Initial Run-on and Run-off Control System Plan

For Compliance with the Coal Combustion Residuals Rule
(40 CFR 257.81)

Valmont Station - Ash Disposal Facility
Public Service Company of Colorado
Denver, Colorado

October 17, 2016

PREPARED FOR

VALMONT STATION

1800 North 63rd Street
Boulder, Colorado 80301

Table of Contents

List of Tables

List of Figures

List of Appendices

Table of Abbreviations and Acronyms

Abbreviation	Definition
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
cfs	cubic feet per second
CN	Curve Number
EPA	Environmental Protection Agency
HSG	Hydrologic Soil Group
NOAA	National Oceanic and Atmospheric Administration
RCRA	Resource Conservation and Recovery Act
SCS	Soil Conservation Service
TR-20	Technical Release 20
TR-55	Technical Release 55

1.0 Introduction

On April 17, 2015 the U.S. Environmental Protection Agency (EPA) published regulations under Subtitle D of the Resource Conservation and Recovery Act (RCRA) meant to control the safe disposal of coal combustion residuals (CCR) generated by coal-fired electric utilities. The rule defines a set of requirements for the disposal and handling of CCR within CCR units (defined as either landfills or surface impoundments). The requirements include preparation of a Run-on and Run-off Control System Plan for all existing and new CCR landfills.

This Run-on and Run-off Control System Plan was prepared for the CCR landfill unit at the Valmont Station, operated by Public Service Company of Colorado (PSCo), an Xcel Energy Company. It was prepared in accordance with the requirements of 40 Code of Federal Regulations (CFR) 257.81. The regulation requires an initial Run-on and Run-off Control System Plan be prepared no later than October 17, 2016.

1.1 Facility Description

The Valmont Station CCR landfill unit is located approximately 0.5 mile north of the power plant on the north side of Leggett Reservoir. The Valmont Station is approximately 4 miles east of downtown Boulder, Colorado.

A location map is included as **Figure 1**.

The CCR landfill unit is the highest topographic point in the immediate area. It is located along a natural slope north of the Leggett Reservoir. To the west it is bordered by 63rd Street, to the north and off of Valmont Station property is a former mine tailings pond, and to the east is the Valmont Reservoir. The CCR landfill parcel is approximately 60 acres, of which approximately 53 acres contain landfilled CCR. The landfilled areas consist of disposal cells designated as Area A-1, A-2, and A-3; Area B-1; Area C-1; Area D-1; Area E-1; and Area Q-1 and Q-2. Area D-1 and a portion of Area E-1 are the current active disposal cells. According to PSCo, Areas A-1, A-2, A-3, B-1, and C-1 as well as the sideslopes of Q-1 and Q-2 (below elevation 5290) were closed prior to publication of 40 CFR 257. Areas Q-1 and Q-2 (top portions – above 5290 feet) are closed and covered, but will require final closure in the future in accordance with 40 CFR 257.

1.2 Regulatory Requirements

40 CFR 257.81 requires that an owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill design, construct, operate, and maintain:

1) a run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm;
2) a run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm; and
3) a run-off control system designed to handle run-off so that it does not cause a discharge of pollutants to waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES) under Section 402 of the Clean Water Act.

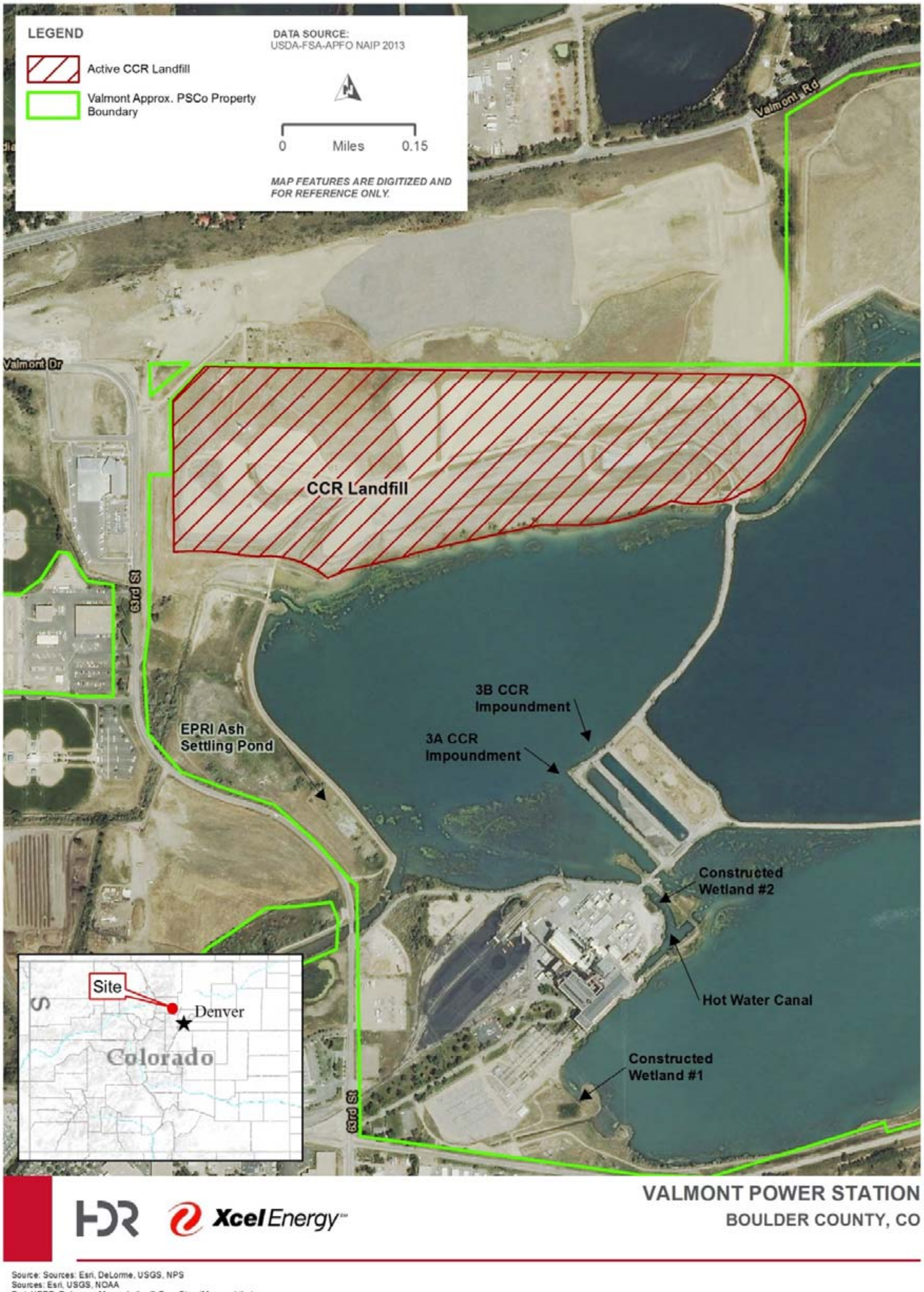


Figure 1. Valmont Power Station Location Map

2.0 Run-on / Run-off Controls for CCR Landfill

A hydrologic and hydraulic analysis was completed for the active portion of the CCR landfill unit in accordance with 40 CFR 257.81. Per §257.53, the active portion means "*that part of the CCR unit that has received or is receiving CCR or non-CCR waste and that has not completed closure in accordance with §257.102"*.

According to PSCo, prior to publication of 40 CFR 257.81 Areas A, B, C, and the Q-1 and Q-2 sideslopes were completed and closed. These areas were closed with final cover material and are fully vegetated and are not considered active portions of the CCR landfill unit. Therefore, these areas, including all permanent run-off control systems in these areas, were not included in this evaluation.

The evaluation included preparation of a surface water run-off model using HydroCAD® 10.00-11 to determine whether existing run-on and run-off control systems meet the required criteria for controlling run-on and run-off from the 25-year, 24-hour storm event. The evaluation was completed using the best available information at the time and was based on an original survey completed in 2009 and updated in May 2016.

2.1 Description of CCR Landfill and Drainage Area

Based on the survey data, active landfill operations are taking place over an approximate 13.47-acre area which includes Area D-1 and part of Area E-1 of the CCR landfill unit. The drainage area extends beyond the active landfill operations as a result of a soil stockpile located west of the active area that drains run-off into the active portion. The drainage area is approximately 14.67 acres and consists of approximately 1.76 acres of ash disposal lifts, 1.44 acres of contact pond area, 1.45 acres of a soil stockpile area and the remaining 10.01 acres is poorly vegetated native soils. The active ash lifts are being constructed along the eastern portion of the active area and is bordered to the north, south, and east by a berm and to the west by the contact pond. The berm prevents surface water run-off in contact with CCR from discharging outside the limits of the active landfill area.

In addition, the upper portions of Q-1 and Q-2 represent areas that have accepted CCR material after April 17, 2015. These areas are no longer accepting CCR material, and have been graded, covered, and seeded, but are not yet considered closed in accordance with 40 CFR 257. Q-1 is approximately 6.3 acres; Q-2 is approximately 3.82 acres.

The active landfill areas and delineated drainage subcatchments are shown on **Figure 2**.

2.2 Description of Existing Run-on / Run-off Controls

2.2.1 Run-on Controls

The active landfill cells are located at, and incised into, the topographic high point of the landfill area which prevents any run-on from entering the active landfill area from the north, east, and south. To the west of the landfill is a soil stockpile area which provides cover soil for the active cell. Surface water run-off from a portion of this stockpile drains into the active landfill area. Ash is being placed from east to west with the contact pond located along the western border of the active ash disposal area. This prevents surface water run-off from the stockpile from directly draining onto the active ash disposal lifts.

The upper portions of areas Q-1 and Q-2 (above 5290 feet) are the final grades for the top of the Q-1 and Q-2 cells. The topography is such that any stormwater will run-off and away from these areas. Due to the elevations of these areas being above the surrounding grade, there is no run-on to Q-1 and Q-2 and no need for run-on controls.

2.2.2 Run-off Control

The contact pond is located centrally within the active, incised landfill area. The active disposal cell is graded to direct surface water run-off from the east and west to the pond which collects run-off. There is no outfall; ponded water is absorbed into the underlying materials or evaporated. The overall area of the contact pond is approximately 1.44 acres.

The Q-1 area drains radially south towards the closed sideslopes where it is captured by a sideslope swale that directs stormwater east to a riprap downchute located on the southeast corner of the Q-1 plateau area. The Q-2 area drains radially north off the landfill and sheet flows towards a low lying area where it collects and infiltrates.

