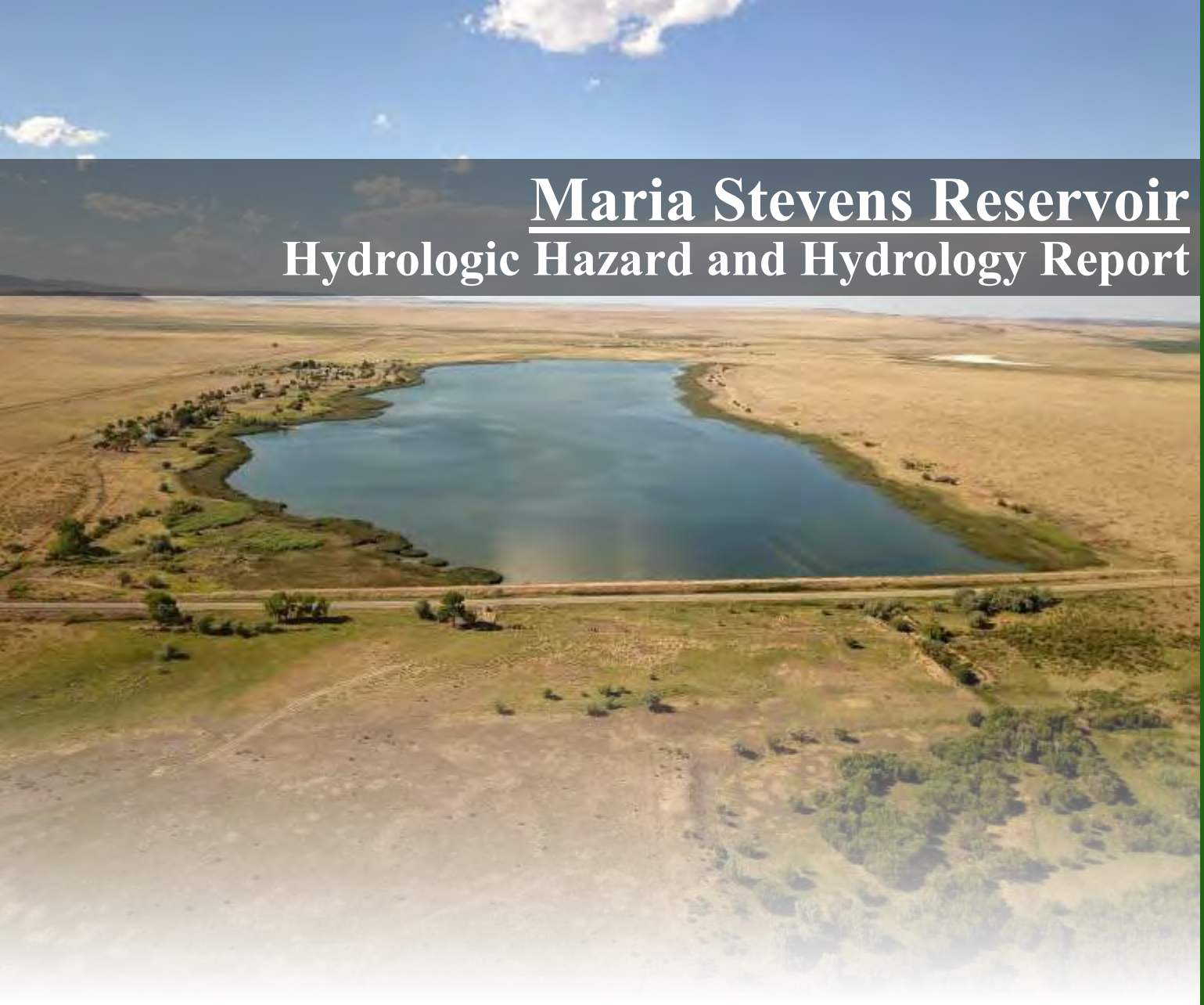
Maria Stevens Reservoir
Hydrologic Hazard and Hydrology Report



June 2022
AG File # 18-117

HUERFANO COUNTY WATER CONSERVANCY DISTRICT

Applegate Group, Inc.
Water Resource Advisors for the West
www.applegategroup.com
303-452-6611

CERTIFICATION

I hereby affirm that this Hydrology Report was prepared under my responsible change, for the owners thereof, and to my knowledge is accurate and adheres to the applicable standards and rules provided by the State of Colorado, Department of Natural Resources, Division of Water Resources, Office of the State Engineer.

_____

Tyler J. Desiderio
Registered Professional Engineer
State of Colorado P.E. No.: 53330

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INTRODUCTION

Maria Stevens Reservoir (DAM ID: 160221) is an existing reservoir that is located about 4.5 miles northeast of Walsenburg along State Highway 10. The reservoir exists on relatively flat to rolling terrain in a shallow draw that drains to the north located in Section 21 of Township 27 South, Range 65 West, 6th Principal Meridian, Water Division 2, and Water District 16 with WDID 1603718. There are three existing dams which impound Maria Stevens Reservoir at the North, South, and West ends of the reservoir. Maria Stevens Reservoir is decreed for an absolute storage right of 2493.1 acre-feet (1260 ac-ft decreed in Case No. CA582 and 1233.1 ac-ft decreed in Case No. 19CW3045).

According to Dam Safety's Jurisdictional Dam database, the Maria Stevens Dams and Reservoir was originally constructed in 1887 to provide irrigation water but also for habitat, fish, and wildlife benefits. The dams are classified as low hazard earthen embankments with the largest being the North Dam at a jurisdictional height of 20-feet. The North dam contains a 12-inch diameter HDPE pipe siphon that currently serves as the main outlet works. Together, the North, West, and South dams span a total of 2,170-feet impounding water to a normal storage level of 2412 acre-feet set by the auxiliary spillway located on the North Dam. The reservoir is located on a tributary to Sand Arroyo, which is a tributary to the Cucharas River. The southern dam is located approximately 1,000 feet from the northern bank of the Cucharas River as shown in Figure 1.

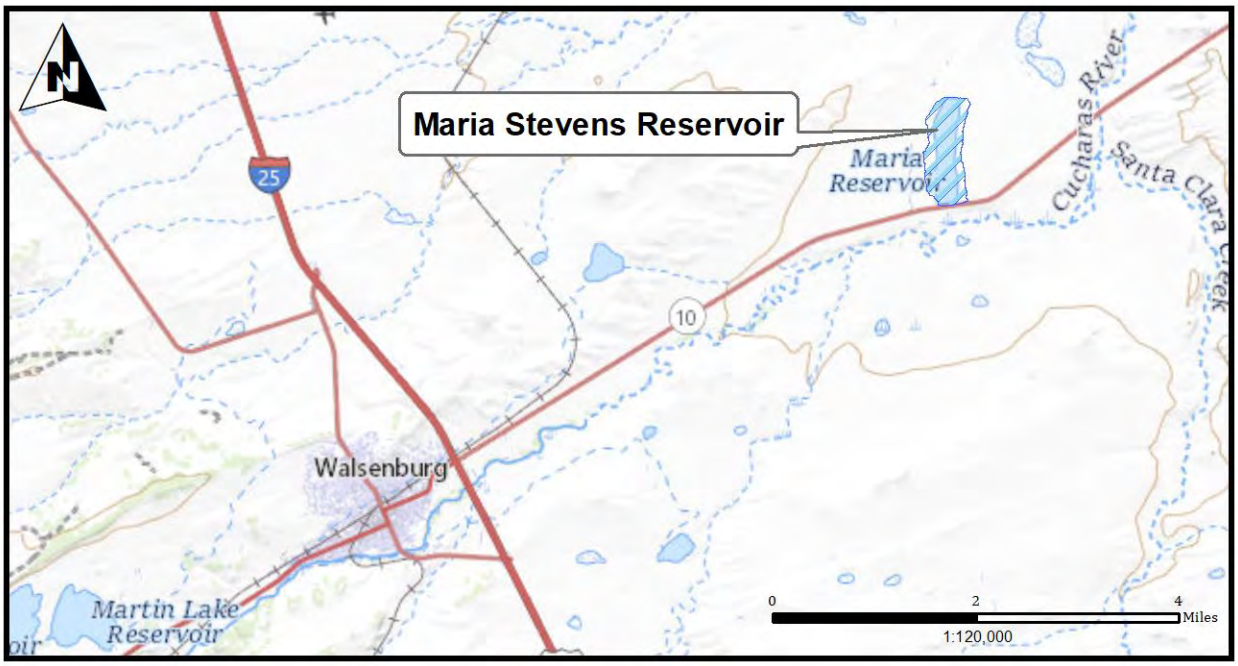


FIGURE 1. GENERAL VICINITY MAP.

The Huerfano County Water Conservancy District (HCWCD) retained Applegate Group, Inc. (Applegate) to complete the enlargement design of the Maria Stevens Reservoir. This report details the hydrologic analysis of Maria Stevens Reservoir and determination of the Inflow Design Flood (IDF) for spillway design and sizing. This report is a part of the 50% design for the dam that includes the enlargement of the dams to increase the storage capacity of the reservoir.

The hydrologic analysis summarized in this report adheres to Rule 6 of the *Rules and Regulations for Dam*

Safety and Dam Construction[1] *(Rules and Regs)* and follows guidance presented in *Hydrologic Basin Response Parameter Estimate Guidelines*[2] (*Hydrology Guidelines*), *Guidelines for the Use of Regional Extreme Precipitation Study* [3] *(Design Storm Guidelines),* and *Guidelines for Hydrologic Hazard Analysis*[4] *(Hydrologic Hazard Guidelines)*.

RESERVOIR CONDITIONS

Maria Stevens Dams and Reservoir enlargement is in the 50% Design Phase at the time this *Report* was prepared. Generally, the enlargement design will entail raising the dam crest, installation of new outlet works controls at the southern dam for augmentation to the Cucharas River, installation of chimney filter and toe drain at the south dam to mitigate historical seepage, and reconfiguration of the existing spillway to increase normal storage capacity and pass the design IDF. Existing and proposed conditions for key elements of the Maria Stevens Dam and Reservoir Enlargement Project relevant to this *Report* are summarized in the following table.

TABLE 1. MARIA STEVENS RESERVOIR EXISTING VS PROPOSED CHARACTERISTICS

Reservoir Data	Existing Conditions	Proposed Conditions
Jurisdictional Height	20.7 feet	13.76 feet
Structural Height	20.9 feet	23.0 feet
Spillway Type	36" CMP	Riprap Lined Channel
Spillway Invert Elevation	5918 feet[1]	5,921 feet
Normal Water Surface Elevation	5,918 feet[1]	5,921 feet
Normal Storage Capacity	2,412 ac-ft	2,891 ac-ft
Max Storage Capacity	2,955 ac-ft[2]	3,855 ac-ft
Dam Crest Elevation	5,920 to 5,922 feet[3]	5,925 feet
Dam Crest Width	12 to 30 feet	15 feet
Normal Freeboard	3 feet	4 feet
Hazard Classification	Low	Significant (assumed)
Hydrologic Hazard Group	Significant (assumed)	Extreme (assumed)

Notes: 1. Elevations based on bathymetric survey performed by R&R Engineers-Surveyors February 2021 and LiDAR data for areas beyond water's edge at time of survey. Survey elevations converted from local datum (SH10 benchmark) to NAVD 88.
2. Outlet invert at downstream manhole below State Highway 10.
3. Estimated outlet capacity per owner (see Dam Safety Engineer's Inspection Report).

The proposed stage-storage curve for the Maria Steven Reservoir is shown in the following figure which was based on a survey of the dam and reservoir performed by R&R Engineers-Surveyors in 2021.

