Run-on and Run-off Control System Plan

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

Pawnee Station – CCR Landfill
Public Service Company of Colorado
Denver, Colorado

October 17, 2016

Revised October 15, 2021

PREPARED FOR

PAWNEE STATION

14940 Morgan County Road 24,
Brush, Colorado 80723

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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
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HSG	Hydrologic Soil Group
Landfill	Pawnee Landfill
NAIP	National Agricultural Imagery Program
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 CCRs 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 at the Pawnee 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 required that an initial Run-on and Run-off Control System Plan be prepared no later than October 17, 2016 and a revision frequency of 5 years.

This revision of the Run-on and Run-off Control System Plan was prepared to reflect the 5-year update for the landfill per the required frequency.

1.1 Facility Description

The Pawnee Station North CCR landfill is located at the Pawnee Station Power Plant at 14940 Morgan County Road 24, Brush, Colorado, approximately one-half mile southwest of the main power plant building. Pawnee Station is approximately four miles southwest of Brush, Colorado.

Figure 1 provides a Site Location Map.

The landfill began operating in 1981 and has been in use ever since. The footprint of the landfill was excavated for borrow soils for the original construction of the power plant, such that the base elevation is below the surrounding grade. The total area of the original excavation is approximately 48 acres. The northern portion is the CCR landfill, which includes an evaporation pond and an earthen dike separating the CCR landfill from the southern portion of the excavated footprint. The southern portion, known as the South Landfill, was historically used for disposal of lime sludge generated from the treatment of raw water for use in the plant. Approximately 150,000 tons of fly ash and 20,000 tons of bottom ash are generated annually and disposed at the North Landfill.

An evaporation pond is located on the southern end of the North CCR landfill. The pond is lined with a geosynthetic clay liner. Stormwater falling on the North CCR landfill flows to the evaporation pond. Stormwater falling on the South Landfill is directed north to the earthen dike. The dike is designed as a porous dike and is intended to pass water from the South Landfill to the evaporation pond.

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. Pawnee Power Station Facility 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."* The North Landfill currently receives CCR waste and is considered active.

The evaluation included preparation of a surface water run-off model using HydroCAD® 10.10-6a to determine whether existing run-on and run-off control systems meet the required criteria for controlling run-on and run-off from the 24-hour, 25 year storm event. The evaluation was completed using the best available information at the time and was based on an aerial drone topographic survey completed on August 25, 2021.

2.1 Description of CCR Landfill and Drainage Area

Based on the survey data, the landfill active area is approximately 15.7 acres. The evaporation pond is approximately 2.1 acres in size. The porous dike separating the CCR landfill from the lime sludge landfill is approximately 1.0 acres. The South non-CCR Landfill is approximately 18.9 acres.

The North CCR landfill active area was divided into 2 drainage areas for the purpose of this analysis. The sideslopes of the landfill are covered with six inches of soil as intermediate cover. Stormwater runoff that hits the side slopes is directed by terraces and ditches around the perimeter of the landfill to a low-lying area east of the landfill. This area is considered the 'Non-Contact' stormwater drainage area and is approximately 9.0 acres.

The top deck portion of the landfill, where CCR waste is placed in lifts, is surrounded by a minor berm that directs the stormwater runoff to the southwest corner of the landfill where it follows a swale to the evaporation pond. This area, along with the sideslope portions of the landfill not captured by terraces, is considered the 'Contact' stormwater drainage area and is approximately 8.9 acres.

The run-off from the South non-CCR Landfill and surrounding areas to the south of the North CCR Landfill also contributes to the evaporation pond. The porous dike allows stormwater collected in the south landfill to travel to the evaporation pond. The 'South' drainage area is estimated to be 31.2 acres total.

The North CCR landfill active area and the South non-CCR landfill and respective drainage areas are shown on **Figure 2**.

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

2.2.1 Run-on Controls

The North CCR landfill is bounded on the east and west sides by a perimeter berm, natural topography on the northern end and the earthen dike on the southern end to limit stormwater run-on/run-off to the landfill.

2.2.2 Run-off Controls

An evaporation pond is located on the southern end of the North CCR landfill. The landfill is graded to direct contact stormwater to the evaporation pond and non-contact stormwater to the low-lying area east of the landfill.

2.3 Surface Water Run-off Model

A surface water run-off model was prepared using HydroCAD® 10.10-6a, which utilizes parameters developed following the Soil Conservation Service (SCS) Technical Release 55 (TR-55) for computing curve numbers and times of concentration in order to generate runoff hydrographs. The model results are included as **Appendix A**. A detailed discussion of the information input 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 input into the model included the 2-year and 25-year, 24 hour storm events. The 24-hour precipitation amounts are summarized in **Table 1**, 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	1.88
25-year	3.37

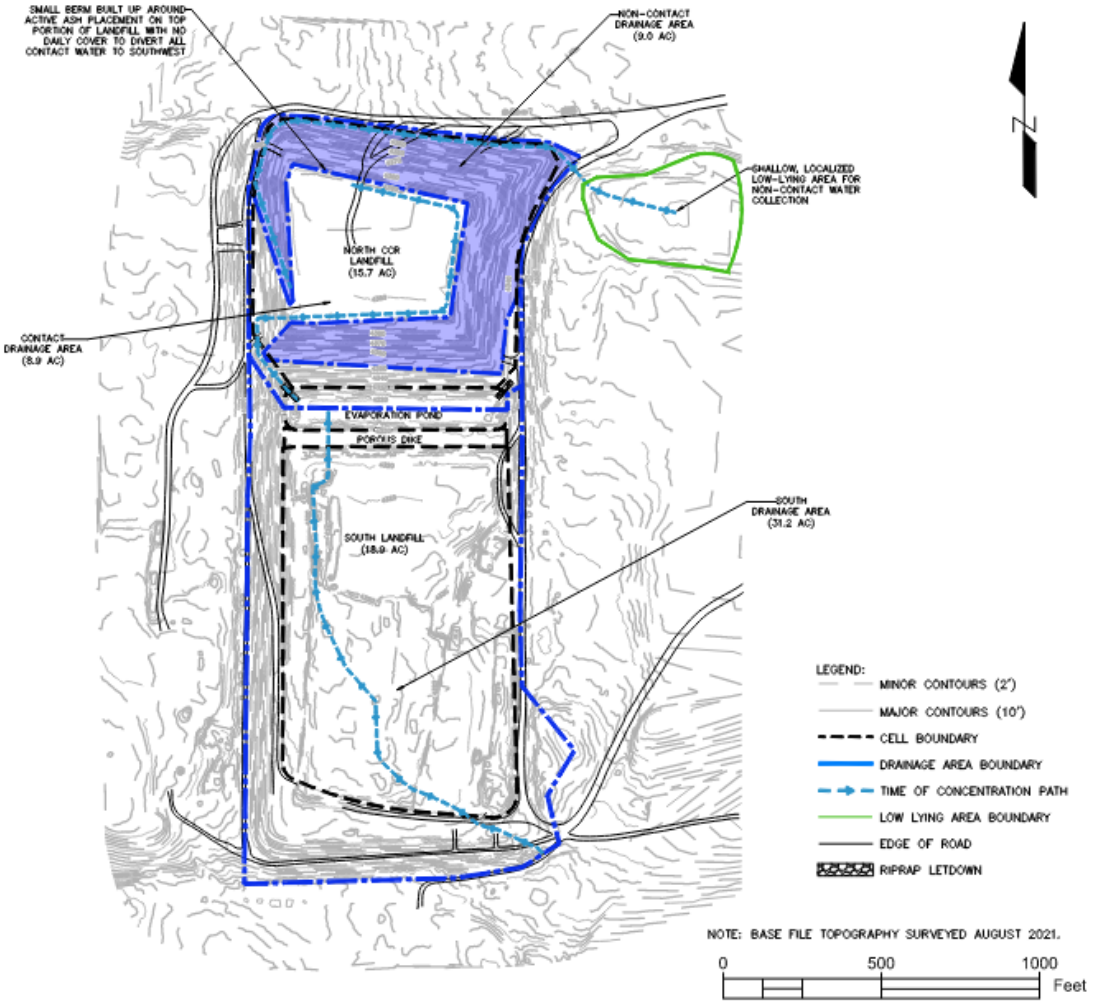


Figure 2. Stormwater Drainage Map

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 area. The North CCR landfill was delineated into two drainage areas and the South non-CCR landfill represents an additional single drainage 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 Valent sand, 3 to 9 percent slopes (VcD). This soil type is in HSG A. A soil report for the native soils is included in **Appendix C**. All ground cover for HSG A was modeled as bare soil, except for a small portion of the south drainage area which was modeled as an open grass area with less than 50 percent cover. The ash itself was assumed to be of HSG D due to its low infiltration properties.

A summary of the breakdown used to calculate the weighted CN is provided in **Table 2** and **Table 3**.

Table 2. Summary of North Contact Area Breakdown

Cover Type	HSG	Area (Acres)	Curve Number
Fallow, Bare Soil (Intermediate Cover)	A	3.5	77
Fallow Bare Soil (Ash)	D	5.4	98
Weighted CN			**87**

Table 3 Summary of North Non-Contact Area Breakdown

Cover Type	HSG	Area (Acres)	Curve Number
Fallow, Bare Soil (Intermediate Cover)	A	9.0	77
Weighted CN			**77**

Table 4. Summary of South Area Breakdown

Cover Type	HSG	Area (Acres)	Curve Number
Fallow, Bare Soil	A	27.8	77
Grass, <50% Cover, Poor	A	3.4	68
Weighted CN			**76**

2.3.3 Time of Concentration

The time of concentration is defined as the time required for runoff 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 runoff from the active landfill area is shown on **Figure 2**.