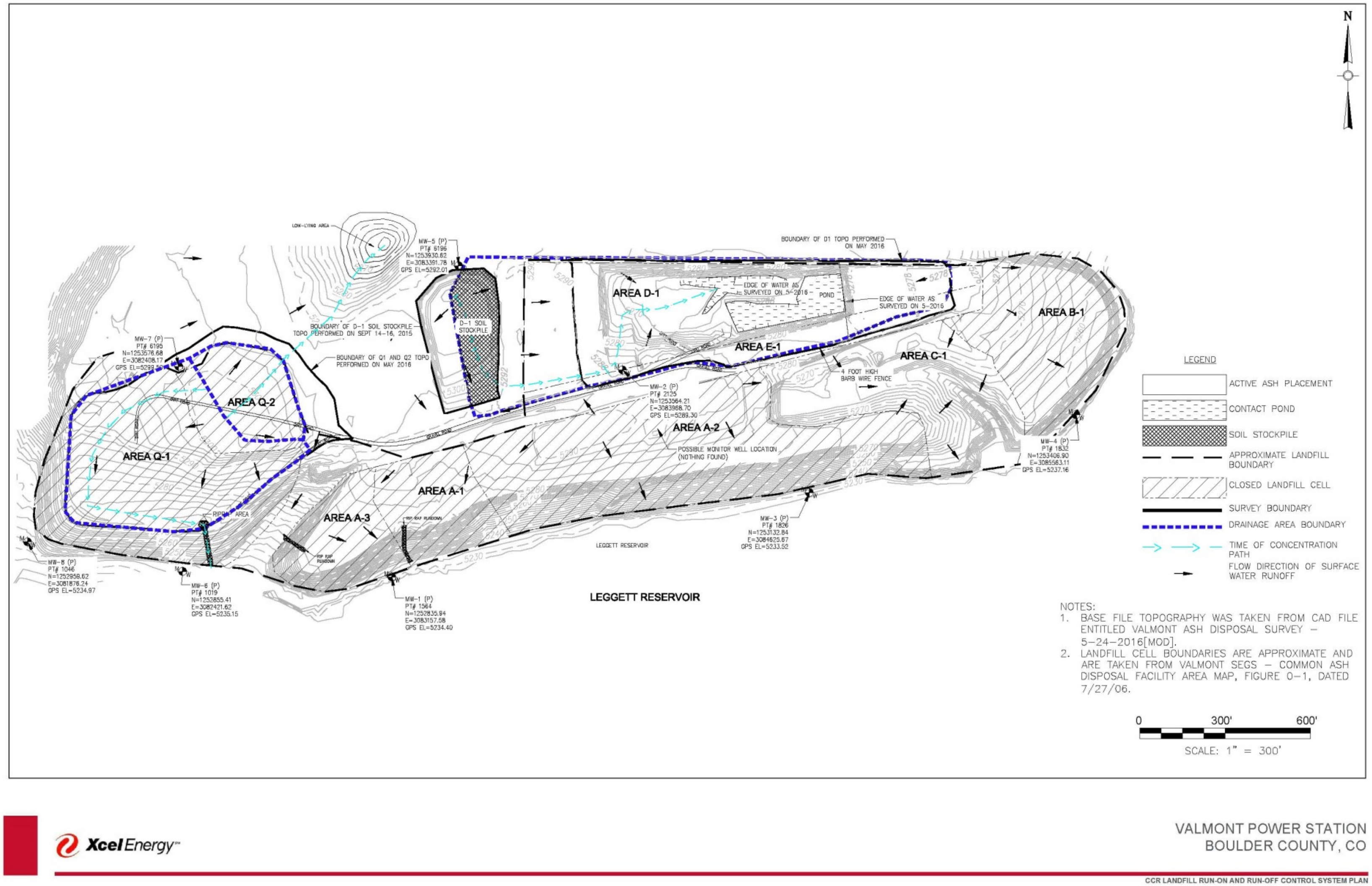


Figure 2. Stormwater Drainage Map

2.3 Surface Water Run-off Model

A surface water run-off model was prepared using HydroCAD® which utilizes procedures outlined in the Soil Conservation Service (SCS) Technical Release 55 (TR-55) for computing curve numbers and times of concentration and SCS TR-20 for calculating and generating run-off hydrographs. The models are included as **Appendix A**. A detailed discussion of the information inputted into the model is provided below.

2.3.1 Rainfall Data

Rainfall data was taken from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server. Rainfall data inputted into the model included the 2-year and 25-year, 24-hour storm events. The precipitation amounts are summarized below and the information from the NOAA Precipitation Frequency Data Server is included as **Appendix B**.

Table 1. Rainfall Data

24 Hour Rainfall Event	Precipitation (inches)
2- year	1.93
25-year	3.88

2.3.2 Weighted Curve Number

The weighted curve number (CN) is determined according to a hydrologic soil group (HSG) and ground cover for a delineated drainage basin. The active portion of the landfill was delineated into one drainage basin which drains to a contact pond centrally located in the active landfill area (refer to **Figure 2**). To compute the weighted CN, the Soil Conservation District Web Soil Survey map was consulted to identify the hydrologic soil groups for the native soils where ash was not present. According to the web soil map, the native soils consist of Valmont cobbly clay loam, 1 to 5 % slopes (VcC). This soil type is in HSG C. The ash itself was assumed to be of HSG D due to its low infiltration properties. The soil stockpile was assumed from native soils surrounding the landfill area and was assumed to be of HSG C. A soil report for the native soils is included in **Appendix C**.

Cover types for the active area were determined based on site photographs taken from site inspections conducted by HDR on November 12, 2015 and August 9, 2016. The ground cover for the ash disposal area was inputted into the model as bare soil.

Area Q-1 and Q-2 were identified as soil type HSG C and modeled as bare soils.

A summary of the breakdown used to calculate the weighted CN is provided in **Table 2**.

Table 2. Summary of Area Breakdown			
Cover Type	**HSG**	**Area (acres)**	**Curve Number**
Ash	D	1.76	94
Poorly vegetated <50%	C	10.01	91
Contact Pond	D	1.44	98
Soil Stockpile	C	1.46	91
Area D-1 Weighted CN			**89**
Areas Q-1 & Q-2 CN	**C**	**6.3 & 3.82**	**91**

2.3.3 Time of Concentration

The time of concentration is defined as the time required for run-off to travel from the most hydrologically distant point of a sub-catchment to the point of collection. It is determined by summing the travel time for consecutive flow segments along the sub-catchment's hydraulic path. The path for the time of concentration used to compute surface water run-off from the active landfill area is shown on **Figure 2.**

2.3.4 Contact Pond

The Area D-1 contact pond was modeled as a detention basin with exfiltration as its only outlet. Exfiltration rates were calculated based on the conductivity of the underlying native soils taken from the Soil Conservation District Web Soil Report (**Appendix C**). According to the report, the native soils have a moderately low to moderately high capacity to transmit water at an estimated rate of 0.06 to 0.20 inch/hour. For the model, the median rate of 0.13 inch/hour was assumed.

The low lying area to the north of Q-2 that receives the run-off from this area was modeled as a stormwater basin. For the model, the medial rate of 0.13 inch/hour was assumed.

2.4 Evaluation of Existing Run-on / Run-off Controls

To comply with 40 CFR 257.81, the existing contact pond must be of sufficient size to collect and control run-off resulting from the 25 year, 24-hour storm event.

Based on the model results the existing depression (contact pond) area is of sufficient size to prevent surface water run-off from discharging outside the active landfill area during the 25 year, 24-hour storm event. The model estimated a peak run-off volume of 56.32 cubic feet per second (cfs) during the 25-year storm event. During the 25-year storm the high water level was estimated to be 5,268.53 feet, which is 9.47 feet below the lowest berm elevation (5,278 feet).

The Q-1 run-off was modeled to have a maximum runoff volume of 27.03 cfs. This runoff is captured by a grass sideslope swale that directs stormwater east to a riprap downchute located on the southeast corner of the Q-1 plateau area that directs the runoff to the reservoir. The swale size and riprap size were evaluated for the 25-year, 24-hour storm event. The riprap downchute has sufficient capacity and the 12" riprap installed will be adequate to withstand the volume and velocity. The velocity of runoff in the grass sideslope swale was calculated to be 8.32 feet per second (fps). Typically, velocities greater than 5.0 fps require riprap to avoid excessive erosion. See calculations in **Appendix A**.

The Q-2 area drains radially north off the landfill and sheet flows towards a low lying area where it collects and infiltrates. Areas Q-2 was modeled to have a maximum runoff flow of 15.54 cfs. There are no run-off controls for the Q-2 area as stormwater simply sheet-flows off the landfill to a low lying area. The low lying area was modeled as a 10-foot deep basin with an area of approximately 46,827 square feet with a top elevation of 5,274 feet and a bottom of 5,264 feet. During the 25-year, 24-hour storm event the maximum basin height reached 5,268.71 feet which leaves over 6 feet of freeboard.

2.5 Improvements to Existing Run-on / Run-off Controls

Based on the available information and the model results, the existing run-on and run-off controls in place for the active portion (Area D-1) of the Valmont CCR landfill unit meet the requirements of 40 CFR Part 257.81 and no improvements are needed.

The existing run-on and run-off controls in place for the active portion of Areas Q-1 and Q-2 (above 5290 feet) meet the requirements of 40 CFR Part 257.81. However, it is recommended that the grass sideslope swale on Area Q-1 be armored with an 8-inch thick layer of 4-inch riprap to prevent future erosion.

3.0 Professional Engineer Certification

Valmont Station CCR Unit 2016 Initial Run-on and Run-off Controls for CCR Landfills Compliance with the Federal Coal Combustion Residuals Rule

The undersigned Registered Professional Engineer is familiar with the requirements of Part 257 of Title 40 of the Code of Federal Regulations (40 CFR Part 257) and has visited and examined the facility, or has supervised examination of the facility by appropriately qualified personnel. The undersigned Registered Professional Engineer attests that this Run-on and Run-off Controls System Plan has been prepared in accordance with good engineering practice, including consideration of applicable industry standards and the requirements of 40 CFR Part 257.

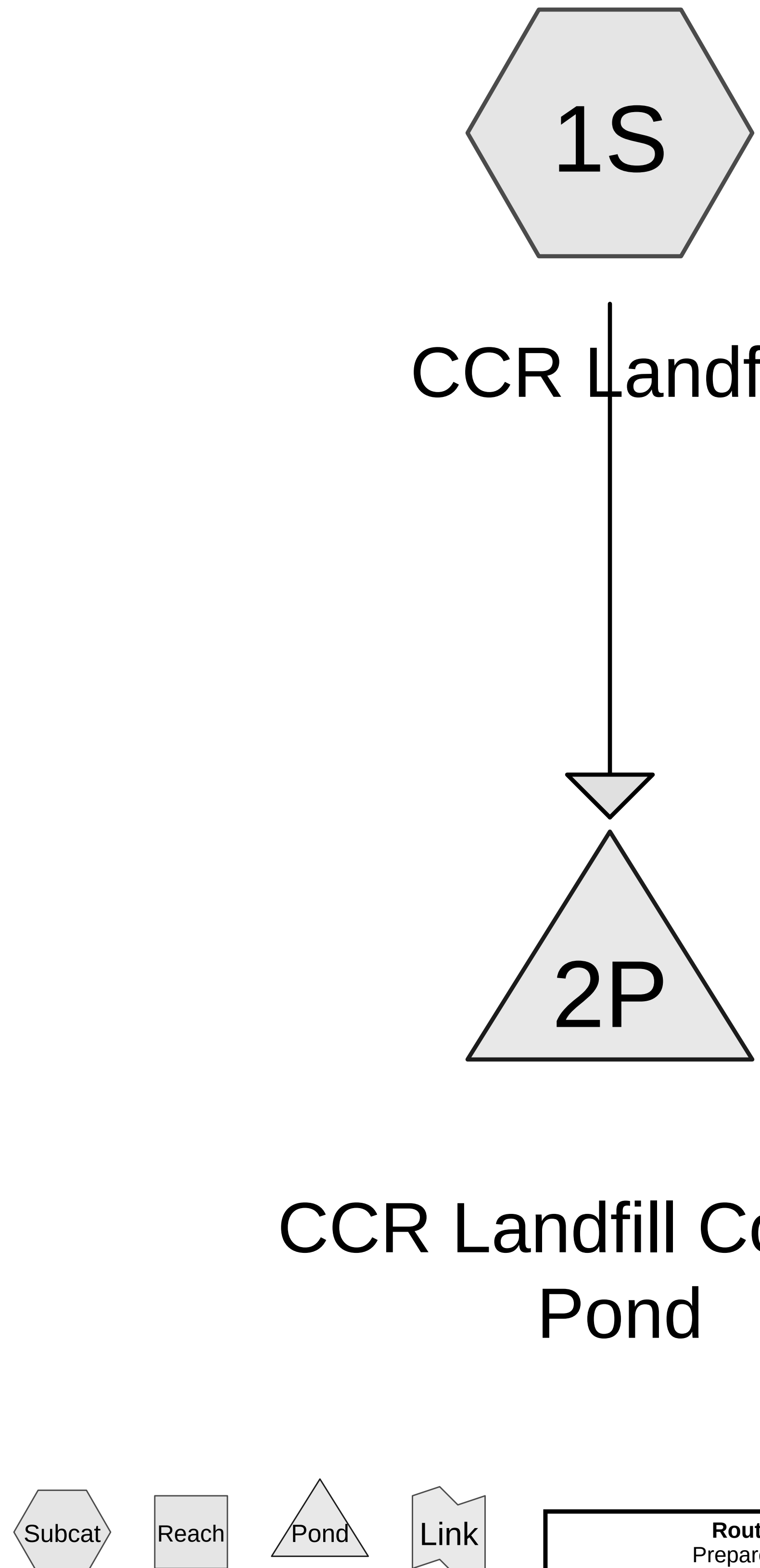
This Plan is valid only to the extent that the facility owner or operator maintains existing run-on and run-off controls described in this Plan to prevent flow onto the active portion and prevent surface discharges of CCR in solution or suspension.

