Run-on and Run-off Control System Plan

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

Hayden Station - CCR Landfill
Public Service Company of Colorado
Denver, Colorado

October 17, 2016

PREPARED FOR

HAYDEN STATION

13125 U.S. Highway 40
Hayden, Colorado 81638

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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
PSCo	Public Service Company of Colorado
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 Systems Plan for all existing and new CCR landfills.

This Run-on and Run-off Control System Plan was prepared for the CCR landfill at the Hayden 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 Hayden Station CCR landfill is located on Routt County Road 27, approximately 1 mile south of the Colorado Highway 40 in Routt County.

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

The CCR landfill parcel consists of approximately 154 acres, of which approximately 136 acres are used for ash disposal and approximately 18 acres for stormwater control structures, access roads, and borrow area. The landfill is located on a steeply sloping upland area between the two surface water drainage areas of Sage Creek and Grassy Creek. Sage Creek is directly west of the landfill and Grassy Creek is east of the landfill. The landfill design includes construction of benches to divert surface water runoff to downslope channels which direct water into detention ponds designed to manage stormwater run-off.

The disposal cells are developed by constructing a compacted native soil berm around the downhill side of the disposal cell and filling the cell in a uniform lift. Prior to starting another lift, a new berm is constructed on the downhill side of the disposal cell. Soil berms are constructed with a top width of approximately 20 feet and range from approximately 2 to 5 feet in height.

As the ash is placed and final design elevations are reached side slopes are covered with the final cover material having a thickness greater than 2 feet. Final side slopes are constructed at a maximum slope of three to one (3H:1V), with 20-foot benches installed every 20 vertical feet providing an overall average slope of approximately 4H:1V. Discrete areas of the CCR landfill are closed when they reach final capacity and independent of closure of the entire facility.

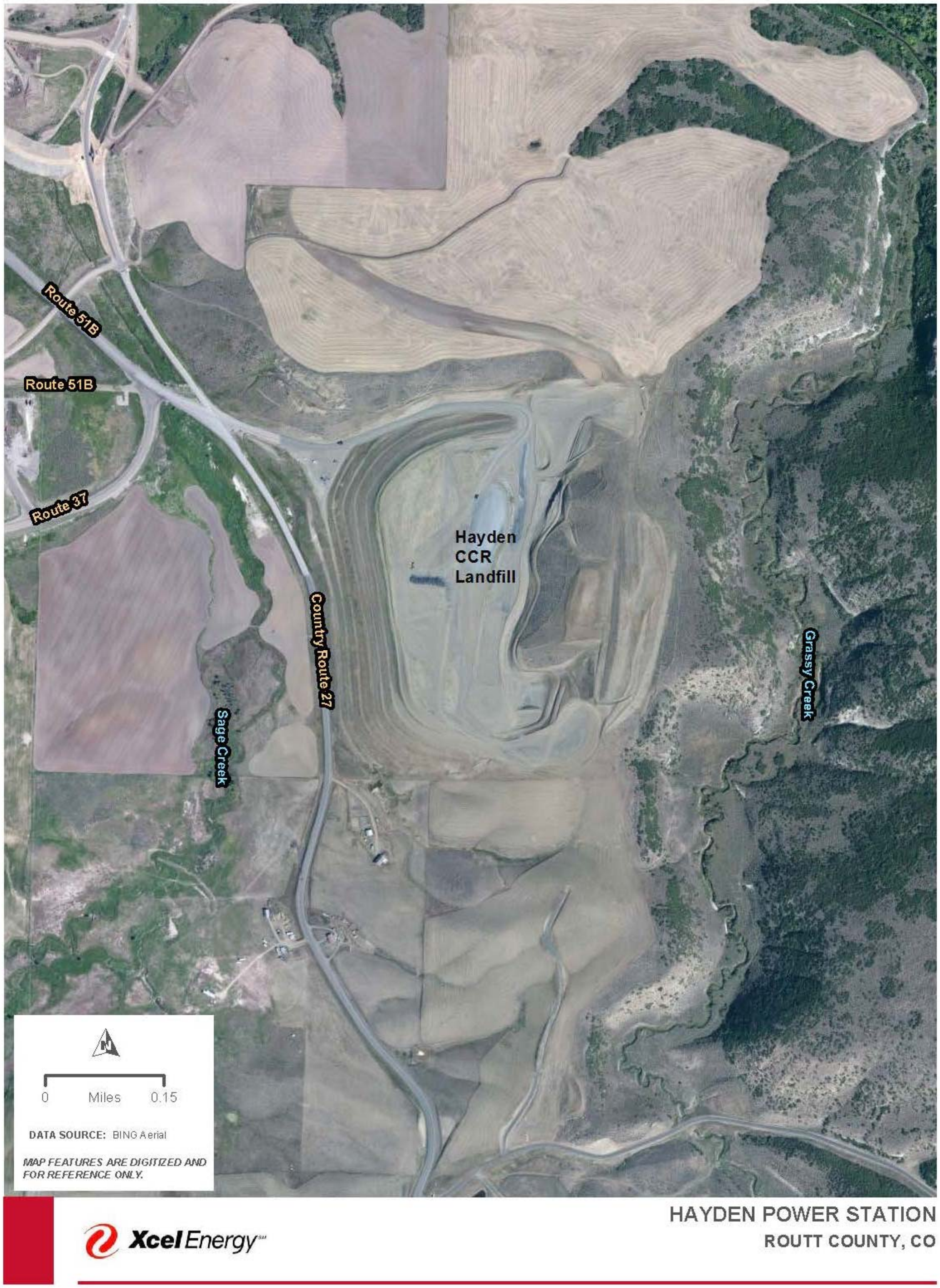


Figure 1. Hayden Facility Location Map

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.

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 in accordance with 40 CFR 257.81 and Part 1 of 6 CCR 1007-2. 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"*.

Prior to publication of 40 CFR 257.81, approximately 18 acres of the southwest portion of the landfill were closed. These areas were capped with the final cover material and are fully vegetated and are not considered active portions of the CCR landfill. Therefore, these areas including all permanent run-off control systems in these areas were not included in this evaluation.

This 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 year storm event. The evaluation was completed using the best available information at the time and was based on a survey completed in May 2013 and updated in October 2015.

