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

PREPARED FOR

PAWNEE STATION

14940 Morgan County Road 24,
Brush, Colorado 80723

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
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 requires that an initial Run-on and Run-off Control System Plan be prepared no later than October 17, 2016.

1.1 Facility Description

The Pawnee Station 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 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 landfill.

An evaporation pond is located on the southern end of the CCR landfill. The pond is lined with a geosynthetic clay liner. Stormwater falling on the CCR landfill flows to the evaporation pond. Stormwater falling on the southern lime sludge landfill is directed north to the earthen dike. The dike is designed as a porous dike and is intended to pass water from the lime sludge 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 evaluation included preparation of a surface water run-off model using Hydrologic Engineering Center Hydrologic Modeling System (HEC- HMS) developed by the United States Army Corps of Engineers. This modeling system was used 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 a photometric topographical survey from December 12, 2014 with portions updated August 13, 2015.

2.1 Description of CCR Landfill and Drainage Area

Based on the survey data, the landfill active area is approximately 16.36 acres. The evaporation pond is approximately 3.3 acres in size. The porous dike separating the CCR landfill from the lime sludge landfill is approximately 1.7 acres. The active landfill area and delineated drainage basin is shown on **Figure 2**.

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

2.2.1 Run-on Controls

The 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 CCR landfill. The landfill is graded to direct stormwater to the evaporation pond.

2.3 Surface Water Run-off Model

A surface water run-off model was prepared using HEC–HMS version 4.2, 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 is 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	1.85
25-year	3.34

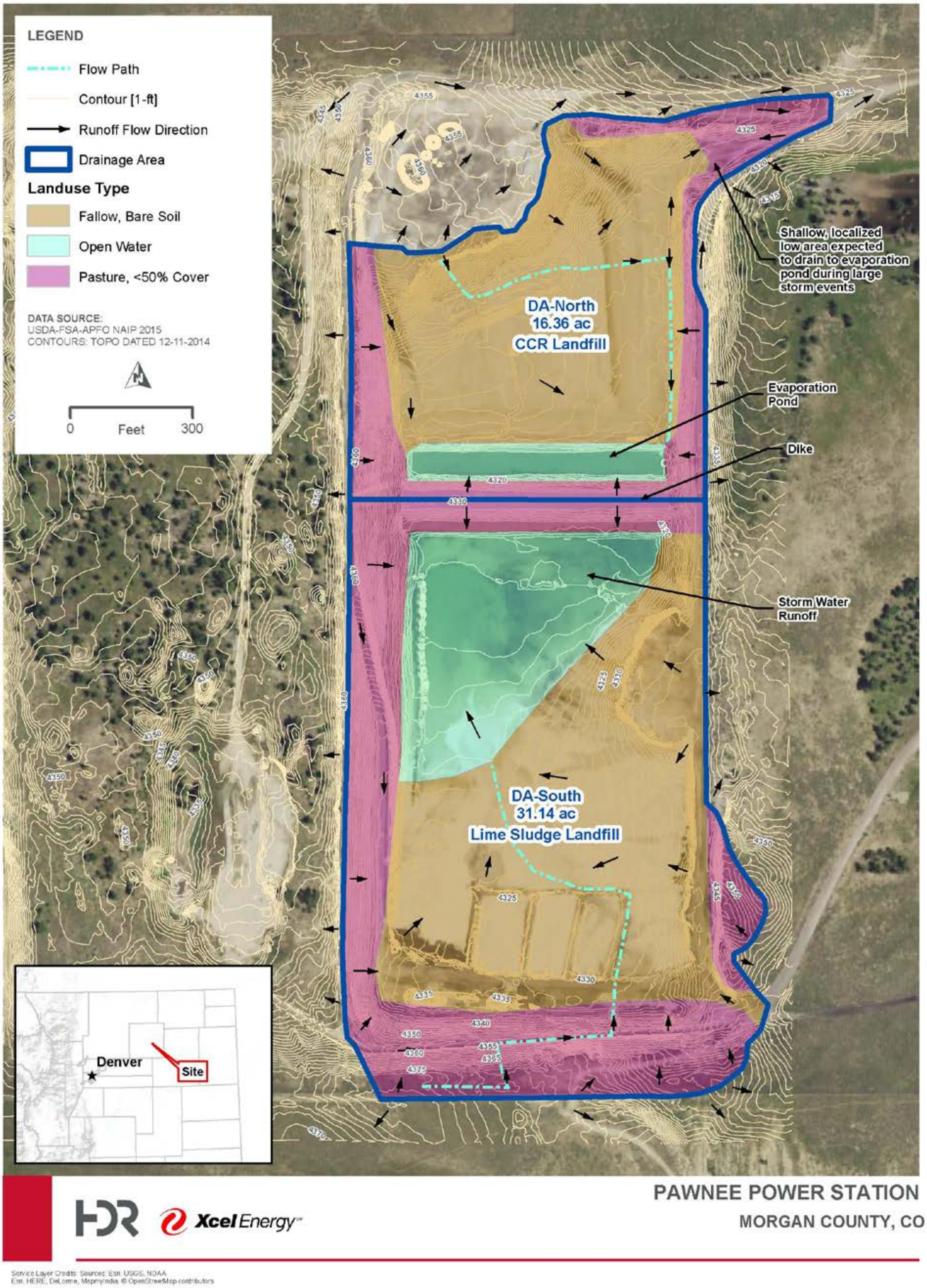


Figure 2. Stormwater Drainage Map

The Frequency Storm rainfall distribution method was utilized within the HEC-HMS model. Precipitation depths for the 5-minute, 15-minutes, 1-hour, 2-hour, 3-hour, 6-hour, and 12-hour frequencies were input into the model along with the 24-hour amounts used to develop the hydrograph.

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 two drainage basins (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**.

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

Table 2. Summary of North Area Breakdown

Cover Type	HSG	Area (Acres)	Curve Number
Fallow, Bare Soil	A	10.62	77
Open Water	A	1.35	98
Pasture, <50% Cover	A	4.39	68
Weighted CN			**76**

Table 3. Summary of South Area Breakdown

Cover Type	HSG	Area (Acres)	Curve Number
Fallow, Bare Soil	A	14.53	77
Open Water	A	6.04	98
Pasture, <50% Cover	A	10.57	68
Weighted CN			**78**

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.

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 surface water run-off from the landfill during the 25 year, 24-hour storm event. Based on the model and calculations performed, a total volume of approximately 71,260 ft^3 of stormwater will be generated from the CCR landfill. This will raise the level of the evaporation pond approximately 1.3 feet. A total volume of approximately 162,780 ft^3 of stormwater will be generated from the lime sludge landfill. To model the worst case scenario, it was assumed that storm water from the lime sludge landfill would transfer instantaneously through the porous dike to the evaporation pond. This inflow would increase the water level in the evaporation pond an additional 2.7 feet.