SIGNATURE:

Colorado PE 0051359

DATE: October 14, 2016

Appendix A - HydroCAD® Model Results



Routing Diagram for Valmont Station
Prepared by HDR Inc, Printed 10/17/2016
HydroCAD® 10.00-11 s/n 08429 © 2014 HydroCAD Software Solutions LLC

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
10.010	86	<50% Grass cover, Poor, HSG C (1S)
1.460	91	Fallow, bare soil, HSG C (1S)
1.760	94	Fallow, bare soil, HSG D (1S)
1.440	98	WATER (1S)
14.670	**89**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
11.470	HSG C	1S
1.760	HSG D	1S
1.440	Other	1S
14.670		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	10.010	0.000	0.000	10.010	<50% Grass cover, Poor	1S
0.000	0.000	1.460	1.760	0.000	3.220	Fallow, bare soil	1S
0.000	0.000	0.000	0.000	1.440	1.440	WATER	1S
0.000	**0.000**	**11.470**	**1.760**	**1.440**	**14.670**	**TOTAL AREA**	

Time span=0.00-50.00 hrs, dt=0.05 hrs, 1001 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: CCR Landfill Runoff Area=14.670 ac 9.82% Impervious Runoff Depth=2.71"
Flow Length=1,302' Tc=11.2 min CN=89 Runoff=56.32 cfs 3.314 af

Pond 2P: CCR Landfill Contact Pond Peak Elev=5,268.53' Storage=0.847 af Inflow=56.32 cfs 3.314 af
Outflow=20.84 cfs 3.314 af

Total Runoff Area = 14.670 ac Runoff Volume = 3.314 af Average Runoff Depth = 2.71"
90.18% Pervious = 13.230 ac 9.82% Impervious = 1.440 ac

Summary for Subcatchment 1S: CCR Landfill

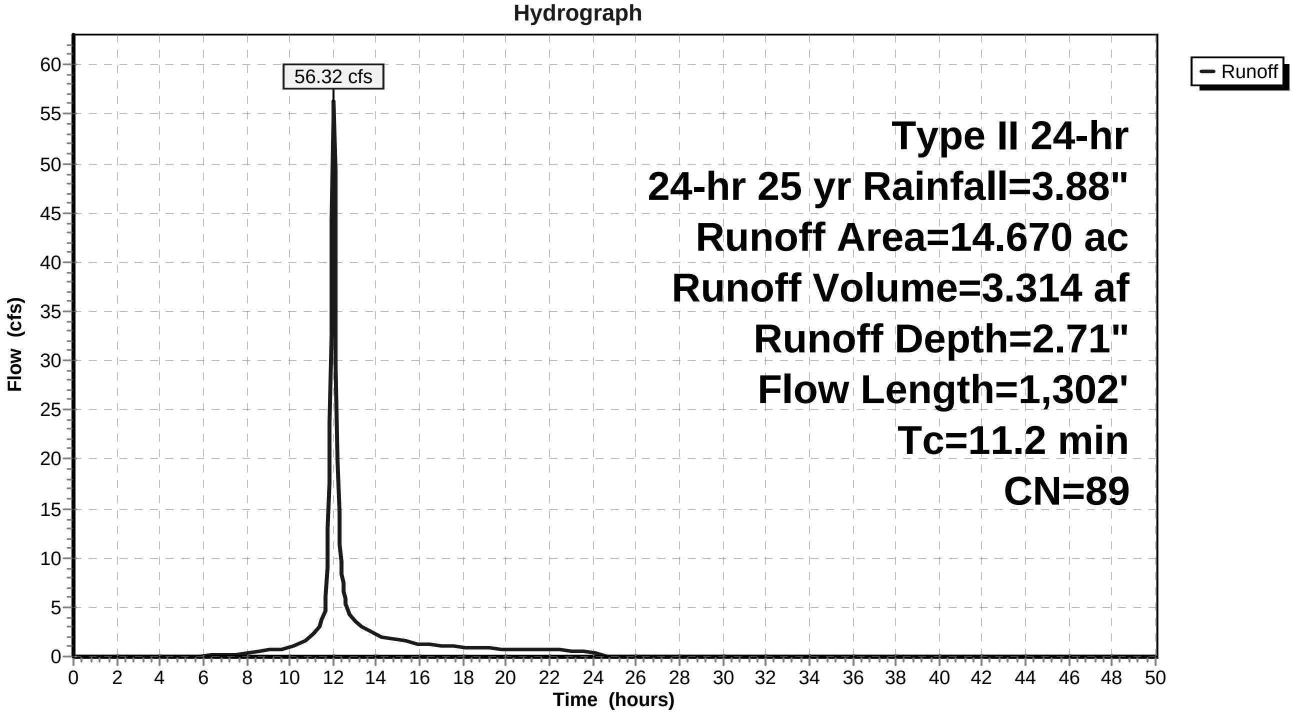
Runoff = 56.32 cfs @ 12.03 hrs, Volume= 3.314 af, Depth= 2.71"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-50.00 hrs, dt= 0.05 hrs
Type II 24-hr 24-hr 25 yr Rainfall=3.88"

	Area (ac)	CN	Description
*	1.440	98	WATER
	1.760	94	Fallow, bare soil, HSG D
	10.010	86	<50% Grass cover, Poor, HSG C
	1.460	91	Fallow, bare soil, HSG C
	14.670	89	Weighted Average
	13.230		90.18% Pervious Area
	1.440		9.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	200	0.0100	0.93		**Sheet Flow, sheet flow** Smooth surfaces n= 0.011 P2= 1.93"
0.6	176	0.0800	4.55		**Shallow Concentrated Flow, leg 1** Unpaved Kv= 16.1 fps
3.6	364	0.0110	1.69		**Shallow Concentrated Flow, leg 2** Unpaved Kv= 16.1 fps
1.1	288	0.0690	4.23		**Shallow Concentrated Flow, leg 3** Unpaved Kv= 16.1 fps
2.3	274	0.0150	1.97		**Shallow Concentrated Flow, leg 4** Unpaved Kv= 16.1 fps
11.2	1,302	Total			

Subcatchment 1S: CCR Landfill



Summary for Pond 2P: CCR Landfill Contact Pond

Inflow Area = 14.670 ac, 9.82% Impervious, Inflow Depth = 2.71" for 24-hr 25 yr event
Inflow = 56.32 cfs @ 12.03 hrs, Volume= 3.314 af
Outflow = 20.84 cfs @ 12.20 hrs, Volume= 3.314 af, Atten= 63%, Lag= 10.5 min
Discarded = 20.84 cfs @ 12.20 hrs, Volume= 3.314 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-50.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 5,268.53' @ 12.20 hrs Surf.Area= 3.099 ac Storage= 0.847 af

Plug-Flow detention time= 19.2 min calculated for 3.311 af (100% of inflow)
Center-of-Mass det. time= 19.3 min (824.6 - 805.3)

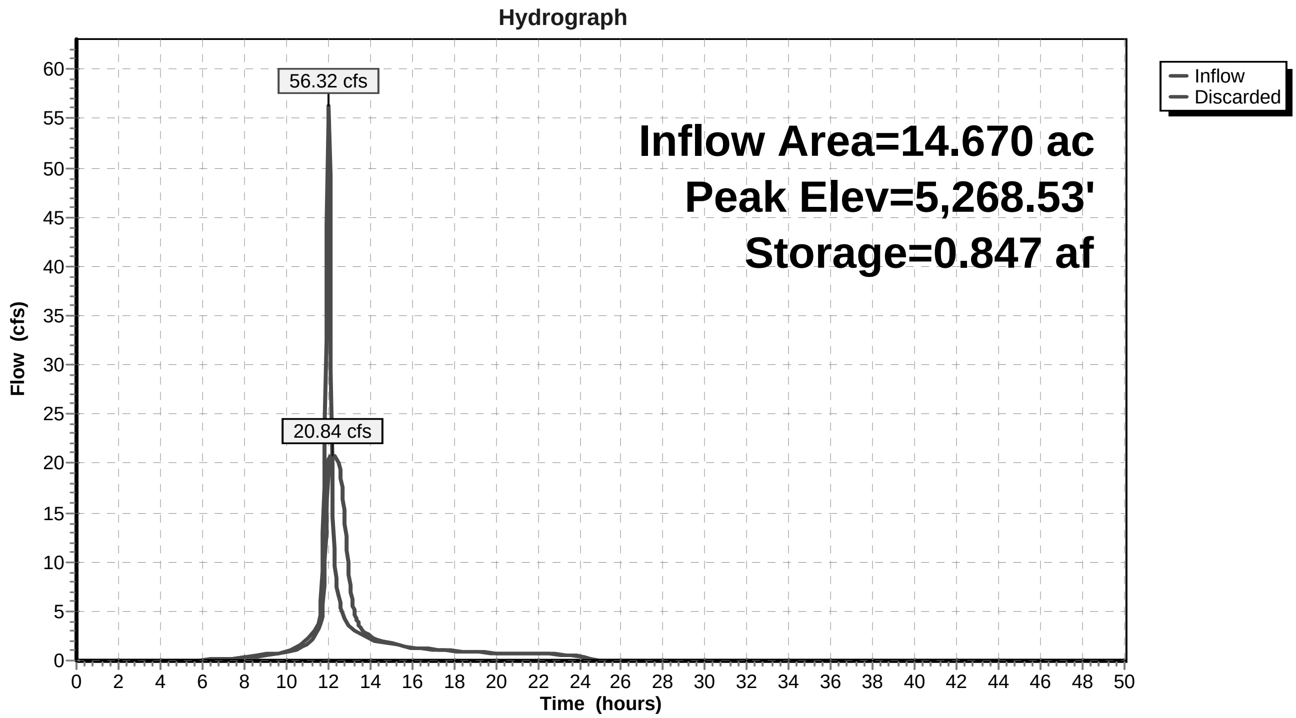
Volume	Invert	Avail.Storage	Storage Description
#1	5,264.00'	2.836 af	**Custom Stage Data (Irregular)**Listed below (Recalc) 28.363 af Overall x 10.0% Voids