2.1 Description of CCR Landfill and Drainage Area

Based on the survey data, the drainage area that includes the active landfill operations is approximately 70.5 acres. All runoff within the drainage area is directed to the contact retention basin in the southeast corner of the landfill. The drainage area consists of approximately 18.9 acres of active ash disposal areas, 4.5 acres of gravel drives, a 0.8-acre contact pond, and 46.3 acres of currently undisturbed and vegetated areas (50-75% grass coverage).

Because the CCR landfill is located between two drainage areas, surface run-off is naturally shed to the east and west away from the landfill. A berm constructed around the active portion separates and directs run-on around the active landfill area and creates a single drainage basin which collects surface run-off from the active portion and directs it to a contact pond constructed in the southeast portion of the active area.

The active landfill area and delineated drainage basin is shown on **Figure 2**.

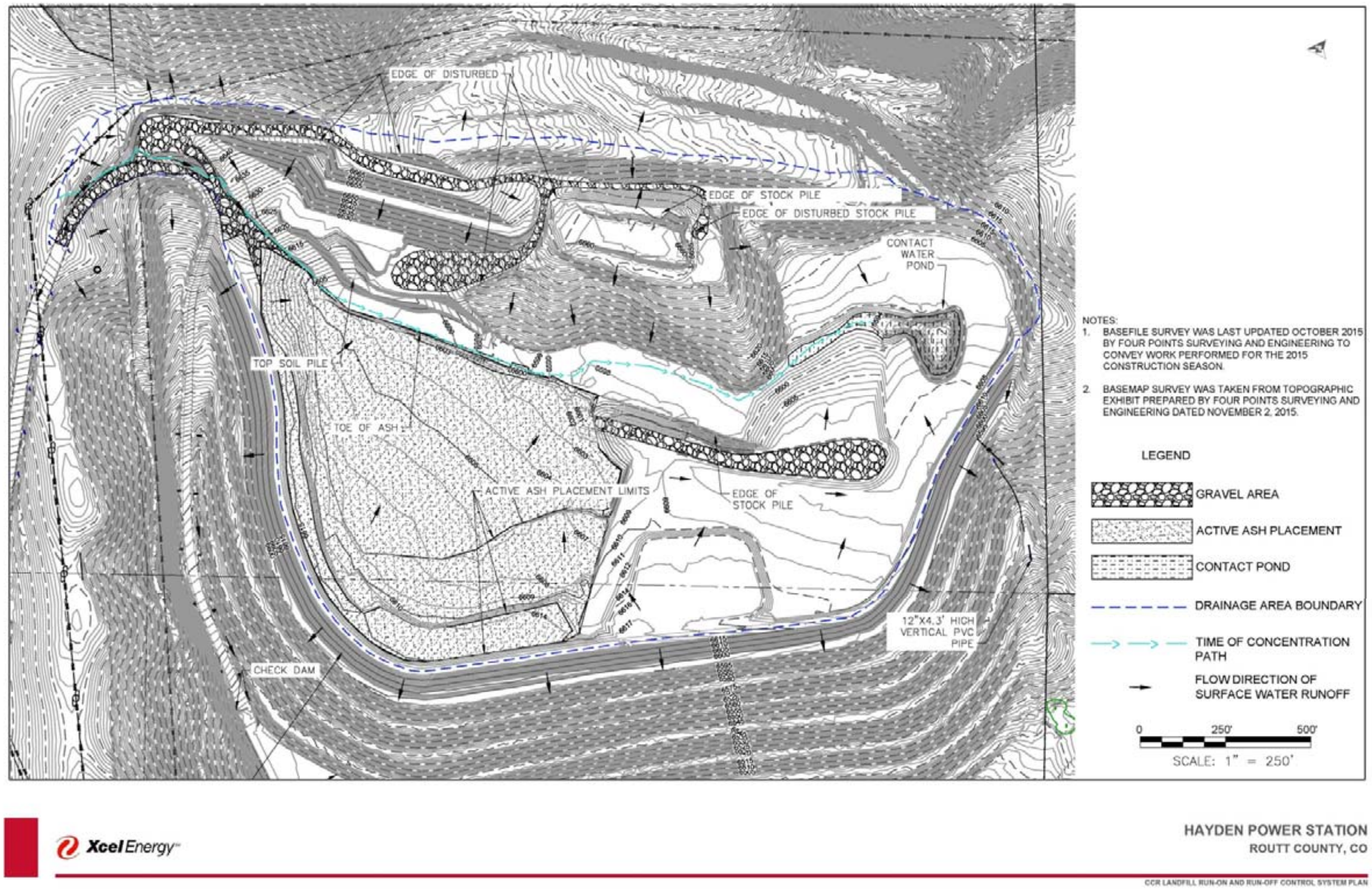


Figure 2. Stormwater Drainage Map

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

2.2.1 Run-on Controls

The active portion of the CCR landfill is surrounded by a 20-foot-wide berm along the outer perimeter. The berm is stabilized with topsoil and vegetation and prevents any run-on from entering the active portion of the landfill area. The active ash disposal cell is located in the northwestern portion of the landfill. The north and west boundaries border the 20-foot-wide perimeter berm which prevents run-on from entering from these areas. To the south, the active ash disposal area is built up approximately 4 feet and a diversion swale is constructed along the east which directs surface water from up-gradient areas east of the active ash disposal cell around the cell and directly to the contact pond. To the south, of the active cell is approximately 1.8 acres of grassland within the active landfill area that drains surface water onto the active ash disposal area.

2.2.2 Run-off Controls

The entire active portion of the CCR landfill consists of soil stockpiles, gravel drives and active ash disposal areas draining towards the southeast portion of the CCR landfill to a contact pond which collects run-off from these areas. The contact pond is approximately 0.8 acre in size with a depth of approximately 12 feet.

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 generating runoff hydrographs. The model is 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	1.21
25-year	2.07

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 located at the southeast portion of 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 Bulkley silty clay 3 to 12 percent slopes (10C) and 12 to 25 percent slopes (10E). These soils are in HSG D. The ash itself was assumed to be of HSG D due to its low infiltration properties. 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 a site inspection conducted by HDR on October 29, 2015. The ground cover for the ash disposal area was inputted into the model as bare soil.