2.3.4 Evaporation Pond

The evaporation pond was modeled as a detention basin with no outlet. The volume lost due to evaporation during the modeled storm event was assumed to be negligible. An elevation-area relationship was developed for the pond using 1-foot contours generated from a photometric topographical survey from December 12, 2014 with portions updated August 13, 2015. The initial pond elevation was assumed to be 4,315.3' based on 2015 NAIP aerial imagery for Morgan County, Colorado. The current elevation of the water in the pond is approximately 4320' based

on the latest drone survey. The available storage capacity of the pond was computed using the current water level as the base.

2.3.5 Low Lying Area

The low-lying area to the east of the North CCR landfill that receives run-off from this area was modeled as a detention basin with exfiltration. Exfiltration rates were calculated based on the conductivity of the native soils taken from the Soil Conservation District Web Soil Report (**Appendix C**). According to the report, the native soil has a representative capacity to transmit water (saturated hydraulic conductivity) of 30.0 inch/hour. This value was used to model the exfiltration rate in the model outlet.

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

To comply with 40 Part 257.81, the existing contact pond must be sufficient size to collect and control runoff resulting from the 25 year, 24-hour storm event. The model was run to evaluate whether the evaporation pond was sufficient size to contain the design storm event.

Based on the model results, the existing evaporation pond is sufficiently sized to prevent discharge of contact stormwater run-off from the landfill during the 25 year, 24-hour storm event. The model estimated a peak run-off volume of 44.08 cubic feet per second (cfs) during the storm event, including run-off from both the North CCR landfill drainage area and South non-CCR landfill drainage area. The maximum storage required in this event would be 4.28 acre-ft with a peak elevation of 4323.8’. It was assumed that the stormwater from the South landfill drainage area would transfer instantaneously through the porous dike to the evaporation pond, so this model reflects the worst-case scenario. The 25-year, 24-hour storm event will cause the water level in the evaporation pond to increase by approximately 3.8’ and leaves 4.38 acre-ft of storage remaining. The elevation of the porous dike, or maximum allowable water level in the evaporation pond, is approximately 4330.8’. Based on this model, there is sufficient freeboard to contain the design storm event.

The non-contact stormwater run-off from the North CCR landfill is directed to the low-lying area to the east where it collects and infiltrates. The runoff area was modeled to have a maximum runoff flow of 18.47 cfs. The low-lying area was modeled as a 6-foot-deep stormwater basin with an area of approximately 3.24 acres with a top elevation of 4316’ and bottom of 4310’. Exfiltration was modeled as the primary outflow with a maximum discharge of 8.76 cfs. During the 25-year, 24-hour storm even the maximum basin height reached was 4310.14’ or 0.91 acre-ft of storage required, which leaves over 5.8’ of freeboard and 89% of storage available.

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 Pawnee North 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.

3.0 Professional Engineer Certification

Pawnee Station CCR Unit 2021 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.

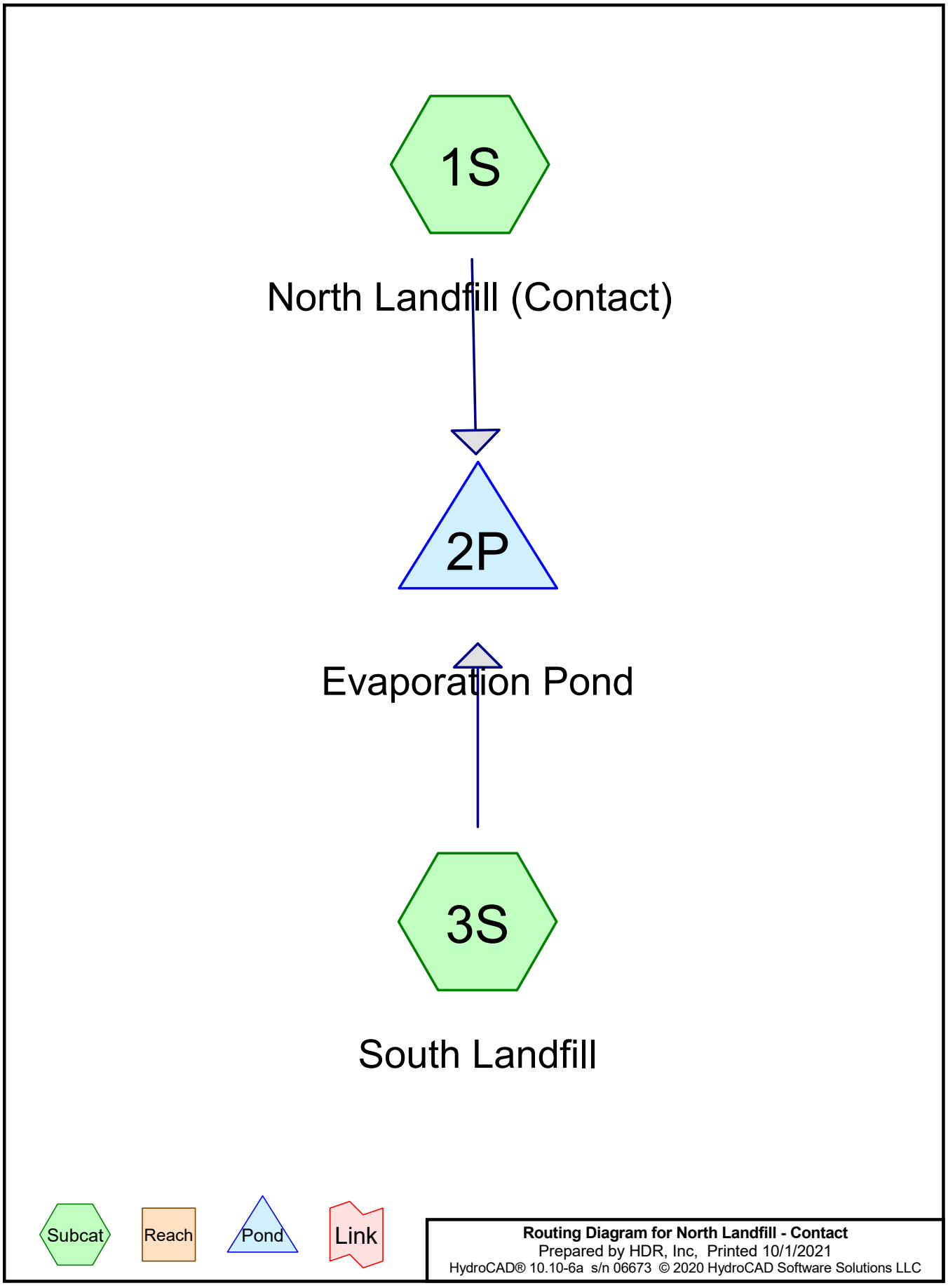
This Plan is valid only to the extent that the facility owner or operator maintains existing run-on and run-off controls described in this Plan to prevent flow onto the active portion and prevent surface discharges of CCR in solution or suspension.

SIGNATURE:

Brent Learch, PE Colorado PE 0056841

DATE: October 15, 2021

APPENDIX A – HydroCAD® MODEL RESULTS


1S
North Landfill (Contact)
2P
Evaporation Pond
3S
South Landfill
Subcat
Reach
Pond
Link
Routing Diagram for North Landfill - Contact
Prepared by HDR, Inc, Printed 10/1/2021
HydroCAD® 10.10-6a s/n 06673 © 2020 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
3.400	68	<50% Grass cover, Poor, HSG A (3S)
31.300	77	Fallow, bare soil, HSG A (1S, 3S)
5.400	94	Fallow, bare soil, HSG D (1S)
40.100	**79**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
34.700	HSG A	1S, 3S
0.000	HSG B	
0.000	HSG C	
5.400	HSG D	1S
0.000	Other	
40.100		**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
3.400	0.000	0.000	0.000	0.000	3.400	<50% Grass cover, Poor	3S
31.300	0.000	0.000	5.400	0.000	36.700	Fallow, bare soil	1S, 3S
34.700	**0.000**	**0.000**	**5.400**	**0.000**	**40.100**	**TOTAL AREA**	

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

Subcatchment 1S: North Landfill (Contact) Runoff Area=8.900 ac 0.00% Impervious Runoff Depth>1.91"
Flow Length=1,475' Tc=27.4 min CN=87 Runoff=16.89 cfs 1.414 af

Subcatchment 3S: South Landfill Runoff Area=31.200 ac 0.00% Impervious Runoff Depth>1.14"
Flow Length=3,041' Tc=36.1 min CN=76 Runoff=28.97 cfs 2.965 af

Pond 2P: Evaporation Pond Peak Elev=4,323.80' Storage=4.376 af Inflow=44.08 cfs 4.379 af
Outflow=0.00 cfs 0.000 af

Total Runoff Area = 40.100 ac Runoff Volume = 4.379 af Average Runoff Depth = 1.31"
100.00% Pervious = 40.100 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: North Landfill (Contact)