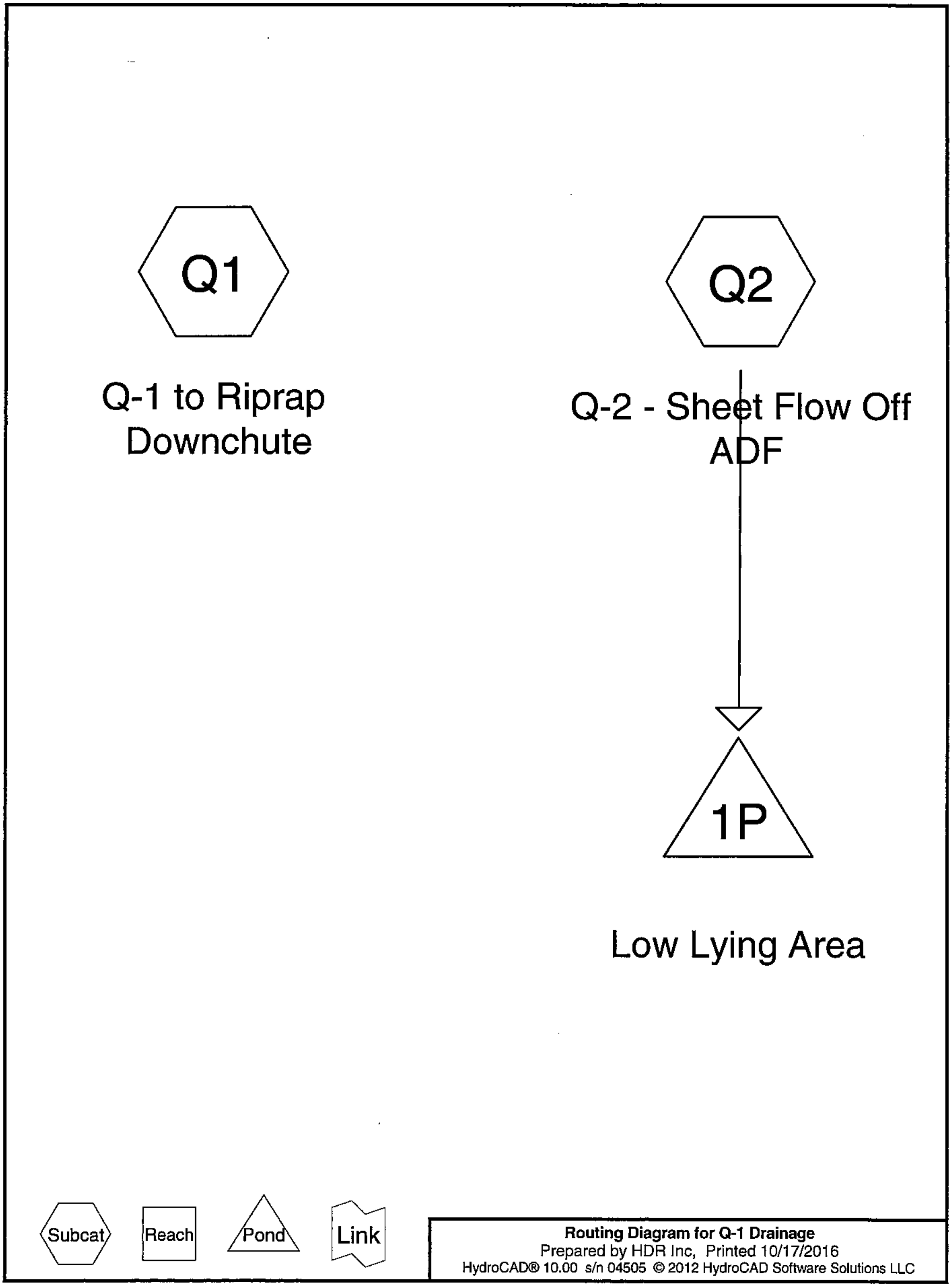
Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
5,264.00	0.482	1,007.7	0.000	0.000	0.482
5,266.00	1.791	6,746.5	2.135	2.135	81.777
5,268.00	2.989	1,831.4	4.729	6.864	158.799
5,270.00	3.416	1,890.2	6.400	13.264	159.208
5,272.00	3.783	1,970.2	7.196	20.460	159.779
5,274.00	4.122	2,056.5	7.903	28.363	160.420

Device	Routing	Invert	Outlet Devices
#1	Discarded	5,264.00'	**0.130 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 0.00'

Discarded OutFlow Max=20.84 cfs @ 12.20 hrs HW=5,268.53' (Free Discharge)
1=Exfiltration (Controls 20.84 cfs)

Pond 2P: CCR Landfill Contact Pond





Routing Diagram for Q-1 Drainage
Prepared by HDR Inc, Printed 10/17/2016
HydroCAD® 10.00 s/n 04505 © 2012 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
10.120	91	Fallow, bare soil, HSG C (Q1, Q2)
10.120	**91**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
10.120	HSG C	Q1, Q2
0.000	HSG D	
0.000	Other	
10.120		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	10.120	0.000	0.000	10.120	Fallow, bare soil	Q1, Q2
0.000	**0.000**	**10.120**	**0.000**	**0.000**	**10.120**	**TOTAL AREA**	

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment Q1: Q-1 to Riprap Downchute Runoff Area=6.300 ac 0.00% Impervious Runoff Depth>2.72"
Flow Length=1,055' Tc=9.5 min CN=91 Runoff=27.03 cfs 1.427 af

Subcatchment Q2: Q-2 - Sheet Flow Off ADF Runoff Area=3.820 ac 0.00% Impervious Runoff Depth>2.72"
Flow Length=819' Tc=11.0 min CN=91 Runoff=15.54 cfs 0.865 af

Pond 1P: Low Lying Area Peak Elev=5,268.71' Storage=36,208 cf Inflow=15.54 cfs 0.865 af
Outflow=0.05 cfs 0.033 af

Total Runoff Area = 10.120 ac Runoff Volume = 2.292 af Average Runoff Depth = 2.72"
100.00% Pervious = 10.120 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment Q1: Q-1 to Riprap Downchute

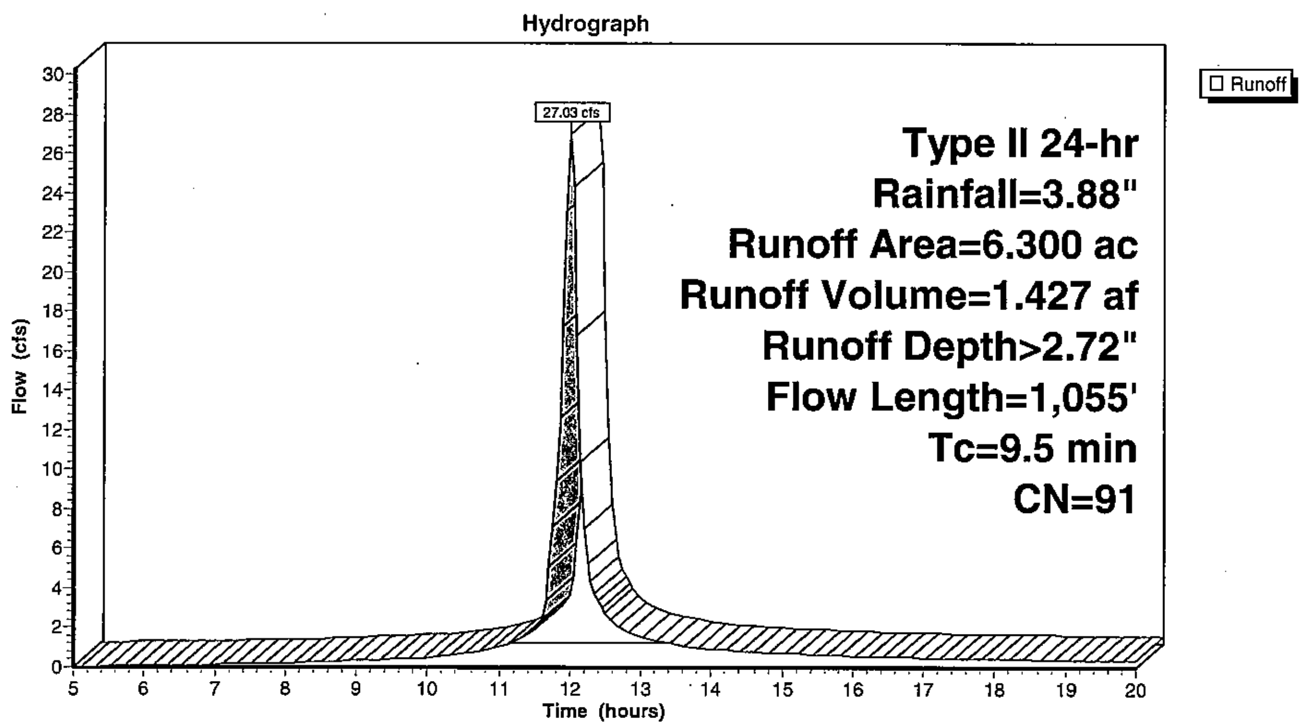
Runoff = 27.03 cfs @ 12.00 hrs, Volume= 1.427 af, Depth> 2.72"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=3.88"

Area (ac)	CN	Description
6.300	91	Fallow, bare soil, HSG C
6.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2	100	0.0200	0.32		**Sheet Flow, sheet flow** Fallow n= 0.050 P2= 1.93"
3.5	427	0.0420	2.05		**Shallow Concentrated Flow, shallow** Nearly Bare & Untilled Kv= 10.0 fps
0.7	390	0.0130	8.94	89.37	**Channel Flow, swale** Area= 10.0 sf Perim= 8.0' r= 1.25' n= 0.022 Earth, clean & straight
0.1	138	0.2600	26.15	313.76	**Channel Flow, Rip Rap Swale** Area= 12.0 sf Perim= 7.4' r= 1.62' n= 0.040 Earth, cobble bottom, clean sides
9.5	1,055	Total			

Subcatchment Q1: Q-1 to Riprap Downchute



Summary for Subcatchment Q2: Q-2 - Sheet Flow Off ADF

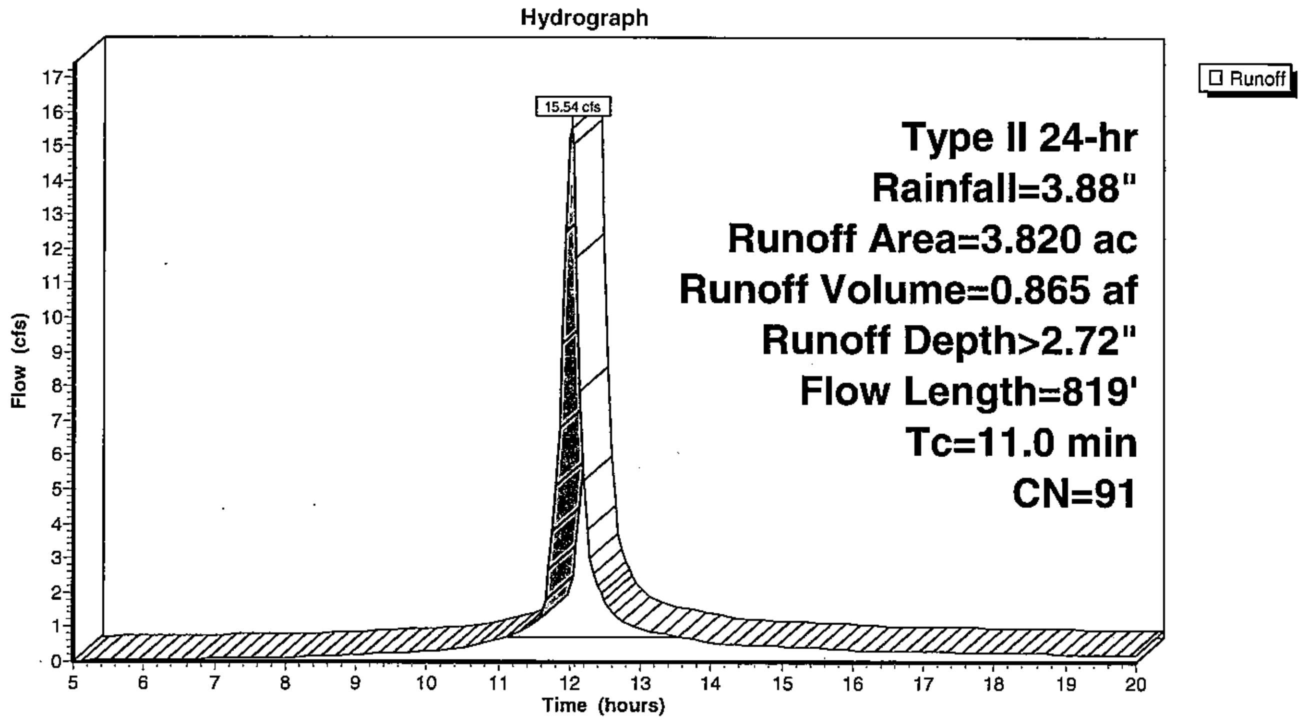
Runoff = 15.54 cfs @ 12.02 hrs, Volume= 0.865 af, Depth> 2.72"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=3.88"