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 (Arces)	Curve Number
50-75% Grass Cover	D	46.28	84
Fallow, bare soil*	D	18.87	94
Gravel surface	D	4.48	96
Water Surface	D	0.84	98
Weighted CN			**88**

*Active ash disposal area

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 contact pond was modeled as a detention basin with evaporation as its only outlet (zero exfiltration). The on-site unconsolidated soil is described in the Engineering Design and Operation Plan (EDOP) by Woodward-Clyde Consultants as alluvial and colluvial deposits with permeabilities in the range of 10^{-6} to 10^{-9} centimeters per second (cm/sec). This permeability was confirmed by the Soil Conservation District Web Soil Report (**Appendix C**). According to the report the native soils have a very low capacity to transmit water at an estimated rate of 0.0 to 0.06 inch/hour. To be conservative, the model was run using the minimum exfiltration rate of 0.001 inch/hour.

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. The model was run to evaluate whether the contact pond was of sufficient size to control runoff from the 25-year, 24-hour storm event.

Based on the model results, the existing 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 57.54 cubic feet per second (cfs) during the 25-year storm. During the 25-year storm the high water level was estimated to be 6,600.17 feet, which is 9.83 feet below the lowest berm elevation (6,610 feet).

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 of the Hayden CCR landfill meet the requirements of 40 CFR Part

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 of the Hayden CCR landfill meet the requirements of 40 CFR Part 257.81. There are no improvements proposed for the existing run-on and run-off control systems for the active portion of the CCR landfill; however, it is recommended that a swale be constructed along the southern boundary of the active ash disposal cell to prevent the 1.8 acres of land up-gradient of this cell from directly discharging surface water onto the active ash disposal cell.

3.0 Professional Engineer Certification

Hayden 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.

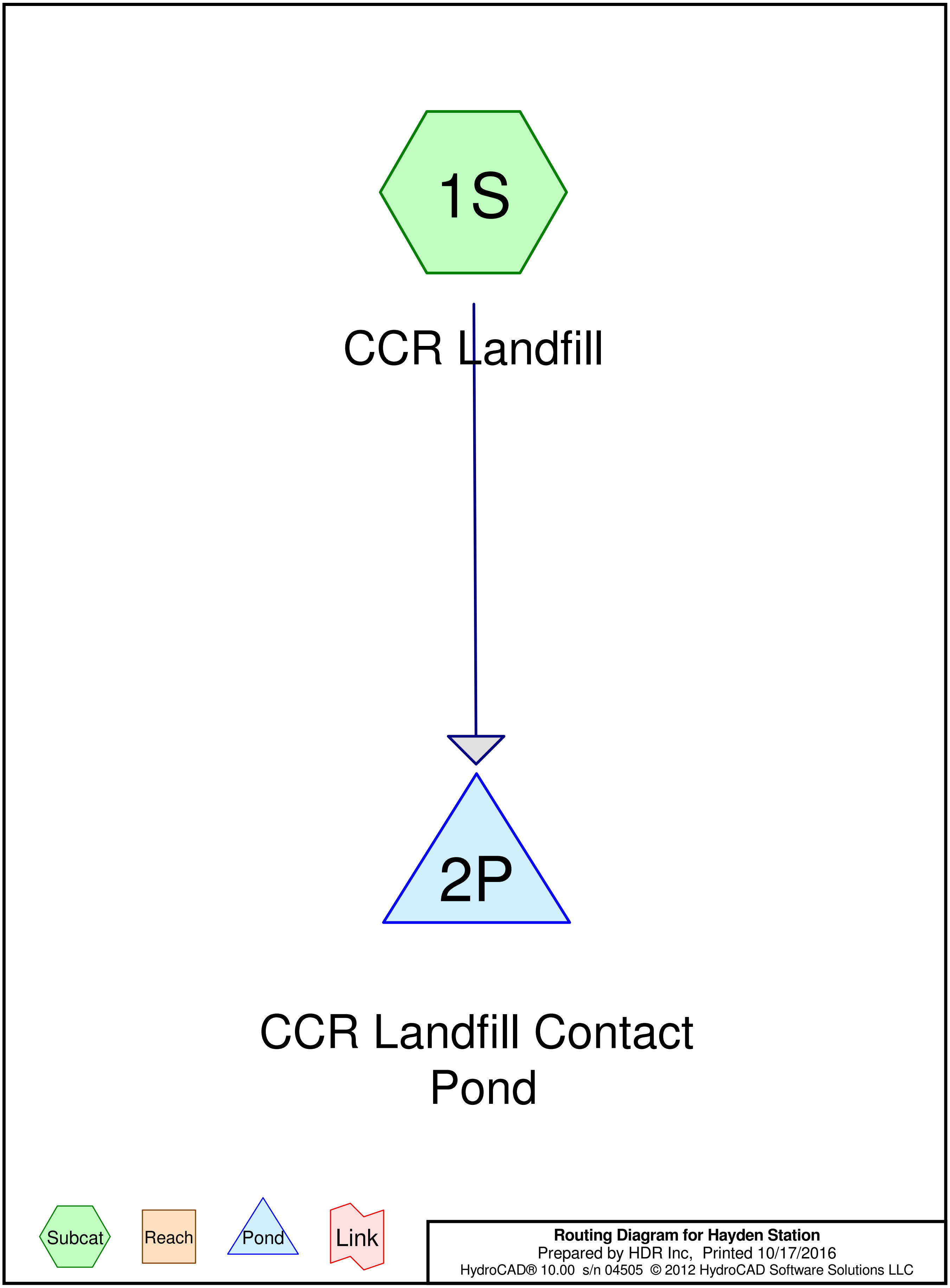
SIGNATURE:

COLORADO LICENSED
CHRISTOPHER M. KOEHLER
51359
PROFESSIONAL ENGINEER

Christopher M. Koehler, PE — Colorado PE 0051359

DATE: October 17, 2016

APPENDIX A - HYDROCAD MODEL RESULTS



Routing Diagram for Hayden Station
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)
46.280	84	50-75% Grass cover, Fair, HSG D (1S)
18.870	94	Fallow, bare soil, HSG D (1S)
4.480	96	Gravel surface, HSG D (1S)
0.840	98	Water Surface, HSG A (1S)
70.470	**88**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.840	HSG A	1S
0.000	HSG B	
0.000	HSG C	
69.630	HSG D	1S
0.000	Other	
70.470		**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	0.000	46.280	0.000	46.280	50-75% Grass cover, Fair	1S
0.000	0.000	0.000	18.870	0.000	18.870	Fallow, bare soil	1S
0.000	0.000	0.000	4.480	0.000	4.480	Gravel surface	1S
0.840	0.000	0.000	0.000	0.000	0.840	Water Surface	1S
0.840	**0.000**	**0.000**	**69.630**	**0.000**	**70.470**	**TOTAL AREA**	