On the date of the survey, the elevation of the water in the evaporation pond was 4315.3 feet. Modeling the worst case scenario, a 25 year, 24-hour storm event will raise the elevation of the pond approximately 4.0 feet to an elevation of 4319.3 feet. The elevation of the porous dike is approximately 4329.8 feet, and the low point elevation along the eastern berm is approximately 4324.0 feet and occurs at the far northeast corner. Based on the model, there is sufficient freeboard to contain the desired storm event.

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 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 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:	
Christopher M. Koehler, PE	Colorado PE 0051359
DATE:	October 14, 2016

APPENDIX A – HEC-HMS MODEL RESULTS

Job No.	10025968	Calc No.	00001

SCS UNIT HYDROGRAPH METHOD - HYDROLOGIC SUMMARY

Project	Xcel Energy Pawnee Power Station - Morgan County, CO	Computed	JF
System	Hydrologic Analysis - HEC-HMS	Date	9/14/2016
Component	Computations	Reviewed	RV
Task	Hydrologic Summary Table	Date	9/15/2016

EXISTING CONDITIONS

DRAINAGE AREA ID	JUNCTION POINT	TOTAL AREA (AC)	TOTAL AREA (SQ MI)	WEIGHTED CURVE NUMBER	TIME OF CONC. (MIN)	LAG TIME (MIN)	Q 2 YR (CFS)	Q 25 YR (CFS)	Q 100 YR (CFS)	REMARKS
DA-North	Evaporation Pond North of Dike	16	0.02556	76	13.6	8.2	7	35	63	
DA-South	Evaporation Pond South of Dike	31	0.04866	78	20.1	12.1	13	61	105	

Notes:

1. SCS Unit Hydrograph Method used for runoff calculations with HEC-HMS v. 4.2.
2. Land use data was developed by HDR using NAIP 2015 Aerial Imagery for Morgan County, CO.
3. Soils data (Sept. 2015) downloaded from NRCS Web Soil Survey.
4. Time of concentration computed following the NRCS TR-55 Method for sheet, shallow concentrated, & channel flow.
5. Rainfall data per NOAA Atlas 14, Volume 8, Version 2 for Fort Morgan, CO (Station ID: 05-3038).

Job No.	10025968	Calc No.	00001

CURVE NUMBER CALCULATIONS - EXISTING CONDITIONS

HDR

Project	Xcel Energy Pawnee Power Station	Computed	JF
System	Hydrologic Analysis - HEC-HMS	Date	9/14/2016
Component	Computations	Reviewed	RV
Task	Curve Number Summary Table	Date	9/15/2016

Existing Conditions

Area ID	Land Use Classification	Area (acres)	Percent Area	Soil Group	Condition II Curve Number	CN* Percent Area
DA-North	Fallow, Bare Soil	10.62	65%	A	77	50.0
	Open Water	1.35	8%	A	98	8.1
	Pasture, <50% Cover	4.39	27%	A	68	18.2
	Total:	**16.36**			**Weighted CN =**	**76**
DA-South	Fallow, Bare Soil	14.53	47%	A	77	35.9
	Open Water	6.04	19%	A	98	19.0
	Pasture, <50% Cover	10.57	34%	A	68	23.1
	Total:	**31.14**			**Weighted CN =**	**78**

Note: Soils data was taken from USDA-NRCS Web Soil Survey; the data is dated Sept. 2015
Land use data was developed by HDR using NAIP 2015 Aerial Imagery for Morgan County, CO
Curve Number data developed from USDA-NRCS TR-55 (1986) - Table 2-2

Job No.	10025968	Calc No.	00001

TIME OF CONCENTRATION CALCULATIONS SUMMARY

Project	Xcel Energy Pawnee Power Station - Morgan County, CO	Computed	JF
System	Hydrologic Analysis - HEC-HMS	Date	9/14/2016
Component	Computations	Reviewed	RV
Task	Time of Concentration Calculations	Date	9/15/2016

TIME OF CONCENTRATION (Tc) CALCULATIONS

Drainage Area ID	Overland/Sheet Flow				$P_{2=}$	1.85	Shallow Concentrated				Channelized			Total T_c (min)*	Tlag (min)	Notes / Assumptions
	n_{0l}		L_{sh} (ft)		S_{sh} (ft/ft)	T_{sh} (min)	Surface	L_{sc} (ft)	S_{sc} (ft/ft)	T_{sc} (min)	V (*fps*)	L	T_{ch} (min)			
DA-North	Fallow	0.05	100		0.210	5.0	Unpaved	1010	0.0149	8.6	#DIV/0!	0	0.0	13.6	8.2	
DA-South	Short grass prairie	0.15	100		0.020	12.9	Unpaved	1400	0.0400	7.2	#DIV/0!	0	0.0	20.1	12.1	

MORGAN COUNTY RAINFALL DATA

Depth-Duration-Frequency Relationship

County: Morgan
Source: NOAA Online
Precip Data: NOAA Atlas 14, Volume 8, Version 2

HEC-HMS INPUT			
	2-yr	25-yr	100-yr
Prob	50 percent	4 percent	1 percent
Int Duration	5 min	5 min	5 min
Storm dur	1 day	1 day	1 day
Int Position	50%	50%	50%
Storm Area			
Depths	inches	inches	inches
5 min	0.326	0.673	0.933
15 min	0.582	1.20	1.67
1 hr	0.964	2.01	2.80
2 hr	1.14	2.40	3.35
3 hr	1.23	2.58	3.61
6 hr	1.40	2.89	3.96
12 hr	1.61	3.14	4.20
1 day	1.85	3.34	4.42