Area (ac)	CN	Description
3.820	91	Fallow, bare soil, HSG C
3.820		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2	100	0.0200	0.32		**Sheet Flow, Sheet Flow** Fallow n= 0.050 P2= 1.93"
2.8	256	0.0230	1.52		**Shallow Concentrated Flow, Shallow Concentrated Flow** Nearly Bare & Untilled Kv= 10.0 fps
3.0	463	0.0650	2.55		**Shallow Concentrated Flow, Off ADF Sheetflow** Nearly Bare & Untilled Kv= 10.0 fps
11.0	819	Total			

Subcatchment Q2: Q-2 - Sheet Flow Off ADF



Summary for Pond 1P: Low Lying Area

[82] Warning: Early inflow requires earlier time span

Inflow Area =	3.820 ac,	0.00% Impervious, Inflow Depth > 2.72"	
Inflow =	15.54 cfs @	12.02 hrs, Volume=	0.865 af
Outflow =	0.05 cfs @	20.00 hrs, Volume=	0.033 af, Atten= 100%, Lag= 478.7 min
Discarded =	0.05 cfs @	20.00 hrs, Volume=	0.033 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 5,268.71' @ 20.00 hrs Surf.Area= 15,434 sf Storage= 36,208 cf

Plug-Flow detention time= 446.6 min calculated for 0.033 af (4% of inflow)
Center-of-Mass det. time= 154.4 min (915.8 - 761.5)

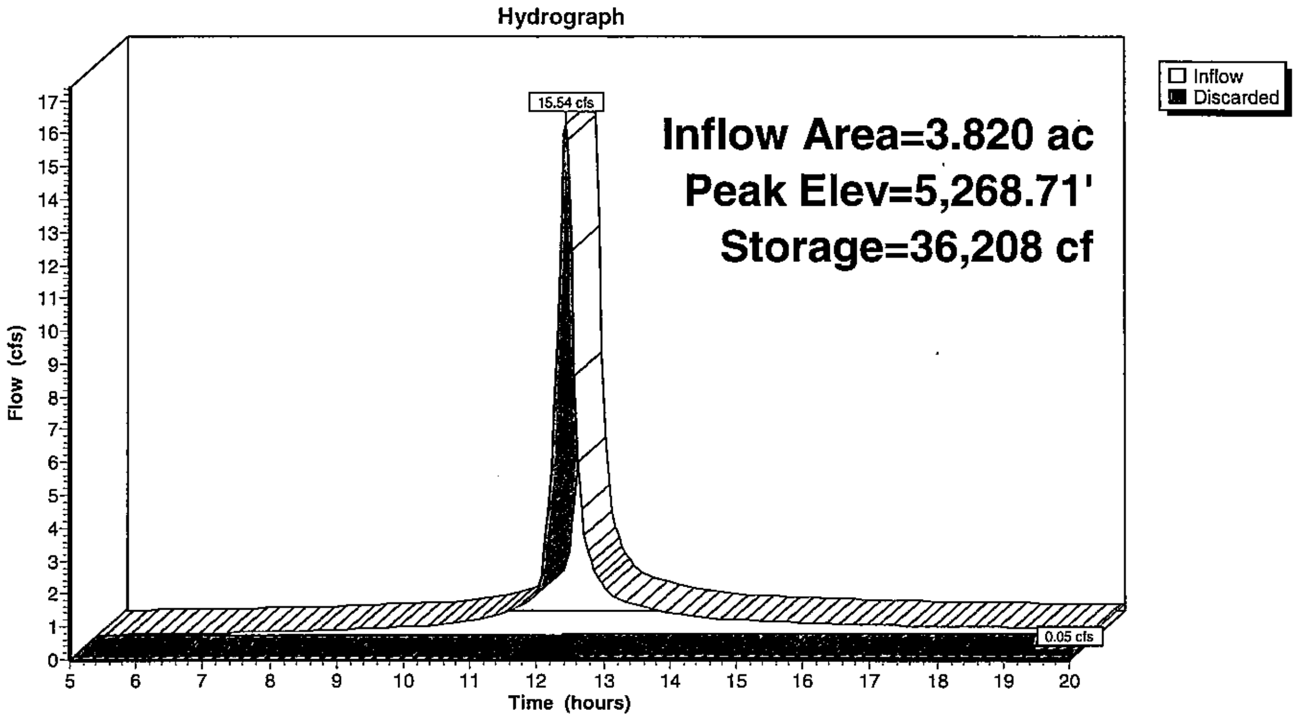
Volume	Invert	Avail.Storage	Storage Description
#1	5,264.00'	187,971 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
5,264.00	1,310	134.0	0	0	1,310
5,266.00	6,500	300.0	7,152	7,152	7,059
5,268.00	12,858	419.0	19,000	26,152	13,906
5,270.00	20,692	534.0	33,241	59,393	22,679
5,272.00	30,974	648.0	51,322	110,714	33,467
5,274.00	46,827	805.0	77,257	187,971	51,678

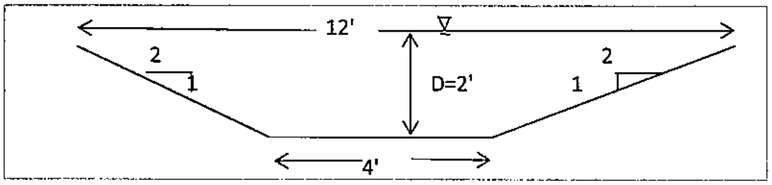
Device	Routing	Invert	Outlet Devices
#1	Discarded	5,264.00'	**0.130 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.05 cfs @ 20.00 hrs HW=5,268.71' (Free Discharge)
1=Exfiltration (Exfiltration Controls 0.05 cfs)

Pond 1P: Low Lying Area



1. Rip Rap Downslope (Typical)



NOTE : Use the fedreal regulatory senario which is the maximum flow in a riprap downchute during the 25-yr, 24-hr storm event.

Q_{25} (ft^3/s)	27.03	25yr storm water flow
S (ft/ft)	0.26	Downchute Slope
n	0.04	Manning's number
ss (ft/ft)	2	:1 sideslopes on downchute
D (ft)	2	Peak design depth
B1 (ft)	4	Width of bottom of swale
B2 (ft)	12	Width of top of swale

Cross sectional area of Trapezoid Swale:

$$A_p = D\left(\frac{b_1 + b_2}{2}\right)$$

$$A_p = 2\left(\frac{8 + 16}{2}\right)$$

Design Ap= 16

Wetted perimeter equation manipulation:

$$P_W = b_1 + 2\left(\sqrt{D^2 + (ssD)^2}\right)$$

$$P_W = 8 + 2\sqrt{5D^2}$$

Design Pw= 12.94

Hydraulic radius equation manipulation:

$$r_H = \frac{A_p}{P_w} =$$ **Design rH= 1.24**

Solve for Maximum flow using Mannings Equation:

$$Q = \frac{1.49}{n}(A_P)(r_H)^{\frac{2}{3}}\sqrt{S}$$

$$Q = \frac{1.49}{n}(14D)(8 + 10D^2)^{\frac{2}{3}}\sqrt{S}$$

Solve For Q (ft3/sec):

Q max= 350.0238

D @ Q25 = 0.384

Dactual < Ddesign THEREFORE OK

2. Swale Velocity Calculation

NOTE : Use the federal regulatory scenario which is the maximum flow in a swale during the 25-yr, 24-hr storm event.

Q_{25} (ft^3/s)	27.03	25 yr storm water flow
D (ft)	0.384	Peak depth from sheet 1

Peak flow area equation manipulation:

$$\boxed{A_p = (D * W) + 0.5(D * 2D) + 0.5(D * 3D)}$$

$$\boxed{A_p = (D * W) + D^2 + \frac{3}{2} D^2}$$

$$\boxed{A_p = 2D + 2.5D^2}$$

A_p = 1.14

Peak velocity equation manipulation:

$$\boxed{Peak \quad Velocity \quad = \frac{Q_{25}}{A_p}}$$

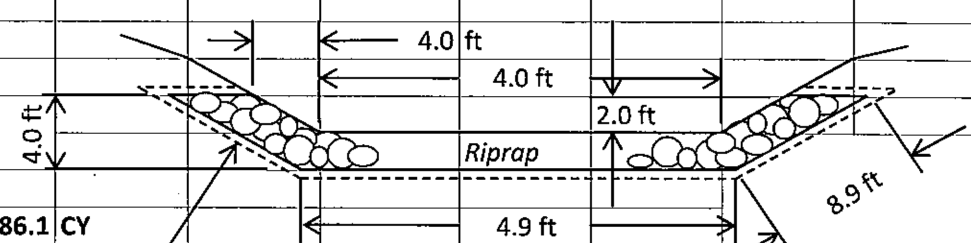
Peak Velocity = 23.78

Peak $Velocity_{DESIGN}$ = 5

$D>D_{DESIGN}$; Therefore NOT OK

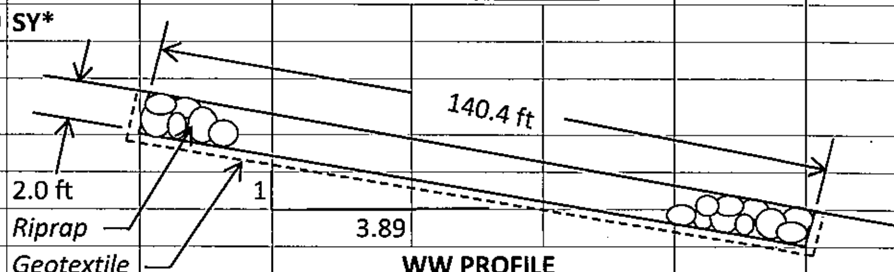
Trapezoidal Riprap-Lined Waterway Design.xlsm