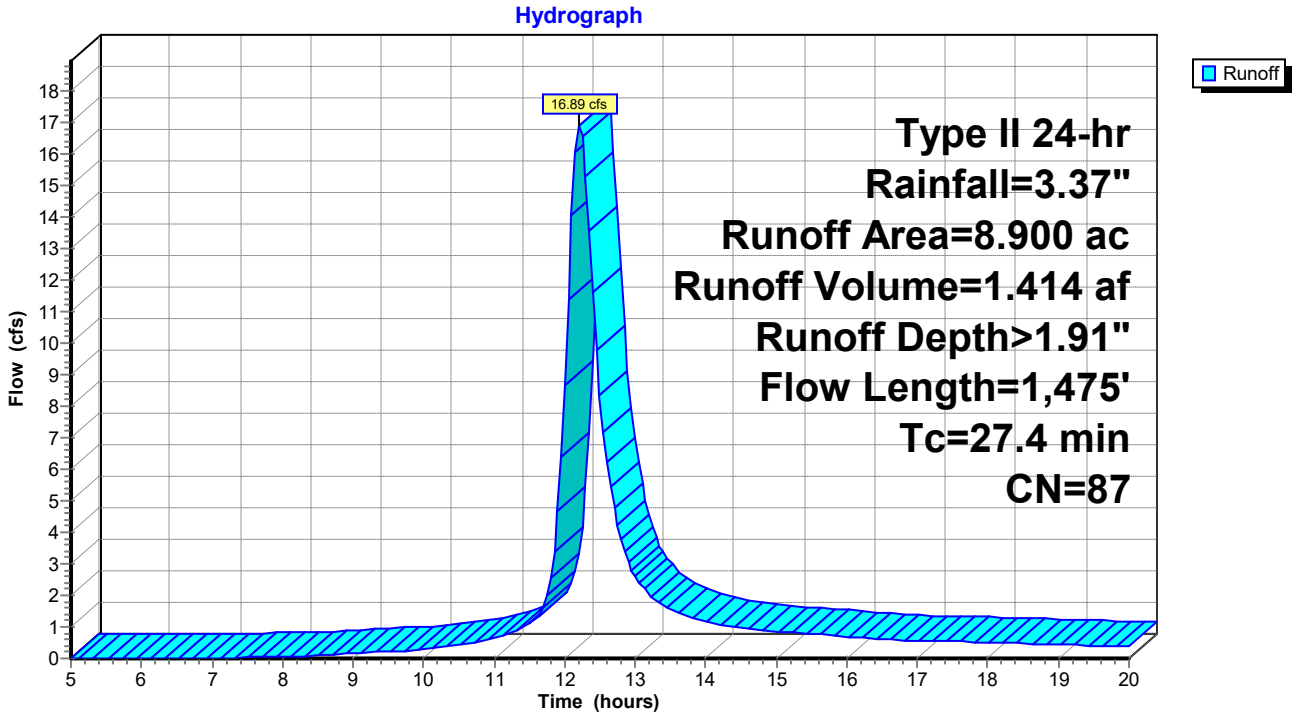
Runoff = 16.89 cfs @ 12.21 hrs, Volume= 1.414 af, Depth> 1.91"
Routed to Pond 2P : Evaporation Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=3.37"

Area (ac)	CN	Description
3.500	77	Fallow, bare soil, HSG A
5.400	94	Fallow, bare soil, HSG D
8.900	87	Weighted Average
8.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.9	100	0.0011	0.10		**Sheet Flow, Sheet Flow** Fallow n= 0.050 P2= 1.88"
10.1	1,063	0.0310	1.76		**Shallow Concentrated Flow, Shallow Concentrated Flow** Nearly Bare & Untilled Kv= 10.0 fps
0.3	242	0.0240	14.19	425.67	**Channel Flow, Swale** Area= 30.0 sf Perim= 19.0' r= 1.58' n= 0.022 Earth, clean & straight
0.1	70	0.1520	13.68	342.04	**Channel Flow, RipRap** Area= 25.0 sf Perim= 10.0' r= 2.50' n= 0.078 Riprap, 12-inch
27.4	1,475	Total			

Subcatchment 1S: North Landfill (Contact)



Summary for Subcatchment 3S: South Landfill

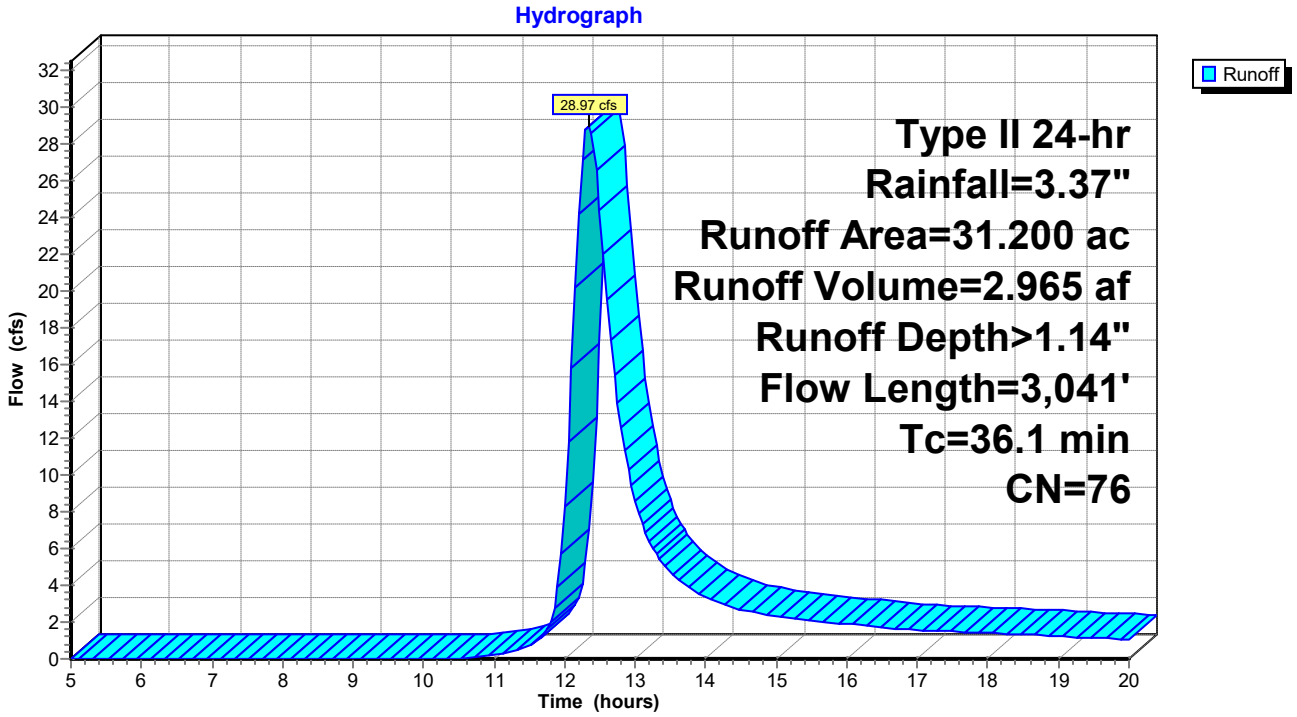
Runoff = 28.97 cfs @ 12.34 hrs, Volume= 2.965 af, Depth> 1.14"
Routed to Pond 2P : Evaporation Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=3.37"

Area (ac)	CN	Description
27.800	77	Fallow, bare soil, HSG A
3.400	68	<50% Grass cover, Poor, HSG A
31.200	76	Weighted Average
31.200		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	100	0.0799	0.55		**Sheet Flow, Sheet Flow** Fallow n= 0.050 P2= 1.88"
33.0	2,941	0.0220	1.48		**Shallow Concentrated Flow, Shallow Concentrated Flow** Nearly Bare & Untilled Kv= 10.0 fps
36.1	3,041	Total			

Subcatchment 3S: South Landfill



Summary for Pond 2P: Evaporation Pond

Inflow Area = 40.100 ac, 0.00% Impervious, Inflow Depth > 1.31"
Inflow = 44.08 cfs @ 12.28 hrs, Volume= 4.379 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

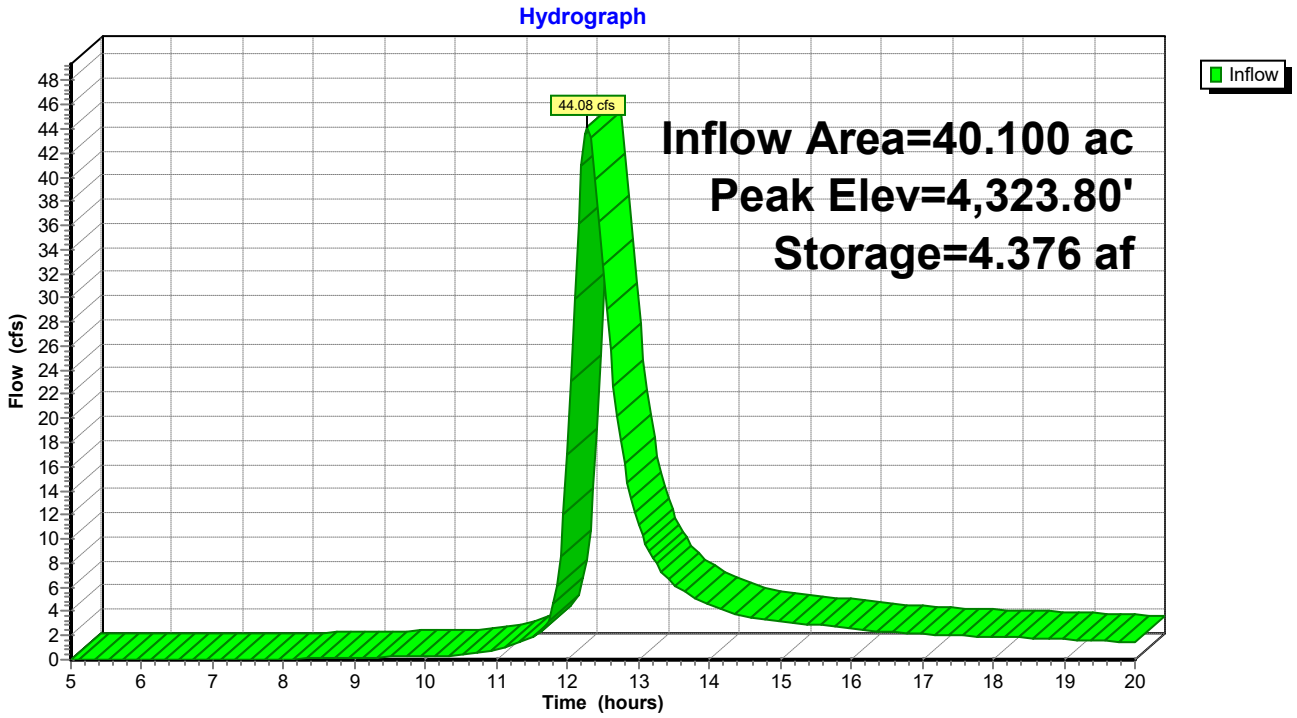
Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 4,323.80' @ 20.00 hrs Storage= 4.376 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