[1] Rules and Regulations for Dam Safety and Dam Construction. Colorado Division of Water Resources, Office of the State Engineer, Dam Safety. Effective January 1, 2020.
[2] Hydrologic Basin Response Parameter Estimation Guidelines, Office of the State Engineer, Dam Safety Branch. Revised May 2008.
[3] Guidelines for the Use of Regional Extreme Precipitation Study (REPS) Rainfall Estimation Tools. Colorado Division of Water Resources, Office of the State Engineer, Dam Safety. Effective January 7, 2020.
[4] Guidelines for Hydrologic Hazard Analysis. Colorado Division of Water Resources, Office of the State Engineer, Dam Safety. Effective January 21, 2020

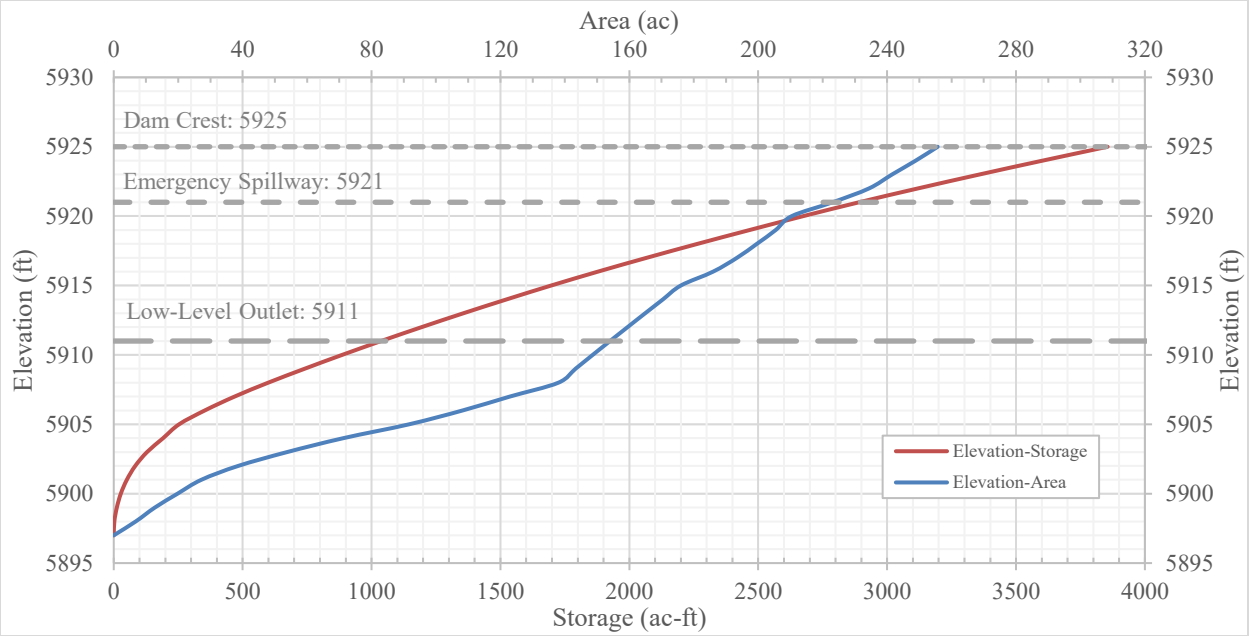


FIGURE 2. STAGE STORAGE CURVE

The proposed emergency spillway in the 50% Design consists of a trapezoidal-shaped open channel, with a 20-foot bottom width and 3H:1V that provides 4-feet of freeboard from the spillway invert to the dam crest. The proposed spillway will also be realigned from its existing location in the dam groin toward the east to improve hydraulics and mitigate dam safety concerns associated with scour and potential headcutting of the channel through the spillway crest. A detailed description of the proposed auxiliary spillway goes beyond the intention of this Report but more details on the current auxiliary spillway design can be found in the *Maria Stevens Reservoir Enlargement 50% Design* Report. The rating curve of the proposed spillway described in the *50% Design Report* is shown in the following figure. Please note that the current auxiliary spillway design is not finalized and subject to change; a *Design Report* detailing the final spillway design will be submitted in accordance with Rule 6.8 of the *Rules and Regs* once the final design phase is complete.

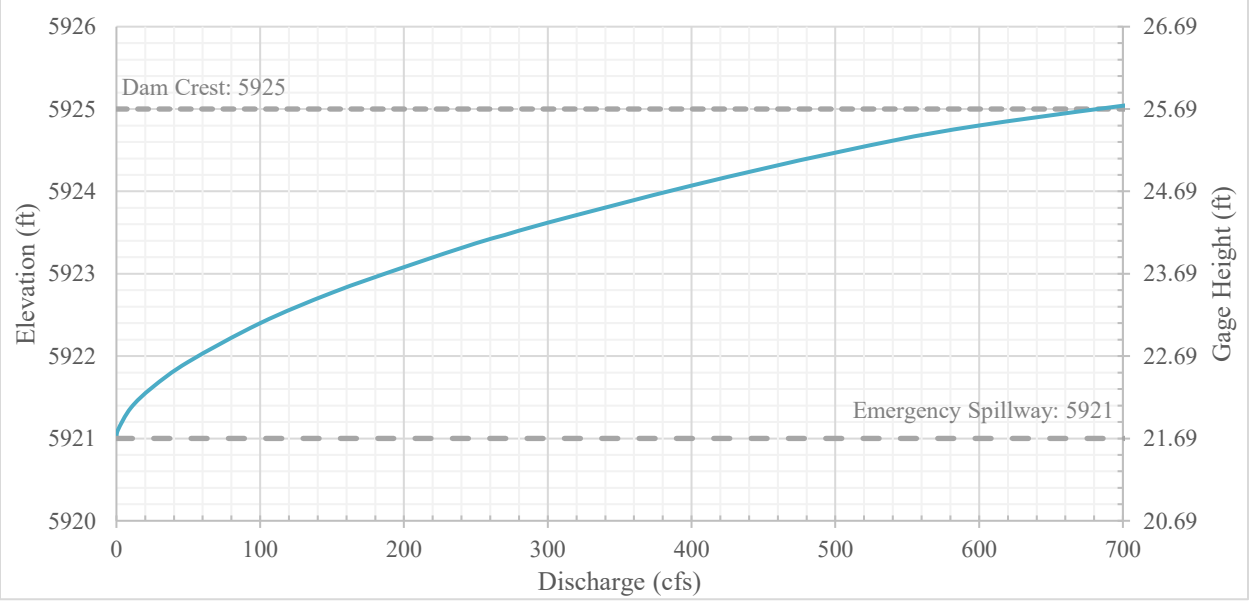


FIGURE 3. 50% DESIGN AUXILIARY SPILLWAY RATING CURVE

HYDROLOGIC HAZARD CLASSIFICATION

Section 2 of the *Hydrologic Hazard Guidelines* allow for the presumption of an Extreme Hydrologic Hazard classification for a structure without further justification. An Extreme Hydrologic Hazard classification was presumed for Maria Stevens Dams and Reservoir in lieu of a formal Hydrologic Hazard Analysis.

HYDROLOGY

Following Rule 7.2 of the *Rules and Regulations*, the Prescriptive Method was used to determine the Inflow Design Flood (IDF) for Maria Stevens Reservoir. The presumed Extreme Hydrologic Hazard designation for Maria Stevens Dams and Reservoir establishes the probable maximum precipitation (PMP) as the design event to determine the IDF.

DRAINAGE BASIN

The contributing drainage basin for the Maria Stevens Reservoir was determined using *USGS Colorado StreamStats Web Application*, with results of the StreamStats analysis provided in Appendix A. The drainage basin contributing to the Maria Steven Reservoir is small at approximately 464 acres. A map of the Maria Stevens Reservoir's drainage basin is shown in the following figure.

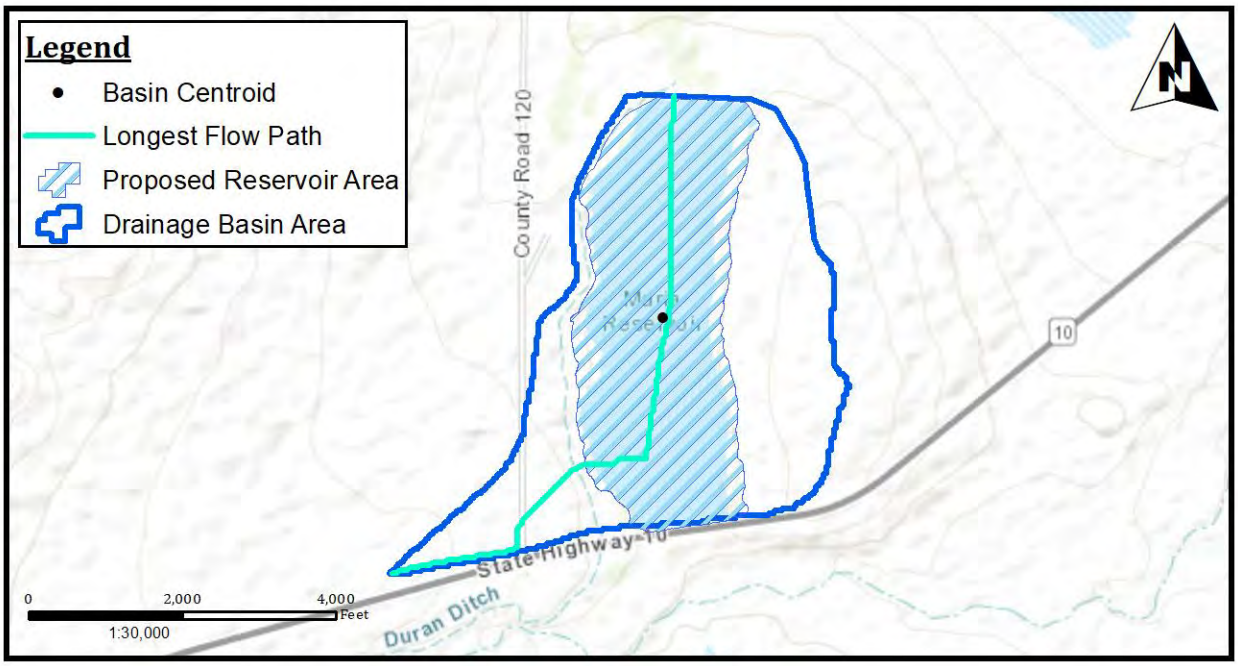


FIGURE 4. MARIA STEVENS DAMS WATERSHED

The topography of the drainage basin is relatively flat ranging in elevation from 5899 to 5970 feet. Geologically, the reservoir is located in an area of the Niobrara Formation (limestone) and the Pierre Shale formation (siltstone and shale). Vegetation surrounding the reservoir is sparse and is predominantly native grasses and small shrubs. The drainage basin is characteristic of the Great Plains, as described in the State of Colorado Hydrologic Basin Response Guidelines. The land use within the drainage basin is agricultural and/or pasture, with a few sheds and houses located on the western bank of the reservoir that fall within the drainage basin boundary.

UNIT HYDROGRAPH

A Clark Unit Hydrograph was utilized to model the drainage basin of Maria Stevens Reservoir response to excess rainfall from the design precipitation per *Hydrologic Basin Response Parameter Estimation Guidelines*. The Clark Unit Hydrograph relies on the time of concentration (T_c), storage coefficient (R), and the time-area relation parameters which are described below:

- **Time of Concentration, T_c:** Time of concentration was calculated according to the following equation, which is recommended for rocky mountain, great plains, or Colorado Plateau type watersheds:

$$T_c = 2.4A^{0.1}L^{0.25}L_{ca}^{0.25}S^{-0.2}$$

  The area (A), length of longest flow path (L), length from concentration point to point along L perpendicular basin centroid (L_{ca}), and watercourse slope (S) were determined utilizing ArcGIS software to analyze USGS StreamStats Colorado data outputs.
- **Storage Coefficient, R:** The storage coefficient for Maria Stevens Reservoir drainage basin was calculated according to the following equation utilizing the aforementioned parameters:

$$R = 0.37T_c^{1.11}L^{0.80}A^{-0.57}$$

- **Time-Area Relation:** A Curve C dimensionless synthetic time-area relation was selected for Maria Stevens Reservoir's drainage basin which is recommended for undeveloped mountain or plains areas with interspersed agriculture fields.