	A	B	C	D	E	F	G	H	I
2	Landowner	Xcel Energy		County	Boulder			V 1.2015	
3	Computed By	CMK		Date	10/14/2016			1/15/2015	
4	Checked by			Date					
5	*Note: Macros must be enabled in this spreadsheet in order for the "Solve" button to work.*								
6	Design flow, Q=	27.03	cfs			WW horiz. Length=		136.0	ft
7	Slope, S=	0.257	ft/ft =	3.89	:1	U/S WW F.L. elev=		35.0	ft
8	Bottom Width, W=	4	ft			D/S WW F.L. elev=		**0.0**	ft
9	Side slope, Z=	2	:1			Waterway drop=		**35.0**	ft
10	Safety factor=	1.2		Typically 1.2		WW length along slope=		**140.4**	ft
11	Rock shape =	Angular							
12	Min. req'd D50=	**12.09**	in			*Spreadsheet formatting key:*			
13	D50 used=	12.00	in	*Select larger D50!*		XXX	*=Input cells*		
14	n=	**0.055**				**X.XX**	*=Output from "Solve" button*		
15	Freeboard=	1.10	ft			**X.XX**	*=Other computed output*		
16						*Red text*	*=Instructions, warnings, info*		
17	Flow depth, d=	**0.62**	ft	Calculated					
18	Critical depth, d_c=	**0.95**	ft						
19	Critical slope, S_c=	**0.054**	ft/ft	$0.7S_c$ =	**0.0376**	ft/ft			
20				$1.3S_c$ =	**0.0698**	ft/ft			
21	Design slope, S=	0.2570	ft/ft	*Design slope OK. Flow is Supercritical.*					
22	Velocity=	**8.34**	fps			Est. riprap unit wt=		1.4	Tons/CY
23				Rock shape = Angular			Rock Gs =	2.65	
24	Riprap thickness:			Required riprap gradation for D50 selected					
25	Minimum=	**2.00**	ft	%	Rock dia., inches		Rock weight, lb		
26	Provided=	2.00	ft	Smaller	min.	max.	min.	max.	
27				100	**18.0**	**24.0**	**425**	**1007**	
28	Sideslope height:			85	**15.6**	**21.6**	**277**	**734**	
29	Minimum=	**1.72**	ft	50	**12.0**	**18.0**	**126**	**425**	
30	Provided=	2.00	ft	10	**9.6**	**15.6**	**64**	**277**	



WW CROSS SECTION

	A	B	C
36	Quantities:		
37	Riprap volume=	**186.1**	**CY**
38	Approx. weight=	**260.5**	**Tons**
39	Geotextile area=	**509.9**	**SY***

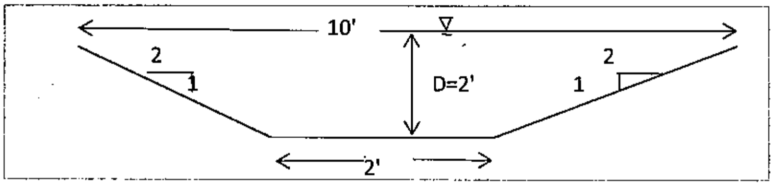


WW PROFILE

*Geotextile area includes actual covered surfaces only (no extra for laps or anchorage)

Client:	Xcel Energy	Job No. :	10025968	Computed By:	CMK
Project:	Valmont	Date Checked:		Date:	10/14/2016
Detail:	RipRap Swale Calculations	Checked By:		Page No. :	1

1. Grass Swale (Typical)



NOTE : Use the fedreal regulatory senario which is the maximum flow in a grass downchute during the 25-yr, 24-hr storm event.

Q_{25} (ft^3/s)	27.03	25yr storm water flow
S (ft/ft)	0.013	Downchute Slope
n	0.022	Manning's number
ss (ft/ft)	2	:1 sideslopes on downchute
D (ft)	2	Peak design depth
B1 (ft)	4	Width of bottom of swale
B2 (ft)	10	Width of top of swale

Cross sectional area of Trapezoid Swale:

$$\boxed{A_p = D\left(\frac{b_1 + b_2}{2}\right)}$$

$$\boxed{A_p = 2\left(\frac{8 + 16}{2}\right)}$$

Design Ap= 14

Wetted perimeter equation manipulation:

$$\boxed{P_W = b_1 + 2\left(\sqrt{D^2 + (ssD)^2}\right)}$$

$$\boxed{P_W = 8 + 2\sqrt{5D^2}}$$

Design Pw= 12.94

Hydraulic radius equation manipulation:

$$\boxed{r_H = \frac{A_p}{P_w} =}$$ **Design rH= 1.08**

Solve for Maximum flow using Mannings Equation:

$$\boxed{Q = \frac{1.49}{n}(A_P)(r_H)^{\frac{2}{3}}\sqrt{S}}$$

$$\boxed{Q = \frac{1.49}{n}(14D)(8 + 10D^2)^{\frac{2}{3}}\sqrt{S}}$$

Solve For Q (ft3/sec):

Q max= 113.91075
D @ Q25 = 0.808
Dactual < Ddesign THEREFORE OK

2. Swale Velocity Calculation

NOTE : Use the federal regulatory scenario which is the maximum flow in a swale during the 25-yr, 24-hr storm event.

Q_{25} (ft^3/s)	27.03	25 yr storm water flow
D (ft)	0.808	Peak depth from sheet 1

Peak flow area equation manipulation:

$$\boxed{A_p = (D * W) + 0.5(D * 2D) + 0.5(D * 3D)}$$

$$\boxed{A_p = (D * W) + D^2 + \frac{3}{2}D^2}$$

$$\boxed{A_p = 2D + 2.5D^2}$$

A_p = 3.25

Peak velocity equation manipulation:

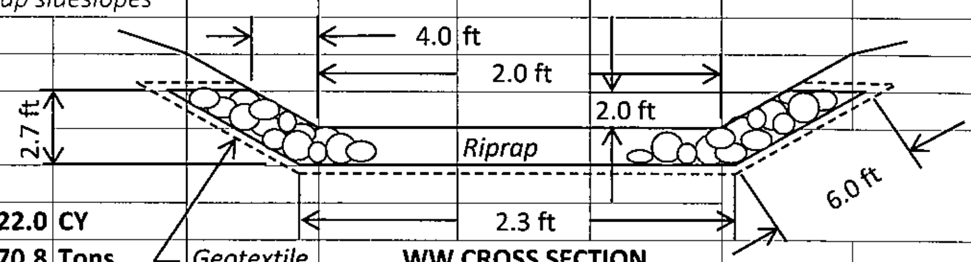
$$\boxed{Peak \quad Velocity \quad = \frac{Q_{25}}{A_p}}$$

Peak Velocity = 8.32

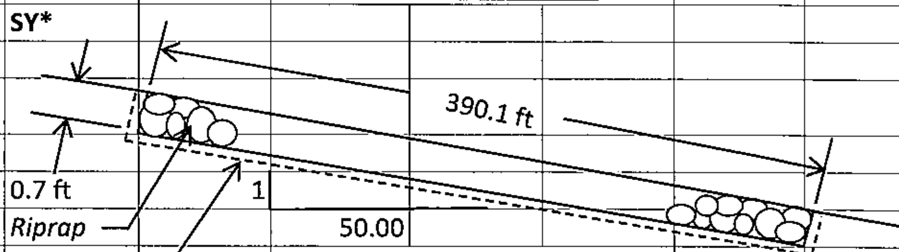
Peak $Velocity_{DESIGN}$ = 5

$D > D_{DESIGN}$; Therefore NOT OK

	A	B	C	D	E	F	G	H	I
1	**Trapezoidal Riprap-Lined Waterway Design.xlsm**								
2	Landowner	Xcel Energy		County	Boulder			V 1.2015	
3	Computed By	CMK		Date	10/14/2016			1/15/2015	
4	Checked by			Date					
5	*Note: Macros must be enabled in this spreadsheet in order for the "Solve" button to work.*								
6	Design flow, Q=	27.03	cfs			WW horiz. Length=		390.0	ft
7	Slope, S=	0.02	ft/ft =	50.00	:1	U/S WW F.L. elev=		8.0	ft
8	Bottom Width, W=	2	ft			D/S WW F.L. elev=		**0.2**	ft
9	Side slope, Z=	2	:1			Waterway drop=		**7.8**	ft
10	Safety factor=	1.2		Typically 1.2		WW length along slope=		**390.1**	ft
11	Rock shape =	Angular							
12	Min. req'd D50=	**3.62**	in			*Spreadsheet formatting key:*			
13	D50 used=	4.00	in			XXX	*=Input cells*		
14	n=	**0.032**				**X.XX**	*=Output from "Solve" button*		
15	Freeboard=	1.10	ft			**X.XX**	*=Other computed output*		
16						*Red text*	*=Instructions, warnings, info*		
17	Flow depth, d=	**1.19**	ft	**Calculated**					
18	Critical depth, d_c=	**1.21**	ft						
19	Critical slope, S_c=	**0.018**	ft/ft	$0.7S_c$ =	**0.0129**	ft/ft			
20				$1.3S_c$ =	**0.0239**	ft/ft			
21	Design slope, S=	0.0200	ft/ft	*0.7Sc<S<1.3Sc. Select a different slope or bottom width.*					
22	Velocity=	**5.18**	fps			Est. riprap unit wt=		1.4	Tons/CY
23				Rock shape = Angular			Rock Gs =	2.65	
24	Riprap thickness:			Required riprap gradation for D50 selected					
25	Minimum=	**0.67**	ft	%	Rock dia., inches		Rock weight, lb		
26	Provided=	0.67	ft	Smaller	min.	max.	min.	max.	
27				100	**6.0**	**8.0**	**16**	**37**	
28	Sideslope height:			85	**5.2**	**7.2**	**10**	**27**	
29	Minimum=	**2.29**	ft	50	**4.0**	**6.0**	**5**	**16**	
30	Provided=	2.00	ft	10	**3.2**	**5.2**	**2**	**10**	
31	*Select taller riprap sideslopes*								
32									
33									
34									
35									
36	Quantities:								
37	Riprap volume=	**122.0**	**CY**						
38	Approx. weight=	**170.8**	**Tons**						
39	Geotextile area=	**750.4**	**SY***						
40									
41									
42	*Geotextile area								
43	includes actual covered								
44	surfaces only (no extra								
45	for laps or anchorage)								
46									