Time span=5.00-35.00 hrs, dt=0.04 hrs, 751 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: CCR Landfill Runoff Area=70.470 ac 1.19% Impervious Runoff Depth=1.02"
Flow Length=2,784' Tc=33.5 min CN=88 Runoff=57.54 cfs 6.001 af

Pond 2P: CCR Landfill Contact Pond Peak Elev=6,600.17' Storage=5.968 af Inflow=57.54 cfs 6.001 af
Outflow=0.05 cfs 0.072 af

Total Runoff Area = 70.470 ac Runoff Volume = 6.001 af Average Runoff Depth = 1.02"
98.81% Pervious = 69.630 ac 1.19% Impervious = 0.840 ac

Summary for Subcatchment 1S: CCR Landfill

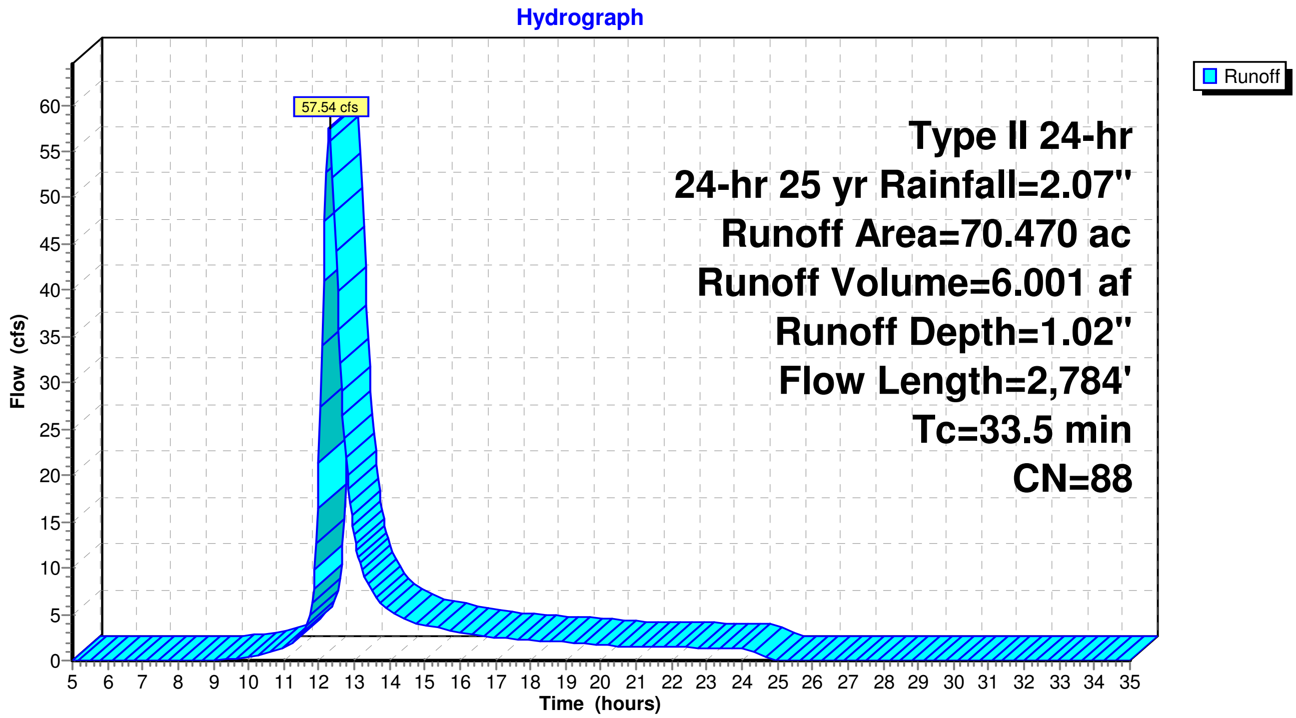
Runoff = 57.54 cfs @ 12.29 hrs, Volume= 6.001 af, Depth= 1.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-35.00 hrs, dt= 0.04 hrs
Type II 24-hr 24-hr 25 yr Rainfall=2.07"

Area (ac)	CN	Description
18.870	94	Fallow, bare soil, HSG D
4.480	96	Gravel surface, HSG D
0.840	98	Water Surface, HSG A
46.280	84	50-75% Grass cover, Fair, HSG D
70.470	88	Weighted Average
69.630		98.81% Pervious Area
0.840		1.19% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	58	0.1400	0.23		**Sheet Flow, sheet flow** Range n= 0.130 P2= 1.21"
4.5	874	0.0500	3.21	0.64	**Trap/Vee/Rect Channel Flow, Drainage Ditch** Bot.W=0.00' D=1.00' Z= 0.2 '/' Top.W=0.40' n= 0.022 Earth, clean & straight
24.8	1,852	0.0060	1.25		**Shallow Concentrated Flow, shallow concentration flow** Unpaved Kv= 16.1 fps
33.5	2,784	Total			

Subcatchment 1S: CCR Landfill



Summary for Pond 2P: CCR Landfill Contact Pond

Inflow Area = 70.470 ac, 1.19% Impervious, Inflow Depth = 1.02" for 24-hr 25 yr event
Inflow = 57.54 cfs @ 12.29 hrs, Volume= 6.001 af
Outflow = 0.05 cfs @ 25.07 hrs, Volume= 0.072 af, Atten= 100%, Lag= 766.6 min
Discarded = 0.05 cfs @ 25.07 hrs, Volume= 0.072 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-35.00 hrs, dt= 0.04 hrs / 3
Peak Elev= 6,600.17' @ 25.07 hrs Surf.Area= 4.561 ac Storage= 5.968 af

Plug-Flow detention time= 917.3 min calculated for 0.072 af (1% of inflow)
Center-of-Mass det. time= 678.6 min (1,535.2 - 856.6)

