7100 West & 900 South

Stormwater Drainage Analysis

Reeve & Associates, Inc.

Solutions You Can Build On

Vaquero Village Cluster Subdivision, Phase 1

7100 West & 900 South

Odgen, UT

submitted to

Weber County Engineering Division
2380 Washington Blvd., Suite 240
Ogden, UT 84401
PH: (801) 399-8374

April 18, 2017

Reeve & Associates, Inc.

Contact: Nate Reeve, PE
5160 South 1500 West
Riverdale, Utah 84405
801-621-3100
Fax 801-621-2666
www. reeve-assoc.com

Ref: 5799-451

Reeve & Associates, Inc.

Table of Contents

Vaquero Village Cluster Subdivision, Phase 1

7100 West & 900 South

Ogden, UT

1.0 Introduction

1.1 Property Location and Introduction

At the request of the County of Salt Lake, Reeve & Associates has prepared the following Storm Drainage Analysis for the proposed subdivision located with entrance at 7100 West & 900 South in Ogden, Utah. Figure #1 contains a vicinity map that shows the proposed location and surrounding properties. The proposed site includes 13 residential lots and large open spaces for recreational use.

The drainage design was determined using the Rational Method. All drainage calculations and detention basin sizing were completed utilizing information for the 10-yr and 100-yr storm events for the Reese, UT area.

The following report outlines the objectives and procedures followed to determine the drainage design. A complete overview of both the hydrologic and hydraulic designs and calculations are presented in detail.

1.2 Property Description

The site sits on 12.42 acres. The proposed site will contain 94,005 s.f. of hard surface area, 178,983 s.f. of landscaped area and 30,000 s.f. of roof area.

The existing site is currently undeveloped. The site is flat with existing ditches on the north and south of the site. The property is bordered to the north, east, and west by undeveloped property. The property is bordered by private residences and 900 South on the south.

Figure #1
Vicinity Map – 7100 West & 900 South

2.0 Drainage System Description

2.1 Existing Drainage Conditions

The existing topography is mostly flat with a general slight slope from east to west. The FEMA flood maps show that this is an area of minimal flood hazard.

2.2 Proposed Drainage System Description

The proposed drainage system is to sheet flow the storm water to strategically located catch basins throughout the site that direct the storm water into an above ground detention basin pond; sized to retain the 100-year storm event. Storm water is discharged from the basin at a rate of 0.1 cfs per acre into the filled and piped irrigation ditch on the north of the site. The size and details of the detention pond are described later in the report. The proposed site plan with topography is laid out in Figure 2.

In the case of a storm event greater than a 100-year storm, storm water will overtop the baffle wall in the control box. Also, an emergency spillway at the top of the basin will direct water to the ditch to the north.

Figure 2 - Proposed Site Layout

Storm Runoff Calculations

Vaquero

1/19/2017

The following runoff calcuations are based on the Rainfall - Intensity - Duratice Frequency Curve for the Reese, UT area taken from NOAA Atlas 14 using a 10 year storm for collection and a 100 year storm for storage. Storage facilities have been designed per requirements provided by the City for a regional detention pond. A majority of water run off collected from the property will be diverted into a holding pond and released at a reduced rate as part of the detention pond. Design calculations here are presented for the overall property development.

The calculations are as follows:

1. Drainage Area:

Total Area =	12.42	acres or	541,203	ft²
Total Collectec Area	6.31		288,888	

Developed Runoff Coefficient

Runoff Coefficients

Single Family Residence Paved Area	79,905	C = 0.9
Landscaped Area	178,983	C = 0.2
Roof	30,006	C = 0.9
Weighted Runoff Coefficient		C = 0.47

2. Time of Concentration:

Use: **30 min.**

Estimated from storm water runoff overland flow time

3. Rainfall Intensities:

10-yr 30-min (conveyance) 1.39 in/hr

4. Peak Run-off:

Runoff Coefficient	C =	0.47
Rainfall Intensity	i =	1.39 IN./HR.
Acreage	A =	6.63 ACRES
		288,888 ft²
Runoff Quantity	Q =	CiA
Q (max at pond iternal)	**Q =**	**4.36 ft³/s**

5. Allowable Discharge:

Typical allowable discharge Q = (0.1 x acres)

Allowable Discharge = Q = 0.66 ft³/s

6. Volume of Run-off for 100-year 24-Hour Storm Event:

C= 0.47
A= 288,888 ft²
Q(out) = 0.66 ft³/s

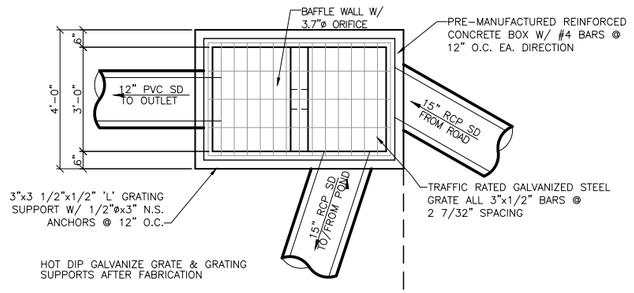
time (min)	time (sec)	i (in./hr.)	Q (cfs)	Vol. in (cf)	Vol. out (cf)	Difference (cf)
0	0	0.00	0.00	6	0	0
5	300	6.59	20.55	6,165	199	5,966
10	600	5.00	15.59	9,355	398	8,957
15	900	4.14	12.91	11,619	597	11,022
30	1800	2.79	8.70	15,666	1,194	14,466
60	3600	1.72	5.36	19,309	2,388	16,921
120	7200	0.94	2.94	21,196	4,775	16,420
180	10800	0.64	2.00	21,621	7,163	14,459
360	21600	0.36	1.12	24,111	14,325	9,788
720	43200	0.22	0.69	29,636	28,650	986
1440	86400	0.12	0.39	33,408	57,300	-23,892

Total Required Detention Volume 16,921 ft³

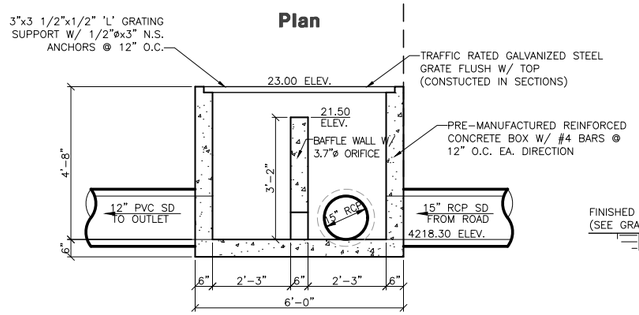
7. Orifice Sizing Area:

Given:
Q = 0.66 cfs
2g = 64.4 ft/s²
H = 2.50 ft
Cd = 0.7 for circular openings
R = SQRT(Q/(0.7*p*(64.4*H)^0.5))
R = 0.15 feet
1.85 inches
D = 3.70 inches

THE REQUIRED VOLUME OF THE DETENTION BASIN IS 16921 CU. FT.
ORIFICE DIAMETER AT OUTLET IS 3.70"ø



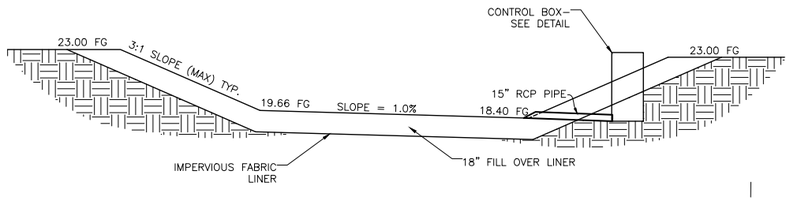
Plan



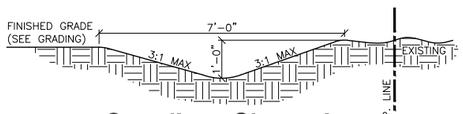
Section

Detention Basin Control Box
SCALE: NONE

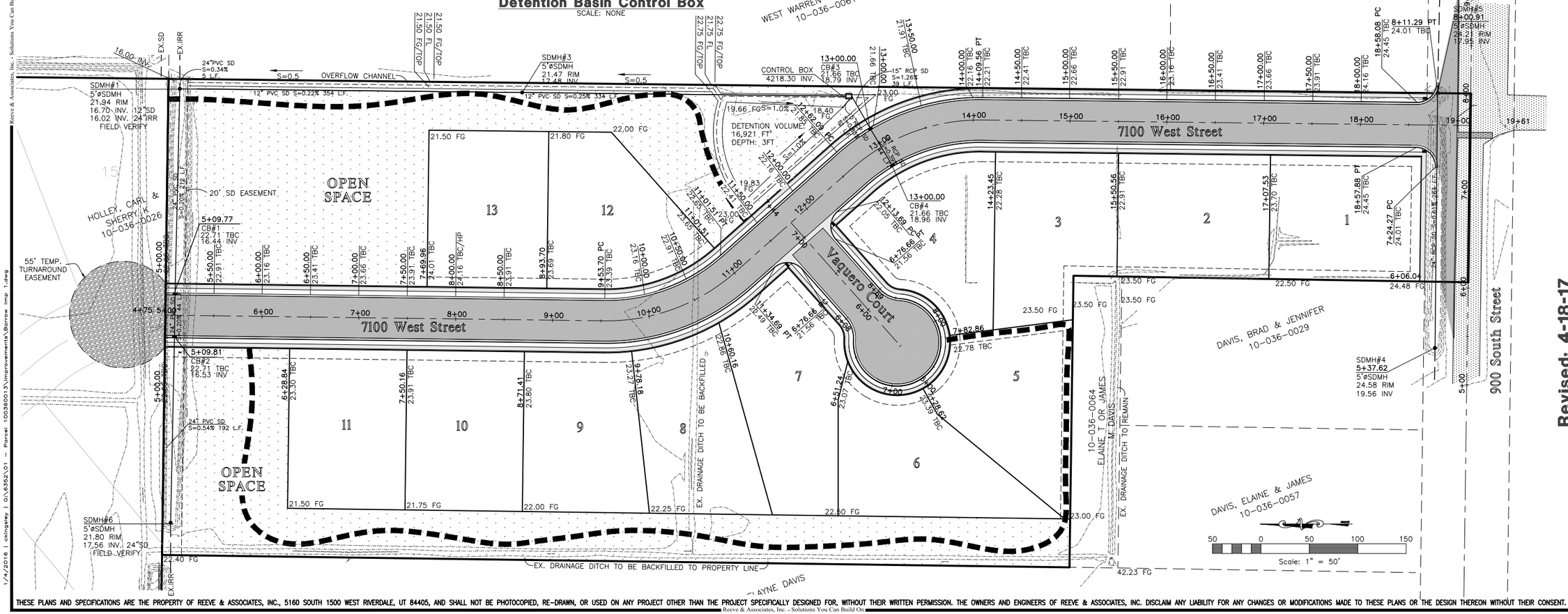
STAGE STORAGE TABLE			
ELEV	AREA (sq. ft.)	DEPTH (ft)	CONIC TOTAL VOL. (cu. ft.)
4218.40	0.00	0.000	0.00
4,218.65	511.70	0.250	64.78
4,219.65	6,629.51	1.250	3059.12
4,220.65	8,609.00	2.250	10656.85
4,221.65	10,027.57	3.250	19966.12



Detention Basin
SCALE: NO SCALE



Overflow Channel
SCALE: NO SCALE



Reeve & Associates, Inc.
5160 SOUTH 1500 WEST, RIVERDALE, UT 84405
TEL: (801) 621-3100 FAX: (801) 621-2666 www.reeve-assoc.com
LAND PLANNERS • CIVIL ENGINEERS • LAND SURVEYORS
TRAFFIC ENGINEERS • STRUCTURAL ENGINEERS • LANDSCAPE ARCHITECTS

REVISIONS

DATE		DESCRIPTION
09-13-16	CK	County Comments
12-22-16	ER	County Comments
1-24-17	KH	Storm Drain
2-2-17	KH	DEQ comments
4-3-17	RH	Review Comments
4-3-17	TP	Client Comments

Vaquero Village Cluster Subdivision Phase 1

WEBER COUNTY, UTAH

Grading & Drainage Plan

Revised: 4-18-17

REGISTERED PROFESSIONAL ENGINEER
375328
J. NATE REEVE
04/18/2017
STATE OF UTAH

Project Info.

Engineer: J. NATE REEVE
Drafter: C. KINGSLEY
Begin Date: 4-4-16
Name: VAQUERO VILLAGE SUBDIVISION PHASE 1
Number: 6352-01

Sheet 8 of 14 Sheets

3.0 Drainage Analysis and Design Criteria

3.1 Regulations and Development Criteria

The Rational Method was used to determine the amount of runoff (Q) in cubic feet per second that the proposed project would generate upon completion. The Rational Method is used to predict the runoff for small basins by utilizing runoff coefficients based off land use. According to Weber County design standards, the Rational Method is used for small areas of 30 acres or less. The proposed development site sits on 12.42 acres.

Rainfall intensity data was obtained from data compiled by NOAA Atlas 14. An analysis was performed for the 10-year event for collection and conveyance systems and the 100-year storm event for detention sizing.

The runoff on site will be detained in the above ground detention basin before being discharged at the maximum post development runoff rate of 0.1 cfs/acre. A portion of the site equal to 14,100 s.f. on the north of the site bypasses the onsite detention system and drains directly to the ditch which is to be piped. Per verbal discussion with the county engineer this discharge is acceptable due to the site grading requirements and the large capacity of the ditch system.

3.2 Hydrologic Criteria

3.2.1 Rainfall Intensity

The rainfall intensities for the project were determined using data compiled by NOAA Atlas 14. The rainfall intensity for the 10-year storm is shown in Table 1 below. The rainfall intensity for the 100-year storm is shown in Table 2 below.

Table 1 – Rainfall Intensity – 10-year storm event

Time(min)	*Intensity (inches/hour)*
5	**3.28**
10	**2.50**
15	**2.06**
30	**1.39**
60	**0.86**
120	**0.50**
1440	**0.09**

Source: NOAA Atlas 14

Table 2 – Rainfall Intensity – 100-year storm event

Time(min)	*Intensity (inches/hour)*
5	**6.59**
10	**5.00**
15	**4.14**
30	**2.79**
60	**1.72**
120	**0.94**
1440	**0.12**

Source: NOAA Atlas 14

3.2.2 On-Site Retention Analysis

The next step is to determine the weighted runoff coefficient for a fully developed scenario based upon the developed surface types and areas.

The amount of paved area being retained is to be 79,905 square feet (with 14,100 square feet excepted from 94,005 square feet), with 178,983 square feet of landscaping, and 30,000 square feet of roof.

The weighted runoff coefficient was found by determining the runoff coefficient for each surface area within the designated area and determining the weighted average. See the Table 3 below for the weighted runoff coefficient results.

Table 3 – Runoff Coefficient

Surface Type	*Area (ft²)*	*Coefficient*
Paved Area	*79,905*	**0.9**
Landscaped Area	*178,983*	**0.2**
Roof	*30,000*	**0.9**
	Weighted Coefficient	**0.47**

To determine the amount of water that would need to be retained during a 100-year storm, for each time interval the difference of volume between existing conditions and proposed conditions was reviewed. The highest difference is what the system should be able to retain, see appendix for complete calculations. The total volume required to retain on-site is listed in Table 4 – see appendix for complete calculations.

Table 4 – Required Volume for On-Site Detention

Retention System	*Volume (cf)*
Basin	**16,921**

Based on the calculations and results demonstrated above, and according to our professional opinion, we propose that the on-site detention system shall have the capacity to hold up to 16,921 cubic feet. The proposed site plan will provide a total of 19,966 cubic feet in volume at the high water elevation which is greater than the required amount. Refer to the appendix for calculations that size the required volume.

3.3 Hydraulic Criteria

3.3.1 Detention Basin Design

To retain the total 100-year storm, a volume of 16,921 cubic feet is needed to be detained. It is proposed that this is to be done with an above ground holding pond. The location and layout of the detention system can be found in the appendix.

On-site Pond

Calculations that size the holding pond were performed through the use of AutoCAD Civil3D 2016 tools. Outputs for the calculations can be seen in Table 5 below.

Table 5 – Detention Basin Stage Storage

Elevation	*Area (sq. ft.)*	*Depth (ft.)*	*Total Volume (cu.ft.)*
4218.40	**0**	**0.00**	**0**
4218.65	**512**	**0.25**	**65**
4219.65	**6630**	**1.25**	**3059**
4220.65	**8609**	**2.25**	**10657**
4221.65	**10028**	**3.25**	**19966**

19,966 c.f. > 16,921 c.f. req'd

In the event of a storm event greater than the 100-yr storm, storm water will overtop the baffle wall in the control box as well as flow into an emergency channel to the ditch in the north.

3.3.2 Pipe Sizing Requirements

The conveyance and collection system is required to be sized for the 10 year storm. In addition, the pipes on the north and south of the site where the existing ditches are to be filled and piped must have capacity for the existing flow. Calculations for the capacity of each existing ditch are included in the appendix. The required and calculated capacities for each pipe are shown in Table 6 below – see appendix for calculations for each pipe. Please note that pipe 8 is a combination of pipes 5 through 7. As calculations for these individual segments have been included, pipe 8 has been omitted from the table and calculations.

Table 6 – Calculated Pipe Flow

Pipe #	*Location*	*Size (In.)*	*Slope (%)*	*Manning n*	*Required Capacity (cfs)*	*Calculated Capacity (cfs)*
1	*CB4-CB3*	*15*	*0.39*	*0.013*	*2.17*	*4.03*
2	*CB3-Control Box*	*15*	*1.26*	*0.013*	*4.33*	*7.25*
3	*Control Box-SDMH3*	*12*	*0.25*	*0.013*	*0.66*	*1.78*
4	*SDMH3-SDMH1*	*12*	*0.22*	*0.013*	*0.66*	*1.67*
5	*SDMH1-CB1*	*24*	*0.20*	*0.013*	*7.35*	*10.12*
6	*CB1-CB2*	*24*	*0.20*	*0.013*	*7.15*	*10.12*
7	*CB2-Exist Pipe*	*24*	*0.20*	*0.013*	*6.95*	*10.12*
9	*900 South*	*24*	*0.61*	*0.012*	*8.96*	*17.67*

4.0 Summary and Conclusions

The overall intent of this report was to ensure that the generated runoff from the proposed development did not have any adverse effects to the existing drainage patterns of the area and to ensure that the onsite drainage system and detention basin were sized for the required 100-year storm.

In our professional opinion, the on-site detention system will be able to detain the water accumulated during a 100-year storm event and release at the approved rate.

Appendix

Storm Runoff Calculations

Vaquero

1/19/2017 KHH

The following runoff calculations are based on the Rainfall - Intensity - Duration Frequency Curve for the Reese, UT area taken from NOAA Atlas 14 using a 10 year storm for collection and a 100 year storm for storage. Storage facilities have been designed per requirements provided by the City for a regional detention pond. A majority of water run off collected from the property will be diverted into a holding pond and released at a reduced rate as part of the detention pond. Design calculations here are presented for the overall property development.

The calculations are as follows:

1. Drainage Area:

Total Area =	12.42	acres or	541,203	ft^2
Total Collected Area	6.31		288,888	

Developed Runoff Coefficient

Runoff Coefficients

Single Family Residence	Paved Area	79,905	C = 0.9
	Landscaped Area	178,983	C = 0.2
	Roof	30,000	C = 0.9

Weighted Runoff Coefficient C = 0.47

2. Time of Concentration:

Use: **30 min.**

Estimated from storm water runoff overland flow time

3. Rainfall Intensities:

10-yr 30-min (conveyance) 1.39 in/hr

4. Peak Run-off:

Runoff Coefficient	C =	0.47		0.9
Rainfall Intensity	i =	1.39	IN./HR.	1.39
Acreage	A =	6.63	ACRES	0.32
		288,888	ft^2	
Runoff Quantity	Q =	CiA		
Q (max at pond iternal)	**Q =**	**4.30**	**ft^3/s**	**0.40**

5. Allowable Discharge:

Typical allowable discharge Q = (0.1 x acres)

Allowable Discharge = Q = 0.66 ft^3/s

6. Volume of Run-off for 100-year 24-Hour Storm Event:

C = 0.47

A = 288,888 ft^2

Q(out) = 0.66 ft^3/s

time (min)	time (sec)	i (in./hr.)	Q (cfs)	Vol. in (cf)	Vol. out (cf)	Difference (cf)
0	0	0.00	0.00	0	0	0
5	300	6.59	20.55	6,165	199	5,966
10	600	5.00	15.59	9,355	398	8,957
15	900	4.14	12.91	11,619	597	11,022
30	1800	2.79	8.70	15,660	1,194	14,466
60	3600	1.72	5.36	19,309	2,388	16,921
120	7200	0.94	2.94	21,195	4,775	16,420
180	10800	0.64	2.00	21,621	7,163	14,459
360	21600	0.36	1.12	24,113	14,325	9,788
720	43200	0.22	0.69	29,636	28,650	986
1440	86400	0.12	0.39	33,408	57,300	-23,892

Total Required Detention Volume 16,921 ft^3

7. Orifice Sizing Area:

Given:

Q =	0.66	cfs	
2g =	64.4	ft/s^2	
H =	2.50	ft	
Cd =	0.7		for circular openings
R =	SQRT(Q/(0.7*pi*(64.4*H)^0.5))		
R =	0.15	feet	
	1.85	inches	
D =	**3.70**	**inches**	

SUMMARY:

The required volume of the detention basin is 16,921.1 ft^3

Orifice Diameter at Outlet is 3.70 inches

Cross Section for Trapezoidal Channel - 1

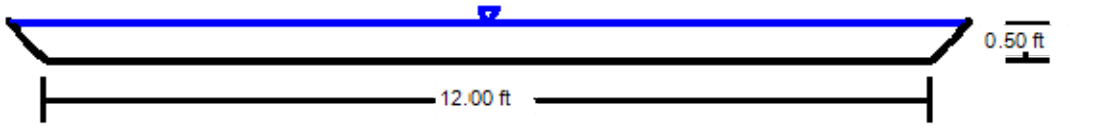
Project Description

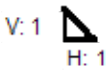
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00140	ft/ft
Normal Depth	0.50	ft
Left Side Slope	0.94	ft/ft (H:V)
Right Side Slope	0.94	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	6.95	ft³/s

Cross Section Image





Cross Section for Trapezoidal Channel - 2

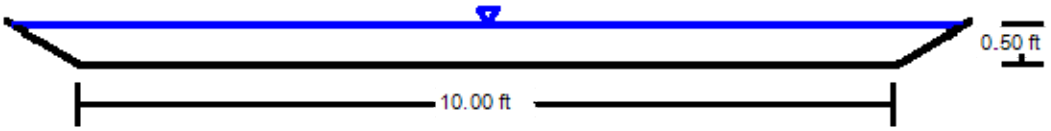
Project Description

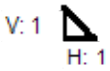
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00320	ft/ft
Normal Depth	0.50	ft
Left Side Slope	1.67	ft/ft (H:V)
Right Side Slope	1.67	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	8.96	ft³/s

Cross Section Image





Cross Section for Circular Pipe - 1

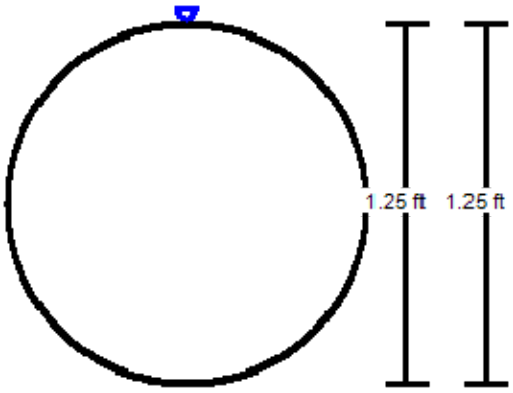
Project Description

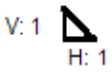
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00390	ft/ft
Normal Depth	1.25	ft
Diameter	1.25	ft
Discharge	4.03	ft^3/s

Cross Section Image





Cross Section for Circular Pipe - 2

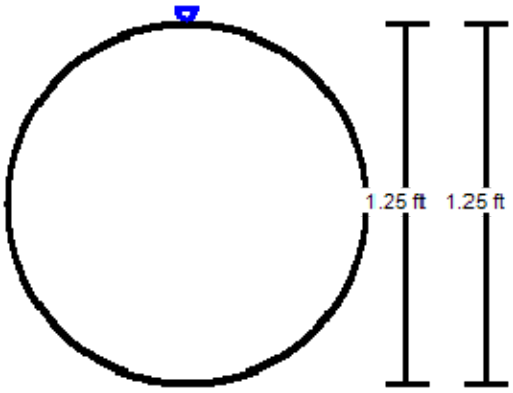
Project Description

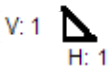
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.01260	ft/ft
Normal Depth	1.25	ft
Diameter	1.25	ft
Discharge	7.25	ft^3/s

Cross Section Image





Cross Section for Circular Pipe - 3

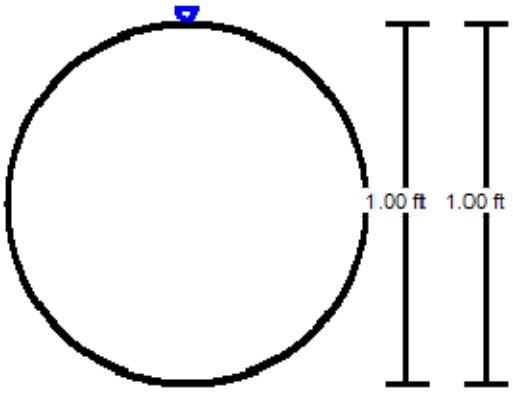
Project Description

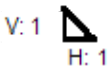
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00250	ft/ft
Normal Depth	1.00	ft
Diameter	1.00	ft
Discharge	1.78	ft^3/s

Cross Section Image





Cross Section for Circular Pipe - 4

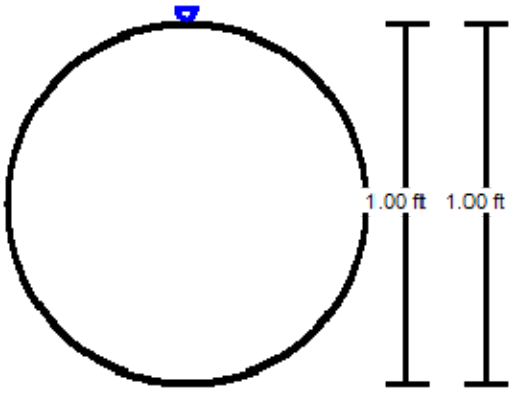
Project Description

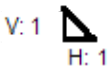
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00220	ft/ft
Normal Depth	1.00	ft
Diameter	1.00	ft
Discharge	1.67	ft³/s

Cross Section Image





Cross Section for Circular Pipe - 5

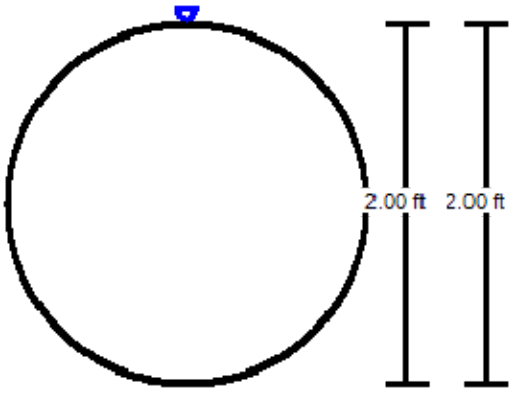
Project Description

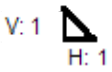
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00200	ft/ft
Normal Depth	2.00	ft
Diameter	2.00	ft
Discharge	10.12	ft³/s

Cross Section Image





Cross Section for Circular Pipe - 6

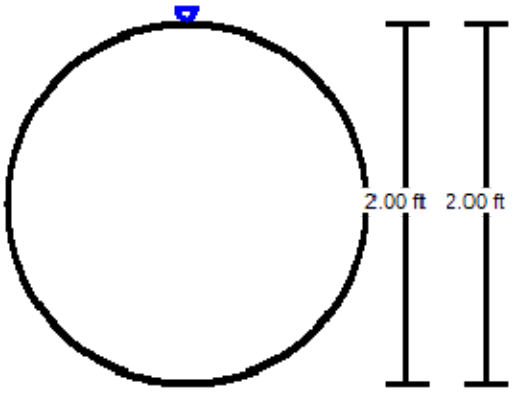
Project Description

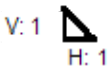
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00200	ft/ft
Normal Depth	2.00	ft
Diameter	2.00	ft
Discharge	10.12	ft³/s

Cross Section Image





Cross Section for Circular Pipe - **7**

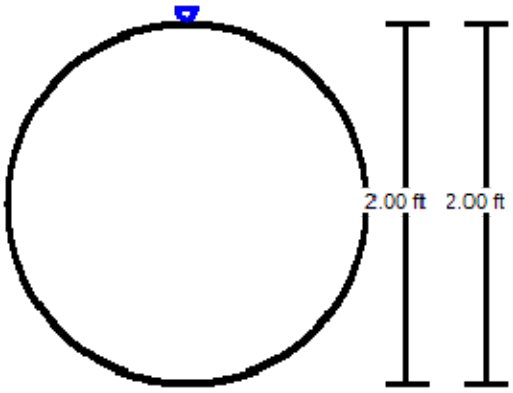
Project Description

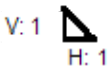
Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00200	ft/ft
Normal Depth	2.00	ft
Diameter	2.00	ft
Discharge	10.12	ft³/s

Cross Section Image





Cross Section for Circular Pipe - 9

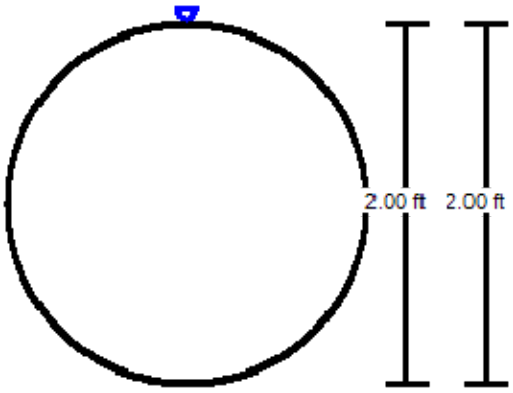
Project Description

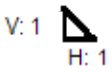
Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00610	ft/ft
Normal Depth	2.00	ft
Diameter	2.00	ft
Discharge	17.67	ft^3/s

Cross Section Image





Reeve & Associates, Inc.

5160 South 1500 West
Riverdale, Utah 84405
801-621-3100
Fax 801-621-2666
website: www. reeve-assoc.com