WW CROSS SECTION



WW PROFILE

Appendix B - NOAA Rainfall Data

NOAA Atlas 14, Volume 8, Version 2
Location name: Boulder, Colorado, US*
Latitude: 40.0280°, Longitude: -105.2050°
Elevation: 5290 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.210** (0.171–0.258)	**0.257** (0.210–0.317)	**0.349** (0.283–0.431)	**0.438** (0.353–0.544)	**0.582** (0.459–0.769)	**0.708** (0.538–0.939)	**0.848** (0.617–1.15)	**1.00** (0.694–1.39)	**1.23** (0.811–1.75)	**1.42** (0.900–2.02)
10-min	**0.307** (0.251–0.378)	**0.376** (0.307–0.464)	**0.511** (0.415–0.631)	**0.642** (0.518–0.796)	**0.852** (0.671–1.13)	**1.04** (0.788–1.38)	**1.24** (0.903–1.68)	**1.47** (1.02–2.04)	**1.81** (1.19–2.56)	**2.08** (1.32–2.95)
15-min	**0.375** (0.306–0.461)	**0.459** (0.374–0.566)	**0.623** (0.506–0.769)	**0.783** (0.631–0.971)	**1.04** (0.819–1.37)	**1.26** (0.961–1.68)	**1.52** (1.10–2.05)	**1.79** (1.24–2.49)	**2.20** (1.45–3.12)	**2.54** (1.61–3.60)
30-min	**0.519** (0.423–0.639)	**0.633** (0.516–0.780)	**0.856** (0.695–1.06)	**1.07** (0.866–1.33)	**1.43** (1.12–1.89)	**1.74** (1.32–2.30)	**2.08** (1.51–2.82)	**2.46** (1.70–3.41)	**3.02** (1.99–4.29)	**3.49** (2.21–4.95)
60-min	**0.644** (0.525–0.792)	**0.784** (0.639–0.966)	**1.06** (0.858–1.31)	**1.32** (1.07–1.64)	**1.75** (1.38–2.31)	**2.12** (1.61–2.82)	**2.54** (1.85–3.44)	**3.00** (2.07–4.16)	**3.68** (2.42–5.21)	**4.24** (2.68–6.01)
2-hr	**0.769** (0.633–0.937)	**0.935** (0.769–1.14)	**1.26** (1.03–1.54)	**1.57** (1.28–1.93)	**2.07** (1.65–2.71)	**2.51** (1.93–3.30)	**3.00** (2.20–4.02)	**3.54** (2.47–4.86)	**4.33** (2.88–6.08)	**4.99** (3.20–7.01)
3-hr	**0.845** (0.699–1.02)	**1.03** (0.847–1.24)	**1.37** (1.13–1.67)	**1.71** (1.39–2.08)	**2.24** (1.79–2.90)	**2.70** (2.08–3.52)	**3.22** (2.37–4.28)	**3.79** (2.66–5.16)	**4.62** (3.09–6.44)	**5.30** (3.42–7.41)
6-hr	**1.03** (0.861–1.24)	**1.25** (1.04–1.50)	**1.64** (1.36–1.98)	**2.02** (1.67–2.45)	**2.62** (2.10–3.35)	**3.13** (2.44–4.04)	**3.70** (2.76–4.87)	**4.32** (3.06–5.83)	**5.23** (3.54–7.21)	**5.97** (3.89–8.26)
12-hr	**1.31** (1.10–1.55)	**1.57** (1.32–1.87)	**2.05** (1.71–2.44)	**2.49** (2.07–2.98)	**3.18** (2.57–4.01)	**3.76** (2.95–4.78)	**4.40** (3.30–5.71)	**5.09** (3.64–6.78)	**6.09** (4.16–8.30)	**6.90** (4.55–9.45)
24-hr	**1.59** (1.35–1.87)	**1.93** (1.64–2.27)	**2.54** (2.14–2.99)	**3.08** (2.58–3.65)	**3.88** (3.15–4.80)	**4.54** (3.58–5.68)	**5.25** (3.97–6.71)	**6.00** (4.33–7.87)	**7.06** (4.87–9.49)	**7.90** (5.28–10.7)
2-day	**1.82** (1.55–2.11)	**2.26** (1.93–2.63)	**3.01** (2.56–3.51)	**3.65** (3.08–4.27)	**4.56** (3.71–5.54)	**5.29** (4.19–6.50)	**6.03** (4.60–7.60)	**6.82** (4.96–8.81)	**7.88** (5.49–10.5)	**8.72** (5.89–11.7)
3-day	**1.98** (1.70–2.29)	**2.43** (2.08–2.81)	**3.19** (2.72–3.69)	**3.84** (3.26–4.47)	**4.77** (3.91–5.76)	**5.51** (4.40–6.74)	**6.28** (4.82–7.87)	**7.08** (5.19–9.10)	**8.18** (5.74–10.8)	**9.04** (6.15–12.1)
4-day	**2.12** (1.82–2.44)	**2.56** (2.20–2.95)	**3.31** (2.84–3.82)	**3.95** (3.37–4.59)	**4.89** (4.02–5.88)	**5.63** (4.51–6.87)	**6.41** (4.94–8.00)	**7.22** (5.32–9.25)	**8.34** (5.88–11.0)	**9.22** (6.31–12.3)
7-day	**2.46** (2.13–2.80)	**2.90** (2.51–3.31)	**3.65** (3.15–4.18)	**4.30** (3.69–4.94)	**5.23** (4.33–6.24)	**5.98** (4.83–7.22)	**6.75** (5.25–8.35)	**7.56** (5.62–9.60)	**8.68** (6.18–11.3)	**9.56** (6.60–12.6)
10-day	**2.75** (2.40–3.12)	**3.21** (2.79–3.64)	**3.97** (3.45–4.53)	**4.63** (3.99–5.30)	**5.57** (4.64–6.60)	**6.32** (5.13–7.58)	**7.09** (5.54–8.71)	**7.90** (5.90–9.96)	**9.00** (6.44–11.7)	**9.86** (6.85–12.9)
20-day	**3.59** (3.16–4.04)	**4.11** (3.61–4.62)	**4.97** (4.35–5.59)	**5.68** (4.94–6.43)	**6.68** (5.61–7.80)	**7.47** (6.11–8.83)	**8.26** (6.51–10.0)	**9.07** (6.84–11.3)	**10.2** (7.35–13.0)	**11.0** (7.73–14.3)
30-day	**4.27** (3.78–4.77)	**4.88** (4.30–5.44)	**5.85** (5.15–6.55)	**6.66** (5.82–7.49)	**7.76** (6.54–8.97)	**8.61** (7.08–10.1)	**9.45** (7.49–11.3)	**10.3** (7.81–12.7)	**11.4** (8.30–14.5)	**12.2** (8.67–15.8)
45-day	**5.11** (4.54–5.66)	**5.85** (5.19–6.49)	**7.04** (6.23–7.83)	**8.00** (7.03–8.94)	**9.29** (7.85–10.6)	**10.2** (8.46–11.9)	**11.2** (8.91–13.3)	**12.1** (9.23–14.8)	**13.3** (9.72–16.7)	**14.1** (10.1–18.1)
60-day	**5.80** (5.17–6.40)	**6.69** (5.96–7.39)	**8.10** (7.18–8.96)	**9.22** (8.13–10.2)	**10.7** (9.05–12.2)	**11.8** (9.75–13.6)	**12.8** (10.2–15.2)	**13.8** (10.6–16.8)	**15.1** (11.1–18.8)	**15.9** (11.5–20.4)

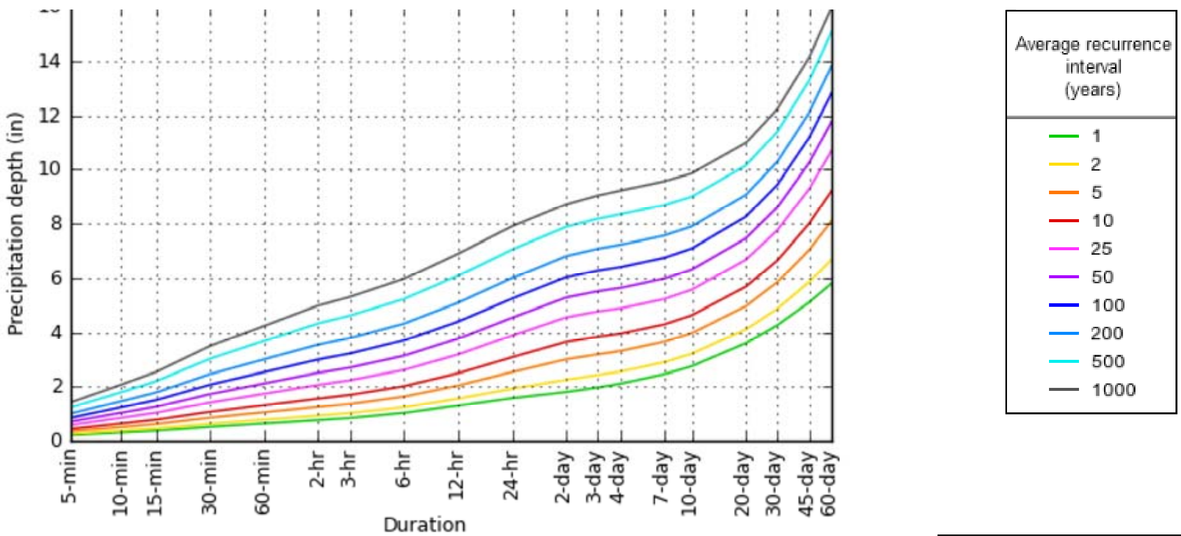
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

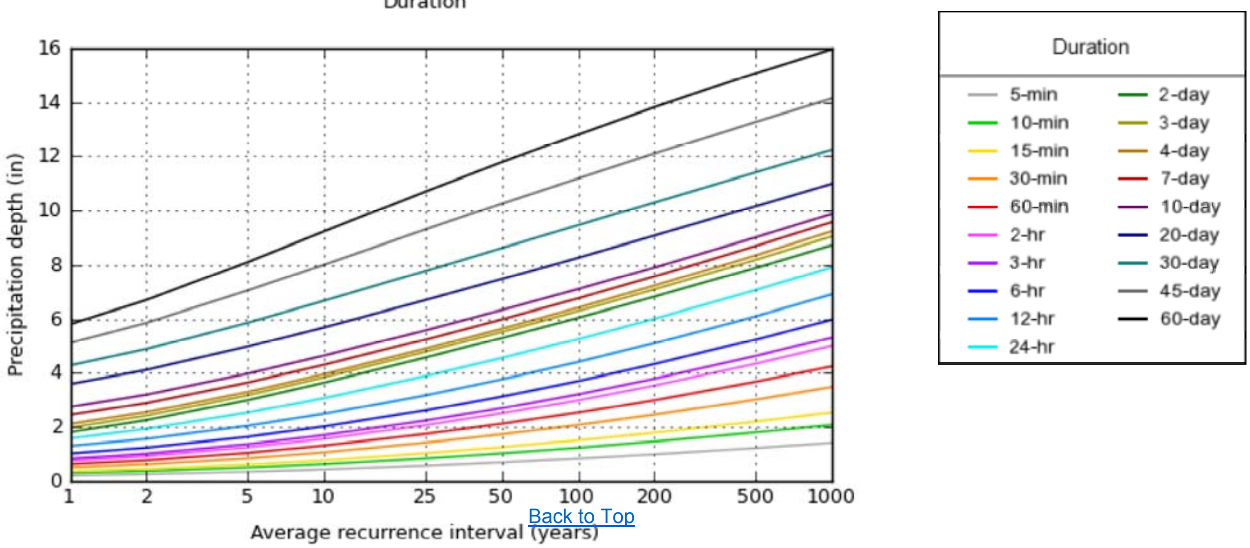
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper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