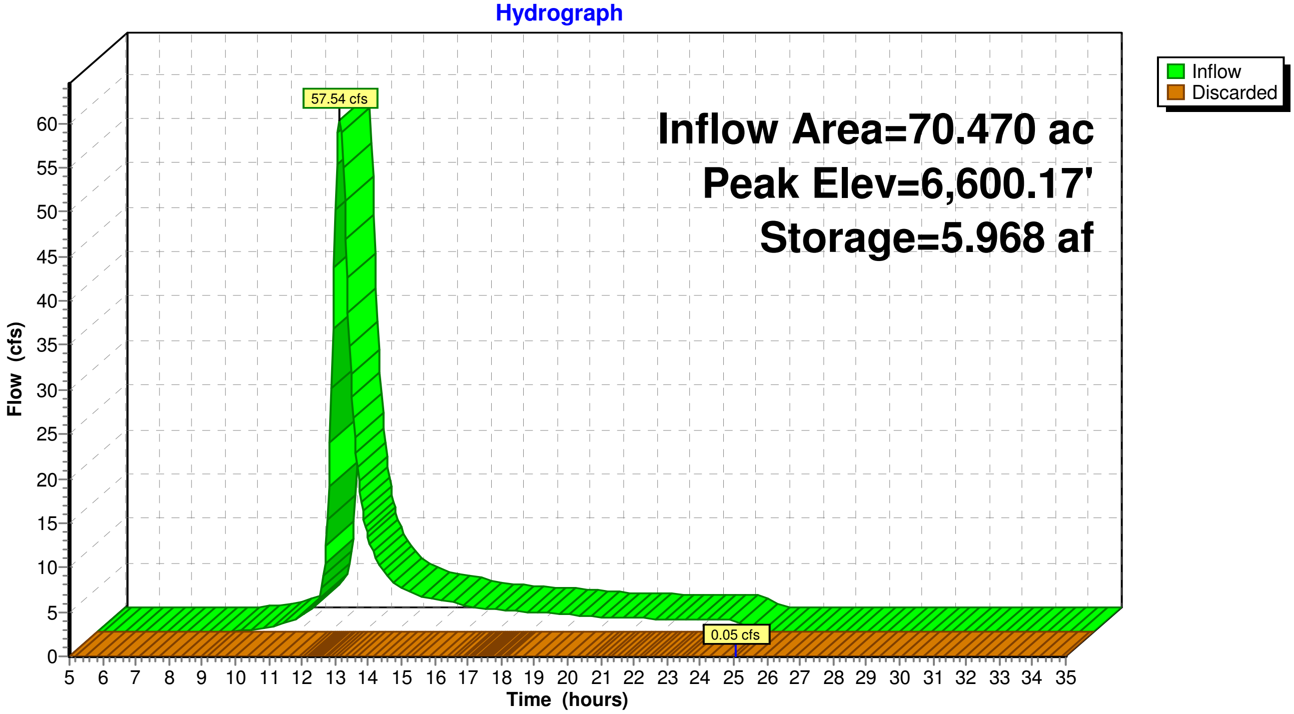
Volume	Invert	Avail.Storage	Storage Description
#1	6,545.20'	7.024 af	**Custom Stage Data (Irregular)** Listed below (Recalc) 70.244 af Overall x 10.0% Voids

Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
6,545.20	1.155	2,137.4	0.000	0.000	1.155
6,546.00	1.377	2,169.5	1.011	1.011	1.411
6,548.00	1.761	2,291.5	3.130	4.142	2.410
6,550.00	2.184	2,422.8	3.937	8.079	3.546
6,552.00	2.768	2,581.5	4.940	13.020	5.002
6,584.00	0.020	121.1	32.248	45.268	17.190
6,586.00	0.122	286.7	0.128	45.396	17.313
6,588.00	0.193	362.5	0.312	45.708	17.404
6,590.00	0.262	456.4	0.453	46.161	17.546
6,592.00	0.346	587.9	0.606	46.767	17.798
6,594.00	0.486	745.9	0.828	47.595	18.184
6,596.00	0.840	1,344.9	1.310	48.905	20.473
6,597.00	1.176	1,886.1	1.003	49.908	23.667
6,598.00	2.675	3,030.8	1.875	51.783	33.950
6,599.00	3.619	3,092.5	3.135	54.918	34.644
6,600.00	4.412	4,030.8	4.009	58.927	46.854
6,601.00	5.331	4,505.9	4.864	63.792	54.264
6,602.00	7.643	5,207.4	6.452	70.244	66.712

Device	Routing	Invert	Outlet Devices
#1	Discarded	6,545.20'	**0.001 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 0.00' Phase-In= 0.01'

Discarded OutFlow Max=0.05 cfs @ 25.07 hrs HW=6,600.17' (Free Discharge)
└─**1=Exfiltration** (Controls 0.05 cfs)

