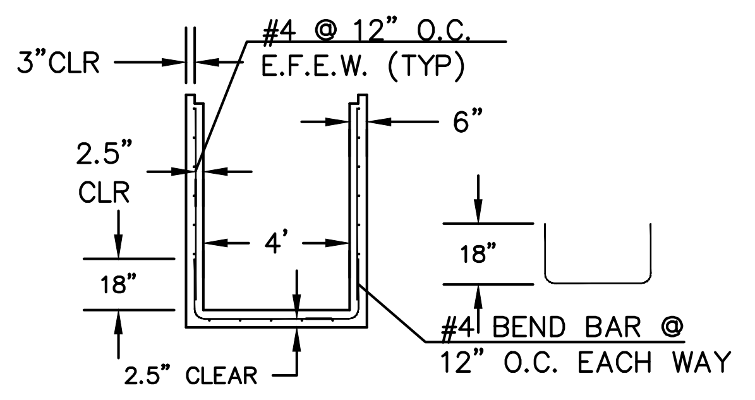
N:jobs\1733.00\Drawings\SDP\173300 FDM.dwg, PR-DR #2, 8/13/2018 3:48:49 PM

TIMBERRIDGE ESTATES

PROPOSED DETENTION BASIN DETAILS

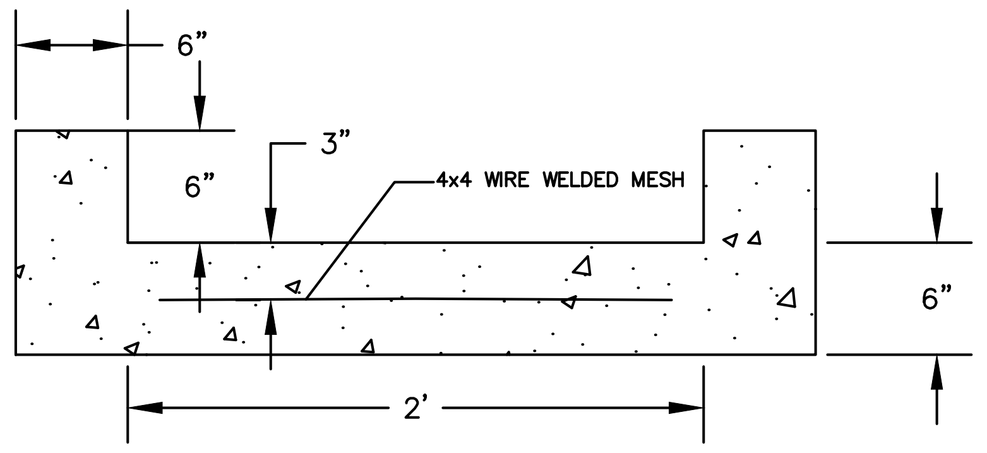
AUGUST 2018

PRELIMINARY DRAWING
NOT FOR CONSTRUCION



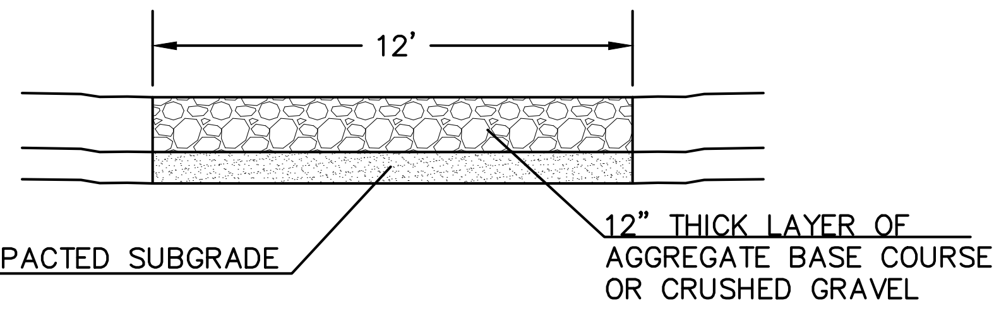
4'x4' OUTLET BOX STRUCTURAL DETAIL

NOT TO SCALE



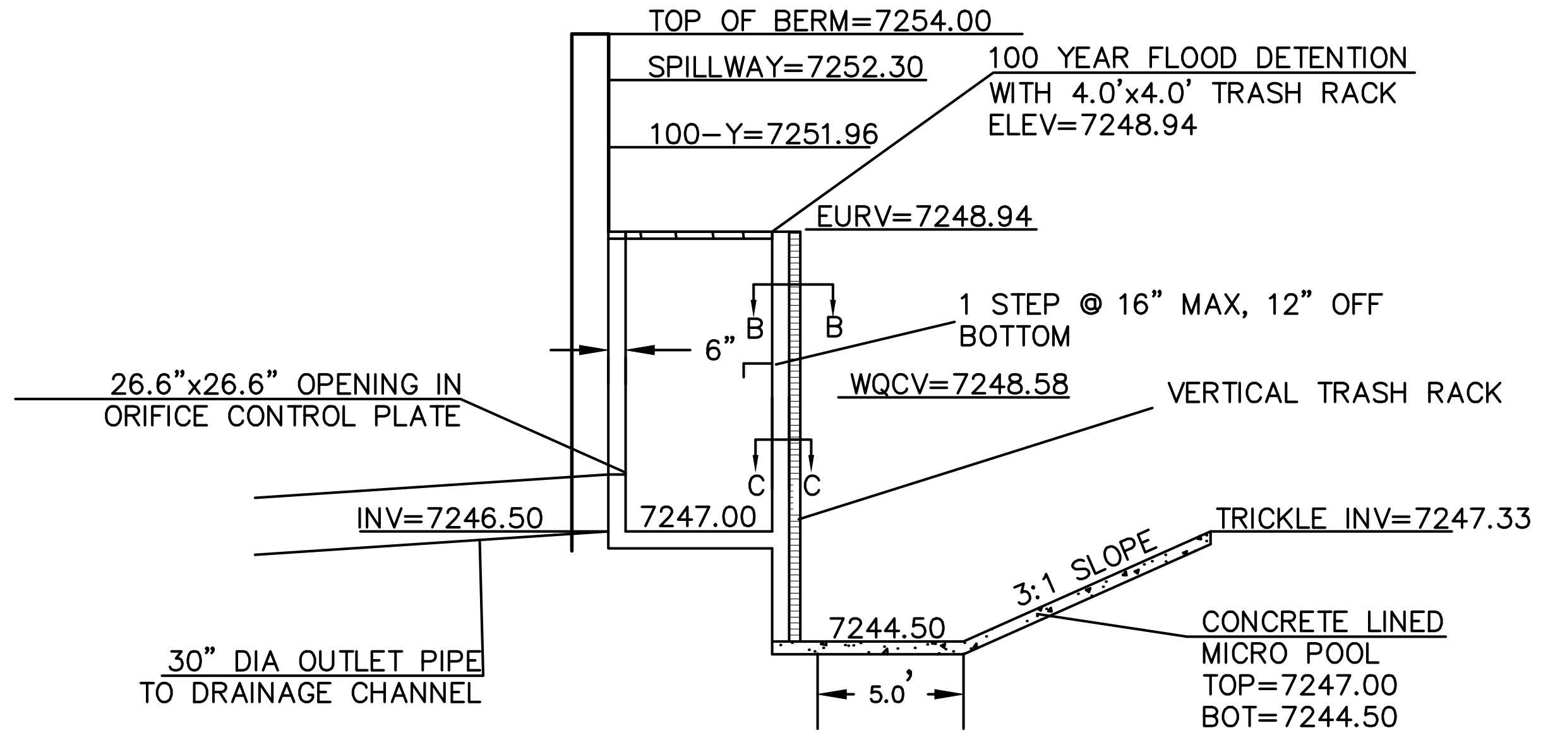
2' CONCRETE TRICKLE CHANNEL

NOT TO SCALE



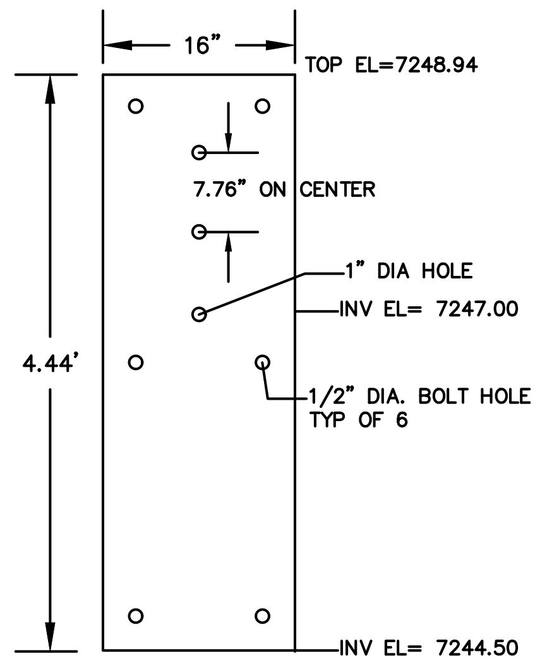
12' MAINTENANCE ACCESS ROAD SECTION

NOT TO SCALE



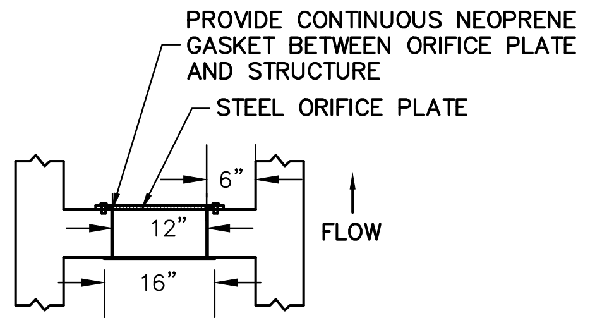
OUTLET STRUCTURE

NOT TO SCALE



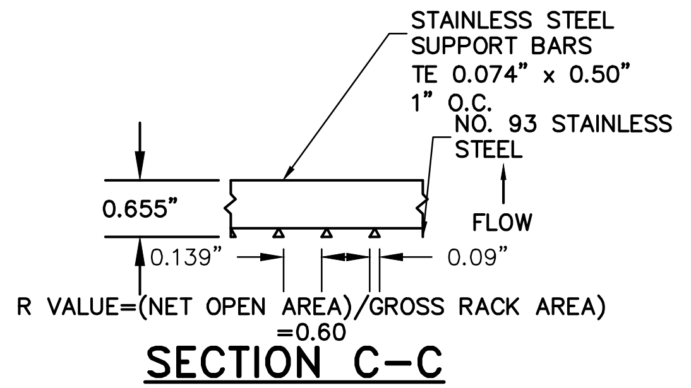
ORIFICE PLATE PERFORATED HOLE PATTERN

NOT TO SCALE



SECTION B-B

NOT TO SCALE

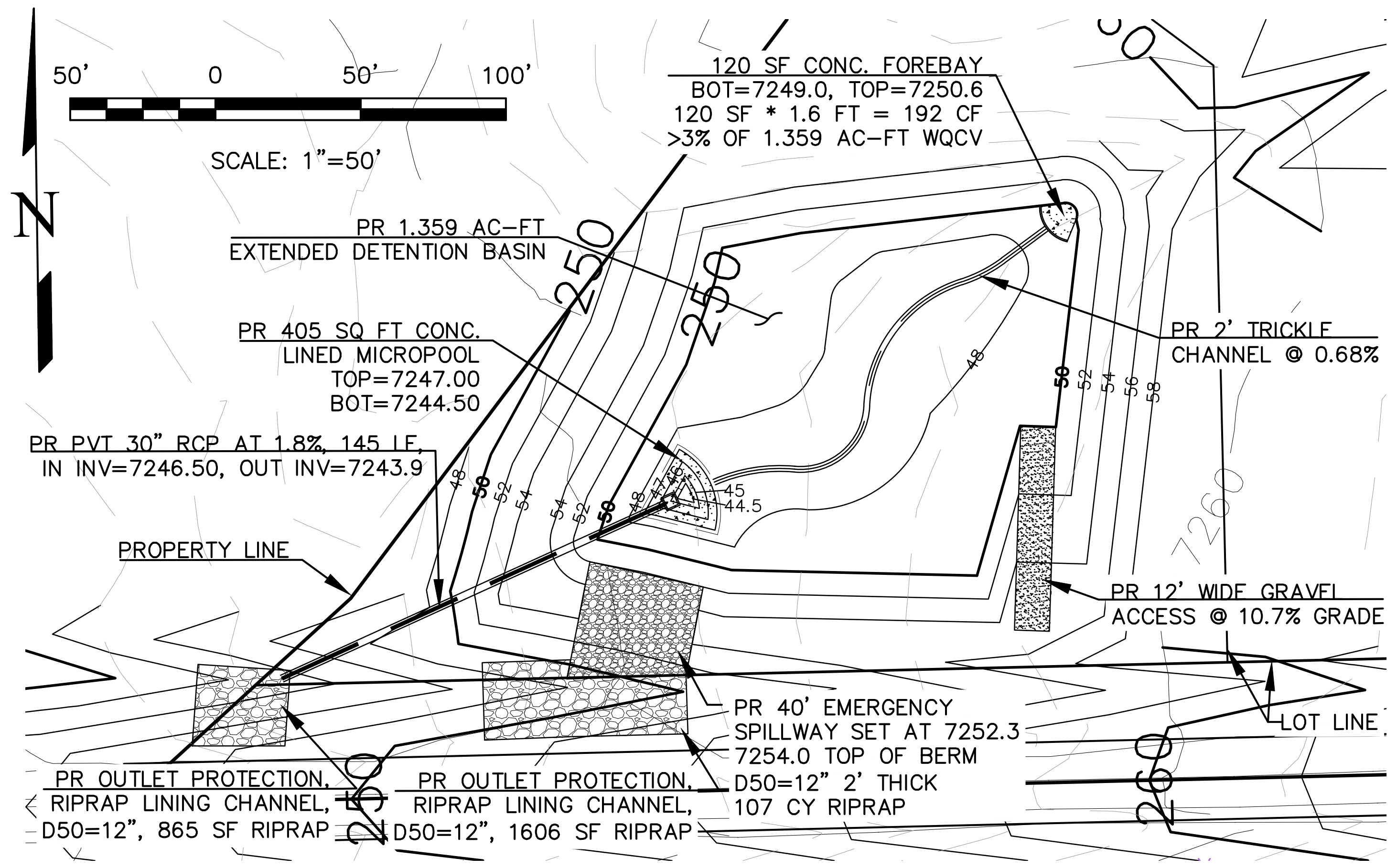


R VALUE=(NET OPEN AREA)/GROSS RACK AREA)
=0.60

SECTION C-C

NOT TO SCALE

POND OUTLET OVERALL DETAIL



EXTENDED DETENTION BASIN DETAIL

REVISIONS

NO.	DESCRIPTION	DATE
1	REV'D PER 6/2/16 CTY COMMENTS	8/22/16

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

PREPARED FOR:
TIMBERRIDGE ESTATES, LLC
ATTN:
2760 BROGANS BLUFF
COLORADO SPRINGS, CO 80919

Terra Nova Engineering, Inc.
"Creative Civil Engineering Solutions"

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

TIMBERRIDGE ESTATES

PROPOSED DETENTION BASIN DETAILS

DESIGNED BY DLM
DRAWN BY DLM
CHECKED BY LD
H-SCALE 1"=200'
V-SCALE N/A
JOB NO. 1733.00
DATE ISSUED 08/10/18
SHEET NO. 4 OF 4

N:\jobs\1733.00\Drawings\SDP\173300 FDM.dwg, PR-POND, 8/13/2018 3:48:59 PM