NOAA Atlas 14, Volume 8, Version 2 FT MORGAN
Station ID: 05-3038
Location name: Fort Morgan, Colorado, US*
Latitude: 40.2600°, Longitude: -103.8156°
Elevation:
Elevation (station metadata): 4359 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	0.269 (0.214-0.348)	0.326 (0.260-0.422)	0.430 (0.341-0.558)	0.526 (0.415-0.686)	0.673 (0.517-0.929)	0.798 (0.595-1.11)	0.933 (0.669-1.33)	1.08 (0.740-1.59)	1.29 (0.847-1.95)	1.46 (0.928-2.22)
10-min	0.394 (0.314-0.509)	0.477 (0.380-0.618)	0.630 (0.499-0.817)	0.770 (0.607-1.00)	0.986 (0.758-1.36)	1.17 (0.871-1.63)	1.37 (0.980-1.95)	1.58 (1.08-2.32)	1.89 (1.24-2.85)	2.14 (1.36-3.26)
15-min	0.480 (0.383-0.621)	0.582 (0.463-0.754)	0.768 (0.609-0.997)	0.940 (0.741-1.23)	1.20 (0.924-1.66)	1.43 (1.06-1.99)	1.67 (1.20-2.38)	1.93 (1.32-2.83)	2.31 (1.51-3.48)	2.61 (1.66-3.97)
30-min	0.651 (0.519-0.841)	0.785 (0.625-1.02)	1.03 (0.819-1.34)	1.26 (0.996-1.65)	1.62 (1.25-2.24)	1.92 (1.44-2.68)	2.25 (1.62-3.22)	2.62 (1.79-3.85)	3.14 (2.06-4.74)	3.56 (2.26-5.42)
60-min	0.796 (0.634-1.03)	0.964 (0.767-1.25)	1.27 (1.01-1.65)	1.56 (1.23-2.04)	2.01 (1.54-2.77)	2.39 (1.78-3.33)	2.80 (2.01-4.01)	3.26 (2.23-4.79)	3.91 (2.56-5.91)	4.44 (2.82-6.75)
2-hr	0.940 (0.759-1.20)	1.14 (0.921-1.46)	1.51 (1.22-1.93)	1.86 (1.49-2.39)	2.40 (1.87-3.26)	2.85 (2.16-3.92)	3.35 (2.44-4.72)	3.90 (2.71-5.64)	4.68 (3.12-6.97)	5.32 (3.43-7.97)
3-hr	1.01 (0.823-1.28)	1.23 (1.00-1.56)	1.63 (1.32-2.07)	2.01 (1.61-2.56)	2.58 (2.03-3.48)	3.08 (2.34-4.18)	3.61 (2.65-5.04)	4.19 (2.94-6.01)	5.03 (3.38-7.42)	5.71 (3.71-8.48)
6-hr	1.14 (0.941-1.42)	1.40 (1.15-1.74)	1.86 (1.53-2.32)	2.28 (1.85-2.85)	2.89 (2.29-3.82)	3.41 (2.63-4.54)	3.96 (2.94-5.41)	4.55 (3.23-6.40)	5.38 (3.67-7.79)	6.05 (4.00-8.84)
12-hr	1.34 (1.12-1.64)	1.61 (1.34-1.97)	2.09 (1.73-2.56)	2.51 (2.07-3.10)	3.14 (2.52-4.05)	3.65 (2.85-4.78)	4.20 (3.16-5.63)	4.78 (3.44-6.60)	5.59 (3.87-7.95)	6.24 (4.19-8.97)
24-hr	1.59 (1.35-1.92)	1.85 (1.56-2.23)	2.31 (1.94-2.78)	2.72 (2.27-3.30)	3.34 (2.72-4.25)	3.86 (3.06-4.98)	4.42 (3.38-5.84)	5.02 (3.68-6.83)	5.88 (4.13-8.23)	6.57 (4.48-9.29)

Xcel Energy: Pawnee Power Station
Morgan County, Colorado
HEC-HMS 4.2 Output

Evaporation Pond (DA-North):
24-hour, 100-year storm event
NOAA Atlas 14 precipitation frequencies

Pond-North Elev-Area Relationship

Elevation (FT)	Area (AC)
4316.0	0.8165
4318.0	1.0318
4320.0	1.2630
4322.0	2.1337

*Assume initial pond elevation at 4317.0

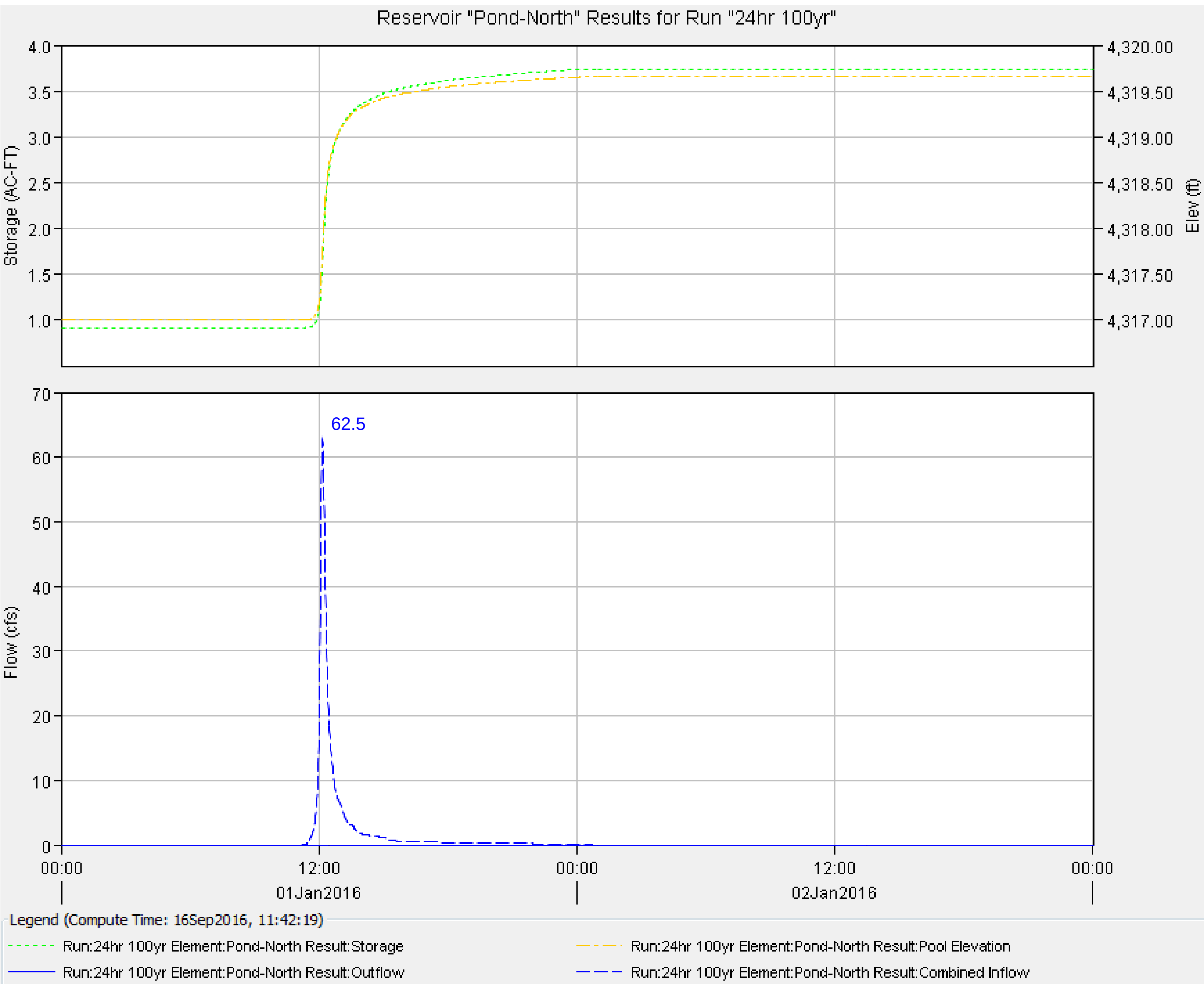
Project: Xcel_Pawnee_Power_Station   Simulation Run: 24hr 100yr
Reservoir: Pond-North

Start of Run: 01Jan2016, 00:00   Basin Model: Existing
End of Run: 03Jan2016, 00:01   Meteorologic Model: 100-year
Compute Time: 16Sep2016, 11:42:19   Control Specifications: Control 1

Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow: 62.5 (CFS)   Date/Time of Peak Inflow: 01Jan2016, 12:10
Peak Discharge: 0.0 (CFS)   Date/Time of Peak Discharge: 01Jan2016, 00:00
Inflow Volume: 2.07 (IN)   Peak Storage: 3.7 (AC-FT)
Discharge Volume: 0.00 (IN)   Peak Elevation: 4319.7 (FT)



Evaporation Pond (DA-North):

24-hour, 25-year storm event
NOAA Atlas 14 precipitation frequencies

Pond-North Elev-Area Relationship

Elevation (FT)	Area (AC)
4316.0	0.8165
4318.0	1.0318
4320.0	1.2630
4322.0	2.1337

*Assume initial pond elevation at 4317.0

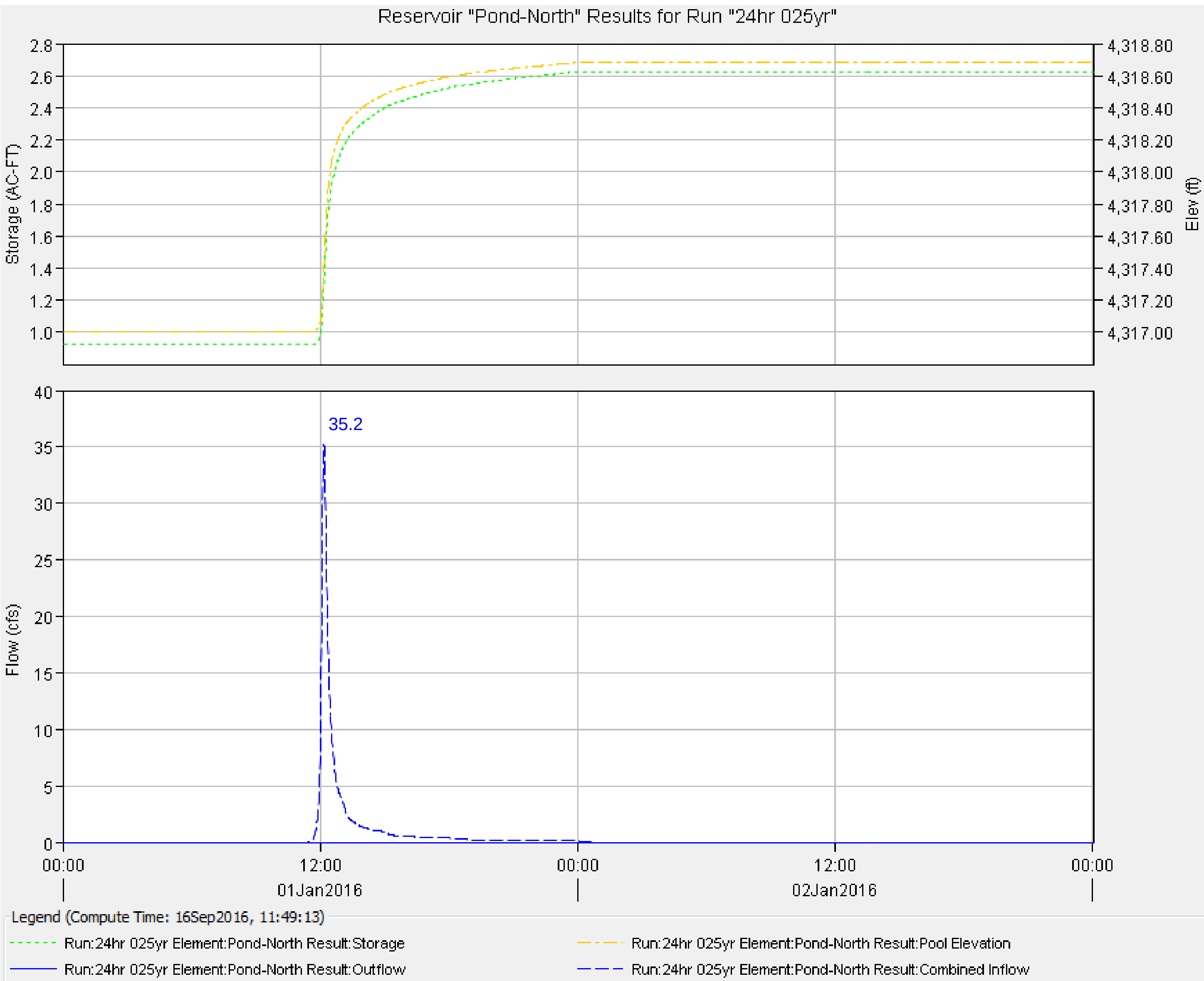
Project: Xcel_Pawnee_Power_Station   Simulation Run: 24hr 025yr
Reservoir: Pond-North

Start of Run:	01Jan2016, 00:00	Basin Model:	Existing
End of Run:	03Jan2016, 00:01	Meteorologic Model:	025-year
Compute Time:	16Sep2016, 11:49:13	Control Specifications:	Control 1

Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow:	35.2 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:10
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	1.25 (IN)	Peak Storage:	2.6 (AC-FT)
Discharge Volume:	0.00 (IN)	Peak Elevation:	4318.7 (FT)



Xcel Energy: Pawnee Power Station
Morgan County, Colorado
HEC-HMS 4.2 Output

Lime Slurry Pond (DA-South):

24-hour, 100-year storm event
NOAA Atlas 14 precipitation frequencies

Pond-South Elev-Area Relationship

Elevation (FT)	Area (AC)
4317.0	3.7534
4318.0	4.7149
4319.0	5.6934
4320.0	6.9962
4322.0	9.2836
4325.0	12.5670

*Assume initial pond elevation at 4318.0

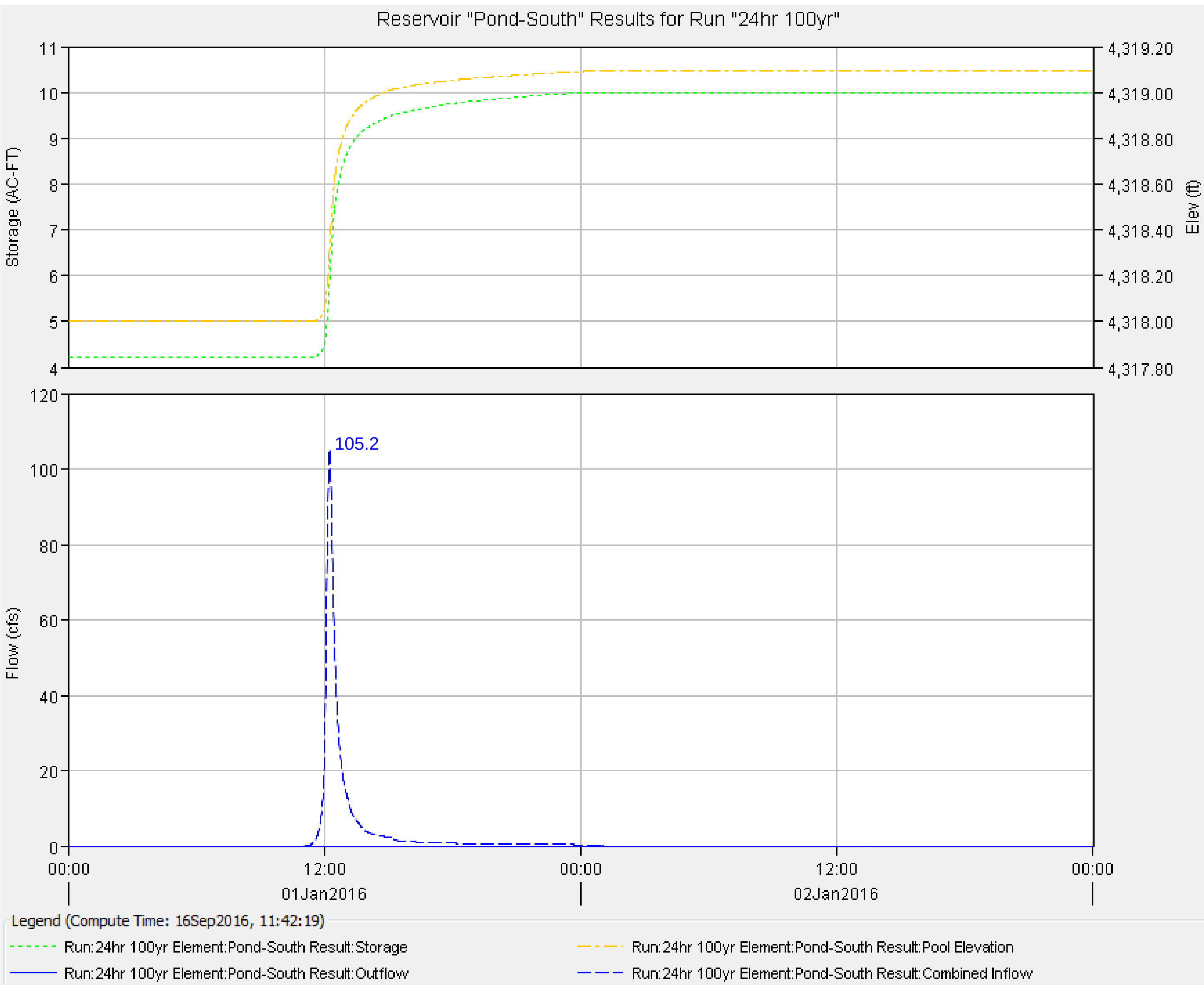
Project: Xcel_Pawnee_Power_Station   Simulation Run: 24hr 100yr
Reservoir: Pond-South

Start of Run:	01Jan2016, 00:00	Basin Model:	Existing
End of Run:	03Jan2016, 00:01	Meteorologic Model:	100-year
Compute Time:	16Sep2016, 11:42:19	Control Specifications:	Control 1

Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow:	105.2 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:14
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	2.23 (IN)	Peak Storage:	10.0 (AC-FT)
Discharge Volume:	0.00 (IN)	Peak Elevation:	4319.1 (FT)



Xcel Energy: Pawnee Power Station
Morgan County, Colorado
HEC-HMS 4.2 Output

Lime Slurry Pond (DA-South):

24-hour, 25-year storm event
NOAA Atlas 14 precipitation frequencies

Pond-South Elev-Area Relationship

Elevation (FT)	Area (AC)
4317.0	3.7534
4318.0	4.7149
4319.0	5.6934
4320.0	6.9962
4322.0	9.2836
4325.0	12.5670

*Assume initial pond elevation at 4318.0

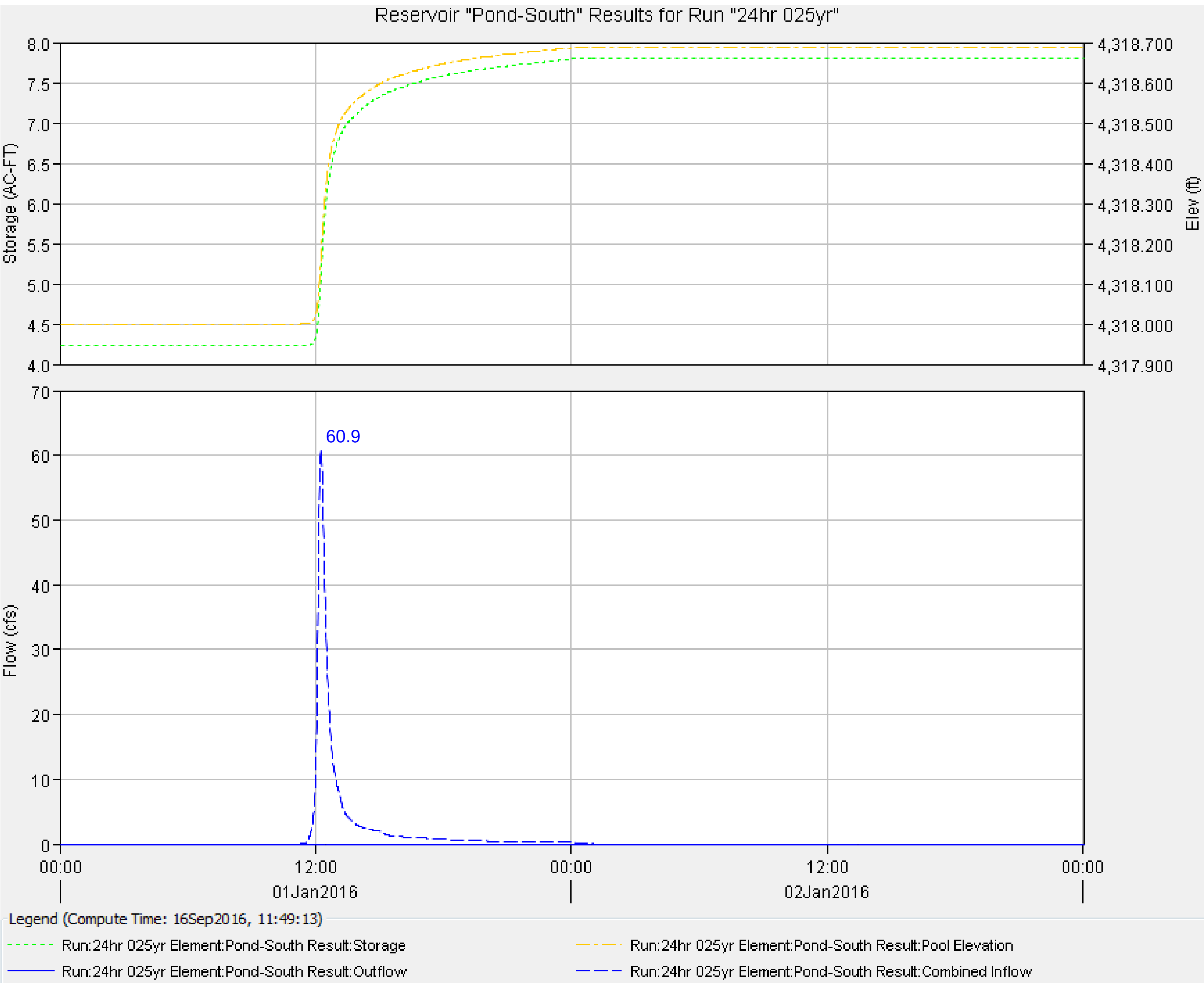
Project: Xcel_Pawnee_Power_Station   Simulation Run: 24hr 025yr
Reservoir: Pond-South

Start of Run:	01Jan2016, 00:00	Basin Model:	Existing
End of Run:	03Jan2016, 00:01	Meteorologic Model:	025-year
Compute Time:	16Sep2016, 11:49:13	Control Specifications:	Control 1

Volume Units: (•) IN ( ) AC-FT

Computed Results

Peak Inflow:	60.9 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:15
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	1.38 (IN)	Peak Storage:	7.8 (AC-FT)
Discharge Volume:	0.00 (IN)	Peak Elevation:	4318.7 (FT)



APPENDIX B – NOAA RAINFALL DATA

NOAA Atlas 14, Volume 8, Version 2 FT MORGAN
Station ID: 05-3038
Location name: Fort Morgan, Colorado, US*
Latitude: 40.2600°, Longitude: -103.8156°
Elevation:
Elevation (station metadata): 4359 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	**0.269** (0.214-0.348)	**0.326** (0.260-0.422)	**0.430** (0.341-0.558)	**0.526** (0.415-0.686)	**0.673** (0.517-0.929)	**0.798** (0.595-1.11)	**0.933** (0.669-1.33)	**1.08** (0.740-1.59)	**1.29** (0.847-1.95)	**1.46** (0.928-2.22)
10-min	**0.394** (0.314-0.509)	**0.477** (0.380-0.618)	**0.630** (0.499-0.817)	**0.770** (0.607-1.00)	**0.986** (0.758-1.36)	**1.17** (0.871-1.63)	**1.37** (0.980-1.95)	**1.58** (1.08-2.32)	**1.89** (1.24-2.85)	**2.14** (1.36-3.26)
15-min	**0.480** (0.383-0.621)	**0.582** (0.463-0.754)	**0.768** (0.609-0.997)	**0.940** (0.741-1.23)	**1.20** (0.924-1.66)	**1.43** (1.06-1.99)	**1.67** (1.20-2.38)	**1.93** (1.32-2.83)	**2.31** (1.51-3.48)	**2.61** (1.66-3.97)
30-min	**0.651** (0.519-0.841)	**0.785** (0.625-1.02)	**1.03** (0.819-1.34)	**1.26** (0.996-1.65)	**1.62** (1.25-2.24)	**1.92** (1.44-2.68)	**2.25** (1.62-3.22)	**2.62** (1.79-3.85)	**3.14** (2.06-4.74)	**3.56** (2.26-5.42)
60-min	**0.796** (0.634-1.03)	**0.964** (0.767-1.25)	**1.27** (1.01-1.65)	**1.56** (1.23-2.04)	**2.01** (1.54-2.77)	**2.39** (1.78-3.33)	**2.80** (2.01-4.01)	**3.26** (2.23-4.79)	**3.91** (2.56-5.91)	**4.44** (2.82-6.75)
2-hr	**0.940** (0.759-1.20)	**1.14** (0.921-1.46)	**1.51** (1.22-1.93)	**1.86** (1.49-2.39)	**2.40** (1.87-3.26)	**2.85** (2.16-3.92)	**3.35** (2.44-4.72)	**3.90** (2.71-5.64)	**4.68** (3.12-6.97)	**5.32** (3.43-7.97)
3-hr	**1.01** (0.823-1.28)	**1.23** (1.00-1.56)	**1.63** (1.32-2.07)	**2.01** (1.61-2.56)	**2.58** (2.03-3.48)	**3.08** (2.34-4.18)	**3.61** (2.65-5.04)	**4.19** (2.94-6.01)	**5.03** (3.38-7.42)	**5.71** (3.71-8.48)
6-hr	**1.14** (0.941-1.42)	**1.40** (1.15-1.74)	**1.86** (1.53-2.32)	**2.28** (1.85-2.85)	**2.89** (2.29-3.82)	**3.41** (2.63-4.54)	**3.96** (2.94-5.41)	**4.55** (3.23-6.40)	**5.38** (3.67-7.79)	**6.05** (4.00-8.84)
12-hr	**1.34** (1.12-1.64)	**1.61** (1.34-1.97)	**2.09** (1.73-2.56)	**2.51** (2.07-3.10)	**3.14** (2.52-4.05)	**3.65** (2.85-4.78)	**4.20** (3.16-5.63)	**4.78** (3.44-6.60)	**5.59** (3.87-7.95)	**6.24** (4.19-8.97)
24-hr	**1.59** (1.35-1.92)	**1.85** (1.56-2.23)	**2.31** (1.94-2.78)	**2.72** (2.27-3.30)	**3.34** (2.72-4.25)	**3.86** (3.06-4.98)	**4.42** (3.38-5.84)	**5.02** (3.68-6.83)	**5.88** (4.13-8.23)	**6.57** (4.48-9.29)
2-day	**1.85** (1.58-2.19)	**2.11** (1.81-2.50)	**2.58** (2.20-3.07)	**3.00** (2.55-3.58)	**3.63** (3.00-4.54)	**4.16** (3.34-5.26)	**4.71** (3.66-6.12)	**5.31** (3.95-7.10)	**6.16** (4.40-8.47)	**6.84** (4.74-9.51)
3-day	**2.03** (1.75-2.38)	**2.29** (1.98-2.69)	**2.76** (2.38-3.25)	**3.19** (2.72-3.77)	**3.82** (3.18-4.72)	**4.34** (3.52-5.44)	**4.90** (3.84-6.30)	**5.51** (4.13-7.29)	**6.36** (4.59-8.66)	**7.04** (4.93-9.70)
4-day	**2.17** (1.88-2.52)	**2.44** (2.12-2.84)	**2.92** (2.52-3.41)	**3.34** (2.87-3.92)	**3.98** (3.33-4.88)	**4.51** (3.68-5.60)	**5.07** (3.99-6.46)	**5.67** (4.28-7.44)	**6.51** (4.73-8.80)	**7.19** (5.07-9.83)
7-day	**2.47** (2.17-2.84)	**2.79** (2.45-3.21)	**3.33** (2.91-3.84)	**3.79** (3.30-4.39)	**4.46** (3.76-5.36)	**4.99** (4.11-6.09)	**5.54** (4.41-6.94)	**6.12** (4.68-7.89)	**6.91** (5.08-9.18)	**7.53** (5.38-10.2)
10-day	**2.74** (2.42-3.11)	**3.10** (2.74-3.53)	**3.70** (3.26-4.23)	**4.21** (3.68-4.83)	**4.91** (4.16-5.83)	**5.46** (4.53-6.58)	**6.02** (4.82-7.45)	**6.59** (5.07-8.40)	**7.36** (5.45-9.67)	**7.95** (5.73-10.6)
20-day	**3.56** (3.19-3.98)	**4.02** (3.60-4.50)	**4.78** (4.26-5.36)	**5.40** (4.79-6.09)	**6.24** (5.35-7.24)	**6.87** (5.77-8.11)	**7.50** (6.09-9.09)	**8.13** (6.34-10.1)	**8.95** (6.73-11.5)	**9.56** (7.01-12.5)
30-day	**4.26** (3.85-4.71)	**4.81** (4.34-5.33)	**5.70** (5.13-6.33)	**6.41** (5.74-7.16)	**7.37** (6.36-8.44)	**8.08** (6.84-9.42)	**8.77** (7.19-10.5)	**9.46** (7.45-11.7)	**10.3** (7.84-13.1)	**11.0** (8.13-14.2)
45-day	**5.15** (4.69-5.64)	**5.82** (5.30-6.38)	**6.88** (6.25-7.57)	**7.72** (6.97-8.53)	**8.82** (7.68-9.98)	**9.63** (8.21-11.1)	**10.4** (8.59-12.3)	**11.1** (8.84-13.6)	**12.0** (9.22-15.1)	**12.7** (9.51-16.3)
60-day	**5.91** (5.41-6.42)	**6.69** (6.13-7.28)	**7.91** (7.22-8.63)	**8.87** (8.05-9.72)	**10.1** (8.82-11.3)	**11.0** (9.40-12.5)	**11.8** (9.78-13.8)	**12.5** (10.0-15.1)	**13.5** (10.4-16.7)	**14.1** (10.6-17.9)

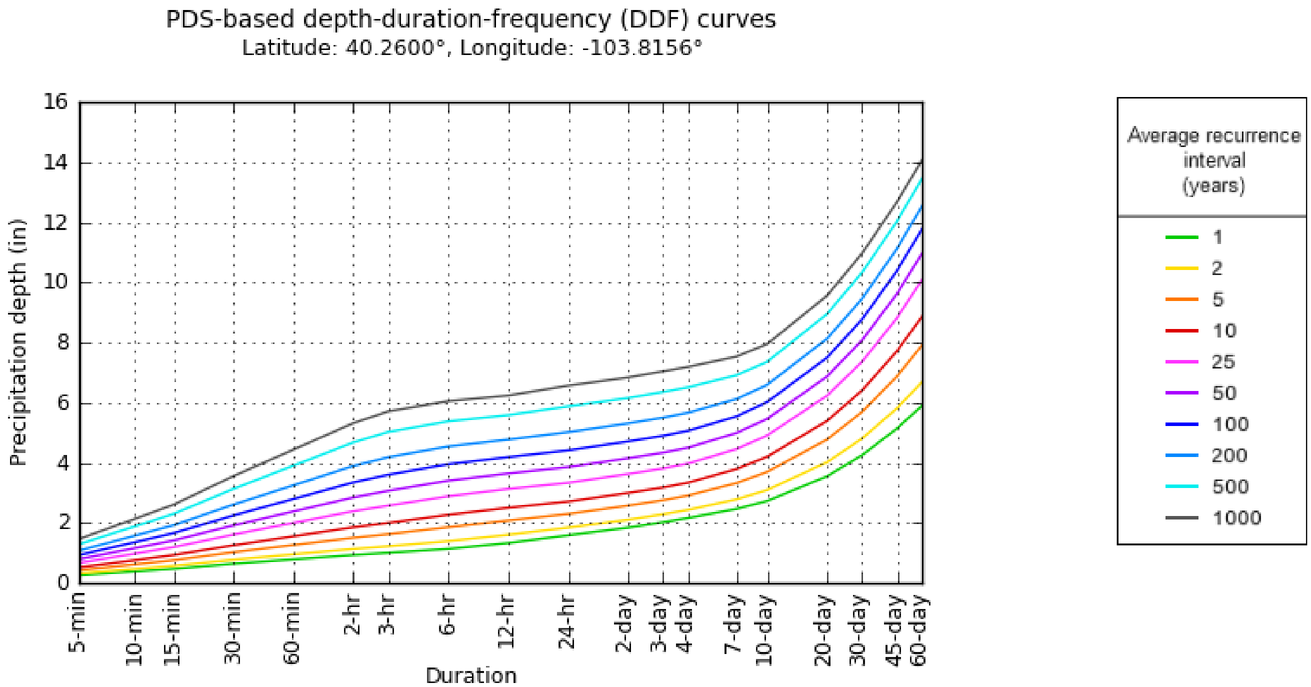
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

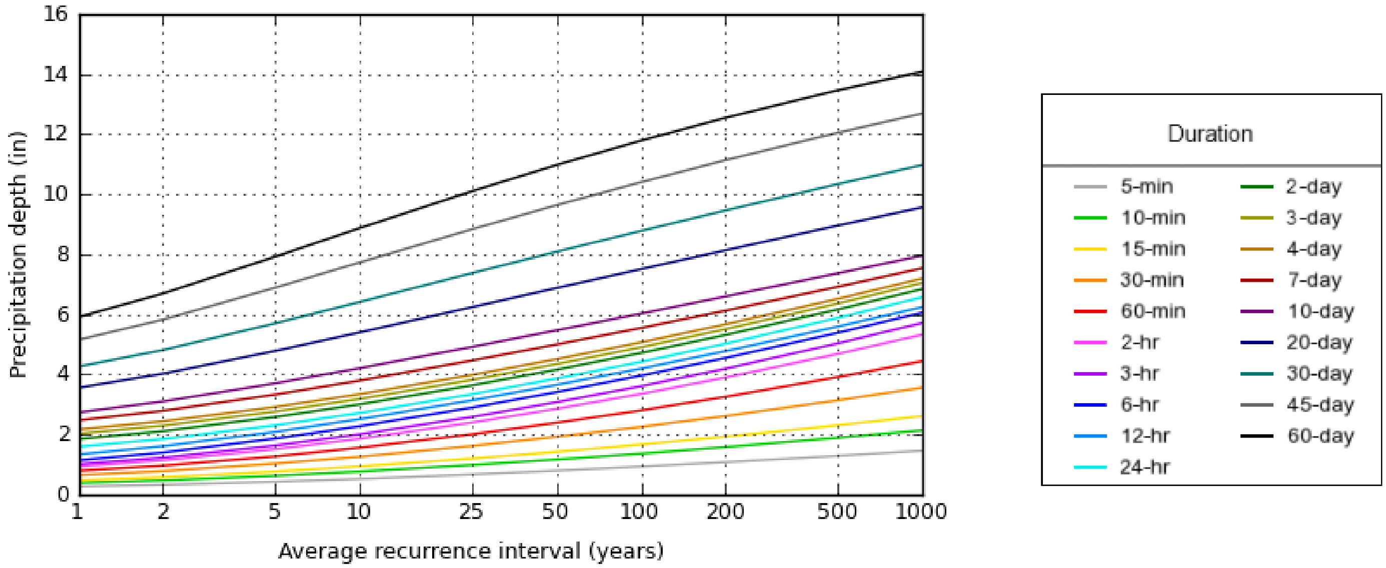
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper 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





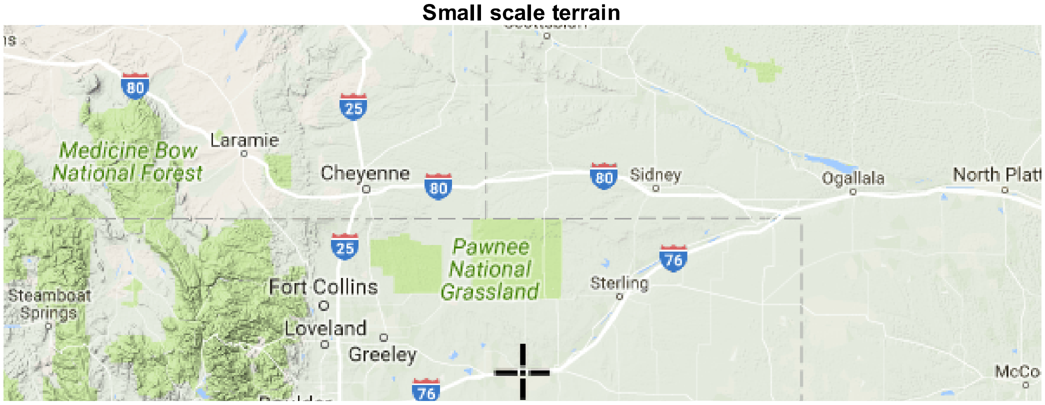
NOAA Atlas 14, Volume 8, Version 2

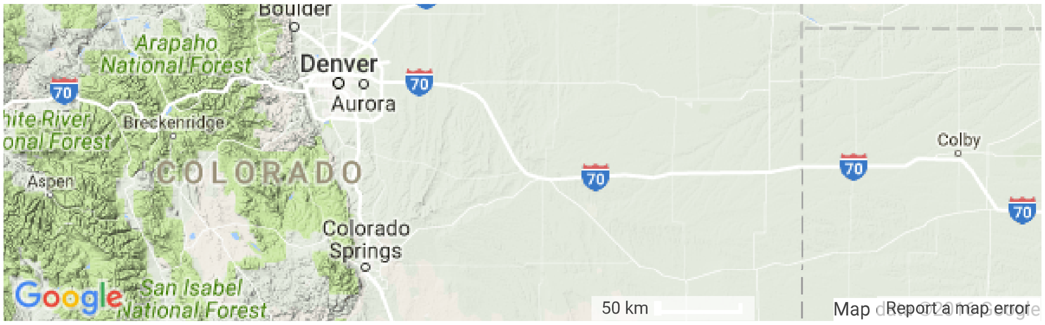
Created (GMT): Thu Sep 8 19:05:48 2016

Back to Top

Maps & aerials

Small scale terrain





Large scale terrain

Large scale map

Large scale aerial

Back to Top

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

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

Morgan County, Colorado

Pawnee Station Soil Information

September 8, 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.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

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: 1:4,390 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1200

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: Morgan County, Colorado
Survey Area Data: Version 16, 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: Sep 30, 2010—Aug 30, 2011

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

Morgan County, Colorado (CO087)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
VcD	Valent sand, 3 to 9 percent slopes	55.5	100.0%
Totals for Area of Interest		**55.5**	**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.

Morgan County, Colorado

VcD—Valent sand, 3 to 9 percent slopes

Map Unit Setting

National map unit symbol: 2tczf
Elevation: 3,050 to 5,150 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 130 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition

Valent and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Valent

Setting

Landform: Dunes, hills
Landform position (two-dimensional): Shoulder, backslope, summit, footslope
Landform position (three-dimensional): Crest, side slope, head slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Noncalcareous eolian sands

Typical profile

A - 0 to 5 inches: sand
AC - 5 to 12 inches: sand
C1 - 12 to 30 inches: sand
C2 - 30 to 80 inches: sand

Properties and qualities

Slope: 3 to 9 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 39.96 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Very low (about 2.4 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: Deep Sand (R067BY015CO), Sands (North) (PE 16-20) (R072XA021KS)
Hydric soil rating: No

Minor Components

Dailey

Percent of map unit: 10 percent
Landform: Interdunes
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: Deep Sand (R067BY015CO), Sands (North) (PE 16-20) (R072XA021KS)
Hydric soil rating: No

Vona

Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Footslope, backslope, shoulder
Landform position (three-dimensional): Side slope, head slope, nose slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Sandy Plains (R067BY024CO), Sandy (North) Draft (April 2010) (PE 16-20) (R072XA022KS)
Hydric soil rating: No

Haxtun

Percent of map unit: 5 percent
Landform: Interdunes
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: Sandy Plains (R067BY024CO), Sandy (North) Draft (April 2010) (PE 16-20) (R072XA022KS)
Hydric soil rating: No

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