Pond 2P: CCR Landfill Contact Pond



APPENDIX B - NOAA RAINFALL DATA

NOAA Atlas 14, Volume 8, Version 2
Location name: Hayden, Colorado, US*
Latitude: 40.4735°, Longitude: -107.1620°
Elevation: 6597 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	0.143 (0.114-0.185)	0.184 (0.147-0.239)	0.257 (0.204-0.335)	0.322 (0.254-0.421)	0.418 (0.320-0.580)	0.497 (0.370-0.701)	0.581 (0.415-0.845)	0.670 (0.457-1.01)	0.796 (0.520-1.24)	0.896 (0.567-1.42)
10-min	0.209 (0.167-0.270)	0.270 (0.215-0.350)	0.377 (0.299-0.490)	0.472 (0.372-0.617)	0.612 (0.468-0.850)	0.728 (0.541-1.03)	0.850 (0.608-1.24)	0.981 (0.670-1.48)	1.17 (0.761-1.82)	1.31 (0.830-2.07)
15-min	0.255 (0.203-0.330)	0.329 (0.262-0.427)	0.459 (0.365-0.597)	0.575 (0.454-0.753)	0.746 (0.571-1.04)	0.888 (0.660-1.25)	1.04 (0.742-1.51)	1.20 (0.817-1.80)	1.42 (0.928-2.22)	1.60 (1.01-2.53)
30-min	0.319 (0.254-0.412)	0.406 (0.324-0.526)	0.561 (0.446-0.730)	0.701 (0.553-0.917)	0.910 (0.698-1.27)	1.09 (0.807-1.53)	1.27 (0.910-1.85)	1.47 (1.01-2.22)	1.76 (1.15-2.74)	1.98 (1.26-3.13)
60-min	0.391 (0.312-0.506)	0.488 (0.390-0.633)	0.660 (0.525-0.859)	0.815 (0.643-1.07)	1.05 (0.801-1.45)	1.24 (0.920-1.74)	1.44 (1.03-2.09)	1.66 (1.13-2.50)	1.97 (1.28-3.06)	2.21 (1.40-3.49)
2-hr	0.463 (0.374-0.590)	0.571 (0.461-0.729)	0.760 (0.612-0.974)	0.929 (0.743-1.20)	1.18 (0.915-1.61)	1.39 (1.04-1.93)	1.61 (1.16-2.30)	1.84 (1.27-2.74)	2.17 (1.44-3.34)	2.44 (1.56-3.80)
3-hr	0.522 (0.426-0.660)	0.635 (0.517-0.804)	0.831 (0.674-1.06)	1.00 (0.809-1.28)	1.26 (0.979-1.70)	1.46 (1.11-2.01)	1.68 (1.22-2.38)	1.91 (1.33-2.81)	2.23 (1.48-3.40)	2.49 (1.60-3.85)
6-hr	0.657 (0.543-0.818)	0.780 (0.644-0.972)	0.991 (0.815-1.24)	1.18 (0.960-1.48)	1.45 (1.14-1.92)	1.67 (1.28-2.25)	1.89 (1.39-2.64)	2.14 (1.50-3.09)	2.47 (1.66-3.71)	2.74 (1.78-4.17)
12-hr	0.844 (0.706-1.03)	0.977 (0.817-1.20)	1.21 (1.01-1.49)	1.42 (1.18-1.76)	1.73 (1.39-2.27)	1.99 (1.55-2.65)	2.27 (1.69-3.12)	2.56 (1.82-3.65)	2.97 (2.02-4.40)	3.31 (2.17-4.97)
24-hr	1.06 (0.901-1.28)	1.21 (1.02-1.46)	1.47 (1.24-1.78)	1.71 (1.43-2.08)	2.07 (1.68-2.67)	2.38 (1.87-3.12)	2.71 (2.05-3.67)	3.06 (2.21-4.32)	3.58 (2.46-5.23)	3.99 (2.65-5.91)
2-day	1.29 (1.11-1.53)	1.46 (1.25-1.73)	1.75 (1.50-2.09)	2.02 (1.72-2.43)	2.44 (2.01-3.10)	2.79 (2.23-3.60)	3.17 (2.43-4.23)	3.58 (2.61-4.96)	4.16 (2.89-5.99)	4.64 (3.11-6.77)
3-day	1.44 (1.25-1.69)	1.63 (1.41-1.91)	1.96 (1.69-2.32)	2.27 (1.94-2.69)	2.73 (2.26-3.42)	3.11 (2.50-3.98)	3.52 (2.71-4.65)	3.96 (2.90-5.44)	4.59 (3.21-6.54)	5.09 (3.44-7.37)
4-day	1.56 (1.36-1.82)	1.77 (1.54-2.06)	2.13 (1.85-2.50)	2.46 (2.12-2.90)	2.95 (2.46-3.67)	3.36 (2.71-4.25)	3.79 (2.93-4.97)	4.25 (3.13-5.79)	4.89 (3.44-6.92)	5.41 (3.67-7.78)
7-day	1.88 (1.65-2.16)	2.11 (1.86-2.43)	2.52 (2.21-2.91)	2.88 (2.51-3.35)	3.41 (2.86-4.17)	3.83 (3.13-4.79)	4.29 (3.35-5.54)	4.77 (3.54-6.40)	5.43 (3.85-7.58)	5.96 (4.08-8.47)
10-day	2.15 (1.91-2.45)	2.40 (2.13-2.74)	2.82 (2.50-3.23)	3.20 (2.81-3.69)	3.74 (3.16-4.53)	4.19 (3.44-5.17)	4.65 (3.66-5.95)	5.14 (3.84-6.84)	5.82 (4.15-8.05)	6.36 (4.38-8.96)
20-day	2.91 (2.63-3.26)	3.20 (2.88-3.58)	3.68 (3.30-4.14)	4.10 (3.65-4.65)	4.71 (4.04-5.60)	5.21 (4.33-6.32)	5.72 (4.56-7.19)	6.27 (4.74-8.19)	7.02 (5.05-9.54)	7.61 (5.30-10.6)
30-day	3.58 (3.25-3.96)	3.92 (3.55-4.35)	4.49 (4.06-5.00)	4.98 (4.47-5.59)	5.68 (4.90-6.67)	6.24 (5.23-7.48)	6.81 (5.46-8.46)	7.41 (5.64-9.58)	8.22 (5.96-11.1)	8.86 (6.21-12.2)
45-day	4.46 (4.08-4.89)	4.91 (4.49-5.39)	5.65 (5.15-6.23)	6.27 (5.67-6.96)	7.12 (6.17-8.23)	7.78 (6.56-9.20)	8.44 (6.81-10.3)	9.11 (6.97-11.6)	9.99 (7.28-13.3)	10.7 (7.52-14.5)
60-day	5.24 (4.83-5.70)	5.81 (5.35-6.34)	6.74 (6.18-7.37)	7.49 (6.81-8.25)	8.49 (7.39-9.72)	9.25 (7.83-10.8)	9.99 (8.09-12.1)	10.7 (8.24-13.6)	11.7 (8.54-15.4)	12.4 (8.76-16.7)

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

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

Please refer to NOAA Atlas 14 document for more information.

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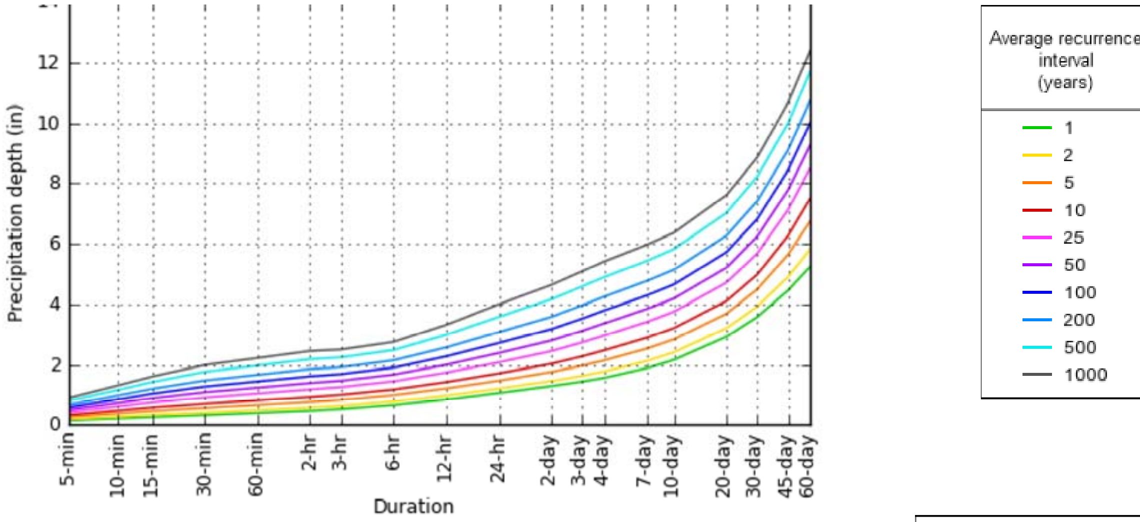
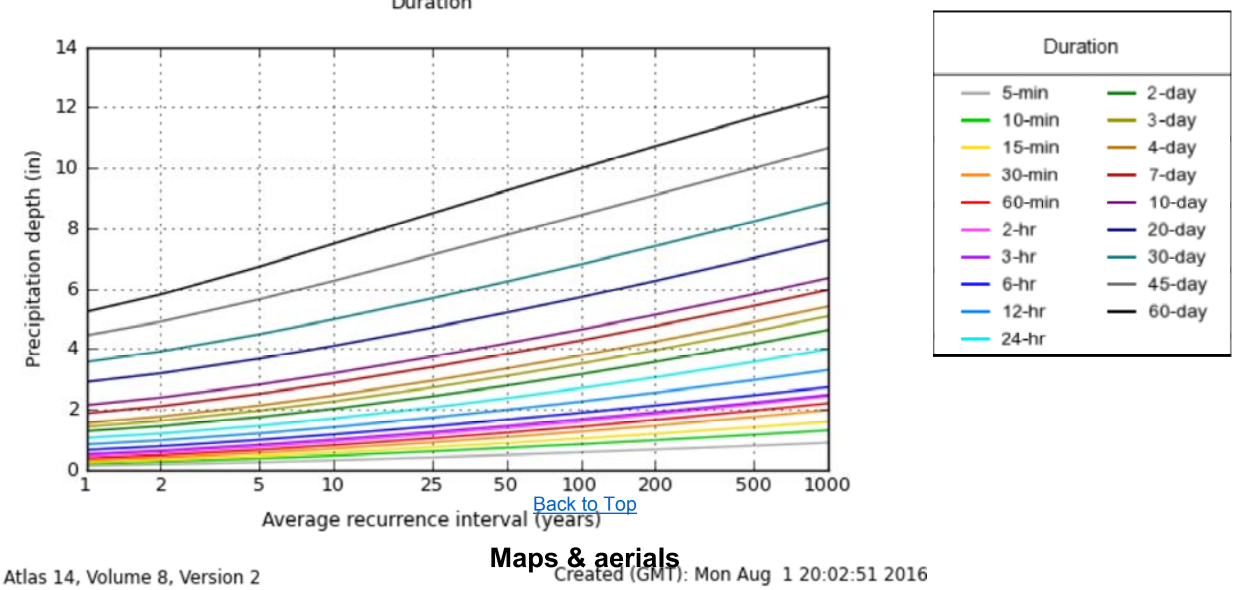
PF graphical





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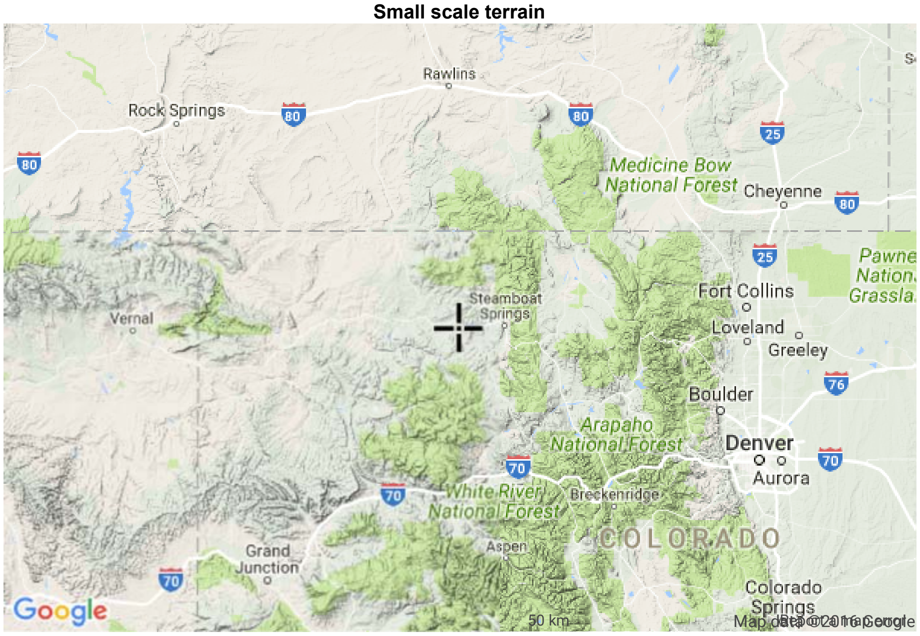
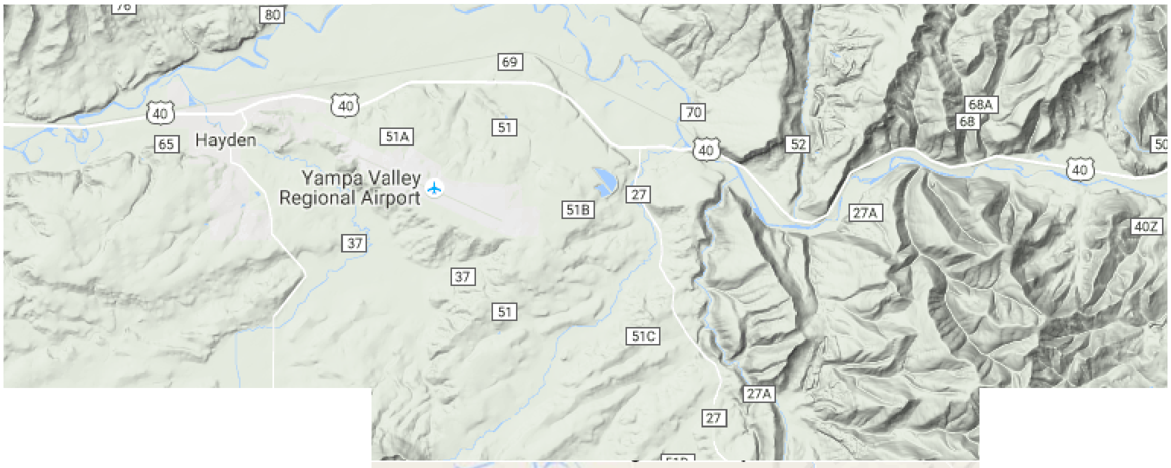
Maps & aerials

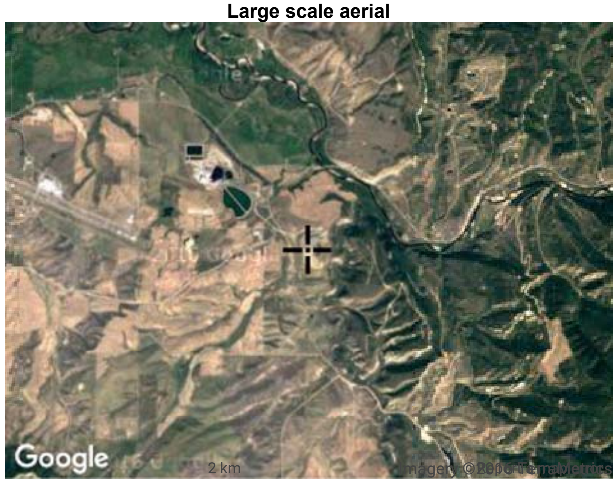
Small scale terrain



Large scale terrain



Large scale aerial



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National Weather Service
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Disclaimer

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 Routt Area, Colorado, Parts of Rio Blanco and Routt Counties

Hayden Station Soil Information

July 12, 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.

Soil Map

Map Scale: 1:6,860 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 100, 200, 400, 600

Feet: 0, 300, 600, 1200, 1800

N

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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: Routt Area, Colorado, Parts of Rio Blanco and Routt Counties
Survey Area Data: Version 6, Sep 22, 2014

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

Date(s) aerial images were photographed: Jun 25, 2010—Sep 6, 2010

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

Routt Area, Colorado, Parts of Rio Blanco and Routt Counties (CO648)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
4E	Yampatika silty clay, 12 to 25 percent slopes	10.2	6.7%
10C	Bulkley silty clay, 3 to 12 percent slopes	63.5	41.8%
10E	Bulkley silty clay, 12 to 25 percent slopes	77.3	50.9%
103	Foidel-Rock outcrop complex, 25 to 65 percent slopes	0.8	0.6%
Totals for Area of Interest		**151.9**	**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.

Routt Area, Colorado, Parts of Rio Blanco and Routt Counties

4E—Yampatika silty clay, 12 to 25 percent slopes

Map Unit Setting

National map unit symbol: k0dz
Elevation: 6,300 to 7,200 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 40 to 44 degrees F
Frost-free period: 80 to 110 days
Farmland classification: Not prime farmland

Map Unit Composition

Yampatika and similar soils: 95 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Yampatika

Setting

Landform: Hills
Landform position (three-dimensional): Head slope, nose slope, side slope, base slope
Down-slope shape: Convex, linear
Across-slope shape: Convex, concave, linear
Parent material: Slope alluvium over residuum weathered from shale

Typical profile

Ap1 - 0 to 4 inches: silty clay
Ap2 - 4 to 10 inches: silty clay
Bw - 10 to 20 inches: very parachannery silty clay
Bky - 20 to 28 inches: parachannery silty clay
Cr - 28 to 32 inches: bedrock

Properties and qualities

Slope: 12 to 25 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 12 percent
Gypsum, maximum in profile: 5 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 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: Claypan (R048BY296CO)

10C—Bulkley silty clay, 3 to 12 percent slopes

Map Unit Setting

National map unit symbol: k0f8
Elevation: 6,200 to 7,200 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 75 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Bulkley

Setting

Landform: Hills
Landform position (three-dimensional): Head slope, nose slope, side slope, base slope, interfluve
Down-slope shape: Linear, convex, concave
Across-slope shape: Linear, concave, convex
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

A - 0 to 4 inches: silty clay
Bss - 4 to 32 inches: silty clay
Bk - 32 to 46 inches: silty clay
Bky - 46 to 60 inches: silty clay

Properties and qualities

Slope: 3 to 12 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 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
Gypsum, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: Claypan (R048BY296CO)

10E—Bulkley silty clay, 12 to 25 percent slopes

Map Unit Setting

National map unit symbol: k0f9
Elevation: 6,200 to 7,200 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 75 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Bulkley

Setting

Landform: Hills
Landform position (three-dimensional): Head slope, nose slope, side slope, base slope, interfluve
Down-slope shape: Linear, concave, convex
Across-slope shape: Linear, convex, concave
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

A - 0 to 4 inches: silty clay
Bkss - 4 to 32 inches: silty clay
Bk - 32 to 46 inches: silty clay
Bky - 46 to 60 inches: silty clay

Properties and qualities

Slope: 12 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 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
Gypsum, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: Claypan (R048BY296CO)

103—Foidel-Rock outcrop complex, 25 to 65 percent slopes

Map Unit Setting

National map unit symbol: k0j5
Elevation: 7,030 to 8,120 feet
Mean annual precipitation: 21 to 27 inches
Mean annual air temperature: 37 to 41 degrees F
Frost-free period: 50 to 80 days
Farmland classification: Not prime farmland

Map Unit Composition

Foidel and similar soils: 70 percent
Rock outcrop: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Foidel

Setting

Landform: Hills
Landform position (three-dimensional): Head slope, nose slope, side slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear, convex, concave
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

A1 - 0 to 5 inches: sandy loam
A2 - 5 to 9 inches: loam
B/E - 9 to 20 inches: clay loam
B/E - 20 to 25 inches: loam
Bt - 25 to 60 inches: clay loam

Properties and qualities

Slope: 25 to 65 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: Brushy Loam (R048AY238CO)

Description of Rock Outcrop

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear, concave
Across-slope shape: Concave, convex

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D

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