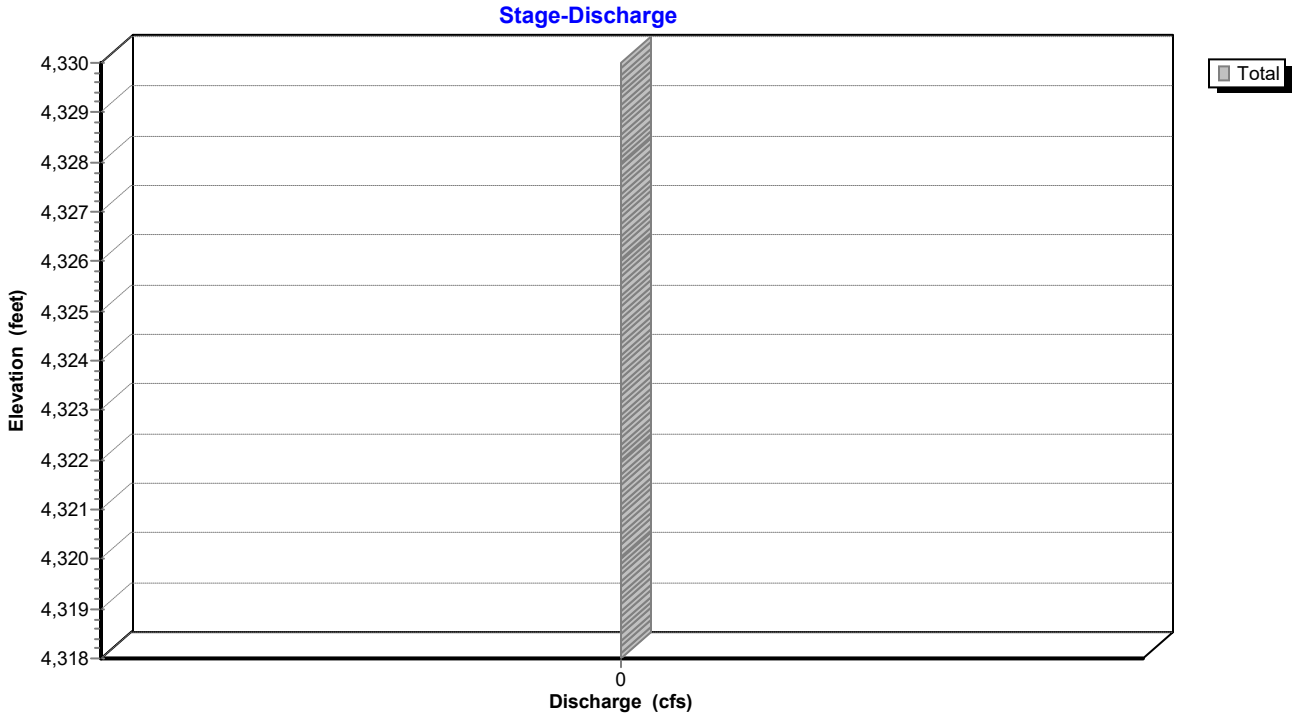
Volume	Invert	Avail.Storage	Storage Description
#1	4,318.00'	9.660 af	**Custom Stage Data** Listed below

Elevation (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
4,318.00	0.000	0.000
4,320.00	0.957	0.957
4,322.00	0.949	1.906
4,324.00	2.742	4.648
4,326.00	3.246	7.894
4,328.00	1.746	9.640
4,330.00	0.020	9.660