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



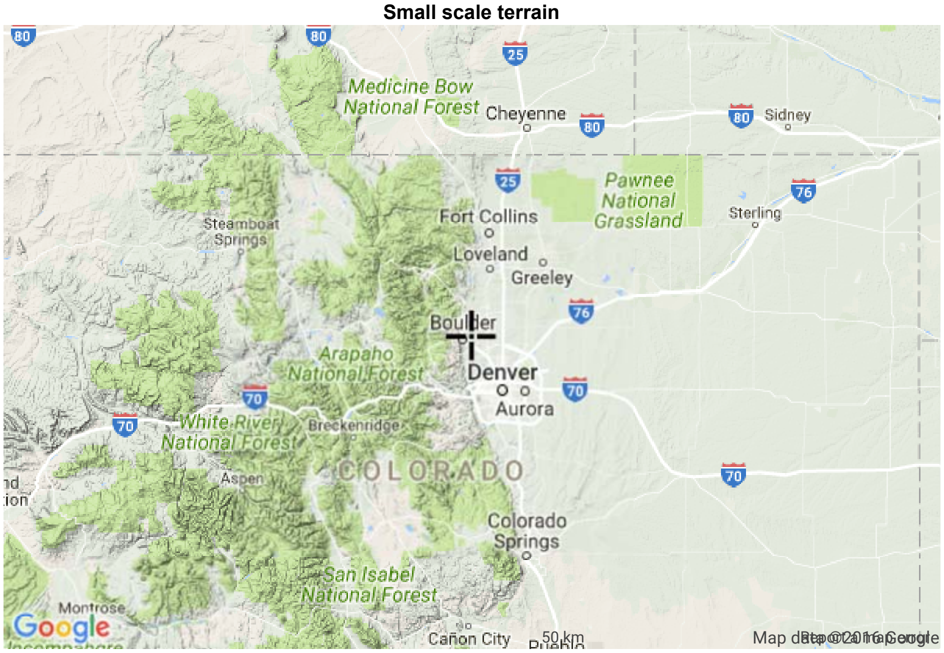


Back to Top

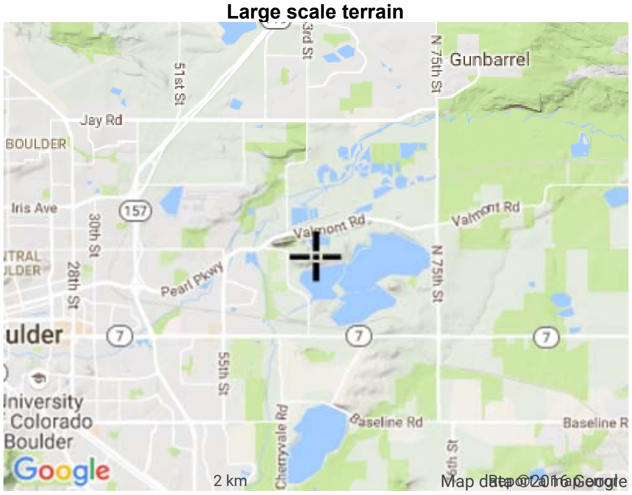
NOAA Atlas 14, Volume 8, Version 2 Created (GMT): Mon Aug 1 20:11:48 2016

Maps & aerials

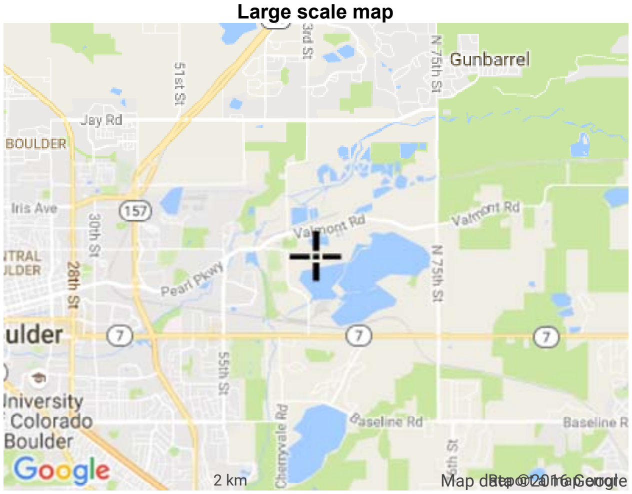
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

[Back to Top]

Questions?: HDSC.Questions@noaa.gov

Appendix C - Soil Conservation District Soil Report

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Boulder County Area, Colorado

Valmont Station

August 9, 2016

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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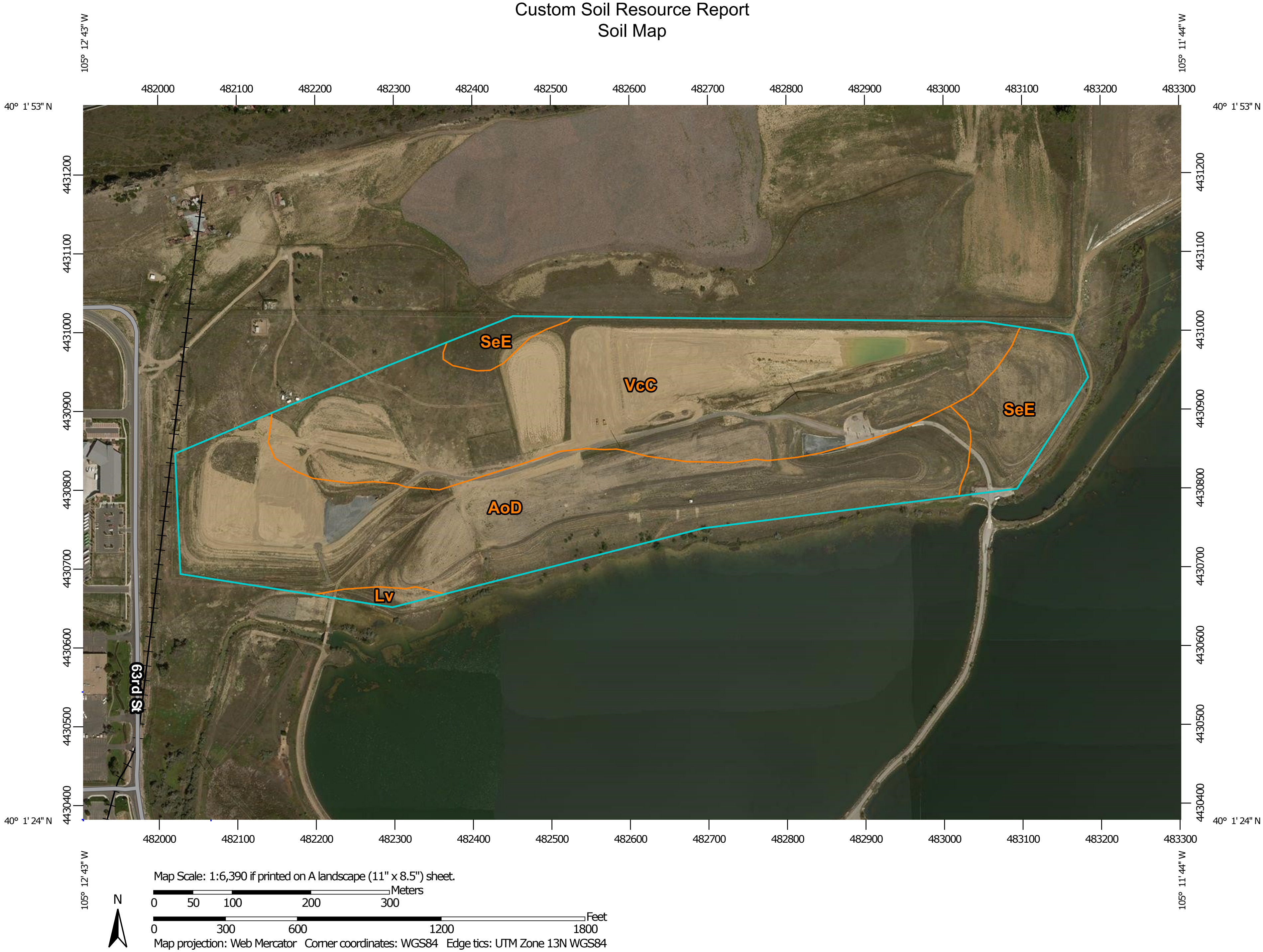
Contents

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Boulder County Area, Colorado
Survey Area Data: Version 12, Sep 22, 2015

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

Date(s) aerial images were photographed: Aug 30, 2014—Sep 18, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Boulder County Area, Colorado (CO643)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
AoD	Ascalon-Otero complex, 5 to 9 percent slopes	30.7	42.5%
Lv	Loveland soils	0.6	0.8%
SeE	Samsil-Shingle complex, 5 to 25 percent slopes	6.7	9.2%
VcC	Valmont cobbly clay loam, 1 to 5 percent slopes	34.3	47.4%
Totals for Area of Interest		**72.3**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Boulder County Area, Colorado

AoD—Ascalon-Otero complex, 5 to 9 percent slopes

Map Unit Setting

National map unit symbol: jpr7
Elevation: 4,900 to 5,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 140 to 155 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Ascalon and similar soils: 50 percent
Otero and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ascalon

Setting

Landform: Ridges, terraces
Landform position (three-dimensional): Side slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed loamy alluvium and/or eolian deposits

Typical profile

H1 - 0 to 6 inches: sandy loam
H2 - 6 to 17 inches: sandy clay loam, sandy loam
H2 - 6 to 17 inches: fine sandy loam, loamy fine sand, sandy loam
H3 - 17 to 60 inches:
H3 - 17 to 60 inches:
H3 - 17 to 60 inches:

Properties and qualities

Slope: 5 to 7 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very high (about 16.8 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy (R067XB026CO)

Description of Otero

Setting

Landform: Ridges
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed loamy alluvium over eolian deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 60 inches: sandy loam, fine sandy loam
H2 - 8 to 60 inches:

Properties and qualities

Slope: 5 to 9 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Available water storage in profile: Very high (about 13.3 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Ecological site: Sandy (R067XB026CO)

Minor Components

Kim

Percent of map unit: 8 percent

Terry

Percent of map unit: 5 percent

Cascajo

Percent of map unit: 2 percent

Lv—Loveland soils

Map Unit Setting

National map unit symbol: jps0
Elevation: 4,900 to 5,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 48 to 52 degrees F

Frost-free period: 140 to 155 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Loveland and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Loveland

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

H1 - 0 to 11 inches: clay loam
H2 - 11 to 30 inches: clay loam, silty clay loam, loam
H2 - 11 to 30 inches: very gravelly sand, gravelly sand, gravelly coarse sand
H2 - 11 to 30 inches:
H3 - 30 to 60 inches:
H3 - 30 to 60 inches:
H3 - 30 to 60 inches:

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Available water storage in profile: Very high (about 17.4 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Ecological site: Salt Meadow (R067XB035CO)

Minor Components

Aquolls

Percent of map unit: 10 percent
Landform: Flood plains

Mcclave

Percent of map unit: 3 percent

Niwot

Percent of map unit: 2 percent

SeE—Samsil-Shingle complex, 5 to 25 percent slopes

Map Unit Setting

National map unit symbol: jpsr
Elevation: 4,900 to 5,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 140 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition

Shingle and similar soils: 40 percent
Samsil and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Samsil

Setting

Landform: Ridges, hills
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from clayey shale

Typical profile

H1 - 0 to 3 inches: clay
H2 - 3 to 12 inches: clay, silty clay
H2 - 3 to 12 inches: weathered bedrock
H3 - 12 to 16 inches:

Properties and qualities

Slope: 5 to 25 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e

Hydrologic Soil Group: D
Ecological site: Shaly Foothill (R049BY212CO)

Description of Shingle

Setting

Landform: Ridges, hills
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 4 inches: loam
H2 - 4 to 13 inches: silt loam, loam
H2 - 4 to 13 inches: weathered bedrock
H3 - 13 to 17 inches:

Properties and qualities

Slope: 5 to 25 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Available water storage in profile: Low (about 3.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: Shaly Foothill (R049BY212CO)

Minor Components

Renohill

Percent of map unit: 6 percent

Kutch

Percent of map unit: 5 percent

Gaynor

Percent of map unit: 4 percent

VcC—Valmont cobbly clay loam, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: jpsy
Elevation: 4,900 to 5,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 140 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition

Valmont and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Valmont

Setting

Landform: Terraces, fan remnants
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravelly and cobbly loamy alluvium

Typical profile

H1 - 0 to 8 inches: cobbly clay loam
H2 - 8 to 22 inches: clay loam, clay
H2 - 8 to 22 inches: very gravelly loam, very gravelly sandy loam
H3 - 22 to 60 inches:
H3 - 22 to 60 inches:

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Cobbly Foothills (R048AY346CO)

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf