FINAL DRAINAGE PLAN AND REPORT

16140 OLD DENVER ROAD

PART OF THE NW1/4 SEC. 26, T.11S., R.67W., 6th P.M.

EL PASO COUNTY

February 3, 2017

Revised
January 5, 2018

Revised
October 23, 2019

Revised
February 7, 2020

Revised
May 18, 2020

Revised
January 18, 2021

Revised
April 27, 2021

Prepared for

All About Outdoor Storage

PCD File No. PPR-16-037

Oliver E. Watts, Consulting Engineer, Inc.
Colorado Springs, Colorado

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April 27, 2021

El Paso County D.O.T.
2880 International Circle
Colorado Springs, CO 80910

ATTN: *Gilbert LaFarge*

SUBJECT: Drainage Plan and Report
All About Outdoor Storage PPR-16-037

Transmitted herewith for your review and approval is the drainage plan and report for All About Outdoor Storage at 16140 Old Denver Road in El Paso County. This report will accompany the change in use request for subject development, as requested in you review letter of January 6, 2017. It has been revised in accordance with our meeting with you and Elizabeth Nijkamp April 17, 2017, subsequent additional surveys performed at your request, and your comments of January 5, 2018, January 28, 2020, March 12, 2020, November 16, 2020, and February 18, 2021. This plan will reflect the anticipated ultimate development of the entire site.

Please contact me if I may provide any further information.

Oliver E. Watts, Consulting Engineer, Inc.

BY: ______________________
Oliver E. Watts, President

Encl:

Drainage Report, 7 pages
Computations, 11 pages
FEMA Map Panel No. 08041C0286 G
SCS Soils Map and Interpretation Sheet
Backup Information, 6 sheets
Vivid Report, 8 pages
Drainage Plan, Dwg 17-4958-03
Outlet Structure Details, Dwg 17-4958-07

1. ENGINEER'S STATEMENT:

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

Oliver E. Watts, Consulting Engineer, Inc.

7/12/24

Oliver E. Watts Colo. PE-LS No. 9853

2. OWNERS / DEVELOPER'S STATEMENT:

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

All About Outdoor Storage

By: ______________________________

16140 Old Denver Road
P.O. Box 73
Monument, CO 80132-0073

3. EL PASO COUNTY:

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

____

Jennifer Irvine, P.E., date
County Engineer / ECM Administrator

Conditions:

4. LOCATION AND DESCRIPTION:

All About Outdoor Storage is located at 16140 Old Denver Road adjacent to the Southerly City limits for the Town of Monument in Section 26, T.11S., R.67W. of the 6th P.M. in El Paso County. A change is land use from a landscape rock yard to a RV storage use was requested, and this report is a result of the 1st County review letter of January 6, 2017. The effect of this change in use is analyzed.

The site is located on Teachout Creek, and unstudied drainage basin lying south of Dirty Woman Creek. None of the requirements in the Dirty Woman Creek MDBPS affect this site. This and adjacent sites drain westerly to the Union Pacific Railroad right of way and southerly into the Teachout Creek Creek crossing, which immediately discharges into Monument Creek. The drainage outfall from this site remains on private ground east of the railroad right of way.

The front portion of the total property is leased and used by All About Outdoor Storage, and the rear is used for equipment storage by another owner, as shown on the drainage plan. The existing detention pond near the southwest corner was constructed in 1986; however the County files could not be found. There is no history of drainage problems with the existing construction and it does not appear that the outlet works or spillway have discharged since construction.

5. FLOOD PLAIN STATEMENT:

This subdivision is not within the limits of a flood plain or flood hazard area, according to FEMA map panel number 08041C0286 G, dated December 7, 2018, a copy of which is enclosed for reference.

6. METHOD AND CRITERIA:

The method used for all computations is that specified in the City-County Drainage Criteria Manual, using the rational method for areas of the size of the development. Detention computations are based on UD-Detention work sheets, for existing and full spectrum detention conditions. All computations are enclosed for reference and review. The approach is to use as many of the existing facilities as possible, consistent with the referenced meetings with El Paso County personnel.

The soils in the subdivision have been mapped by the local USDA/SCS office, and a soils map and interpretation sheet are enclosed for reference. All soils in this area are of hydrologic group **"B"** within the affected area.

7. DESCRIPTION OF RUNOFF:

The major change in the development resulting from the proposed change of use is a change in the pavement over the storage site from gravel to a shaved asphalt surface, in order to mitigate dust. The site is totally graded and runoff is westerly to an existing detention pond in the southwest corner adjacent to the D&RG railroad right of way. Existing and proposed runoffs are computed contrasting the two pavement types and the detention pond is analyzed in accordance with its intended use as a full spectrum extended detention basin.

Basin A consists of the total All About Outdoor Storage property and sheet flows to the westerly boundary where the historic runoff of 15.9 cfs / 31.8 cfs (5-year / 100- year runoffs), increases to 22.7 cfs / 49.9 cfs. The historic gravel surface of this site is analyzed to represent total shaved asphaltic pavement, rolled and compacted in place over the entire property, including the entrance roadway. This runoff will sheet flow in the historic manner into the equipment storage portion of the site. No change in grading will be required, nor will drainage structures of any sort be required.

Basis B consists of the majority of the equipment storage portion of the property, and is anticipated to develop in similar manor to Basin A, consisting of a native gravel surface. It now has numerous pieces of construction equipment in storage but will be configured for vehicle storage similar to that in Basin A. An existing metal building constructed in 1999 will remain in place. The total runoff will sheet flow to the existing detention pond in the southwest corner of the site. The combined historic runoff at the pond site of 19.1 cfs / 41.5 cfs will be increased to 22.4 cfs / 49.6 cfs, based on an anticipated total impervious ratio of 70%. No additional drainage provisions will be required other than normal maintenance of existing facilities.

The existing detention pond was originally constructed in 1986 as a detention basin for peak flow mitigation, along with those of similar structures on the two adjacent northerly lots. No design details are on file. The total storage in the pond to the spillway is 0.155 acre feet, with 0.559 acre feet available to the top of the embankment. There are two 8-inch drains stubbed into the pond, exiting into a 5 foot diameter vertical RCP outlet works, with an 8- inch PVC outlet works, discharging onto the owner's property to the south. The existing pond shows no sign of erosion at the spillway or along the embankment, and there is no sign that the outlet pipe has ever carried runoff. It apparently has functioned adequately since its construction in 1986, giving it a current history of nearly 35 years adequate service. Because of this, an infiltration test was taken by Vivid geotechnical, the results of which are enclosed. The anticipated infiltration values are incorporated into the design sheets.

The existing outlet works will be replaced with a full spectrum outlet works as prescribed by the Denver Urban drainage criteria. The details of the outlet are included with the drainage plans and the computation sheets are enclosed, based on the geometry of the proposed pond. As shown the pond has a capacity of 1.503 acre feet at elevation 6787. The water quality capture volume is 0.193 AF, the EURV is 0.591 AF. The required detention for the 100-year storm is 1.049 AF. Corresponding water surface values are shown on the outlet structure detail sheet. The maximum water surface for the 100-year storm is at elevation 84.77, and the emergency spillway is set at elevation 86.00. The detention computations show a peak outfall of 14.9 CFS for the pond, well below the historic runoff value of 41.5 cfs. Based on the spillway geometry type VL riprap is provided. An 18 inch RCP outlet is proposed with a reectangular orifice plate.

The outfall of the 18" RCP outlet pipe is within a small triangular portion of the boundary of this parcel as shown on the drainage plan. A channel runs southerly from there through a dense willow patch and outside the railroad right of way to the Teachout Creek channel that crosses the railroad into Monument Creek as shown on the enclosed FEMA map. Computations sheets are enclosed showing that the channel is stable through the willow thicket and needs no improvement.

Access ramps are to be provided as shown on the drainage plan to provide County required construction vehicular access to the pond for maintenance.

Basin "C" consists of an area adjacent to the D&RG right of way that was constructed to provide a dike routing the runoff into the pond, and is a range land type cover. The runoff is 0.1cfs /0.5cfs into the right of way

8. FOUR STEP PROCESS

The following process has been followed to minimize adverse impacts of urbanization

A. Employ Reduction Practiced: The scope of the development has been minimized consistent with zoning requirements to present the minimum footprint in providing a commercial development of the type proposed by the owner. The pavements chosen create a minimum of runoff consistent with the requirement amount of protection. The undisturbed portions are to be landscaped to increase the pervious percent.

B. Stabilize Drainageways: The site will be graded to route the runoff over improved installations to provide channel stabilizing in the natural erosive material over the site. Improvements above those shown on the approved plans will be made on an as-needed basis. Discharge from the site will be into a stable channel, being the historic discharge location. An analysis of this channel is included in the computations. There will be no adverse affect on downstream developments as a result of this subdivision

C. Provide Water Quality Capture Volume (WQCV): The above described EDB is to be provided to provide water quality treatment and a reduced rate of discharge from the development as specified by County regulations. Details are shown on the enclosed ED-Detention work sheets, as summarized above. That portion to be graded at this time is below one acre. The WQCV will be released through the orifice plate figuration in the outlet structure.

D. Consider Need for Industrial and Commercial BMP's: This is a commercial RV storage site, so source control problems will be a minimum. During construction of the detention pond and site improvements, standard site specific state of the art BMP's will be employed to minimize and mitigate erosive problems. Grading and erosion control plans will be submitted for approval as required.

9. COST ESTIMATE:

All items are private.

Item No.	Description	Quantity	Unit Cost	Cost
1	Pond Excavation	1647 CY	$ 5.00	$ 8,235.00
2	Pond Embankment	489 CY	10.00	4,890.00
3	DU EDB Outlet Structure	LS	25,000	25,000.00
4	18" RCP	47.20 LF	65.00	3,068.00
5	VL Riprap	116 CY	112.00	12,992.00
	Subtotal Construction Cost			$ 54,185.00
	Engineering	10%		5,418.50
	Total Estimated Cost			$ 59,603.50

9. FEES:

Fees are not applicable

10. SUMMARY

The "All About Outdoor Storage" site is a 12.090 acre commercial RV storage site. The front (east) 7.002 acre portion is now in use for that purpose, and the rear remainder is vacant storage except for the existing detention pond in the Southwest corner. The proposed drainage facilities will adequately convey, detain and outfall runoff from the site to existing sufficient downstream facilities. These facilities are designed so that the total site may be used for RV storage without further revision to the drainage plan and facilities. Site runoff and storm drain and appurtenances will not adversely affect the downstream and surrounding developments.

The drainage analysis has been prepared in accordance with the current City of Colorado Springs and El Paso County Drainage Criteria Manuel. Supporting information and calculations are included in this report.

References

1. City/ County Drainage Criteria Manuel, Volumes 1 and 2, May, 2014
2. El Paso County Engineering Criteria Manual.

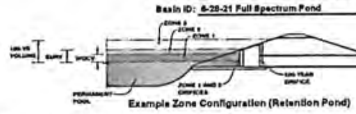
1/11

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: All About Outdoor Storage, 18140 Old Denver Road, El Paso County, Colorado

Basin ID: 6-28-21 Full Spectrum Pond



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	11.55	acres
Watershed Length =	1,130	ft
Watershed Slope =	0.024	ft/ft
Watershed Imperviousness =	48.00%	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) =	0.193	acre-feet
Excess Urban Runoff Volume (EURV) =	0.591	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.474	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	0.650	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	0.887	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	1.253	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	1.505	acre-feet
100-yr Runoff Volume (P1 = 2.52 in.) =	1.836	acre-feet
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet
Approximate 2-yr Detention Volume =	0.444	acre-feet
Approximate 5-yr Detention Volume =	0.610	acre-feet
Approximate 10-yr Detention Volume =	0.814	acre-feet
Approximate 25-yr Detention Volume =	0.894	acre-feet
Approximate 50-yr Detention Volume =	0.935	acre-feet
Approximate 100-yr Detention Volume =	1.049	acre-feet

Optional User Override 1-hr Precipitation

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

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.193	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.397	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.458	acre-feet
Total Detention Basin Volume =	1.049	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 = 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	--	--	--	3,549	0.081		
	--	0.50	--	--	--	3,930	0.090	1,830	0.042
ELEV 6792	--	1.00	--	--	--	4,428	0.102	3,915	0.090
	--	1.50	--	--	--	4,886	0.112	6,239	0.143
	--	2.00	--	--	--	5,429	0.125	8,812	0.202
	--	2.50	--	--	--	10,066	0.231	12,740	0.292
	--	3.00	--	--	--	11,770	0.270	18,199	0.418
	--	3.50	--	--	--	13,799	0.317	24,591	0.565
	--	4.00	--	--	--	15,177	0.348	31,835	0.731
	--	4.50	--	--	--	15,982	0.367	39,625	0.910
ELEV 6796	--	5.00	--	--	--	16,809	0.386	47,823	1.098
	--	5.50	--	--	--	17,645	0.405	56,436	1.296
ELEV 6797	--	6.00	--	--	--	18,536	0.426	65,482	1.503
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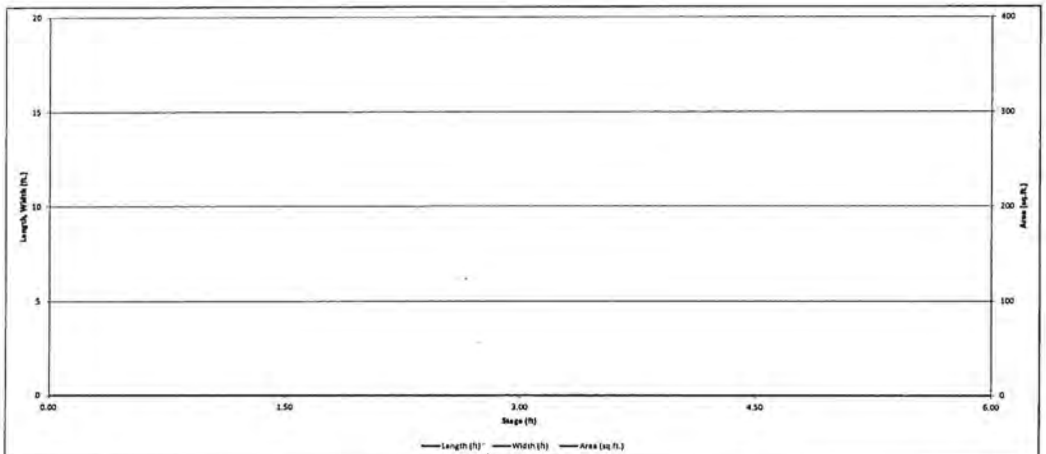
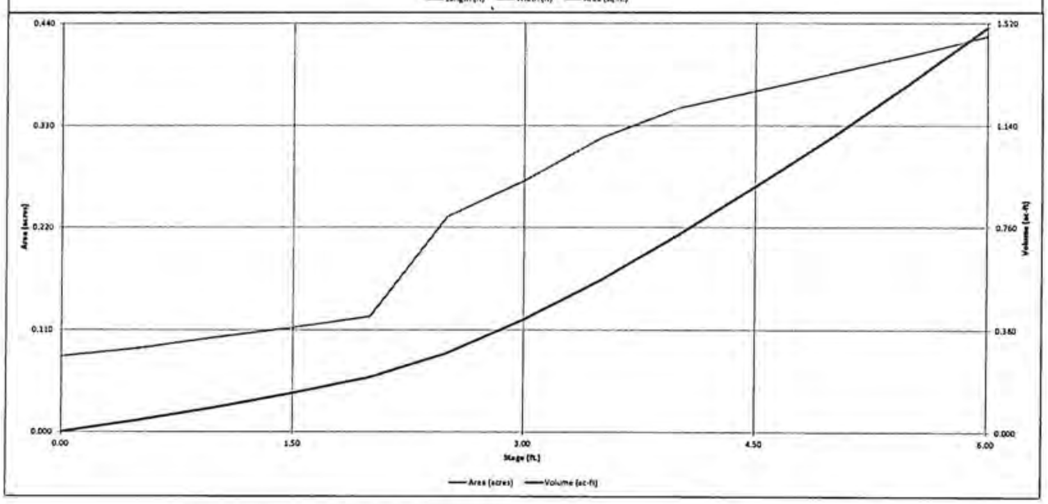
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



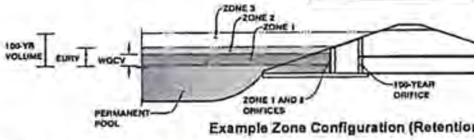


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: All About Outdoor Storage 6-28-21

Basin ID:



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.92	0.193	Orifice Plate
Zone 2 (EURV)	3.59	0.397	Orifice Plate
Zone 3 (100-year)	4.88	0.458	Weir&Pipe (Restrict)
		1.049	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 =	3.59	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	14.40	inches
Orifice Plate: Orifice Area per Row =	N/A	inches

Calculated Parameters for Plate

WQ Orifice Area per Row =	N/A	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	1.20	2.39					
Orifice Area (sq. inches)	1.99	1.23	1.23					

	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 =	3.75	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	4.00	N/A	feet
Overflow Weir Slope =	3.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	3.00	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 =	4.75	N/A	feet
Over Flow Weir Slope Length =	3.16	N/A	feet
Grate Open Area / 100-yr Orifice Area =	5.01	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	8.85	N/A	ft^2
Overflow Grate Open Area w/ Debris =	4.43	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 =	1.00	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	18.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	18.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

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

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	5.00	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	57.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.30	feet
Stage at Top of Freeboard =	6.30	feet
Basin Area at Top of Freeboard =	0.43	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	0.00
Calculated Runoff Volume (acre-ft) =	0.193	0.591	0.474	0.650	0.887	1.253	1.505	1.836	0.000
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.193	0.590	0.474	0.650	0.886	1.252	1.504	1.835	#N/A
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.02	0.19	0.63	0.87	1.17	0.00
Predevelopment Peak Q (cfs) =	0.0	0.0	0.1	0.2	2.2	7.2	10.0	13.5	0.0
Peak Inflow Q (cfs) =	3.1	9.4	7.5	10.3	14.0	19.7	23.6	28.8	#N/A
Peak Outflow Q (cfs) =	0.1	0.2	0.2	0.2	1.8	6.4	9.7	13.9	#N/A
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.1	0.9	0.9	1.0	1.0	#N/A
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	#N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.2	0.7	1.1	1.5	#N/A
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	#N/A
Time to Drain 97% of Inflow Volume (hours) =	38	58	53	60	61	58	56	54	#N/A
Time to Drain 99% of Inflow Volume (hours) =	41	64	58	66	69	67	66	65	#N/A
Maximum Ponding Depth (ft) =	1.78	3.47	3.09	3.65	4.09	4.49	4.69	4.90	#N/A
Area at Maximum Ponding Depth (acres) =	0.12	0.31	0.28	0.33	0.35	0.37	0.37	0.38	#N/A
Maximum Volume Stored (acre-ft) =	0.176	0.552	0.442	0.613	0.762	0.902	0.976	1.059	#N/A

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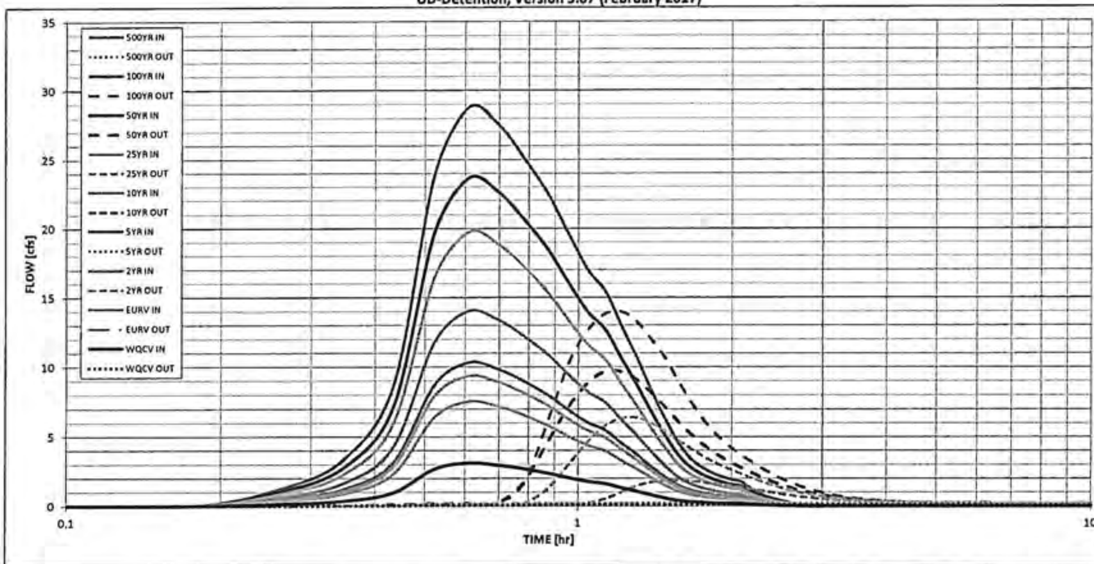
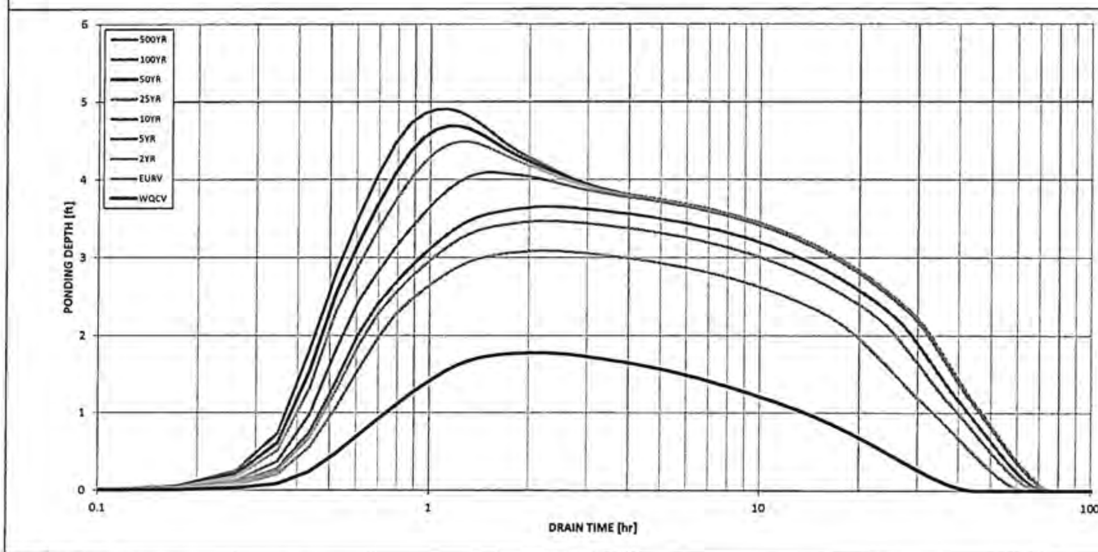
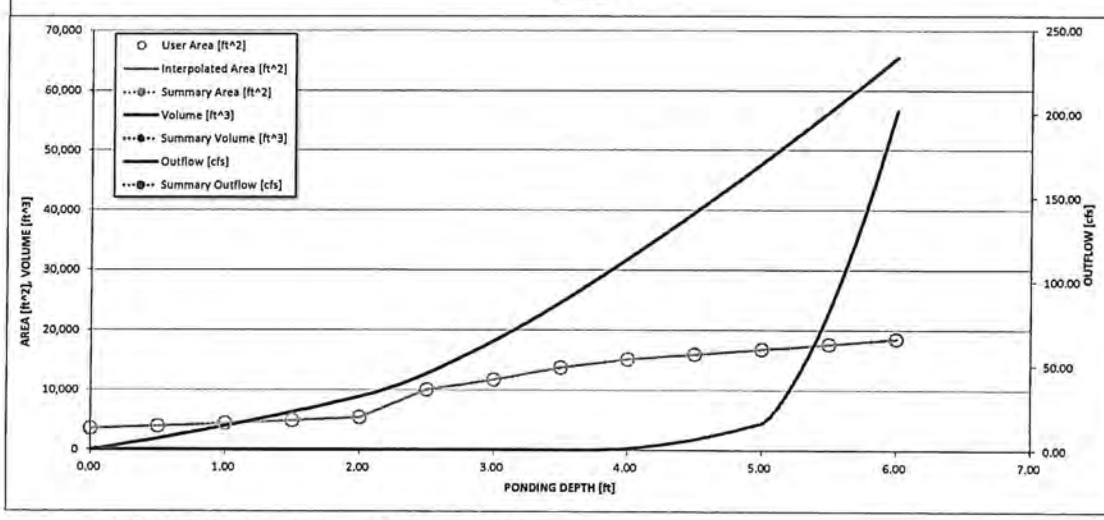
Detention Basin Outlet Structure Design

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			

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Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

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

	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	#N/A
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.23 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	0:05:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
Hydrograph	0:10:28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
Constant	0:15:41	0.14	0.42	0.34	0.46	0.62	0.86	1.02	1.24	#N/A
0.956	0:20:55	0.38	1.12	0.90	1.23	1.67	2.33	2.79	3.38	#N/A
	0:26:09	0.97	2.88	2.32	3.16	4.28	5.99	7.16	8.69	#N/A
	0:31:23	2.66	7.90	6.38	8.69	11.76	16.46	19.67	23.85	#N/A
	0:36:37	3.11	9.37	7.55	10.32	14.02	19.72	23.64	28.77	#N/A
	0:41:50	2.96	8.94	7.19	9.84	13.39	18.86	22.62	27.54	#N/A
	0:47:04	2.69	8.14	6.55	8.96	12.19	17.17	20.59	25.07	#N/A
	0:52:18	2.38	7.27	5.84	8.00	10.91	15.38	18.46	22.50	#N/A
	0:57:32	2.04	6.27	5.03	6.91	9.43	13.33	16.02	19.55	#N/A
	1:02:46	1.78	5.46	4.39	6.02	8.21	11.59	13.93	16.98	#N/A
	1:07:59	1.61	4.95	3.97	5.46	7.44	10.51	12.63	15.40	#N/A
	1:13:13	1.32	4.08	3.27	4.50	6.16	8.73	10.51	12.83	#N/A
	1:18:27	1.06	3.33	2.66	3.68	5.05	7.17	8.64	10.58	#N/A
	1:23:41	0.80	2.56	2.04	2.83	3.91	5.58	6.75	8.28	#N/A
	1:28:55	0.58	1.90	1.51	2.11	2.92	4.21	5.11	6.30	#N/A
	1:34:08	0.43	1.38	1.10	1.53	2.11	3.07	3.74	4.63	#N/A
	1:39:22	0.34	1.07	0.85	1.18	1.63	2.35	2.85	3.52	#N/A
	1:44:36	0.28	0.88	0.70	0.97	1.34	1.92	2.33	2.86	#N/A
	1:49:50	0.24	0.75	0.60	0.83	1.14	1.63	1.97	2.42	#N/A
	1:55:04	0.21	0.66	0.52	0.73	1.00	1.43	1.72	2.12	#N/A
	2:00:17	0.19	0.59	0.47	0.65	0.90	1.28	1.55	1.90	#N/A
	2:05:31	0.18	0.55	0.44	0.60	0.83	1.18	1.42	1.74	#N/A
	2:10:45	0.13	0.40	0.32	0.44	0.61	0.87	1.05	1.29	#N/A
	2:15:59	0.09	0.29	0.23	0.32	0.44	0.63	0.76	0.94	#N/A
	2:21:13	0.07	0.22	0.17	0.24	0.33	0.47	0.56	0.69	#N/A
	2:26:26	0.05	0.16	0.13	0.17	0.24	0.34	0.42	0.51	#N/A
	2:31:40	0.04	0.11	0.09	0.13	0.17	0.25	0.30	0.37	#N/A
	2:36:54	0.02	0.08	0.06	0.09	0.12	0.18	0.21	0.26	#N/A
	2:42:08	0.02	0.06	0.04	0.06	0.09	0.13	0.15	0.19	#N/A
	2:47:22	0.01	0.04	0.03	0.04	0.06	0.09	0.10	0.13	#N/A
	2:52:35	0.01	0.02	0.02	0.02	0.03	0.05	0.06	0.08	#N/A
	2:57:49	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.04	#N/A
	3:03:03	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	#N/A
	3:08:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:13:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:18:44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:23:58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:29:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:34:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:39:40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:44:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:50:07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:55:21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:00:35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:05:49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:11:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:16:16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:21:30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:26:44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:31:58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:37:11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:42:25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:47:39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:52:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:58:07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:03:20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:08:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:13:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:19:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:24:16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:29:29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:34:43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:39:57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:45:11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:50:25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:55:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:00:52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:06:06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:11:20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:16:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A

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Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Summary Stage-Area-Volume-Discharge Relationships

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

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

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

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

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

MOVE MAJOR BASIN	SUB BASIN	AREA		BASIN		Tc MIN	I		SOIL GRP	DEV. TYPE	C		FLOW		RETURN PERIOD	
		PLANIM READ	ACRES	LENGTH	HEIGHT								qp	qp		
HISTORIC	A	COGO		100	S=2.7%	6.6									5	100
			S=1.69%	+650	V=2.6	+4.2										
		80%	6.89			10.8	3.9	6.6	B	GRAVEL	0.59	0.70	15.9	31.8	5	100
	B	40%	4.66	+380	V=1.7	+3.6			B	STORE	0.30	0.50				
	TOTAL	64%	11.55			14.4	3.5	5.8	B	MIX	0.473	0.619	19.1	41.5	5	100
	C		0.35	300	1.64%	34	2.2	3.7	B	MDW	0.09	0.36	0.1	0.5	5	100
DEVELOPED	A			100	S=2.7%	4.6			B	AC GRAV						
			S=1.69%	+650	V=2.6	+4.2										
			6.89			8.8	4.3	7.3			0.74	0.83	21.9	41.7	5	100
	B		4.17	+380		+3.6			B	STORE	0.30	0.50				
			0.49						B	POND	0.121	0.39				
	TOTAL	70%	11.55			12.4	3.5	6.2	B	80%	0.555	0.692	22.4	49.6	5	100

HYDROLOGICAL COMPUTATION – BASIC DATA
PROJ: 16140 OLD DENVER ROAD BY: O.E. WATTS
RATIONAL METHOD DATE: 1-27-17 10-23-19

OLIVER E. WATTS, CONSULTING ENGINEER, INC.
614 ELKTON DRIVE COLORADO SPRINGS, CO 80907

STREET AND STORM SEWER CALCULATIONS

STREET	LOCATION	DISTANCE	ELEVATION & SLOPE	TOTAL RUNOFF	STREET FLOW / CAPACITY	PIPE FLOW	TYPE PIPE, CATCH BASIN & SLOPE %
EXIST OUTLET			TOP=82.84	19.1/41.5		49.9	5' DIA RCP VERT, d=0.90'
			WS 84.02 S=0.94%			49.9	8" PVC, CAP = 1.52 REPLACE 30" RCP S=0.97% MIN hi=1.65 WS=84.85
Outlet			81.00				
		35.63	4.47%	/14		14	24"RCP S=0.4%min
			79.41				
Spillway		Q=14.6 +_	2CFS/ft	3:1			USE VL Riprap

Worksheet for Irregular Section - 1

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.02400	ft/ft
Discharge:	26.30	ft^3/s

Options		
Current Roughness Weighted Methc	ImprovedLotters	
Open Channel Weighted Roughnes:	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.100	
Water Surface Elevation:	78.00	ft
Elevation Range:	76.69 to 78.82 ft	
Flow Area:	16.37	ft^2
Wetted Perimeter:	28.08	ft
Top Width:	27.92	ft
Normal Depth:	1.31	ft
Critical Depth:	0.87	ft
Critical Slope:	0.19411	ft/ft
Velocity:	1.61	ft/s
Velocity Head:	0.04	ft
Specific Energy:	1.35	ft
Froude Number:	0.37	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(-0+22, 78.82)	(0+32, 78.42)	0.100

Section Geometry

Station	Elevation
-0+22	78.82
0+08	77.78

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Worksheet for Irregular Section - 1

Station	Elevation
0+22	76.69
0+32	78.42

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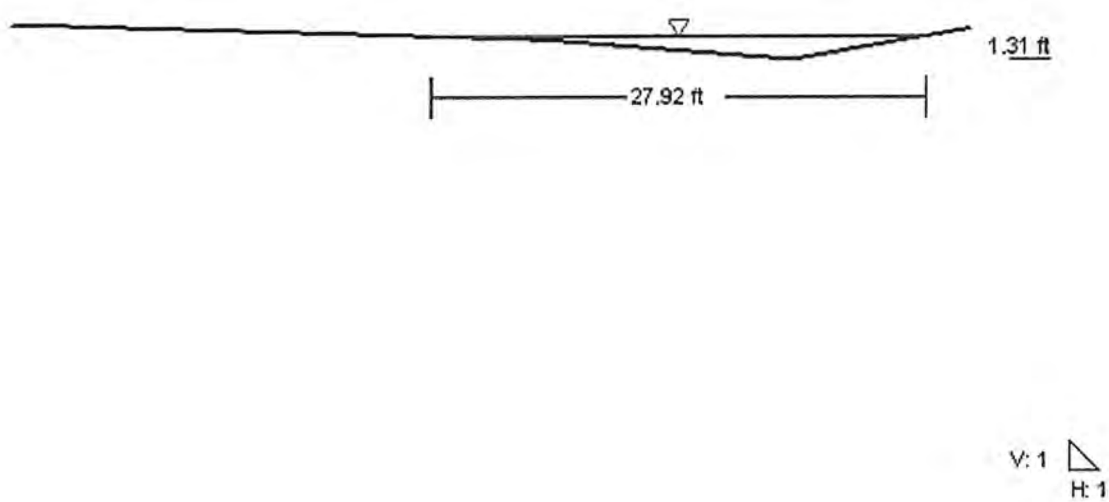
17-4958 All About Outdoor Storage, 0+56.18 Outrll Channel
Cross Section for Irregular Section - 1

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

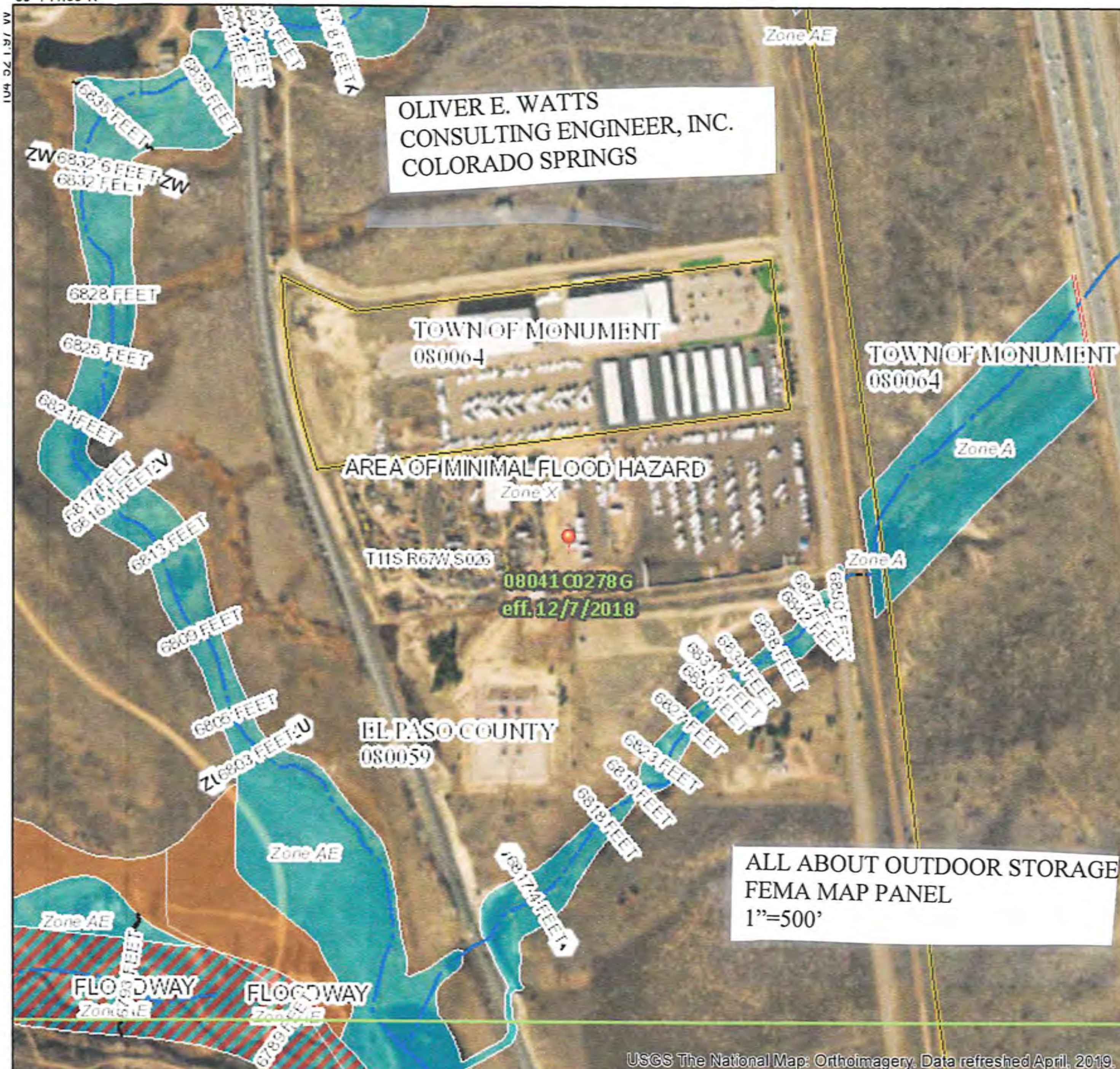
Section Data		
Roughness Coefficient:	0.100	
Channel Slope:	0.02400	ft/ft
Normal Depth:	1.31	ft
Elevation Range:	76.69 to 78.82 ft	
Discharge:	26.30	ft^3/s



National Flood Hazard Layer FIRMette

FEMA

39°4'11.55"N



104°51'24.51"W

39°3'43.61"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Legend

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

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

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

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

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

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

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represen an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 10/24/2019 at 11:58:09 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

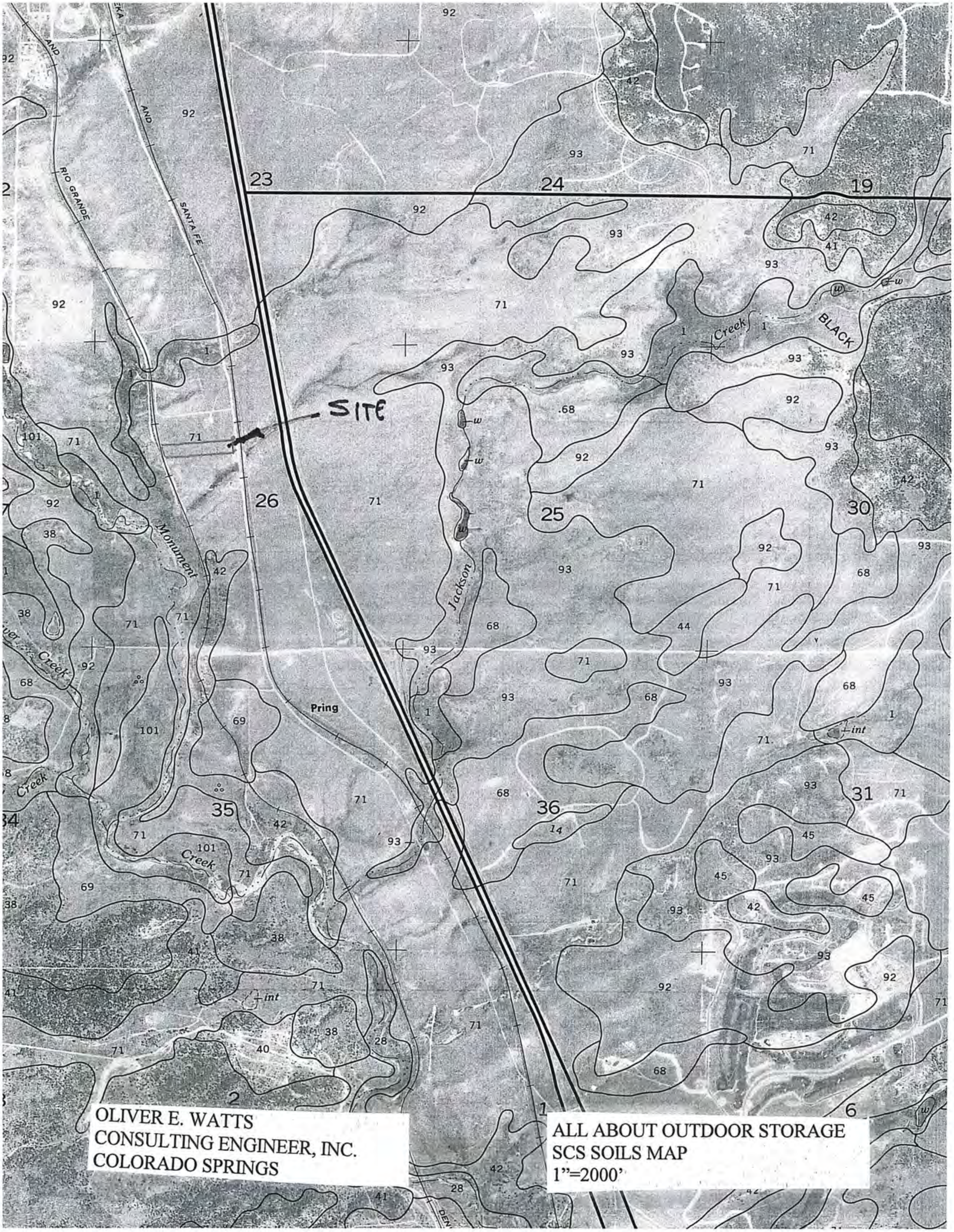

SITE
RIO GRANDE
SANTA FE
Monument
Creek
Jackson
BLACK
Creek
Pring
23
24
19
26
25
30
35
36
31
2
1
6
OLIVER E. WATTS
CONSULTING ENGINEER, INC.
COLORADO SPRINGS
ALL ABOUT OUTDOOR STORAGE
SCS SOILS MAP
1"=2000'

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Manvel: 50	C	None	---	---	>60	---	High.
Manzanola: 51, 52, 53	C	None to rare	---	---	>60	---	Moderate.
Midway: 54	D	None	---	---	10-20	Rippable	Moderate.
Nederland: 55	B	None	---	---	>60	---	Moderate.
Nelson: [1]56:							
Nelson part	B	None	---	---	20-40	Rippable	Low.
Tassel part	D	None	---	---	10-20	Rippable	Low.
Neville: 57	B	None	---	---	>60	---	High.
[1]58:							
Neville part	B	None	---	---	>60	---	High.
Rednun part	C	None	---	---	>60	---	Moderate.
Nunn: 59	C	None	---	---	>60	---	Moderate.
Olney: 60, 61	B	None	---	---	>60	---	Moderate.
[1]62:							
Olney part	B	None	---	---	>60	---	Moderate.
Vona part	B	None	---	---	>60	---	Moderate.
Paunsaugunt: [1]63:							
Paunsaugunt part	D	None	---	---	10-20	Hard	Moderate.
Rock outcrop part	D	---	---	---	---	---	---
Penrose: [1]64:							
Penrose part	D	None	---	---	10-20	Rippable	Low.
Manvel part	C	None	---	---	>60	---	High.
Perrypark: 65	B	None	---	---	>60	---	Moderate.
Peyton: 66, 67	B	None	---	---	>60	---	Moderate.
[1]68, [1]69:							
Peyton part	B	None	---	---	>60	---	Moderate.
Pring part	B	None	---	---	>60	---	Moderate.
Pits, gravel: 70	A	---	---	---	---	---	---
Pring: 71, 72	B	None	---	---	>60	---	Moderate.
Razor: 73, 74	C	None	---	---	20-40	Rippable	Moderate.

See footnote at end of table.

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.

$$t_c = t_i + t_t$$ (Eq. 6-7)

Where:

t_c = time of concentration (min)

t_i = overland (initial) flow time (min)

t_t = travel time in the ditch, channel, gutter, storm sewer, etc. (min)

3.2.1 Overland (Initial) Flow Time

The overland flow time, t_i, may be calculated using Equation 6-8.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}}$$ (Eq. 6-8)

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5}$$ (Eq. 6-9)

Where:

V = velocity (ft/s)

C_v = conveyance coefficient (from Table 6-7)

S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

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

The travel time is calculated by dividing the flow distance (in feet) by the velocity calculated using Equation 6-9 and converting units to minutes.

The time of concentration (t_c) is then the sum of the overland flow time (t_i) and the travel time (t_t) per Equation 6-7.

3.2.3 First Design Point Time of Concentration in Urban Catchments

Using this procedure, the time of concentration at the first design point (typically the first inlet in the system) in an urbanized catchment should not exceed the time of concentration calculated using Equation 6-10. The first design point is defined as the point where runoff first enters the storm sewer system.

$$t_c = \frac{L}{180} + 10 \qquad \text{(Eq. 6-10)}$$

Where:

t_c = maximum time of concentration at the first design point in an urban watershed (min)

L = waterway length (ft)

Equation 6-10 was developed using the rainfall-runoff data collected in the Denver region and, in essence, represents regional "calibration" of the Rational Method. Normally, Equation 6-10 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, the time of concentration is calculated by accumulating the travel times in downstream drainageway reaches.

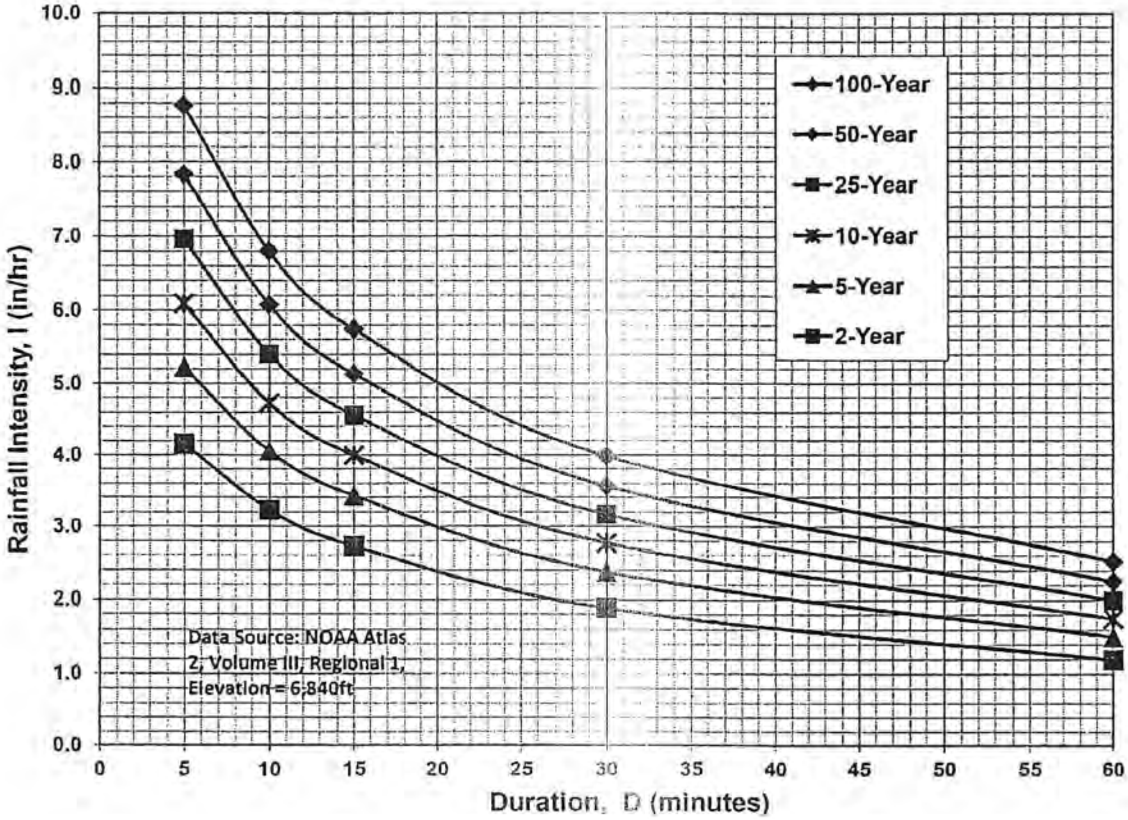
3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

3.2.5 Post-Development Time of Concentration

As Equation 6-8 indicates, the time of concentration is a function of the 5-year runoff coefficient for a drainage basin. Typically, higher levels of imperviousness (higher 5-year runoff coefficients) correspond to shorter times of concentration, and lower levels of imperviousness correspond to longer times of

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_{5} = -1.50 \ln(D) + 7.583$

$I_{2} = -1.19 \ln(D) + 6.035$

Note: Values calculated by equations may not precisely duplicate values read from figure.

$$Q = \frac{0.463}{n} D^{8/3} S^{1/2}$$

$$Q = KS^{1/2}$$

DIAMETER -IN.-	AREA -FT2-	D 8/3 -FT-	K			
			N=0.010	N=0.013	N=0.024	N=0.026
2	0.02182	0.008413	0.3895	---	---	---
4	0.08727	0.053420	2.4733	---	---	---
6	0.19630	0.157500	7.2922	5.609	---	---
8	0.34910	0.339200	15.7050	12.081	---	---
10	0.54540	0.615000	28.4745	21.903	---	---
12	0.78540	1.000000	46.3000	35.615	---	---
15	1.22720	1.813100	83.9465	64.574	---	---
18	1.76710	2.948300	136.5100	105.000	56.88	52.5
21	2.40530	4.447400	205.9100	158.400	85.80	79.2
24	3.14160	6.349600	293.9900	226.140	122.49	113.0
27	3.97610	8.692700	402.4700	309.590	167.70	154.7
30	4.90870	11.512600	533.0300	410.030	222.10	205.0
33	5.93960	14.844100	---	528.680	---	---
36	7.06860	18.720800	866.7700	666.700	361.20	333.3
39	8.29580	23.175100	---	825.400	---	---
42	9.62110	28.238900	---	1005.000	544.80	502.5
48	12.56640	40.317500	---	1436.000	777.80	718.0
54	15.90430	55.195000	---	1966.000	1065.00	983.0
60	19.63500	73.100400	---	2604.000	1410.00	1302.0
66	23.75830	94.254200	---	3357.000	1818.00	1678.0
72	28.27430	118.869400	---	4234.000	2293.00	2117.0
78	33.18310	147.152900	---	5241.000	2839.00	2620.0
84	38.48450	179.306000	---	6386.000	3459.00	3193.0
90	44.17860	215.524500	---	7676.000	4158.00	3838.0
96	50.26550	256.000000	---	9118.000	4939.00	4559.0
108	63.61730	350.466600	---	12480.000	6761.00	6140.0
120	78.53980	464.158900	---	16530.000	8954.00	8265.0

Oliver E. Watts
Consulting Engin
Colorado Springs

Figure 13-12c. Emergency Spillway Protection

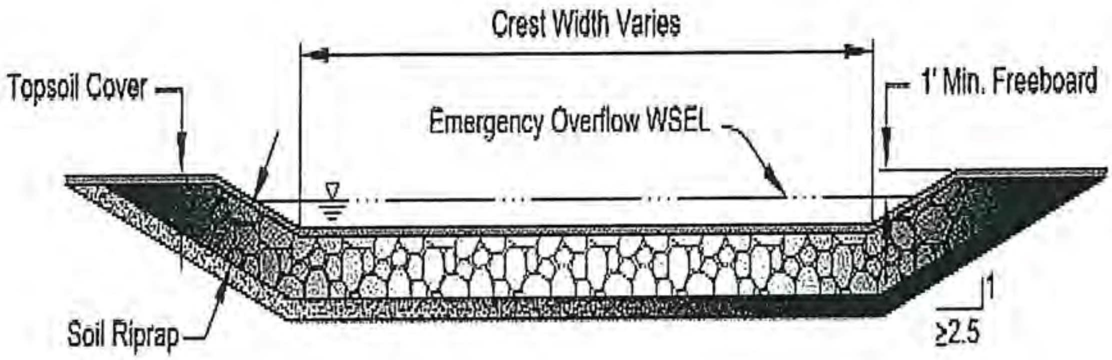
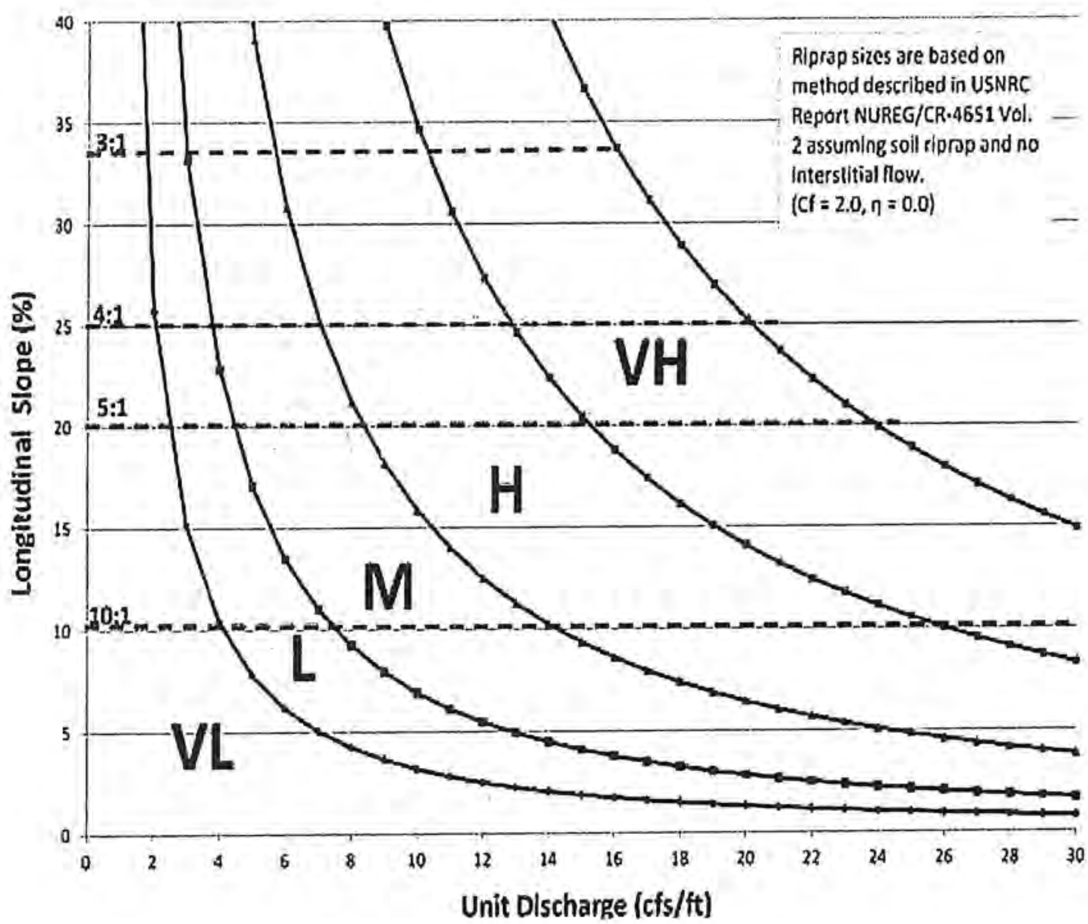


Figure 13-12d. Riprap Types for Emergency Spillway Protection



VIVID Engineering Group, Inc.

1053 Elkton Drive, Colorado Springs, CO 80907

April 24, 2019

Kelly McKoon
All About Outdoor Storage
16140 Old Denver Road, Monument, CO 80132
info@allaboutoutdoorstorage.com
levivankekerix@gmail.com

CC: Oliver E. Watts
Oliver E. Watts Consulting Engineer, Inc.
614 Elkton Drive, Colorado Springs, CO 80907
olliewatts@aol.com

Subject: Double-Ring Infiltration Test Results
Project: Proposed Detention Pond Facility, All About Outdoor Storage, 16140 Old Denver Road, Monument, Colorado
Project No: D19-2-189

Dear Kelly:

Vivid Engineering Group, Inc. (VIVID) has performed a double-ring infiltration test in general accordance with ASTM D3385 for the proposed detention pond facility located at 16140 Old Denver Road, Monument, Colorado.

Our services consisted of performing a double-ring infiltration test within the existing detention pond area that is planned for expansion. This effort also included advancing a geotechnical boring to check for lateral drainage during the infiltration test, and obtaining a subgrade sample for soil gradation analysis testing. This letter transmits our results.

FIELD INVESTIGATION

On April 9, 2019, a test pit was excavated within the existing detention pond area by All About Outdoor Storage personnel to a depth of approximately 1.5 feet below the ground surface. This is the approximate depth of the bottom of the proposed detention pond. The double-ring infiltration test was performed on April 9, 2019 within the excavated test location. Photographs depicting the test pit area are presented in Appendix C to letter.

At the completion of the double-ring infiltration test, a boring (boring B-1) was performed within the test pit for the purpose of checking for lateral drainage that may have occurred during the test. The boring was advanced to a depth of approximately 5.5 feet below the existing ground surface using a 3-inch diameter hand auger. A bulk sample was taken of the cuttings from the boring.

Appendix A to this letter includes a boring log describing the subsurface conditions encountered in the profile boring.

SUBGRADE CONDITIONS

From the ground surface down, the general subsurface profile encountered in the boring consisted of olive-yellow poorly graded sand. Neither bedrock nor groundwater were encountered in the profile boring. The boring log in Appendix A should be reviewed for a more detailed description of the subsurface conditions encountered.

LABORATORY TESTING

A sample of the subgrade materials were taken from the profile boring. Geotechnical laboratory testing was conducted and included soil gradation. The poorly graded sand materials were judged to be non-plastic and have only 4 percent fines (percent passing the No. 200 sieve). This type of clean sand material generally exhibits high permeability. Results of the geotechnical laboratory testing are presented in Appendix B.

DOUBLE-RING INFILTRATION TESTING

The average infiltration rate obtained at the test location was approximately **48.3 cm/hour.** Water was not observed moving laterally around the test location, based on the hand excavation of a shallow bore hole adjacent the double-ring infiltrometer test location.

The double-ring infiltration test results are indicative of the granular (sand) soil encountered on the site.

LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of VIVID's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions and opinions are based on a limited number of observations and data. Data or conclusions presented herein apply to the specific test pit and test locations only. It is likely that subsurface conditions will vary somewhat beyond the locations investigated. VIVID makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

CLOSING

We appreciate this opportunity to serve you, and we look forward to working with you again. Should you have any questions concerning this report, please contact Bill Barreire at 719.491.2292 or wbarreire@vivideg.com, or Benjamin Moore at 720.461.3692 or bmoore@vivideg.com.

Sincerely,

04-24-19

William (Bill) J. Barreire, PE
Senior Geotechnical Engineer

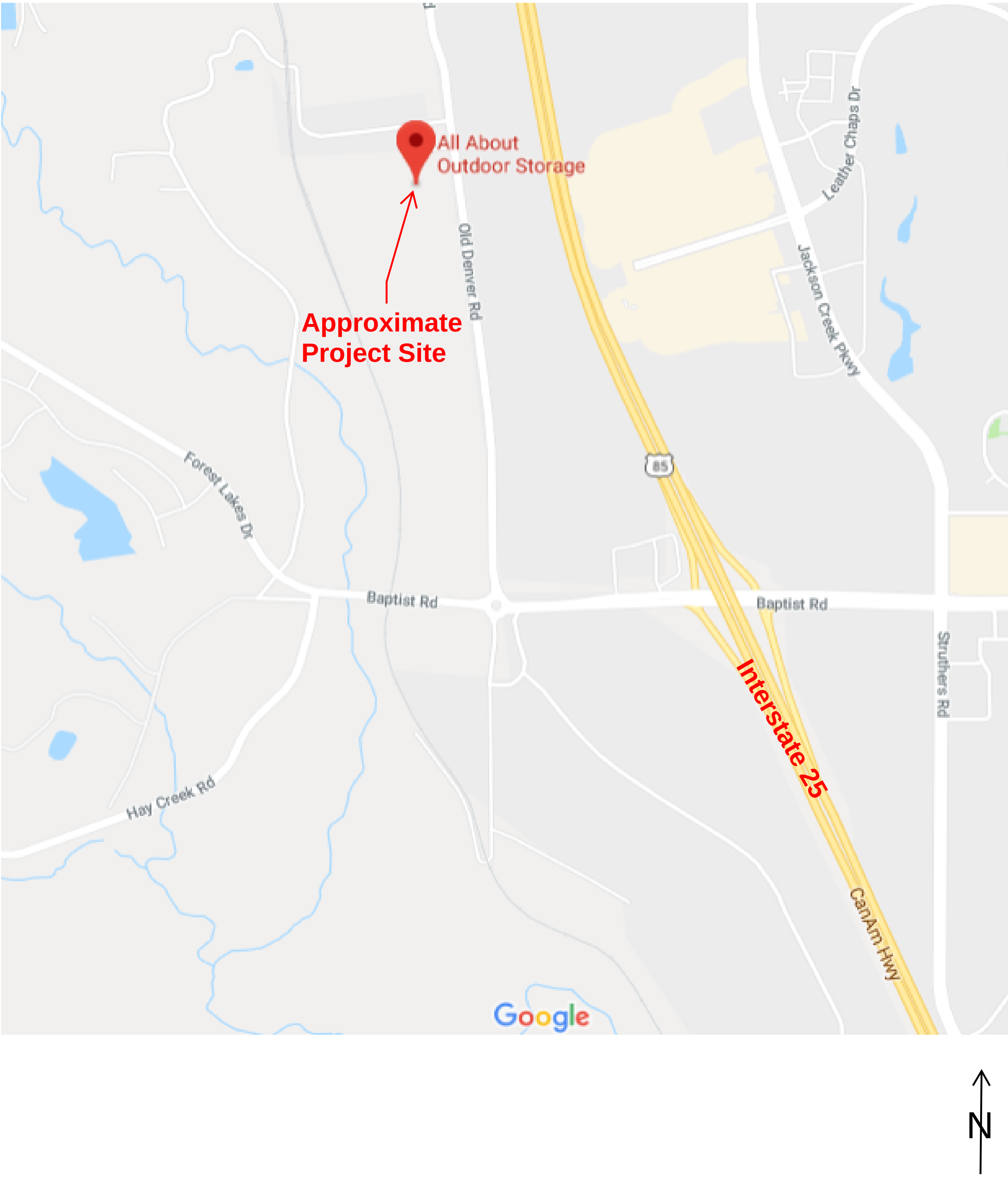
Benjamin Moore, EIT
Staff Engineer

ATTACHMENTS:

FIGURE 1 – VICINITY MAP
FIGURE 2 – EXPLORATION LOCATION PLAN

APPENDIX A – LOG OF EXPLORATORY BORING
APPENDIX B – LABORATORY TEST RESULTS
APPENDIX C – SITE PHOTOS
APPENDIX D – IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL ENGINEERING REPORT

Figures



Not to Scale. Base image obtained from www.google.com/maps, 2019

VIVID Engineering Group	Project No: D19-2-189	**VICINITY MAP**	Figure
	Date: April 23, 2019		1
	Drawn by: BM	Proposed Detention Pond Facility All About Outdoor Storage Monument, Colorado	
	Reviewed by: WJB		

Not to Scale. Base image obtained from Google Earth Pro on June 9, 2017.

VIVID Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
719.896.4356

Project No: D19-2-189
Date: April 23, 2019
Drawn by: BM
Reviewed by: WJB

EXPLORATION LOCATION PLAN

Proposed Detention Pond Facility
All About Outdoor Storage
Monument, Colorado

Figure 2

Appendix A

Logs of Exploratory Borings

VIVID Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

BORING NUMBER B-1

CLIENT	All About Outdoor Storage	**PROJECT NAME**	Proposed Detention Pond Facility
PROJECT NUMBER	D19-2-189	**PROJECT LOCATION**	Monument, CO
DATE STARTED	4/9/19 **COMPLETED** 4/9/19	**GROUND ELEVATION**	**HOLE SIZE** 3 inches
DRILLING CONTRACTOR	VIVID Engineering Group (Hand Auger)	**GROUND WATER LEVELS:**	
DRILLING METHOD	3" Hand Auger	**AT TIME OF DRILLING**	---
LOGGED BY	Ben Moore **CHECKED BY** W. Barreire	**AT END OF DRILLING**	---
NOTES		**AFTER DRILLING**	---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0				Poorly Graded SAND, olive-yellow, moist
2.5				
	GB	Fines = 4.0%		
5.0				
			5.5	
				Bottom of borehole at 5.5 feet.

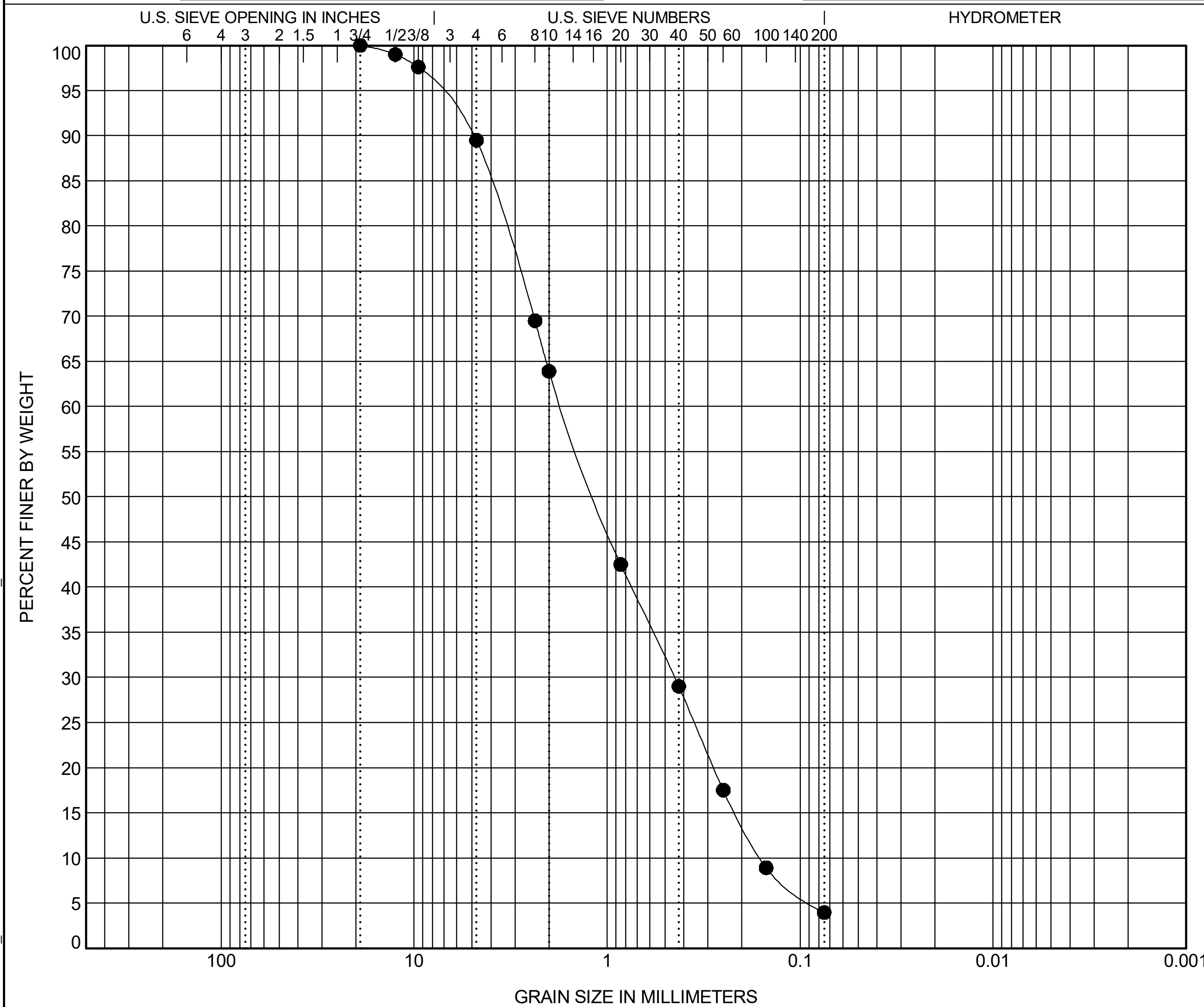
Appendix B

Geotechnical Laboratory Test Results

VIVID Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

GRAIN SIZE DISTRIBUTION

CLIENT All About Outdoor Storage
PROJECT NAME See B-1
PROJECT NUMBER D19-2-189
PROJECT LOCATION Monument, CO



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**B-1**	**1.5**	**POORLY GRADED SAND(SP)**				**0.73**	**10.69**

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-1**	**1.5**	**19**	**1.711**	**0.447**	**0.16**	**10.5**	**85.5**	**4.0**	

Appendix C

Site Photos

TEST LOCATION

TEST LOCATION WITH INFILTROMETER

VIVID Engineering Group	Project No: D19-2-189	SITE PHOTOS	Figure
	Date: April 23, 2019		C-1
	Drawn by: BM	Proposed Detention Pond Facility All About Outdoor Storage Monument, Colorado	
	Reviewed by: WJB		

INFILTROMETER AND PROFILE BORE HOLE

VIVID Engineering Group	Project No: D19-2-189	SITE PHOTOS	Figure
	Date: April 23, 2019		C-2
	Drawn by: BM	Proposed Detention Pond Facility All About Outdoor Storage Monument, Colorado	
	Reviewed by: WJB		

Appendix D

Important Information About This Geotechnical Engineering Report

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation*.

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

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Celebrating over 42 years in business

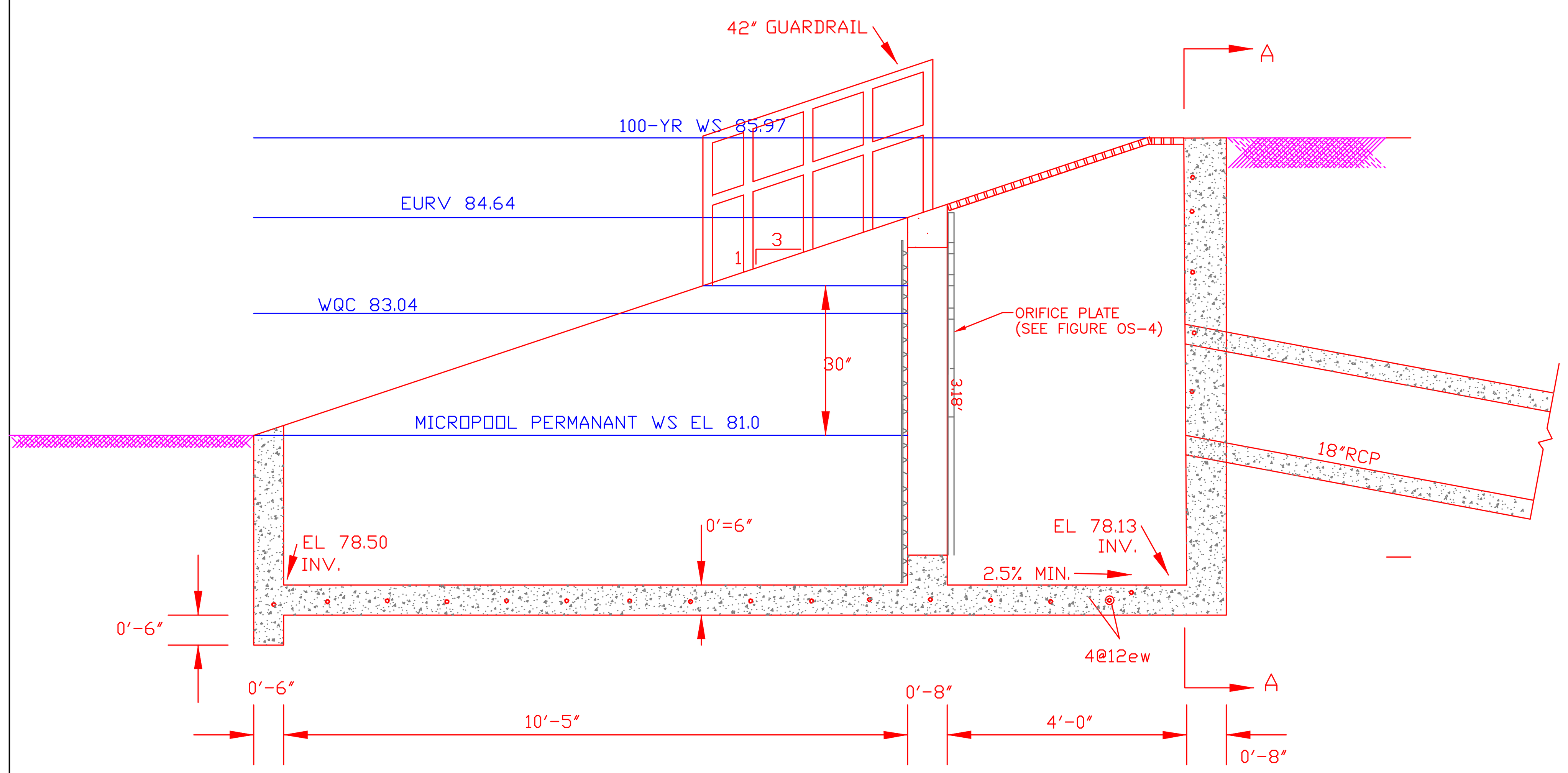
DRAWN BY: O.E.WATTS	APPROVED BY:	REVISIONS 1-18-21 REVISED PER COUNTY COMMENTS	DEW
DATE: 2-2-17	PROJ. NO.	1-8-18 REVISED DETENTION POND	DEW
DWG. NO.: 17-4958-03	DWG.	10-23-19 REVISED PER COUNTY COMMENTS	DEW
SURVEYED BY: DEW, ESW, 10-24-16,1-24-17,4-18-19		4-21-21 REVISED PER COUNTY COMMENTS	DEW

OLIVER E. WATTS
CONSULTING ENGINEER
COLORADO SPRINGS

PROJECT
16140 OLD DENVER ROAD
PART NW1/4 SEC. 26, T.11S., R.67W. 6TH P.M.
EL PASO COUNTY

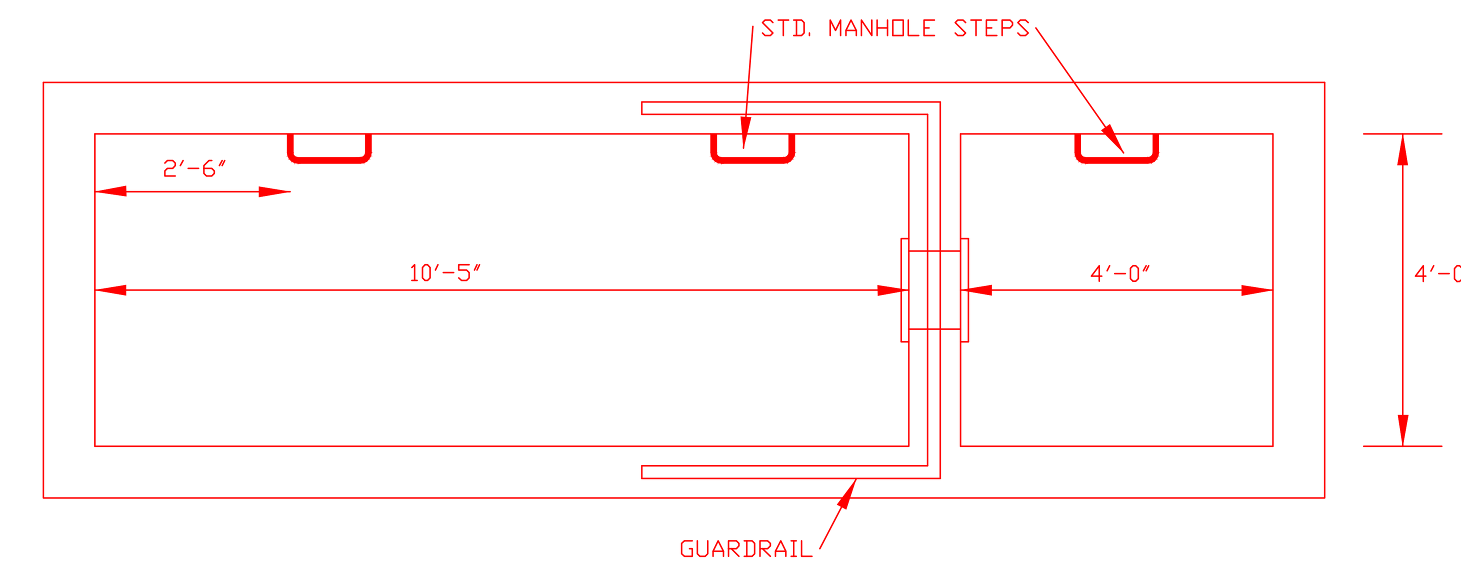
SHT. NAME
DRAINAGE PLAN

SHT. NO. 1 OF 2



OUTLET WORKS PROFILE

1/2"=1'-0"



OUTLET WORKS PLAN

1/2"=1'-0"

NOTE:
ALL TRASH RACKS SHOULD BE SIZED PER FIGURE OS-1

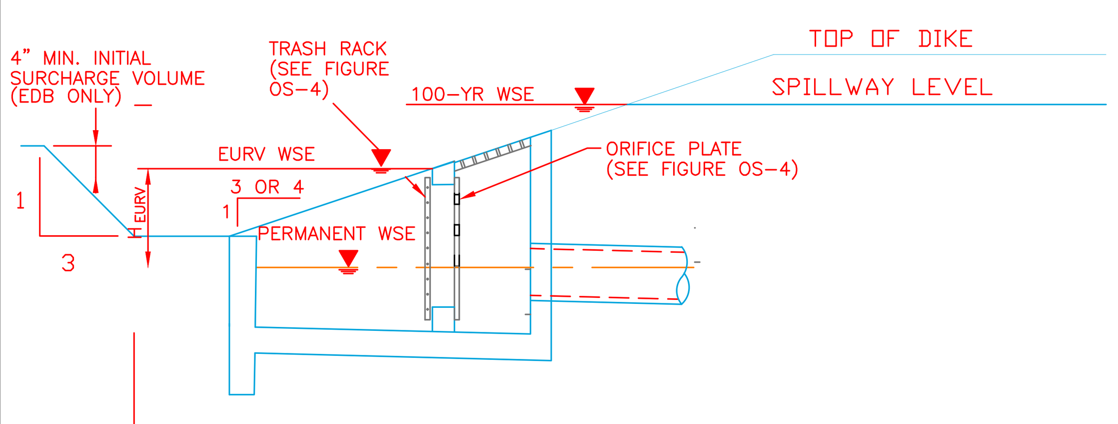
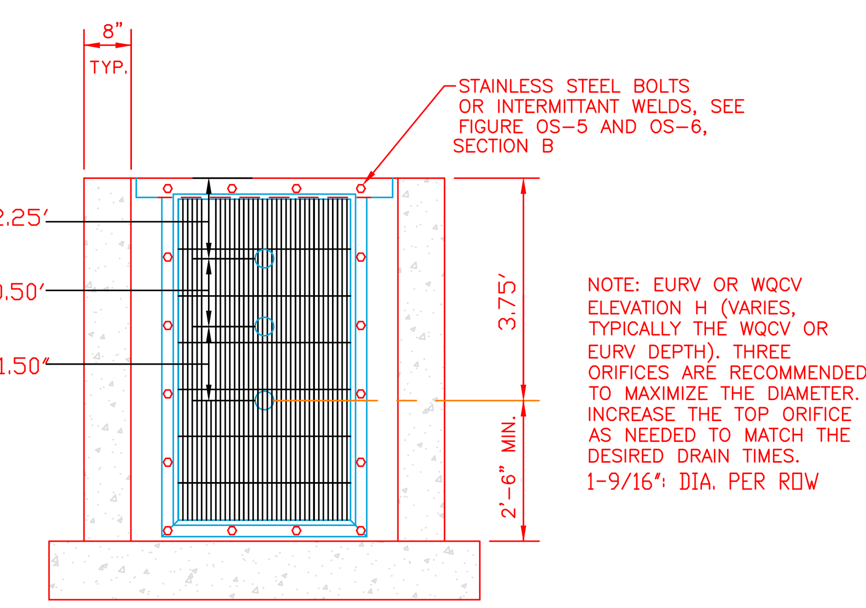


FIGURE OS-2 TYPICAL OUTLET STRUCTURE FOR FULL SPECTRUM DETENTION



NOTE: EURV OR WQCV ELEVATION H (VARIES, TYPICALLY THE WQCV OR EURV DEPTH). THREE ORIFICES ARE RECOMMENDED TO MAXIMIZE THE DIAMETER. INCREASE THE TOP ORIFICE AS NEEDED TO MATCH THE DESIRED DRAIN TIMES. 1-9/16": DIA. PER ROW

ELEVATION

ORIFICE PLATE NOTES:

1. PROVIDE CONTINUOUS NEOPRENE GASKET MATERIAL BETWEEN THE ORIFICE PLATE AND CONCRETE.
2. BOLT PLATE TO CONCRETE 12" ON CENTER MAX.

EURV AND WQCV TRASH RACKS:

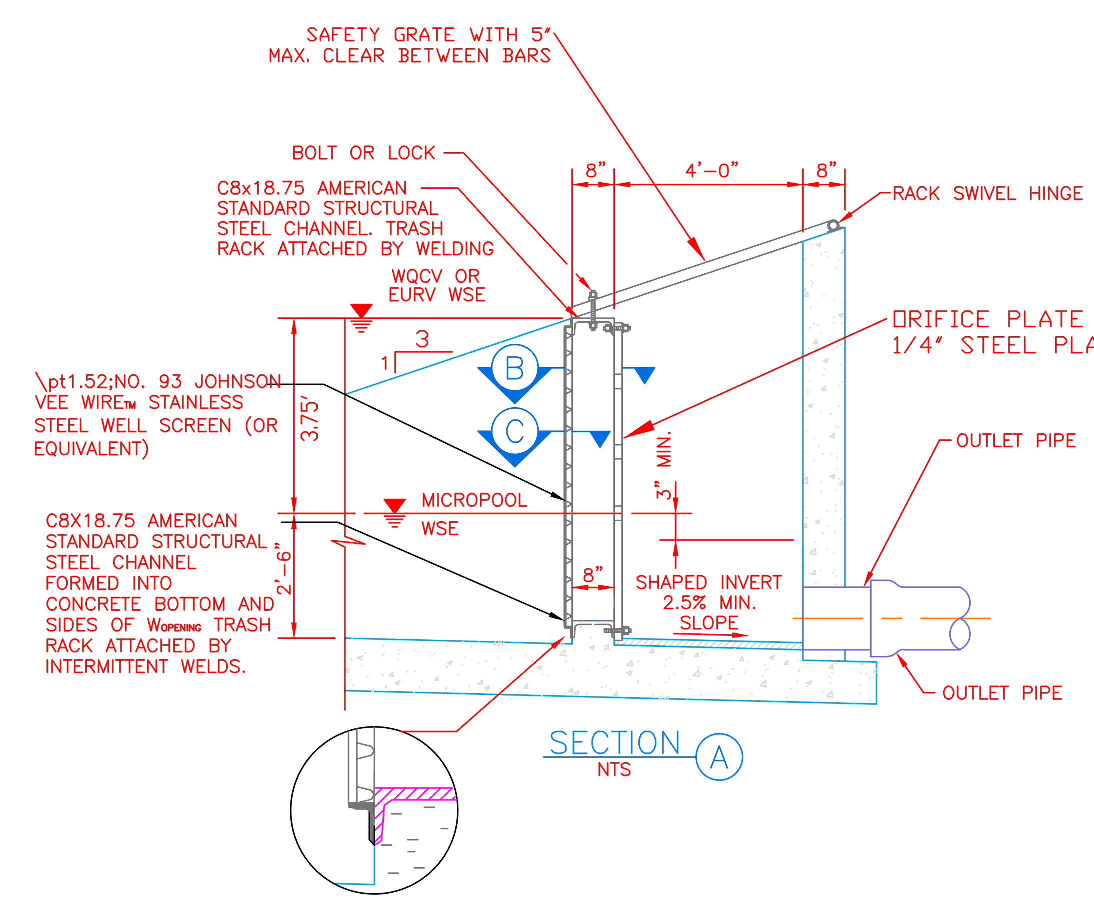
1. WELL-SCREEN TRASH RACKS SHALL BE STAINLESS STEEL AND SHALL BE ATTACHED BY INTERMITTENT WELDS ALONG THE EDGE OF THE MOUNTING FRAME.
2. BAR GATE TRASH RACKS SHALL BE ALUMINUM AND SHALL BE BOLTED USING STAINLESS STEEL HARDWARE.
3. TRASH RACK OPEN AREAS ARE FOR SPECIFIED TRASH RACK MATERIALS. TOTAL TRASH RACK SIZE MAY NEED TO BE ADJUSTED FOR MATERIALS HAVING DIFFERENT OPEN AREA/GROSS AREA RATIO (R VALUE).
4. STRUCTURAL DESIGN OF TRASH RACKS SHALL BE BASED ON FULL HYDROSTATIC HEAD WITH ZERO HEAD DOWNSTREAM OF THE RACK.

OVERFLOW SAFETY GRATES:

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

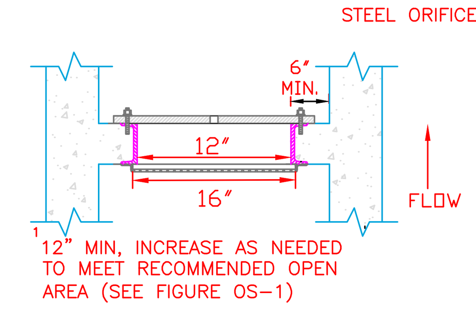
FIGURE OS-4 ORIFICE PLATE AND TRASH RACK DETAILS AND NOTES

NTS



SECTION (A)

NTS



SECTION (B)

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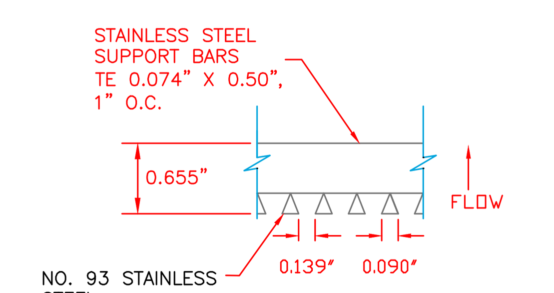

SECTION (C)

NTS

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

FIGURE OS-5 TYPICAL OUTLET STRUCTURE WITH WELL SCREEN TRASH RACK

DRAWN BY: O.E. WATTS DATE: 1-18-21 DWG. NO.: 14-4958-07 SURVEYED BY: OEW, ESW THRU 4-18-19	APPROVED BY: PROJ. NO. DWG.	REVISIONS 4-27-21 REVISED PER CITY REVIEW COMMENTS OEW 7-6-21 REVISED PER CITY REVIEW COMMENTS OEW	OLIVER E. WATTS CONSULTING ENGINEER COLORADO SPRINGS	PROJECT 16140 OLD DENVER ROAD PART NW1/4 SEC. 26, T.11S., R.67W., 6TH P.M. EL PASO COUNTY	SHT. NAME EDB OUTLET DETAILS	SHT. NO. 2 OF 2