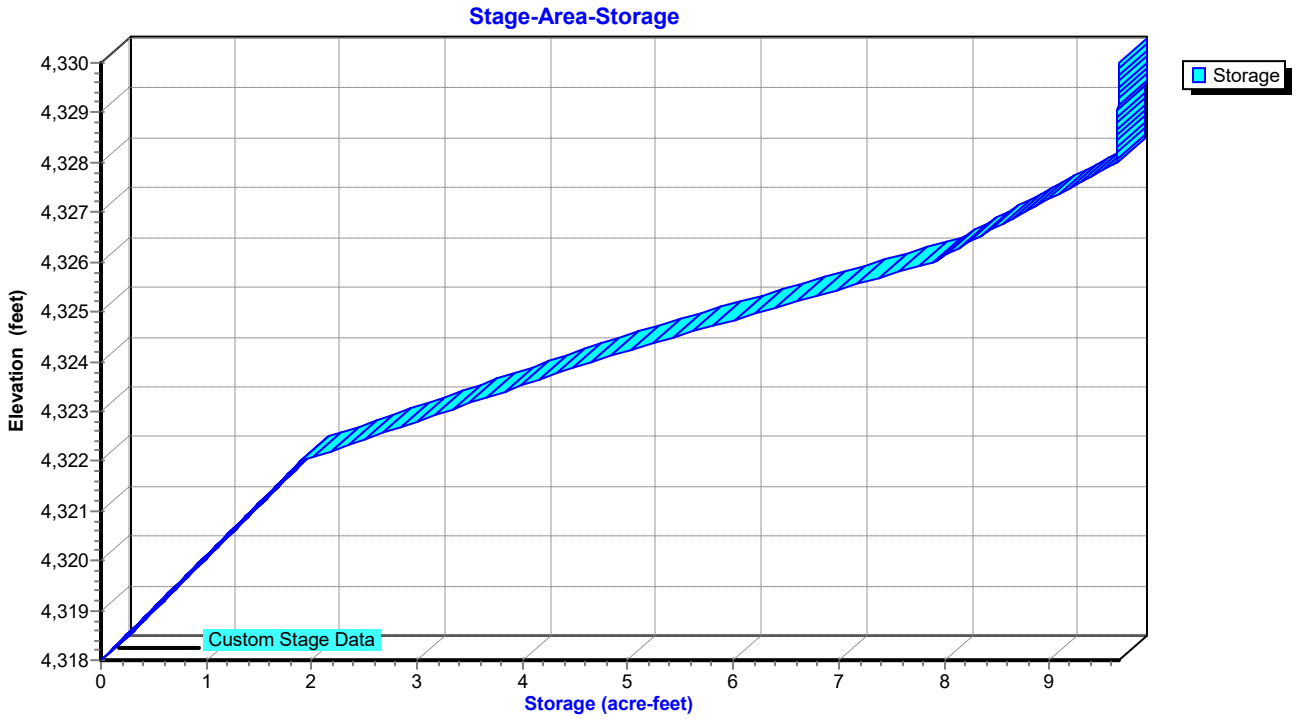
Pond 2P: Evaporation Pond

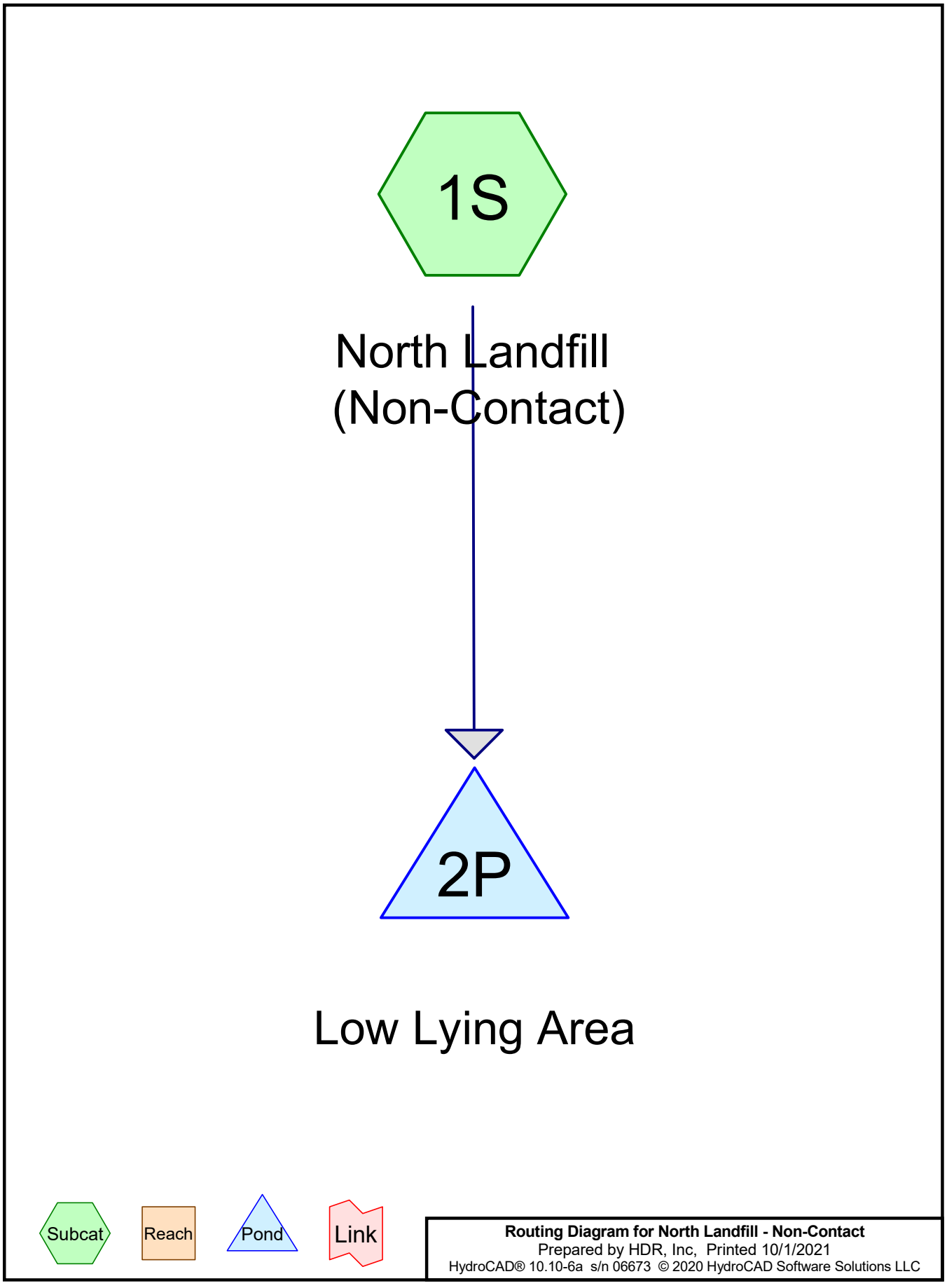


Pond 2P: Evaporation Pond



Pond 2P: Evaporation Pond





Routing Diagram for North Landfill - Non-Contact
Prepared by HDR, Inc, Printed 10/1/2021

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
9.010	77	Fallow, bare soil, HSG A (1S)
9.010	**77**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
9.010	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
9.010		**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
9.010	0.000	0.000	0.000	0.000	9.010	Fallow, bare soil	1S
9.010	**0.000**	**0.000**	**0.000**	**0.000**	**9.010**	**TOTAL AREA**	

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

Subcatchment 1S: North Landfill Runoff Area=9.010 ac 0.00% Impervious Runoff Depth>1.21"
Flow Length=2,254' Tc=9.5 min CN=77 Runoff=18.47 cfs 0.911 af

Pond 2P: Low Lying Area Peak Elev=4,310.23' Storage=0.197 af Inflow=18.47 cfs 0.911 af
Outflow=8.76 cfs 0.908 af

Total Runoff Area = 9.010 ac Runoff Volume = 0.911 af Average Runoff Depth = 1.21"
100.00% Pervious = 9.010 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: North Landfill (Non-Contact)

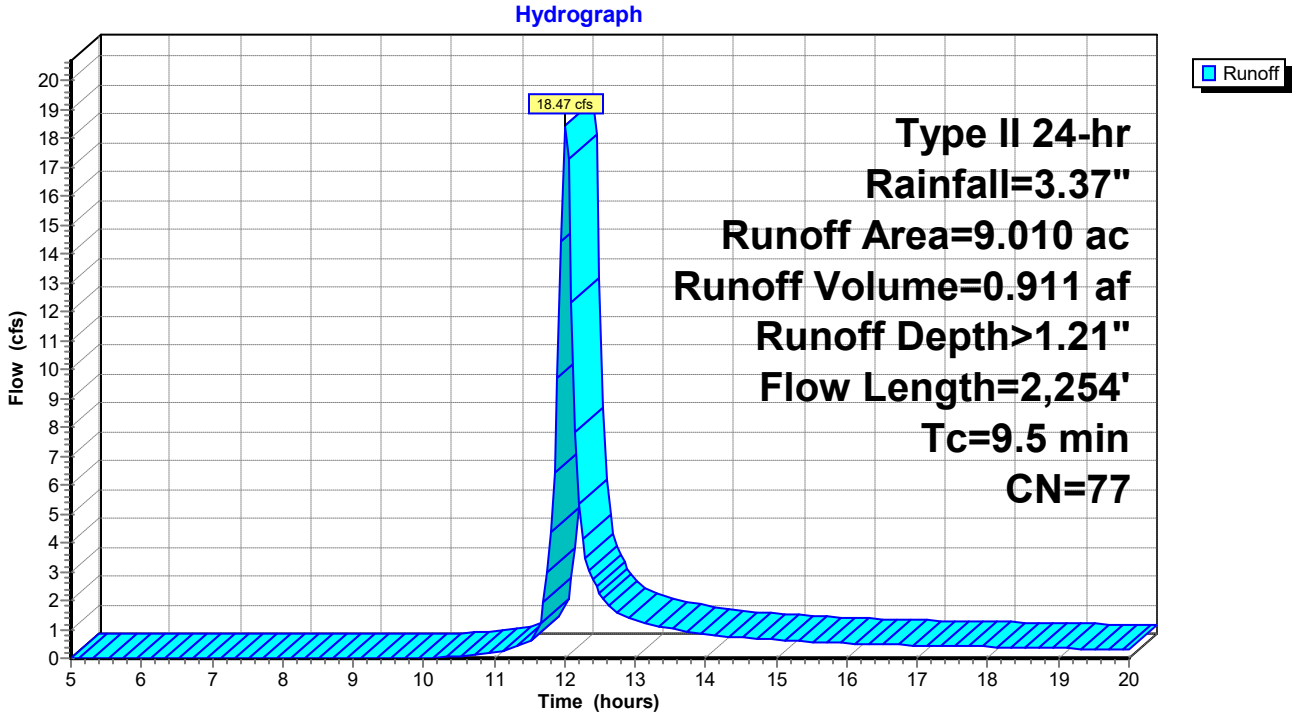
Runoff = 18.47 cfs @ 12.01 hrs, Volume= 0.911 af, Depth> 1.21"
Routed to Pond 2P : Low Lying Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=3.37"

Area (ac)	CN	Description
9.010	77	Fallow, bare soil, HSG A
9.010		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	100	0.0920	0.58		**Sheet Flow, Sheet Flow** Fallow n= 0.050 P2= 1.88"
1.7	250	0.0630	2.51		**Shallow Concentrated Flow, Shallow Concentrated Flow** Nearly Bare & Untilled Kv= 10.0 fps
1.6	1,525	0.0370	15.98	479.31	**Channel Flow, Swale** Area= 30.0 sf Perim= 22.0' r= 1.36' n= 0.022 Earth, clean & straight
3.3	379	0.0360	1.90		**Shallow Concentrated Flow, Shallow Concentrated Flow Land to L** Nearly Bare & Untilled Kv= 10.0 fps
9.5	2,254	Total			

Subcatchment 1S: North Landfill (Non-Contact)



Summary for Pond 2P: Low Lying Area

Inflow Area = 9.010 ac, 0.00% Impervious, Inflow Depth > 1.21"
Inflow = 18.47 cfs @ 12.01 hrs, Volume= 0.911 af
Outflow = 8.76 cfs @ 12.15 hrs, Volume= 0.908 af, Atten= 53%, Lag= 7.8 min
Primary = 8.76 cfs @ 12.15 hrs, Volume= 0.908 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 4,310.23' @ 12.15 hrs Surf.Area= 0.289 ac Storage= 0.197 af

Plug-Flow detention time= 10.3 min calculated for 0.905 af (99% of inflow)
Center-of-Mass det. time= 8.9 min (811.2 - 802.3)

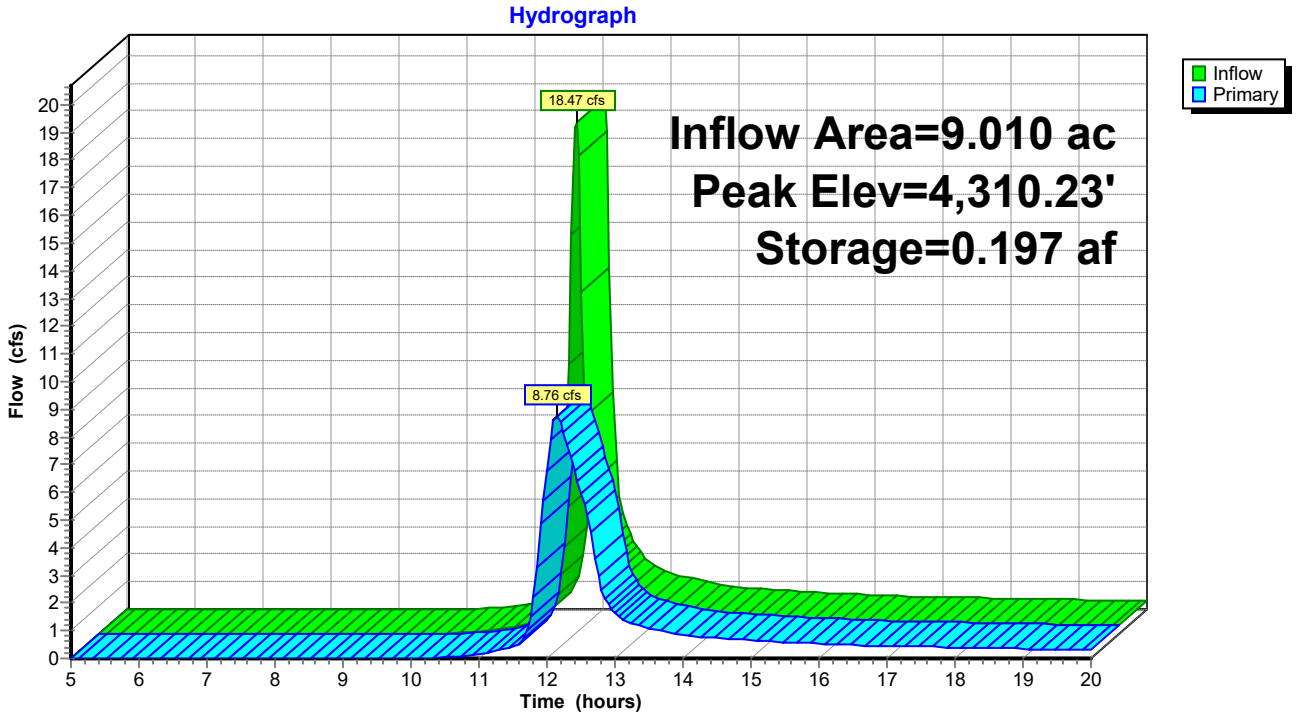
Volume	Invert	Avail.Storage	Storage Description
#1	4,310.00'	8.345 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
4,310.00	0.120	0.000	0.000
4,312.00	1.617	1.737	1.737
4,314.00	2.406	4.023	5.760
4,316.00	0.179	2.585	8.345

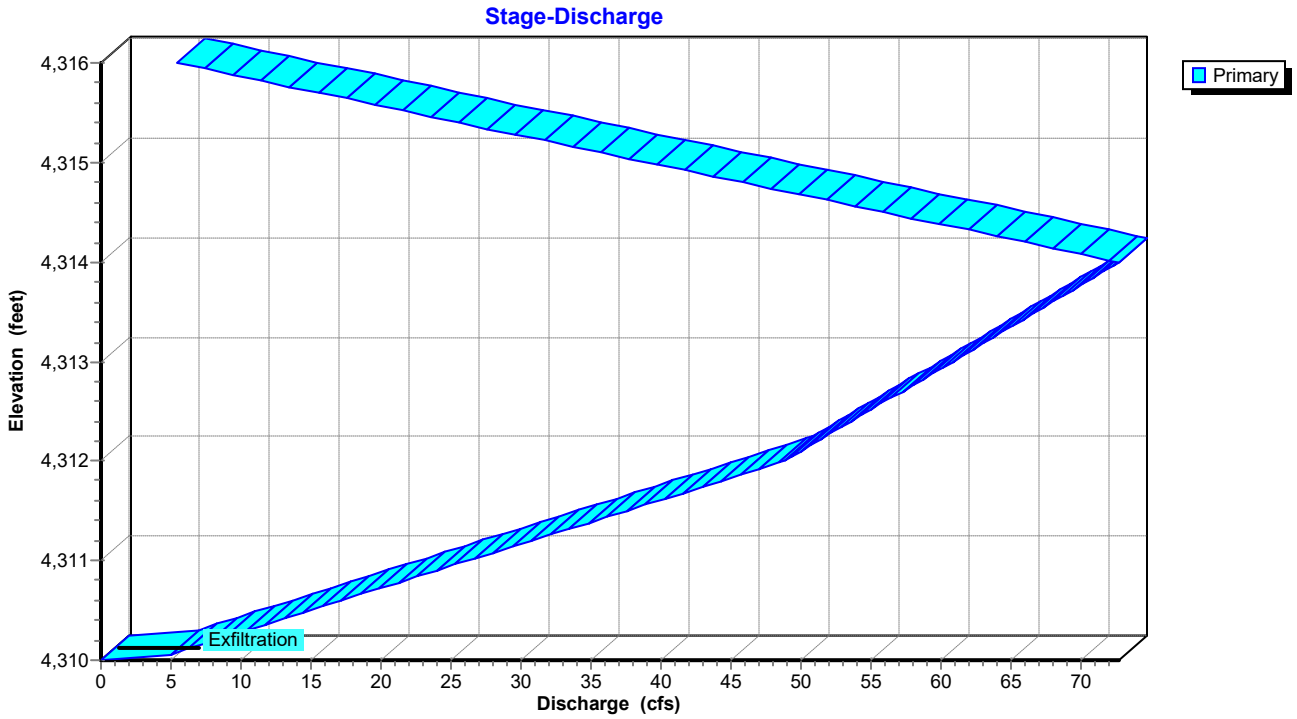
Device	Routing	Invert	Outlet Devices
#1	Primary	4,310.00'	**30.000 in/hr Exfiltration over Surface area**

Primary OutFlow Max=8.74 cfs @ 12.15 hrs HW=4,310.23' (Free Discharge)
1=Exfiltration (Exfiltration Controls 8.74 cfs)

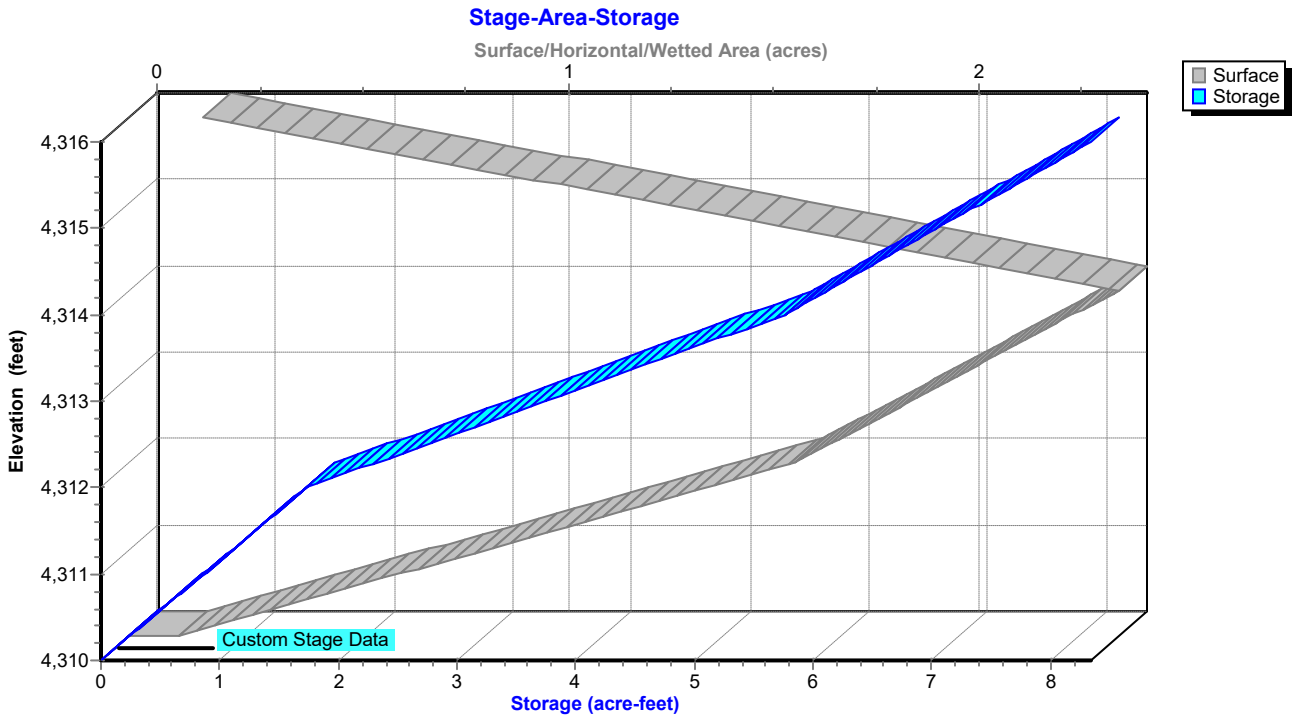
Pond 2P: Low Lying Area



Pond 2P: Low Lying Area



Pond 2P: Low Lying Area



APPENDIX B – NOAA RAINFALL DATA

NOAA Atlas 14, Volume 8, Version 2
Location name: Fort Morgan, Colorado, USA*
Latitude: 40.2115°, Longitude: -103.6842°
Elevation: 4353.58 ft**
* source: ESRI Maps
** source: USGS

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	**0.276** (0.219-0.357)	**0.336** (0.266-0.435)	**0.443** (0.350-0.575)	**0.541** (0.424-0.705)	**0.689** (0.527-0.944)	**0.813** (0.604-1.13)	**0.947** (0.677-1.34)	**1.09** (0.747-1.59)	**1.30** (0.851-1.94)	**1.46** (0.930-2.20)
10-min	**0.404** (0.321-0.523)	**0.492** (0.390-0.636)	**0.649** (0.512-0.842)	**0.792** (0.621-1.03)	**1.01** (0.771-1.38)	**1.19** (0.884-1.65)	**1.39** (0.992-1.96)	**1.60** (1.09-2.32)	**1.90** (1.25-2.83)	**2.14** (1.36-3.22)
15-min	**0.493** (0.391-0.637)	**0.600** (0.475-0.776)	**0.792** (0.624-1.03)	**0.966** (0.758-1.26)	**1.23** (0.940-1.69)	**1.45** (1.08-2.01)	**1.69** (1.21-2.39)	**1.95** (1.33-2.83)	**2.32** (1.52-3.46)	**2.61** (1.66-3.93)
30-min	**0.666** (0.528-0.861)	**0.808** (0.640-1.05)	**1.07** (0.840-1.38)	**1.30** (1.02-1.69)	**1.66** (1.27-2.28)	**1.96** (1.46-2.71)	**2.29** (1.64-3.24)	**2.64** (1.81-3.84)	**3.14** (2.06-4.69)	**3.55** (2.26-5.34)
60-min	**0.815** (0.646-1.05)	**0.991** (0.785-1.28)	**1.31** (1.03-1.70)	**1.60** (1.25-2.09)	**2.04** (1.56-2.81)	**2.42** (1.80-3.35)	**2.82** (2.02-4.00)	**3.26** (2.23-4.74)	**3.89** (2.55-5.80)	**4.39** (2.79-6.60)
2-hr	**0.964** (0.773-1.23)	**1.17** (0.941-1.50)	**1.55** (1.24-1.99)	**1.90** (1.51-2.44)	**2.43** (1.88-3.29)	**2.88** (2.17-3.93)	**3.36** (2.44-4.69)	**3.88** (2.69-5.56)	**4.63** (3.08-6.81)	**5.23** (3.37-7.75)
3-hr	**1.04** (0.840-1.31)	**1.26** (1.02-1.60)	**1.67** (1.35-2.12)	**2.05** (1.64-2.60)	**2.61** (2.04-3.50)	**3.09** (2.34-4.17)	**3.60** (2.63-4.98)	**4.15** (2.91-5.90)	**4.95** (3.32-7.21)	**5.59** (3.63-8.20)
6-hr	**1.19** (0.972-1.48)	**1.44** (1.17-1.79)	**1.88** (1.53-2.35)	**2.28** (1.85-2.86)	**2.89** (2.28-3.80)	**3.39** (2.61-4.51)	**3.94** (2.92-5.36)	**4.52** (3.21-6.32)	**5.35** (3.65-7.68)	**6.02** (3.98-8.71)
12-hr	**1.38** (1.14-1.69)	**1.65** (1.36-2.02)	**2.12** (1.74-2.60)	**2.53** (2.08-3.13)	**3.15** (2.51-4.07)	**3.66** (2.84-4.77)	**4.19** (3.15-5.61)	**4.77** (3.43-6.54)	**5.57** (3.85-7.85)	**6.21** (4.16-8.84)
24-hr	**1.62** (1.36-1.96)	**1.88** (1.58-2.27)	**2.34** (1.96-2.84)	**2.76** (2.29-3.35)	**3.37** (2.73-4.29)	**3.89** (3.07-5.00)	**4.44** (3.38-5.85)	**5.03** (3.67-6.80)	**5.86** (4.12-8.14)	**6.54** (4.45-9.16)
2-day	**1.88** (1.60-2.24)	**2.15** (1.82-2.55)	**2.61** (2.21-3.12)	**3.03** (2.55-3.63)	**3.66** (3.00-4.57)	**4.18** (3.34-5.28)	**4.73** (3.65-6.12)	**5.32** (3.95-7.08)	**6.16** (4.39-8.41)	**6.83** (4.73-9.41)
3-day	**2.06** (1.77-2.43)	**2.33** (1.99-2.74)	**2.80** (2.38-3.30)	**3.22** (2.72-3.82)	**3.84** (3.18-4.75)	**4.36** (3.52-5.46)	**4.92** (3.83-6.31)	**5.52** (4.13-7.26)	**6.36** (4.58-8.60)	**7.04** (4.92-9.61)
4-day	**2.21** (1.90-2.58)	**2.48** (2.13-2.90)	**2.95** (2.53-3.46)	**3.38** (2.88-3.98)	**4.01** (3.33-4.92)	**4.53** (3.67-5.63)	**5.09** (3.99-6.47)	**5.68** (4.28-7.43)	**6.52** (4.72-8.76)	**7.19** (5.06-9.76)
7-day	**2.51** (2.19-2.90)	**2.83** (2.46-3.27)	**3.37** (2.92-3.90)	**3.83** (3.30-4.46)	**4.50** (3.76-5.42)	**5.03** (4.12-6.14)	**5.58** (4.42-6.98)	**6.16** (4.69-7.92)	**6.96** (5.10-9.19)	**7.58** (5.41-10.1)
10-day	**2.79** (2.44-3.19)	**3.15** (2.76-3.61)	**3.75** (3.27-4.31)	**4.26** (3.70-4.92)	**4.97** (4.18-5.92)	**5.53** (4.55-6.67)	**6.09** (4.85-7.53)	**6.67** (5.11-8.48)	**7.45** (5.50-9.74)	**8.05** (5.79-10.7)
20-day	**3.64** (3.23-4.10)	**4.11** (3.65-4.64)	**4.88** (4.31-5.52)	**5.51** (4.85-6.26)	**6.37** (5.42-7.43)	**7.03** (5.85-8.32)	**7.68** (6.20-9.31)	**8.33** (6.47-10.4)	**9.18** (6.87-11.8)	**9.82** (7.18-12.8)
30-day	**4.36** (3.90-4.87)	**4.93** (4.41-5.50)	**5.84** (5.20-6.53)	**6.57** (5.83-7.39)	**7.56** (6.48-8.71)	**8.30** (6.97-9.71)	**9.02** (7.34-10.8)	**9.74** (7.62-12.0)	**10.7** (8.05-13.5)	**11.3** (8.37-14.6)
45-day	**5.28** (4.76-5.83)	**5.97** (5.38-6.60)	**7.06** (6.34-7.83)	**7.93** (7.09-8.83)	**9.07** (7.83-10.3)	**9.91** (8.38-11.5)	**10.7** (8.78-12.7)	**11.5** (9.06-14.0)	**12.4** (9.48-15.6)	**13.1** (9.79-16.8)
60-day	**6.06** (5.49-6.64)	**6.86** (6.22-7.54)	**8.12** (7.33-8.94)	**9.10** (8.18-10.1)	**10.4** (8.98-11.7)	**11.3** (9.59-12.9)	**12.1** (10.00-14.2)	**12.9** (10.3-15.6)	**13.9** (10.6-17.2)	**14.6** (10.9-18.5)

[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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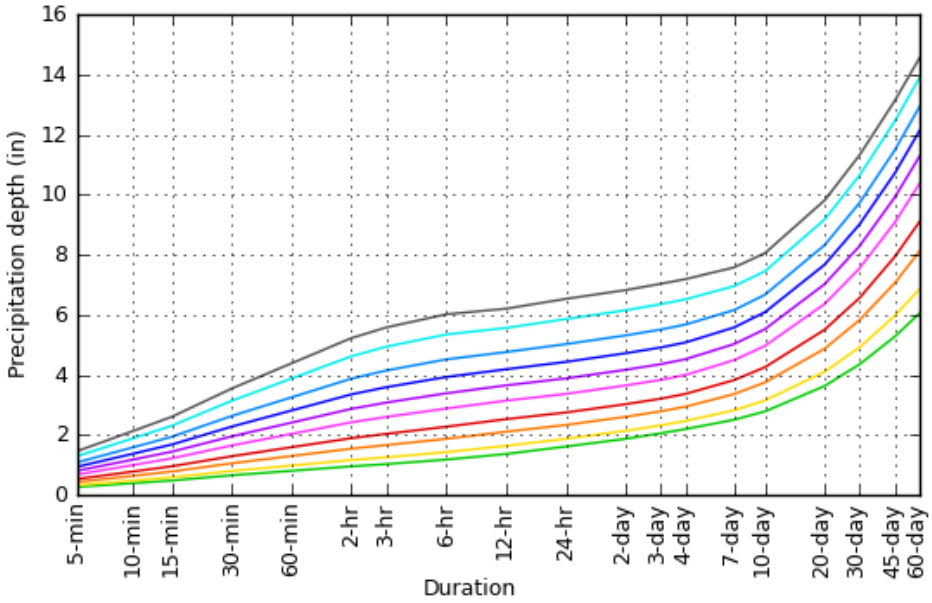
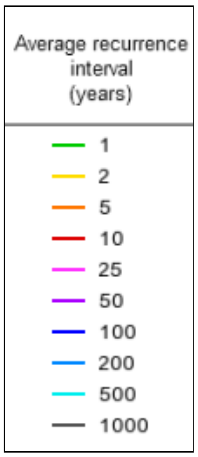
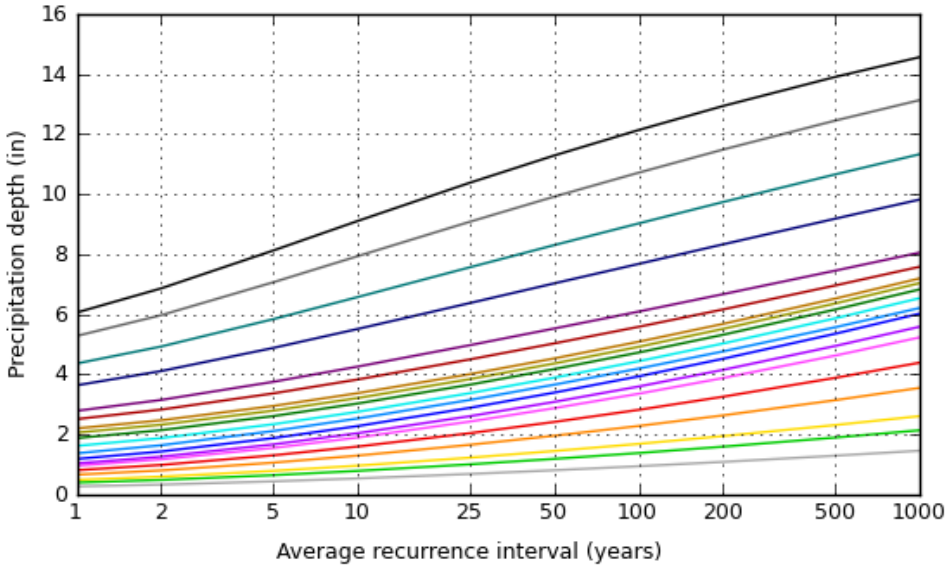
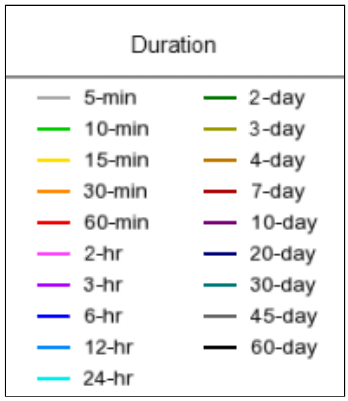
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 40.2115°, Longitude: -103.6842°









NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Tue Sep 14 17:55:31 2021

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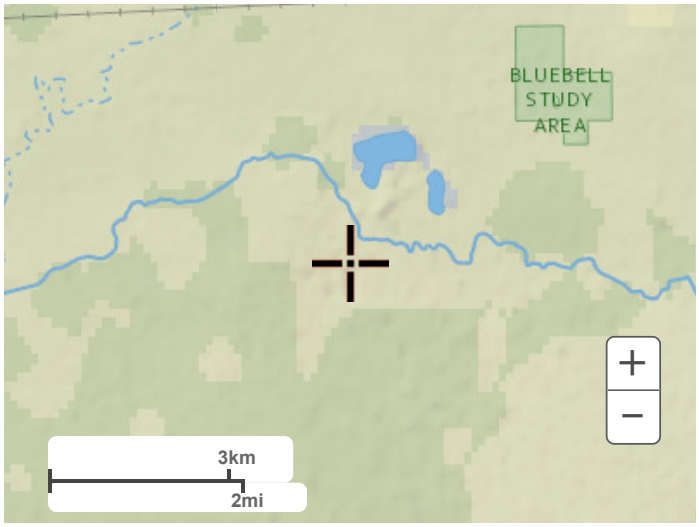
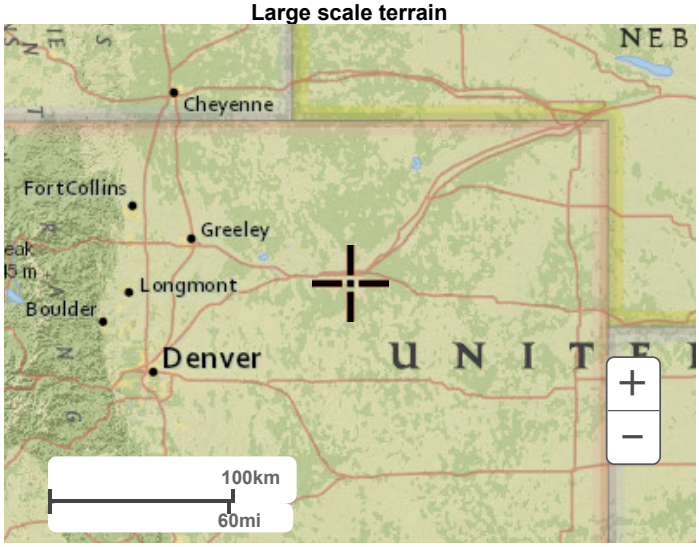
Maps & aerials

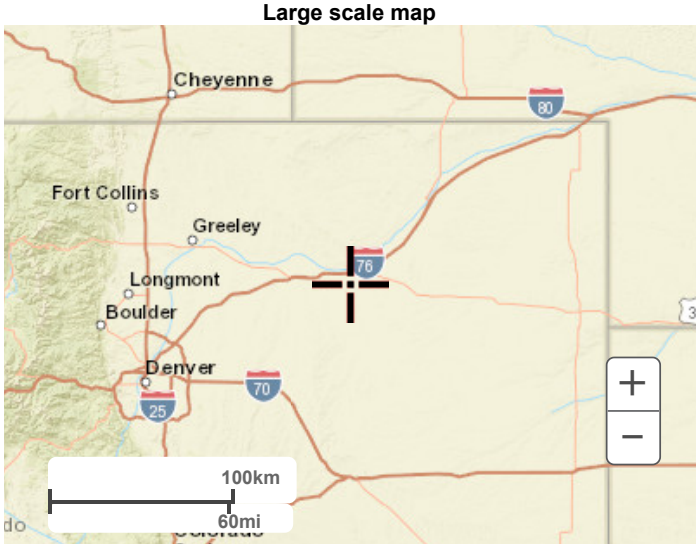
Small scale terrain



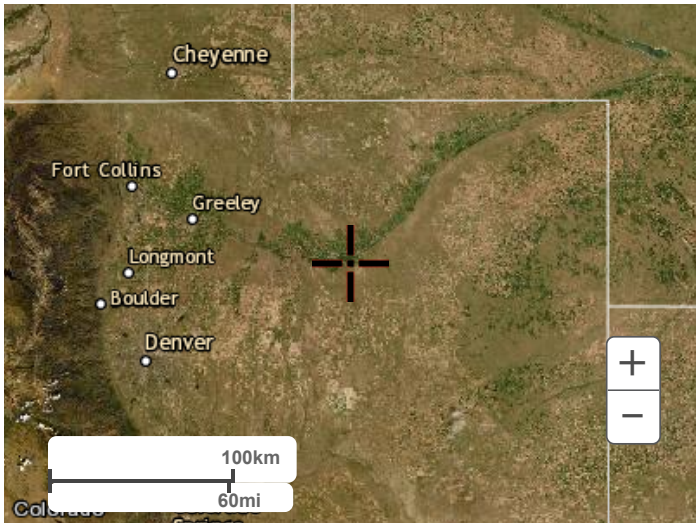
Large scale terrain



Large scale map



Large scale aerial



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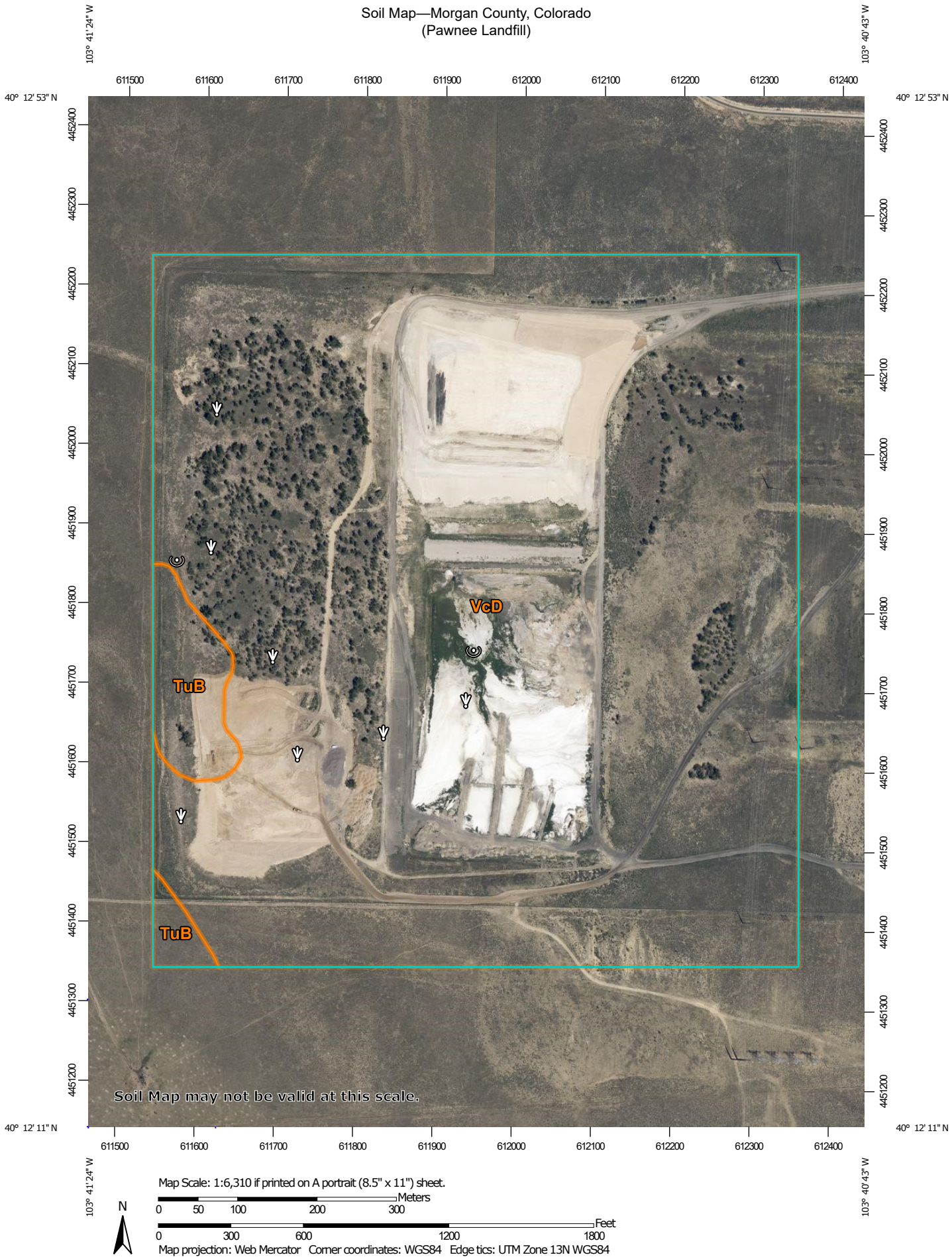
US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX C – SOIL CONSERVATION DISTRICT SOIL REPORT

Soil Map—Morgan County, Colorado
(Pawnee Landfill)



Map Scale: 1:6,310 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 50 100 200 300

Feet
0 300 600 1200 1800

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:
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: Morgan County, Colorado
Survey Area Data: Version 22, Aug 31, 2021

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

Date(s) aerial images were photographed: Jul 19, 2018—Aug 10, 2018

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

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
TuB	Truckton loamy sand, 0 to 3 percent slopes	6.6	3.6%
VcD	Valent sand, 3 to 9 percent slopes	174.2	96.4%
Totals for Area of Interest		**180.7**	**100.0%**