Table 2 summarizes pertinent Clark Unit Hydrograph parameters.

TABLE 2 - CLARK UNIT HYDROGARPH PARAMETERS

Parameter	Value
A	0.725 miles^2
L	1.69 miles
L_{ca}	0.606 miles
S	37.7 ft/mile
T_c	1.13 hours
R	0.78 hours

LOSS METHOD

The Green and Ampt Infiltration Method was used to calculate rainfall losses according to *Hydrology Guidelines*. The Green & Ampt Infiltration Method involves hydraulic conductivity (XKSAT), wetting front capillary suction (PSIF), initial volumetric soil moisture deficit (DTHETA), surface retention loss (IA), and effective impervious area (RTIMP) parameters to model infiltration of rainfall into the soil; development of these parameters are described below:

- **Hydraulic Conductivity, XKSAT:** The NRCS Web Soil Survey database was utilized to determine USDA texture classes for map units occurring within Maria Stevens Reservoir drainage basin (Appendix B).

  Bare ground XKSAT values were applied to individual components of each map unit according to Table 10 of the *Hydrology Guidelines* utilizing the lowest XKSAT value occurring within soil horizons down to a depth of 18 inches. A vegetation cover correction factor was applied to bare ground XKSAT values, except those for sand and loamy sand textures, according to the following equation.

$$C_k = \frac{V_c - 10}{90} + 1.0$$

Where:

C_k = Ratio of XKSAT to Bare Ground XKSAT

V_c = Vegetation Cover % (assumed to be 75% for this analysis based on a review of aerial imagery of the basin)

A composite XKSAT for the basin was developed excluding components containing 'unweathered bedrock' USDA textures.

- **Wetting Front Capillary Suction, PSIF & Initial Volumetric Soil Moisture Deficit, DTHETA:** These parameters were determined according to Figure 4 of the *Hydrology Guidelines* utilizing the composite bare ground XKSAT described above assuming a normal antecedent soil moisture condition.
- **Surface Retention Loss, IA:** Table 8 of the *Hydrology Guidelines* was referenced to determine a surface retention loss parameter value for the basin assuming 75% vegetation cover and an average basin slope of 1% which was ascertained from USGS Colorado StreamStats Web Application.
- **Effective Impervious Area, RTIMP:** Areas of soil map units containing weathered bedrock USDA textures within the first 18 inches of depth were assumed to contribute to the effective impervious area along with the area associated with the normal operating pool of the proposed reservoir.

Spreadsheet for Computing Rainfall Losses tool was obtained from the Dam Safety Branch website and was utilized to calculate the parameters described above and is included in Appendix C. Final Green and Ampt Infiltration parameter values utilized in this analysis are summarized in *TABLE 3* below.

TABLE 3 - GREEN AND AMPT INFILTRATION PARAMETERS

Parameter	Value
Weighted Average % Vegetation Cover	75%
Initial Abstraction (IA)	0.8 inches
Wetting Front Capillary Suction (PSIF)	9 inches
Volumetric Soil Moisture Deficit at the start of rainfall (DTHETA)	0.15
Adjusted Hydrologic Conductivity at Natural Saturation adjusted for vegetation (XKSAT)	0.07 inches/hour
Effective Impervious Area (RTIMP)	46%

DESIGN STORM

Probable Maximum Precipitation (PMP) storm events are required to determine the IDF for Extreme Hydrologic Hazard dams per Rule 7.2.1 of the *Rules and Regs*. Probable Maximum Precipitation storm hyetograph data was gathered utilizing *CO-NM REPS PMP Tool* within ArcGIS using a shapefile of Maria Stevens Reservoir's contributing drainage basin as an input. An Atmospheric Moisture Factor of 1.07 was applied to each PMP storm event considered for Maria Stevens Reservoir which are summarized in the following table:

TABLE 4 - DESIGN RAINFALL SUMMARY

Hydrologic Hazard	Storm	Total Rainfall *(in)*	Total Rainfall x 1.07 *(in)*
Extreme	Local Storm 2-hour Stacked PMP	11.39	12.19
	Local Storm 6-hour Synthetic East PMP	16.59	17.75
	Local Storm 24-hour Synthetic Hybrid PMP	22.19	23.74
	General Storm 72-hour Synthetic East PMP	20.2	21.61
	Tropical Storm 72-hour Synthetic East PMP	13.1	14.02

INFLOW DESIGN FLOOD ROUTING

A HEC-HMS 4.9 model was generated utilizing the hydrologic parameters and proposed reservoir conditions described above to simulate the IDF for Maria Stevens Reservoir under proposed conditions. A copy of the HEC-HMS 4.9 model accompanies this submittal as Appendix D. The starting water surface for the simulation was set to the normal water surface elevation equal to the proposed auxiliary spillway invert elevation at 5,921 feet. Model results for IDFs generated from the PMP storm event variants are summarized in the table below.

TABLE 5. HEC-HMS IDF ROUTING RESULTS

Storm Event	Design Rainfall (in)	Runoff Volume (ac-ft)	Peak Runoff (cfs)
Local Storm 2-hour Stacked PMP	12.19	425.7	2,347.4
Local Storm 6-hour Synthetic East PMP	17.75	627.4	2,134.1
Local Storm 24-hour Synthetic Hybrid PMP	23.74	830.0	1,785.6
General Storm 72-hour Synthetic East PMP	21.61	677.4	672.3
Tropical Storm 72-hour Synthetic East PMP	14.02	446.0	423.9

Inflow Design Flood hydrographs produced from the HEC-HMS model are shown in the following figure.

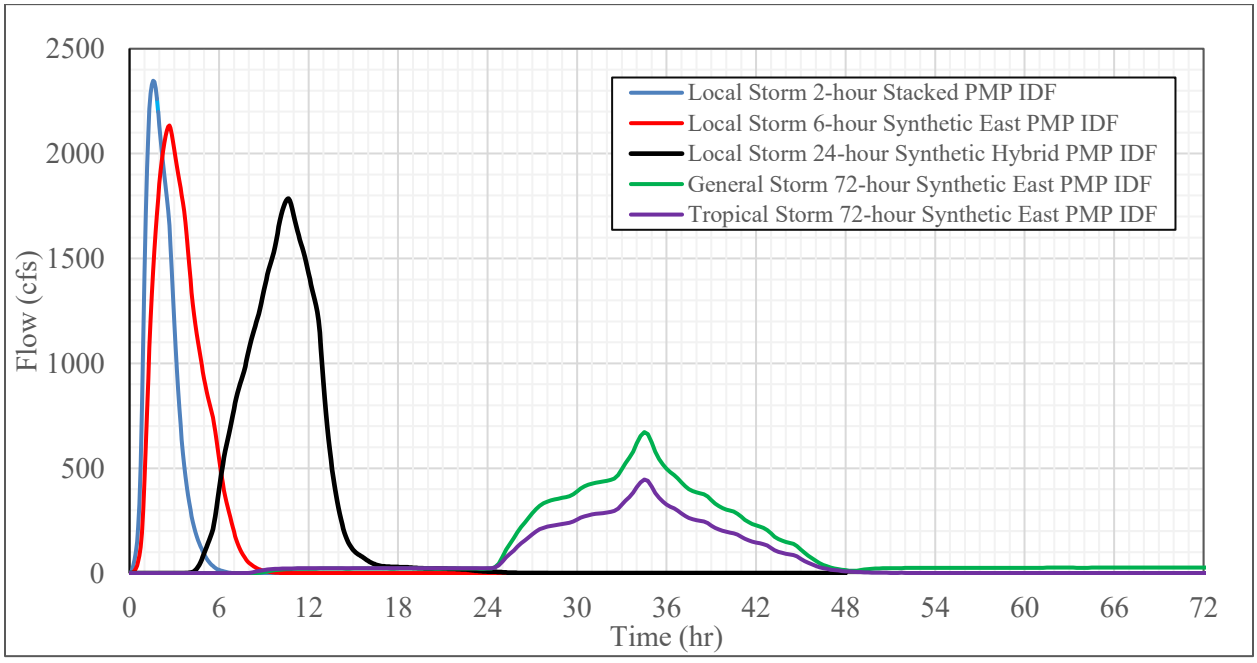


FIGURE 5. PMP DESIGN STORM IDF HYDROGRAPHS

The IDF resulting from the 24-hour Synthetic Hybrid PMP local storm was the critical IDF presuming an Extreme Hydrologic Hazard designation and thus will be utilized for final design of the proposed spillway at Maria Stevens Reservoir. The simulation results indicate that the current auxiliary spillway design is capable of passing the design IDF with 1.1 feet of residual freeboard thus meeting the requirements of Rule 7.4.2.2.2 of the *Rules and Regs*. The design IDF presented along with the spillway discharge hydrograph at this 50% state of analysis are shown in the following figure.

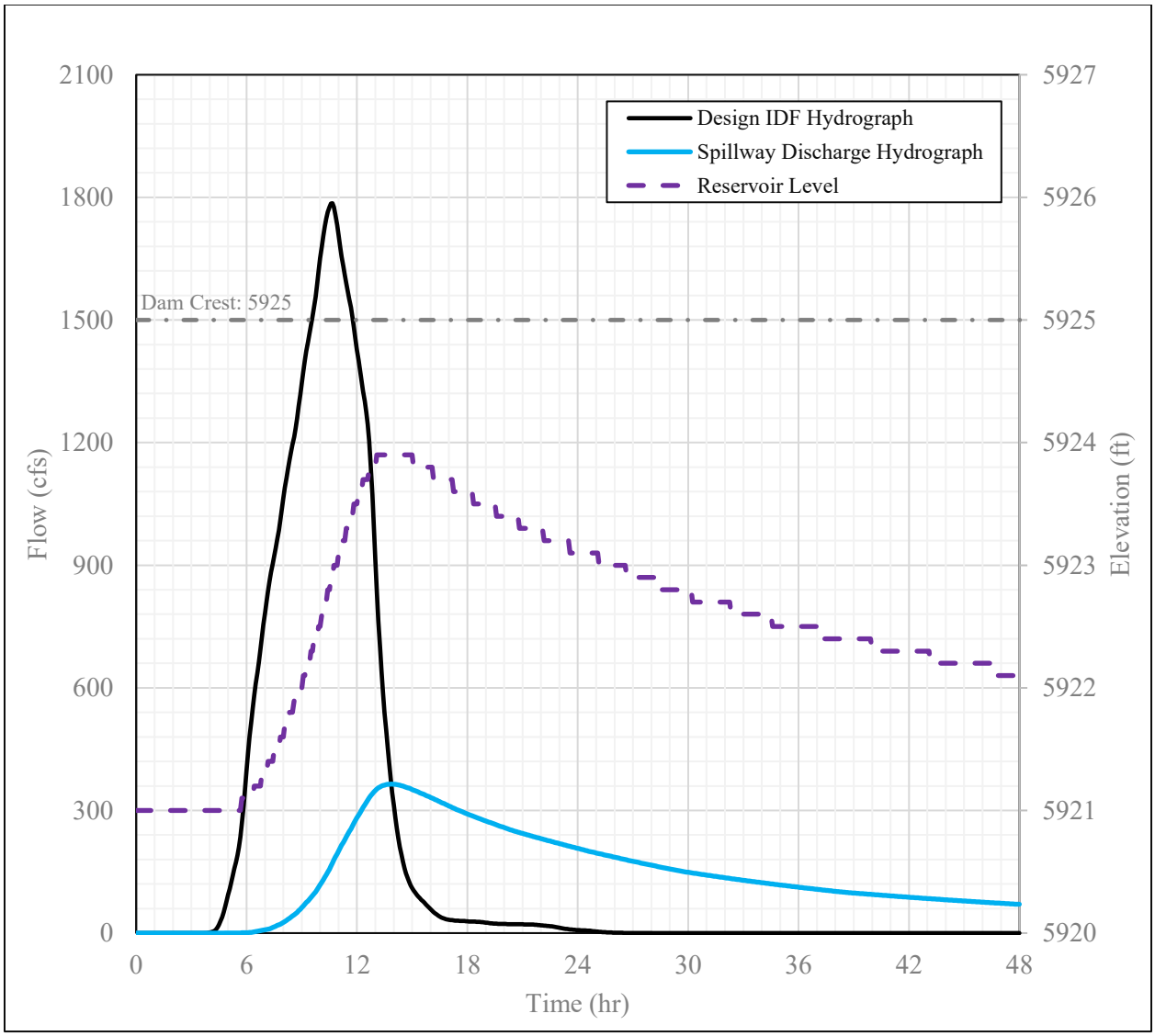


FIGURE 6. DESIGN IDF ROUTING RESULTS

REASONABLENESS CHECK

A 'Reasonableness Check' involves comparing hydrology study results against the available flood record to help validate hydrologic results and assist with model calibration. The concept of a 'Reasonableness Check' is currently being introduced by the Colorado Dam Safety branch along with updated hydrology guidelines to be implemented on hydrologic analysis for dams in Colorado. The updated hydrology guidelines have been released by the Dam Safety Branch in a preliminary draft state and were utilized in this analysis to validate the results of the hydrology study for Maria Stevens Reservoir.

Peak runoff generated from 1%, 0.1% and 0.01% AEP frequency design storms were determined for Maria Stevens Reservoirs following similar methods described above for the PMP design storms. The 1% AEP peak flood flow determined from *USGS Colorado StreamStats Web Application* was also referenced for comparison purposes. Peak flow values were plotted on the observed peak flow and peak flow envelope vs drainage area chart developed for the Eastern Plain region of Colorado as shown in the following figure.

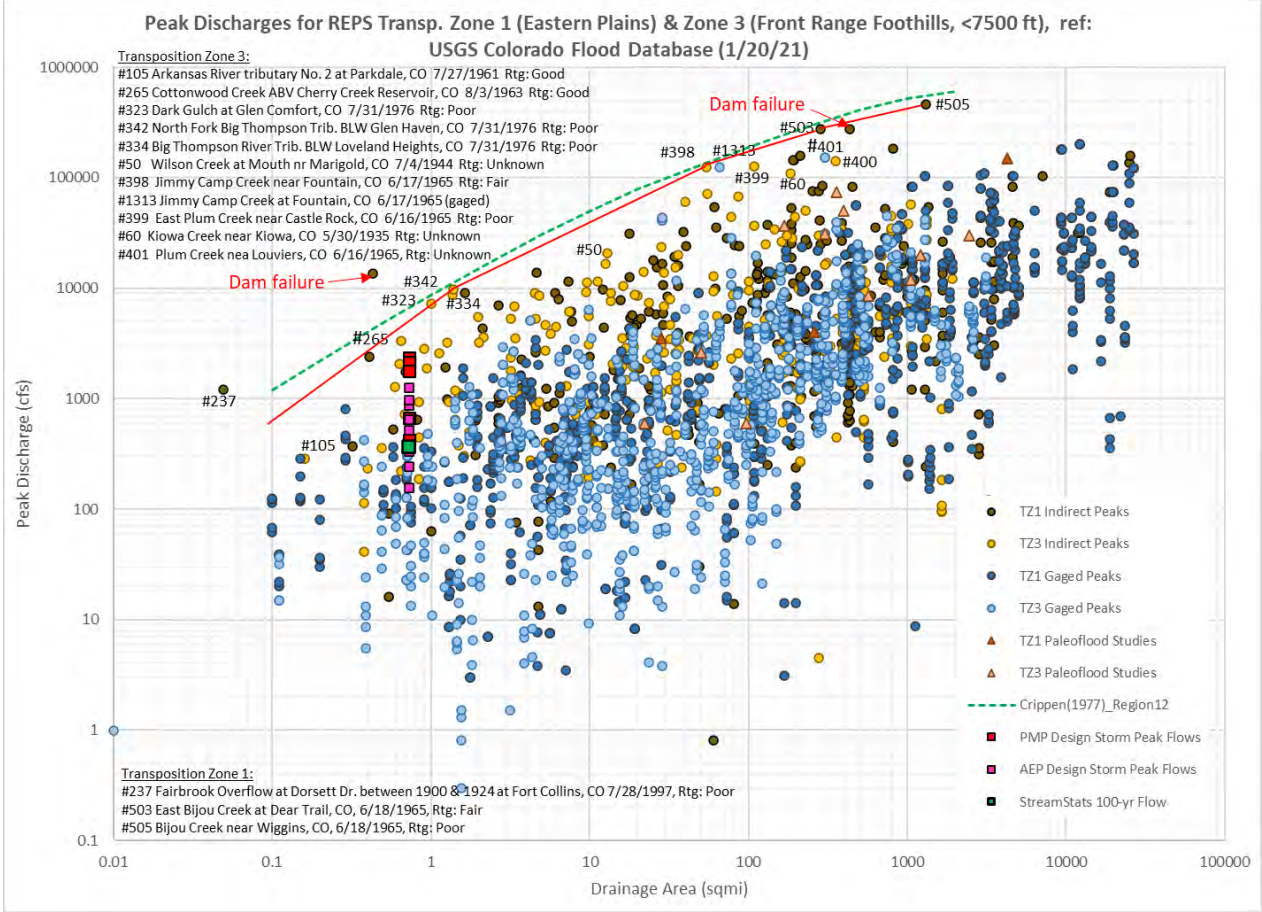


FIGURE 7. PEAK FLOW ENVELOPE CURVE PLOT WITH MARIA STEVENS RESERVOIR IDF PEAK FLOWS

The peak flows generated by HEC-HMS fall within the range of values shown on the chart. The peak flows are clustered toward the upper portion of values most likely due to the conservative nature of the hydrologic analysis presented in this report. The model results were deemed reasonable when compared to values shown on the chart.

SUMMARY

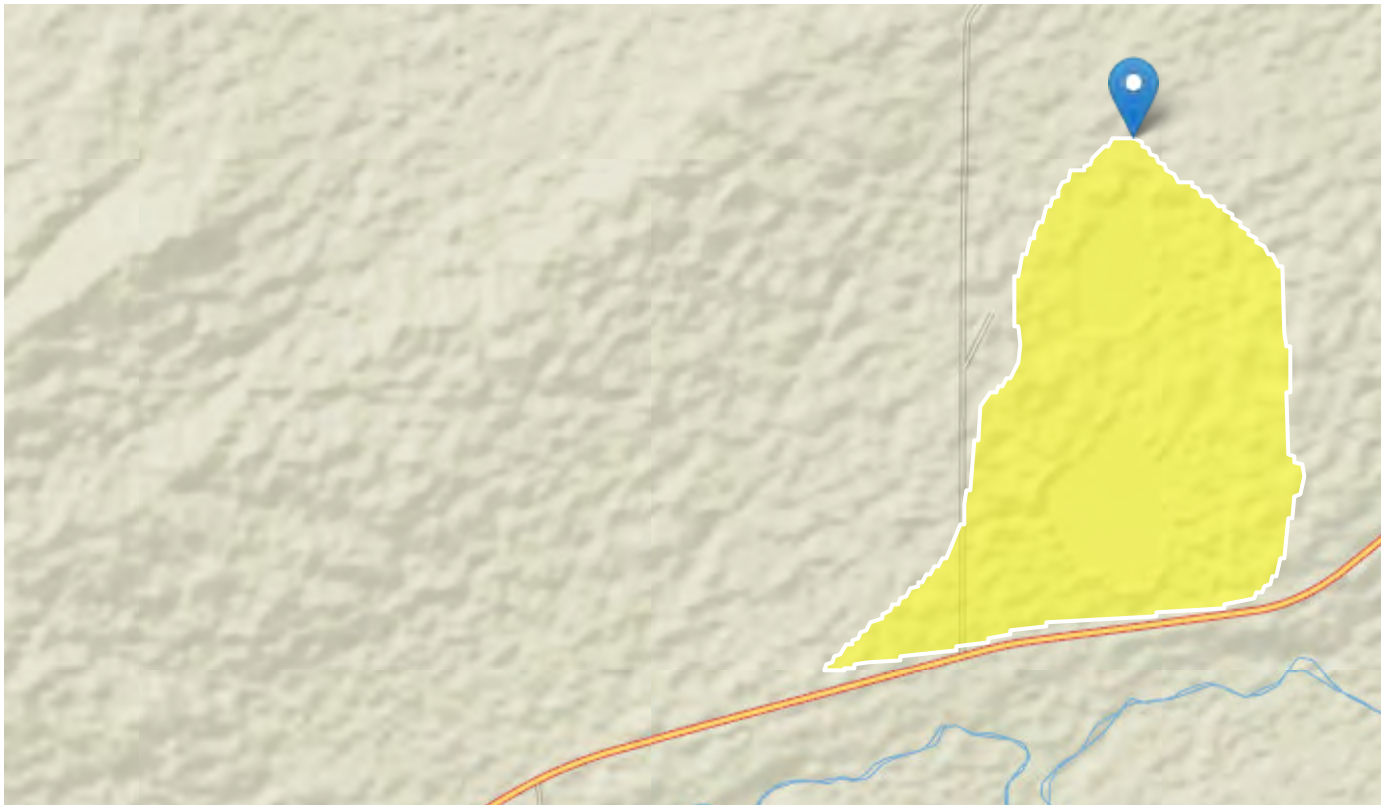
Applegate Group was retained by the Huerfano County Water Conservancy District (HCWCD) to complete a Hydrology Study for Maria Stevens Reservoir as part of a greater effort to enlarge the reservoir. A Hydrology Study was completed according to the *Hydrology Guidelines* presuming an Extreme Hydrologic Hazard designation under proposed reservoir conditions. The corresponding PMP design storms were simulated in a HEC-HMS 4.9 model to determine the controlling design IDF for spillway design. The results of the Hydrology Study determined the 24-hour Synthetic Hybrid PMP local storm as the critical design IDF and confirmed that the auxiliary spillway included in 50% design is able to pass the design IDF with adequate residual freeboard.

APPENDIX A

USGS STREAMSTATS REPORT

StreamStats Report - Maria Stevens

Region ID: CO
Workspace ID: CO20220317220709791000
Clicked Point (Latitude, Longitude): 37.68443, -104.67894
Time: 2022-03-17 16:07:29 -0600



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.73	square
I6H100Y	6-hour precipitation that is expected to occur on average once in 100 years	3	inches
STATSCLAY	Percentage of clay soils from STATSGO	35.7	percent
OUTLETELEV	Elevation of the stream outlet in feet above NAVD88	5903	feet
BSLDEM10M	Mean basin slope computed from 10 m DEM	1	percent

Parameter Code	Parameter Description	Value	Unit
CSL1085LFP	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 2D grid	35.5	feet pe
EL7500	Percent of area above 7500 ft	0	percent
ELEV	Mean Basin Elevation	5925	feet
ELEVMAX	Maximum basin elevation	5970	feet
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	4.54	inches
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	1.82	inches
I6H2Y	Maximum 6-hour precipitation that occurs on average once in 2 years	1.35	inches
LAT_OUT	Latitude of Basin Outlet	37.684463	degree
LC11BARE	Percentage of barren from NLCD 2011 class 31	0	percent
LC11CRPHAY	Percentage of cultivated crops and hay, classes 81 and 82, from NLCD 2011	0	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	0	percent
LC11FOREST	Percentage of forest from NLCD 2011 classes 41-43	0.9	percent
LC11GRASS	Percent of area covered by grassland/herbaceous using 2011 NLCD	45.4	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	7.8	percent
LC11SHRUB	Percent of area covered by shrubland using 2011 NLCD	7.8	percent
LC11SNOIC	Percent snow and ice from NLCD 2011 class 12	0	percent
LC11WATER	Percent of open water, class 11, from NLCD 2011	44.2	percent
LC11WETLND	Percentage of wetlands, classes 90 and 95, from NLCD 2011	2	percent
LFPLENGTH	Length of longest flow path	1.78	miles
LONG_OUT	Longitude of Basin Outlet	-104.678981	degree
MINBELEV	Minimum basin elevation	5900	feet
PRECIP	Mean Annual Precipitation	16.68	inches

Parameter Code	Parameter Description	Value	Unit
RCN	Runoff-curve number as defined by NRCS (http://policy.nrcs.usda.gov/OpenNonWebContent.aspx?content=17758.wba)	83.25	dimens
RUNCO_CO	Soil runoff coefficient as defined by Verdin and Gross (2017)	0.23	dimens
SSURGOA	Percentage of area of Hydrologic Soil Type A from SSURGO	0.55	percent
SSURGOB	Percentage of area of Hydrologic Soil Type B from SSURGO	3.55	percent
SSURGOC	Percentage of area of Hydrologic Soil Type C from SSURGO	49.5	percent
SSURGOD	Percentage of area of Hydrologic Soil Type D from SSURGO	1.29	percent
STORNHD	Percent storage (wetlands and waterbodies) determined from 1:24K NHD	40.2	percent
TOC	Time of concentration in hours	2.86	hours

Peak-Flow Statistics Parameters [Foothills Region Peak Flow 2016 5099]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.73	square miles	0.6	2850
I6H100Y	6 Hour 100 Year Precipitation	3	inches	2.38	4.89
STATSCLAY	STATSGO Percentage of Clay Soils	35.7	percent	9.87	37.5
OUTLETELEV	Elevation of Gage	5903	feet	4290	8270

Peak-Flow Statistics Flow Report [Foothills Region Peak Flow 2016 5099]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
50-percent AEP flood	23.5	ft^3/s	117
20-percent AEP flood	69.5	ft^3/s	87

Statistic	Value	Unit	ASEp
10-percent AEP flood	118	ft^3/s	80
4-percent AEP flood	199	ft^3/s	80
2-percent AEP flood	276	ft^3/s	83
1-percent AEP flood	370	ft^3/s	88
0.5-percent AEP flood	480	ft^3/s	94
0.2-percent AEP flood	655	ft^3/s	104

Peak-Flow Statistics Citations

Kohn, M.S., Stevens, M.R., Harden, T.M., Godaire, J.E., Klinger, R.E., and Mommandi, A.,2016, Paleoflood investigations to improve peak-streamflow regional-regression equations for natural streamflow in eastern Colorado, 2015: U.S. Geological Survey Scientific Investigations Report 2016–5099, 58 p. (http://dx.doi.org/10.3133/sir20165099)

Application Version: 4.7.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.2

APPENDIX B

NRCS WEB SOIL SURVEY REPORT

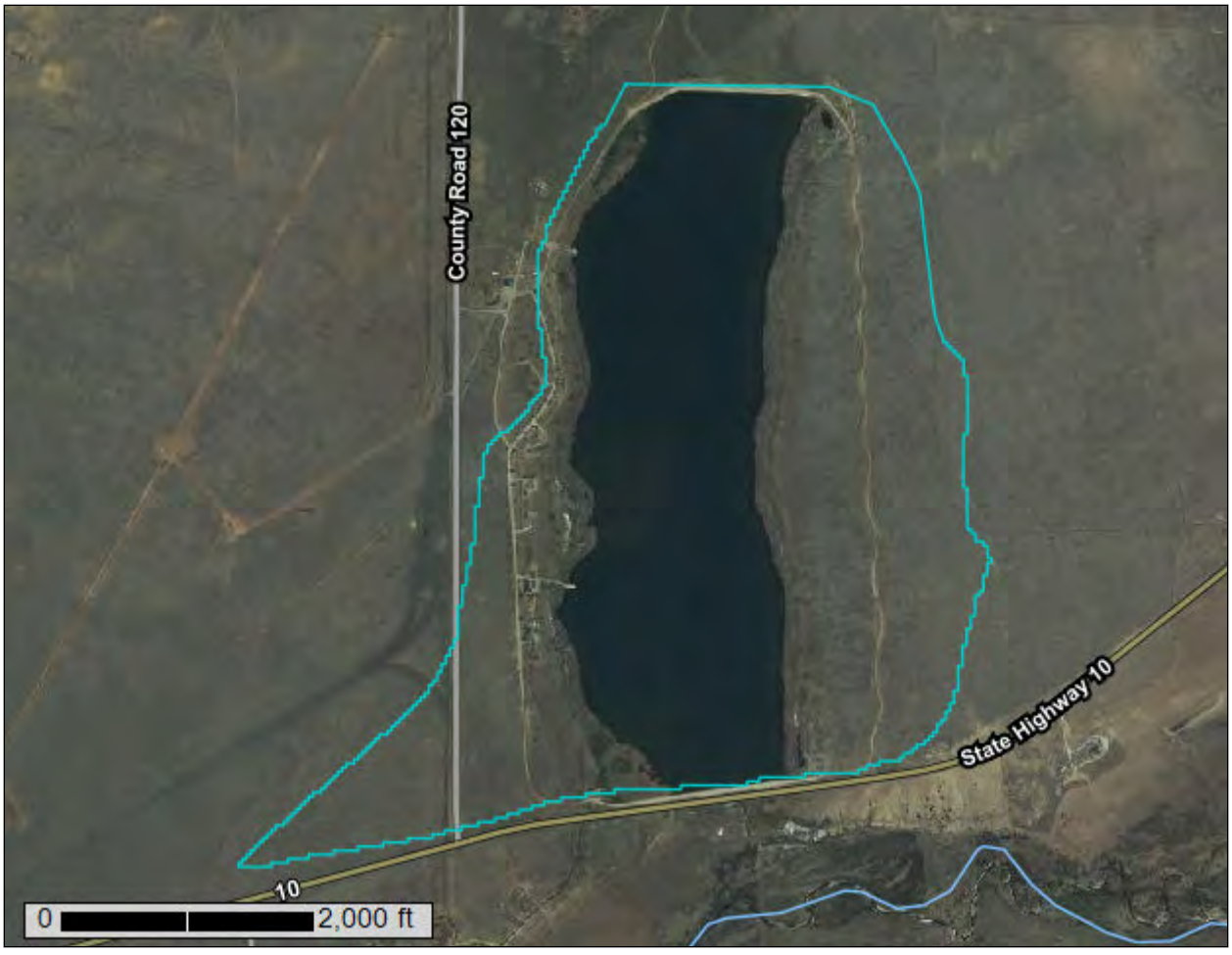
United States Department of Agriculture

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 Huerfano County Area, Colorado



October 28, 2020

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 (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

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

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

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

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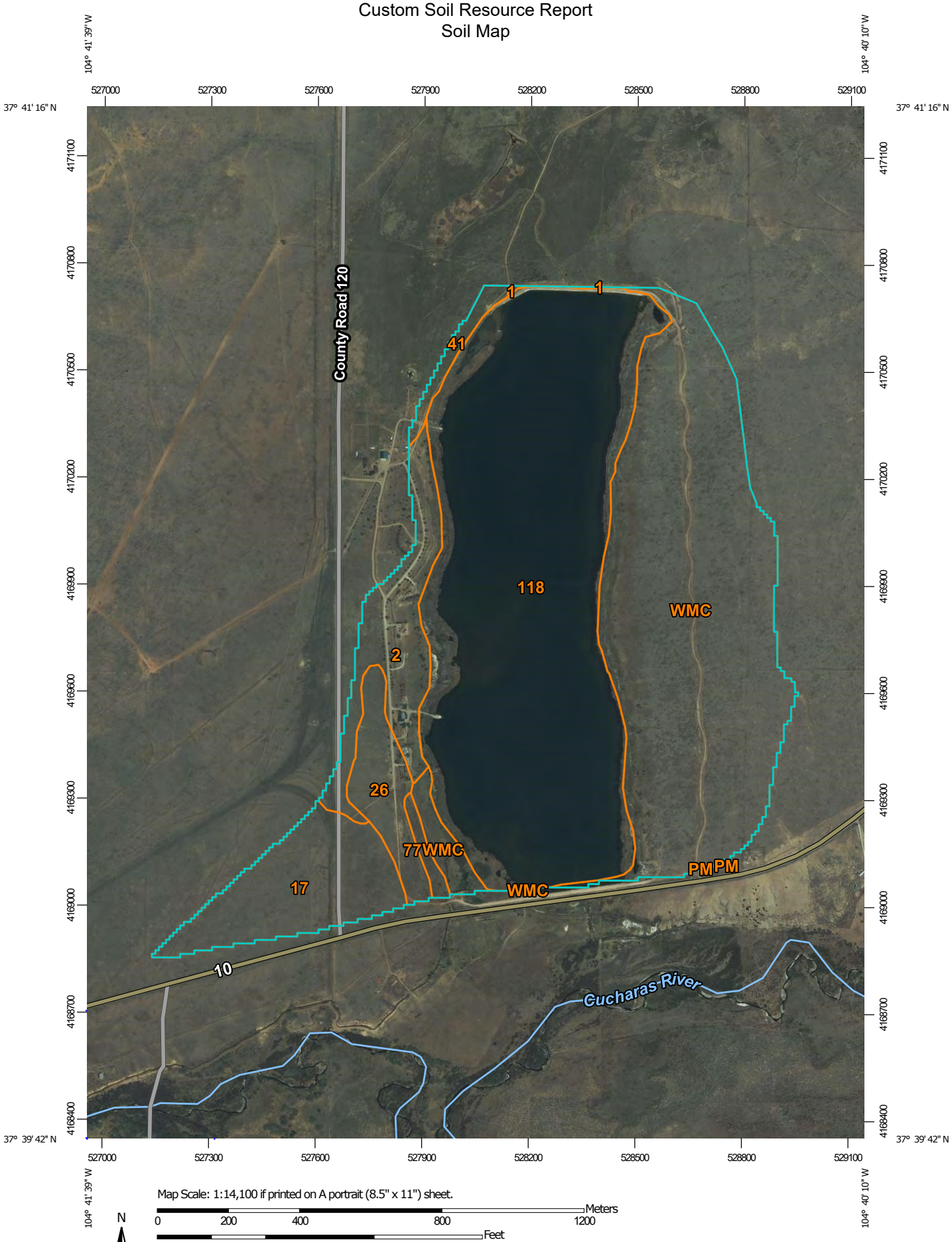
Soil Map

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

Custom Soil Resource Report
Soil Map



MAP LEGEND

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

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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: Huerfano County Area, Colorado
Survey Area Data: Version 17, Jun 10, 2020

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

Date(s) aerial images were photographed: Mar 31, 2020—May 18, 2020

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
1	Apishapa silty clay	0.3	0.1%
2	Baca silt loam, 0 to 3 percent slopes, cool	30.1	6.5%
17	Fort Collins loam, 1 to 3 percent slopes	36.5	7.9%
26	Kim fine sandy loam, 3 to 9 percent slopes	16.8	3.6%
41	Manvel silty clay loam saline, 1 to 5 percent slopes	4.6	1.0%
77	Schamber-Midway complex, 3 to 25 percent slopes	2.6	0.6%
118	Water	212.8	45.8%
PM	Penrose-Minnequa complex, 1 to 15 percent slopes	0.1	0.0%
WMC	Minqwet-Wiley silt loams, 1 to 4 percent slopes, cool	161.1	34.6%
Totals for Area of Interest		**464.9**	**100.0%**

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas

are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

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

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

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

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

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

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

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

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

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

Huerfano County Area, Colorado

1—Apishapa silty clay

Map Unit Setting

National map unit symbol: jnl9
Elevation: 5,500 to 6,000 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 135 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Apishapa and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Apishapa

Setting

Landform: Terraces, alluvial fans, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium derived from shale

Typical profile

A - 0 to 6 inches: silty clay
Cg - 6 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 12 to 36 inches
Frequency of flooding: NoneFrequent
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Slightly saline to strongly saline (4.0 to 16.0 mmhos/cm)
Available water capacity: Moderate (about 7.2 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: D
Ecological site: R069XY030CO - Salt Meadow LRU's A & B
Hydric soil rating: Yes

Minor Components

Manzanola

Percent of map unit: 5 percent

Hydric soil rating: No

2—Baca silt loam, 0 to 3 percent slopes, cool

Map Unit Setting

National map unit symbol: 2rh18
Elevation: 6,000 to 6,500 feet
Mean annual precipitation: 14 to 16 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 140 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Baca, cool, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Baca, Cool

Setting

Landform: Terraces, fans
Landform position (two-dimensional): Shoulder, footslope, summit
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from shale and siltstone

Typical profile

A - 0 to 6 inches: silt loam
Bt1 - 6 to 9 inches: silty clay loam
Bt2 - 9 to 25 inches: clay
Btk - 25 to 32 inches: silty clay loam
Bk1 - 32 to 45 inches: clay loam
Bk2 - 45 to 79 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 3 percent
Maximum salinity: Nonsaline to very slightly saline (0.5 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Forage suitability group: Clayey (G069XW001CO)
Other vegetative classification: Clayey (G069XW001CO), Loamy Plains #2 (067XY002CO_2)
Hydric soil rating: No

Minor Components

Wiley, cool

Percent of map unit: 5 percent
Landform: Fans
Landform position (two-dimensional): Shoulder
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Other vegetative classification: Loamy (G069XW017CO), Loamy Plains #2 (067XY002CO_2)
Hydric soil rating: No

Manzanst, cool

Percent of map unit: 5 percent
Landform: Fans, closed depressions
Landform position (two-dimensional): Backslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY042CO - Clayey Plains LRU's A & B
Other vegetative classification: Clayey (G069XW001CO)
Hydric soil rating: No

17—Fort Collins loam, 1 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2w4ny
Elevation: 5,790 to 8,090 feet
Mean annual precipitation: 14 to 16 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 140 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Fort collins and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fort Collins

Setting

Landform: Fan remnants
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Old alluvium

Typical profile

A - 0 to 4 inches: loam
Bt - 4 to 19 inches: clay loam
Bk1 - 19 to 23 inches: clay loam
Bk2 - 23 to 79 inches: loam

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Very slightly saline (2.0 to 3.9 mmhos/cm)
Available water capacity: High (about 10.1 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Hydric soil rating: No

Minor Components

Baca

Percent of map unit: 10 percent
Landform: Fan remnants
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Hydric soil rating: No

26—Kim fine sandy loam, 3 to 9 percent slopes

Map Unit Setting

National map unit symbol: jnlw
Elevation: 5,500 to 6,500 feet

Mean annual precipitation: 12 to 15 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 135 to 165 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Kim

Setting

Landform: Plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous loamy eolian deposits

Typical profile

A - 0 to 6 inches: fine sandy loam
C - 6 to 60 inches: loam

Properties and qualities

Slope: 3 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: High (about 9.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: B
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Hydric soil rating: No

Minor Components

Otero

Percent of map unit: 15 percent
Hydric soil rating: No

Travesilla

Percent of map unit: 5 percent
Hydric soil rating: No

41—Manvel silty clay loam saline, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: jnmf
Elevation: 5,500 to 6,600 feet
Mean annual precipitation: 12 to 15 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 125 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Manvel, saline, and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Manvel, Saline

Setting

Landform: Fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty alluvium over residuum weathered from limestone and shale

Typical profile

A - 0 to 5 inches: silty clay loam
C1 - 5 to 22 inches: silty clay loam
C2 - 22 to 60 inches: silt loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water capacity: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C

Ecological site: R069XY033CO - Salt Flat LRU's A & B
Hydric soil rating: No

Minor Components

Otero
Percent of map unit: 15 percent
Hydric soil rating: No

Limon
Percent of map unit: 5 percent
Hydric soil rating: No

Apishapa
Percent of map unit: 5 percent
Landform: Alluvial fans, drainageways
Landform position (three-dimensional): Tread
Hydric soil rating: Yes

77—Schamber-Midway complex, 3 to 25 percent slopes

Map Unit Setting
National map unit symbol: jnnp
Elevation: 5,500 to 6,600 feet
Mean annual precipitation: 12 to 15 inches
Mean annual air temperature: 49 to 54 degrees F
Frost-free period: 125 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition
Schamber and similar soils: 65 percent
Midway and similar soils: 20 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Schamber

Setting
Landform: Terraces, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Interfluve, head slope, riser
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy and gravelly alluvium

Typical profile
A - 0 to 5 inches: gravelly sandy loam
AC - 5 to 12 inches: very gravelly sandy loam
Ck - 12 to 60 inches: very gravelly loamy sand

Properties and qualities
Slope: 3 to 10 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very low (about 2.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R069XY046CO - Shaly Plains LRU's A & B
Hydric soil rating: No

Description of Midway

Setting

Landform: Terraces
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey slope alluvium over residuum weathered from shale

Typical profile

A - 0 to 3 inches: clay
C - 3 to 15 inches: clay
Cr - 15 to 19 inches: weathered bedrock

Properties and qualities

Slope: 8 to 25 percent
Depth to restrictive feature: 6 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 15 percent
Maximum salinity: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 15.0
Available water capacity: Very low (about 2.5 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R069XY046CO - Shaly Plains LRU's A & B
Hydric soil rating: No

Minor Components

Kim

Percent of map unit: 15 percent
Hydric soil rating: No

118—Water

Map Unit Composition

Water: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Minor Components

Aquolls

Percent of map unit: 3 percent
Landform: Marshes
Landform position (three-dimensional): Talf
Hydric soil rating: Yes

Other soils

Percent of map unit: 2 percent
Landform: Marshes
Landform position (three-dimensional): Talf
Hydric soil rating: Yes

PM—Penrose-Minnequa complex, 1 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2rgr8
Elevation: 4,500 to 6,500 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 125 to 170 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Penrose

Setting

Landform: Scarps, hogbacks, hills
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Slope alluvium over residuum weathered from limestone

Typical profile

A - 0 to 4 inches: channery loam
C - 4 to 15 inches: channery loam
R - 15 to 79 inches: bedrock

Properties and qualities

Slope: 1 to 15 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 70 percent
Maximum salinity: Nonsaline (0.1 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Very low (about 1.8 inches)

Interpretive groups

Land capability classification (irrigated): 6s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: R069XY058CO - Limestone Breaks LRU's A & B
Other vegetative classification: Limestone Breaks #58 (069XY058CO_2)
Hydric soil rating: No

Description of Minnequa

Setting

Landform: Ridges, interfluves
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Slope alluvium over residuum weathered from limestone and shale

Typical profile

A - 0 to 6 inches: silt loam
Bw - 6 to 18 inches: silt loam
Bky - 18 to 32 inches: loam
Cr - 32 to 79 inches: bedrock

Properties and qualities

Slope: 1 to 9 percent

Depth to restrictive feature: 20 to 39 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 45 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Nonsaline to slightly saline (0.1 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 8.0
Available water capacity: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Forage suitability group: Loamy (G069XW017CO)
Other vegetative classification: Loamy (G069XW017CO)
Hydric soil rating: No

Minor Components

Shingle

Percent of map unit: 5 percent
Landform: Hills, scree slopes
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Convex
Across-slope shape: Linear, convex
Ecological site: R069XY046CO - Shaly Plains LRU's A & B
Other vegetative classification: Needs Field Review (G069XW050CO), Shaly Plains #46 (069XY046CO_2)
Hydric soil rating: No

Rock outcrop

Percent of map unit: 5 percent
Hydric soil rating: No

Wilid

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Other vegetative classification: Loamy (G069XW017CO), Loamy Plains #6 (069XY006CO_2)
Hydric soil rating: No

WMC—Minqwet-Wiley silt loams, 1 to 4 percent slopes, cool

Map Unit Setting

National map unit symbol: 2t50s
Elevation: 6,000 to 6,500 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 120 to 145 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Wiley, cool, and similar soils: 45 percent
Minqwet, cool, and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wiley, Cool

Setting

Landform: Interfluves, fans
Landform position (two-dimensional): Footslope, summit
Landform position (three-dimensional): Base slope, interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and/or alluvium derived from sedimentary rock

Typical profile

A - 0 to 6 inches: silt loam
Bt - 6 to 11 inches: silty clay loam
Btk - 11 to 29 inches: silty clay loam
Bk1 - 29 to 43 inches: silt loam
Bk2 - 43 to 79 inches: silt loam

Properties and qualities

Slope: 1 to 4 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Gypsum, maximum content: 3 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water capacity: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Forage suitability group: Loamy (G069XW017CO)
Other vegetative classification: Loamy (G069XW017CO), Loamy Plains #6 (069XY006CO_2)
Hydric soil rating: No

Description of Minqwet, Cool

Setting

Landform: Ridges, interfluves, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess and/or residuum weathered from limestone and shale

Typical profile

A - 0 to 5 inches: silt loam
Bk1 - 5 to 10 inches: silt loam
Bk2 - 10 to 18 inches: silty clay loam
Bky - 18 to 23 inches: silt loam
Cr - 23 to 79 inches: bedrock

Properties and qualities

Slope: 1 to 4 percent
Depth to restrictive feature: 20 to 30 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Nonsaline to moderately saline (0.5 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R069XY006CO - Loamy Plains, LRU's A & B 10-14 Inches, P.Z.
Forage suitability group: Loamy, Limy (G069XW022CO)
Other vegetative classification: Loamy, Limy (G069XW022CO), Loamy Plains #6 (69XY006XY)
Hydric soil rating: No

Minor Components

Manzanst

Percent of map unit: 5 percent

Landform: Fans, closed depressions
Landform position (two-dimensional): Backslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY042CO - Clayey Plains LRU's A & B
Other vegetative classification: Clayey (G069XW001CO)
Hydric soil rating: No

Penrose

Percent of map unit: 5 percent
Landform: Hogbacks, hills, scarps
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: R069XY058CO - Limestone Breaks LRU's A & B
Other vegetative classification: Not Suited (G069XW000CO), Limestone Breaks #58 (069XY058CO_2)
Hydric soil rating: No

Shingle

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R069XY046CO - Shaly Plains LRU's A & B
Other vegetative classification: Needs Field Review (G069XW050CO), Shaly Plains #46 (069XY046CO_2)
Hydric soil rating: No

APPENDIX C

RAINFALL LOSS SPREADSHEET

RAINFALL LOSSES Table:

BLUE = USER ENTRY
RED = EXCEL CALCULATION

Dam (DAMID): 160221
By: TJD
Date: 3/16/2022

Design Storm: 24-hr PMP (Extreme Storm/PMP (General vs. Local), Frequency Storm)

Soil Depth: 12" to 18" (Guideline: analyze 18" soil depth for Extreme Storm/PMP; 6" depth for 100-YR and more frequent storms; however user may need to analyze soil profile storage to determine relevant depth to analyze)

[B] Soil Survey ID	[C] Map Unit (MU)	[D] Landform Description	[E] Component 1 Infiltration-Limiting Soil Texture (Select from Drop Down List)	[F] % of MU	[G] Ksat1 (in/hr)	[H] Component 2 Infiltration-Limiting Soil Texture (Select from Drop Down List)	[I] % of MU	[J] Ksat2 (in/hr)	[K] Component 3 Infiltration-Limiting Soil Texture (Select from Drop Down List)	[L] % of MU	[M] Ksat3 (in/hr)	[N] Sum % MU	[O] MU Avg. Ksat (in/hr)
DATA SOURCE: Soil Survey shapefile (AREA SYMBOL field)	Soil Survey shapefile (MUSym field)	NRCS Map Unit (MU) Description Report	NRCS Engineering Properties Report	NRCS Component Legend Report	Table 10 (Sabol 2008), VLOOKUP	NRCS Engineering Properties Report	NRCS Component Legend Report	Table 10 (Sabol 2008), VLOOKUP	NRCS Engineering Properties Report	NRCS Component Legend Report	Table 10 (Sabol 2008), VLOOKUP	=[F]+[I]+[L]	Eq. 2, Sabol 2008 =10^{([F]*Log10[G]+[I]Log10[J]+[L]Log10[M])/[N]}
1	1	Apishapa silty clay	silty clay	95	0.02							95	0.02
2	2	Baca silt loam, 0 to 3 percent slopes, cool	clay	90	0.01							90	0.01
3	17	Fort Collins loam, 1 to 3 percent slopes	clay loam	90	0.04							90	0.04
4	26	Kim fine sandy loam, 3 to 9 percent slopes	loam	80	0.25							80	0.25
5	41	Manvel silty clay loam saline, 1 to 5 percent slopes	silty clay loam	75	0.04							75	0.04
6	77	Schamber-Midway complex, 3 to 25 percent slopes	sandy loam	65	0.4	clay	20	0.01				85	0.17
7	118	Water	clay	100	0.01							100	0.01
8	PM	Penrose-Minnequa complex, 1 to 15 percent slopes	loam	50	0.25	silty loam	35	0.15				85	0.20
9	WMC	Minqwet-Wiley silt loams, 1 to 4 percent slopes, cool	silty clay loam	45	0.04	silty clay loam	40	0.04				85	0.04
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SUB-BASIN 1

[B] Soil Survey ID	[P] MU Area (area units must be consistent)	[Q] MU Pervious Area	[R] MU Pervious Area* Log10(MU Avg. Ksat)	[S] % Vegetative Cover (of pervious area only)	[T] % Veg. Cover*MU Pervious Area	[U] % Veg. Cover Adjusted for Sand & Loamy Sand	[V] %Veg Cover Adj for Sand & Loamy Sand *MU Pervious Area	[W] % Impervious	[X] % Impervious *MU Area
DATA SOURCE: Soil Survey shapefile (AREA SYMBOL field)	VLOOKUP from SubX Tab (SubX tab Area data from ArcMap)	=[P]*(1-[W])	=[Q]LOG10[O]	Aerial photo, Land Use Map, Site Visit	=[S]*[Q]	Weights Sand and Loamy Sand as 10% Vegetation Cover	=[U]*[Q]	NRCS Engineering Properties Report, Aerial photo, Site Visit, Zoning Map, etc	=[W]*[P]
1	0	0	-1	75%	0	75%	0		
2	30	30	-60	75%	23	75%	23		
3	37	37	-51	75%	27	75%	27		
4	17	17	-10	75%	13	75%	13		
5	5	5	-6	75%	3	75%	3		
6	3	3	-2	75%	2	75%	2		
7	213	0	0	75%	0	75%	0	100%	213
8	0	0	0	75%	0	75%	0	5%	0
9	161	161	-225	75%	121	75%	121		
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DATA SOURCE: / **SUB-BASIN 1 SUMMARY:**

DATA SOURCE	Code	Parameter	[P]	[Q]	[R]	[S]	[T]	[U]	[V]	[W]	[X]
=Sum[P]	[AA]	Total Sub-basin Area (area units)	465								
=Sum[Q]	[BB]	Total Sub-basin Pervious Area (area units)		252							
=10^(Sum[R]/[BB]), Eq. 2 Sabol 2008	[CC]	Weighted Avg Bare Ground Ksat, (in/hr)[1,2]			0.038863877						
=Sum[T]/[BB], Eq. 1 Sabol 2008	[DD]	Weighted Avg % Vegetation Cover.[3]					75%				
From ArcMap, USGS Stream Stats, etc.	[EE]	Average Sub-basin slope (%)[3]	1.0%								
Use engineering judgment. Dry=Wilting Point, Normal=Field Capacity, OR Saturated	[FF]	Antecedent Moisture Condition[1,3]	normal								
Table 8, Sabol 2008	[GG]	Initial Abstraction (IA), (inches)	0.8								
Figure 4, Sabol 2008 (function of Bare Ground Ksat, [CC])	[HH]	Green & Ampt (G&A) Suction Head, PSIF, (in)	9								
Figure 4, Sabol 2008 (function of Bare Ground Ksat, [CC])	[II]	G&A Soil Moisture Deficit, DTHETA (vol/vol)	0.15								
=Sum[V]/[BB], Eq. 1 Sabol 2008	[JJ]	Sub-basin Weighted Avg Adj. % Vegetation Cover[4] (adjusted for Sand & Loamy Sand).							75%		
=1+([JJ]-10%)/90%, Figure 8 Sabol 2008	[KK]	Vegetation Cover Factor	1.72								
=[KK]*[CC]	[LL]	Adjusted Ksat, XKSAT, (in/hr)	0.07								
=Sum[X]/[AA], Eq. 1 Sabol 2008	[MM]	Weighted Avg. % Impervious (RTIMP)									46%

(yellow) **= HEC-HMS parameter**

Notes:
1. Use to determine G&A Moisture Deficit (DTHETA) from Figure 4 (Sabol 2008)
2. Use to determine G&A Suction Head (PSIF) from Figure 4 (Sabol 2008)
3. Use to determine IA from Table 8 (Sabol 2008)
4. Use to determine Vegetation Cover Factor from Figure 8 (Sabol 2008)

HMS 3.5 Parameter Notes:
A. For IA, use Canopy Loss/Simple Loss Method.
B. For DTHETA, set Saturated Content = 0.46 and Initial Content = 0.46 - DTHETA.

APPENDIX D

HEC-HMS REPORT

Project: Maria_Stevens
Simulation Run: MS LS 24hr PMP Run
Simulation Start: 31 December 2021, 24:00
Simulation End: 2 January 2022, 24:00

HMS Version: 4.9
Executed: 12 April 2022, 17:59

Global Parameter Summary - Subbasin

Area (MI^2)

Element Name	Area (MI^2)
MS Watershed	0.72

Downstream

Element Name	Downstream
MS Watershed	MS Reservoir

Loss Rate: Green and Ampt

Element Name	Percent Impervious Area	Initial Variable	Moisture Deficit	Wetting Front Suction	Hydraulic Conductivity
MS Watershed	46	Moisture Deficit	0.15	9	0.07

Canopy: Simple

Element Name	Allow Simultaneous Precip Et	Plant Uptake Method	Initial Canopy Storage Percent	Canopy Storage Capacity	Crop Coefficient
MS Watershed	Yes	None	0	0.8	1

Transform: Clark

Element Name	Clark Method	Time of Concentration	Storage Coefficient	Time Area Method	Time - Area Percentage Curve
MS Watershed	Specified	1.13	0.78	Paired Data	Time - Area Type C Curve

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
MS Watershed	0.72	1785.6	01Jan2022, 10:40	21.47
MS Reservoir	0.72	364.53	01Jan2022, 13:50	14.81

Subbasin: MS Watershed

Area (MI²) : 0.72
Downstream : MS Reservoir

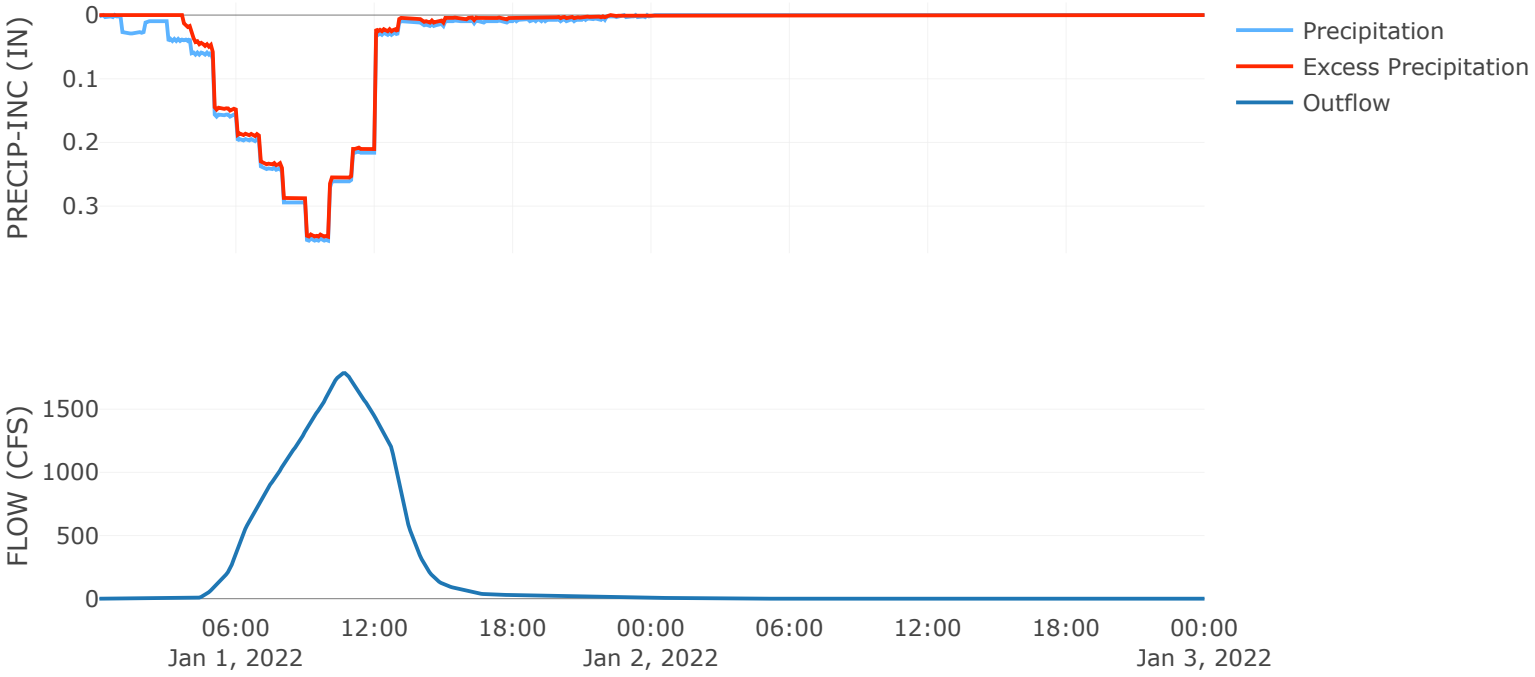
Loss Rate: Green and Ampt	
Percent Impervious Area	46
Initial Variable	Moisture Deficit
Moisture Deficit	0.15
Wetting Front Suction	9
Hydraulic Conductivity	0.07

Canopy: Simple	
Allow Simultaneous Precip Et	Yes
Plant Uptake Method	None
Initial Canopy Storage Percent	0
Canopy Storage Capacity	0.8
Crop Coefficient	1

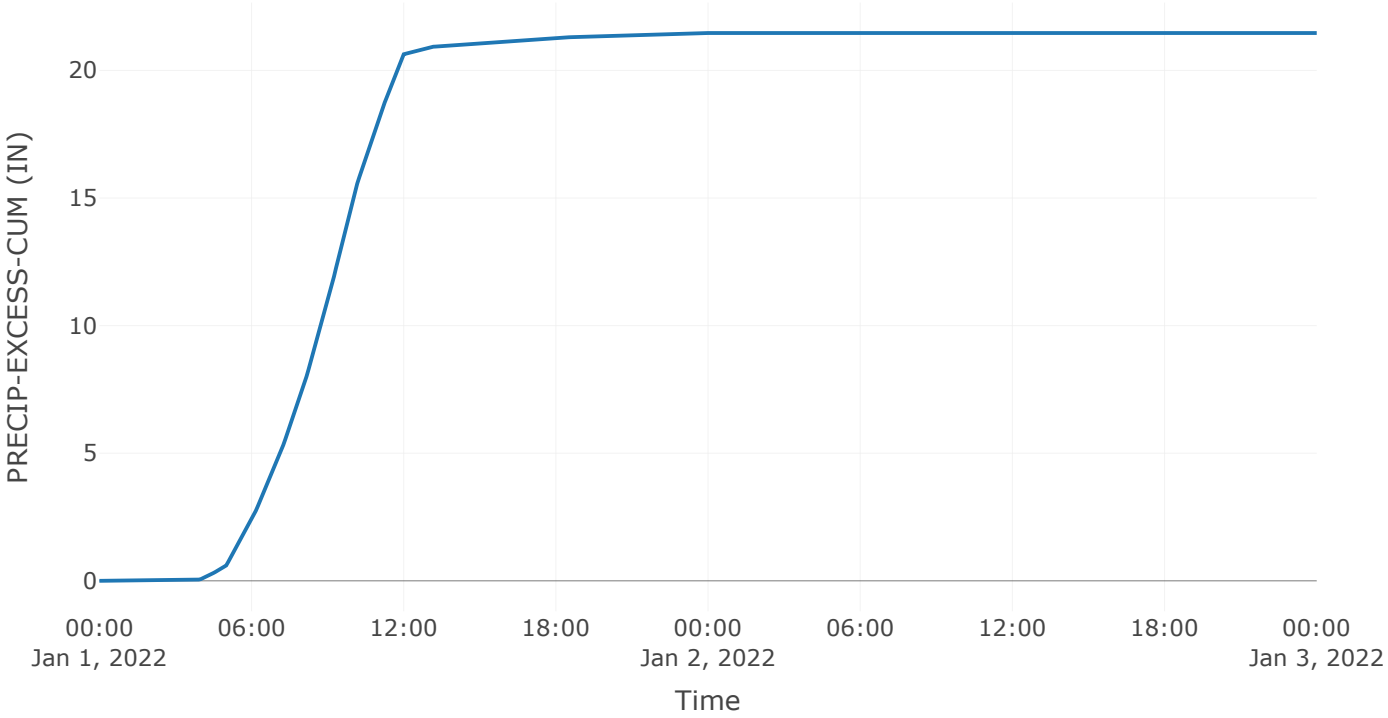
Transform: Clark	
Clark Method	Specified
Time of Concentration	1.13
Storage Coefficient	0.78
Time Area Method	Paired Data
Time - Area Percentage Curve	Time - Area Type C Curve

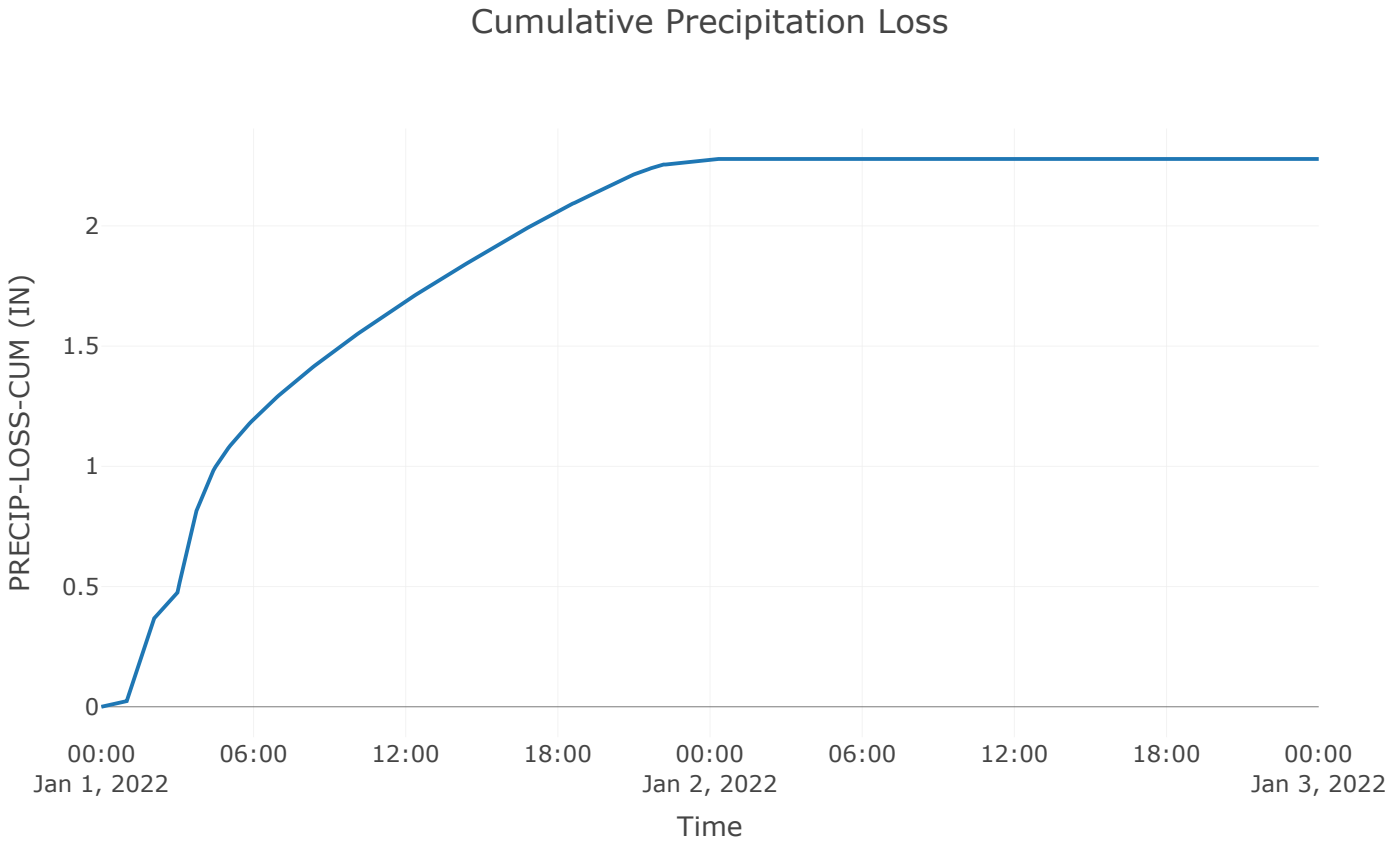
Results: MS Watershed	
Peak Discharge (CFS)	1785.6
Time of Peak Discharge	01Jan2022, 10:40
Volume (IN)	21.47
Precipitation Volume (AC - FT)	918.07
Loss Volume (AC - FT)	88.09
Excess Volume (AC - FT)	829.98
Direct Runoff Volume (AC - FT)	829.98
Baseflow Volume (AC - FT)	0

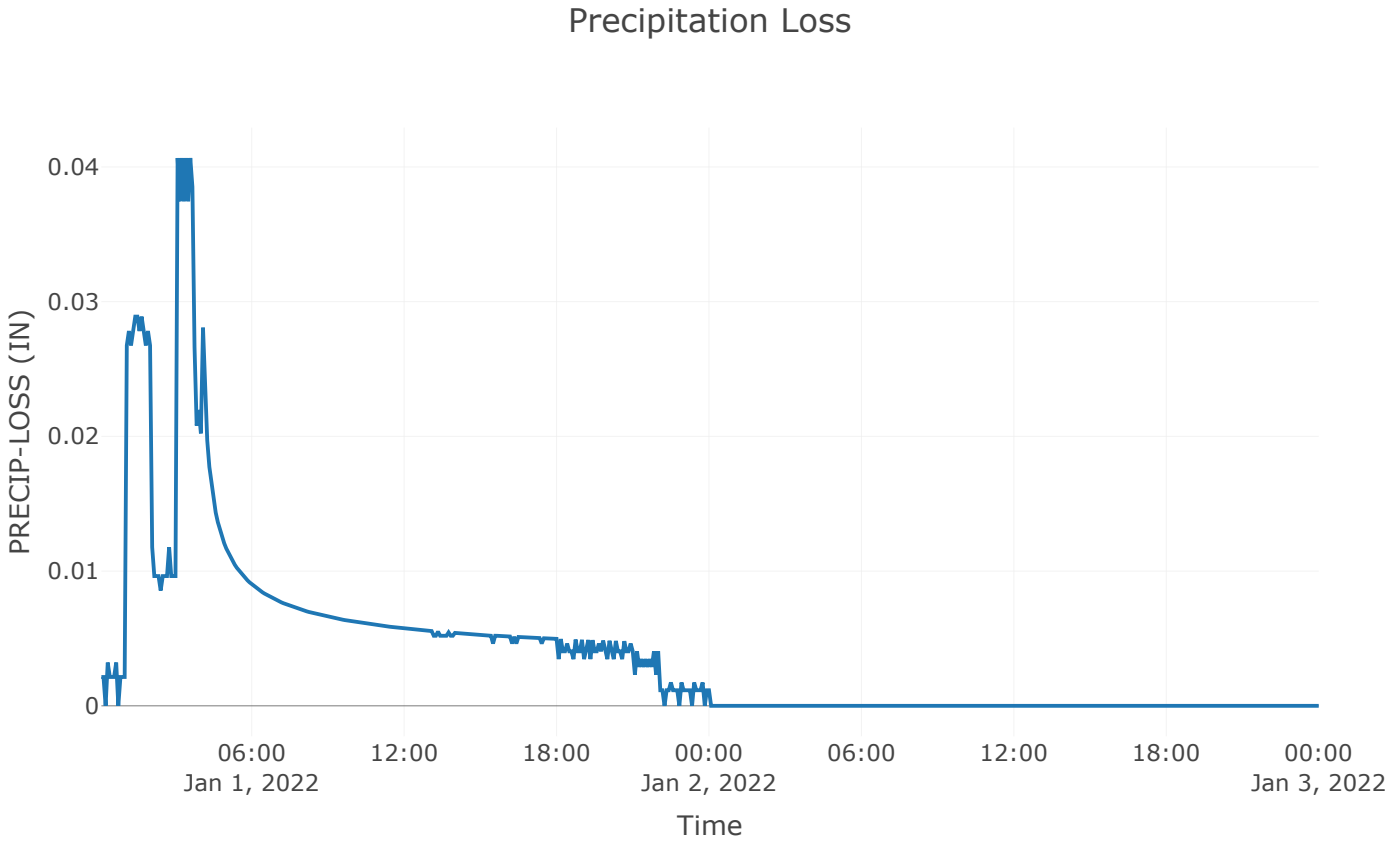
Precipitation and Outflow



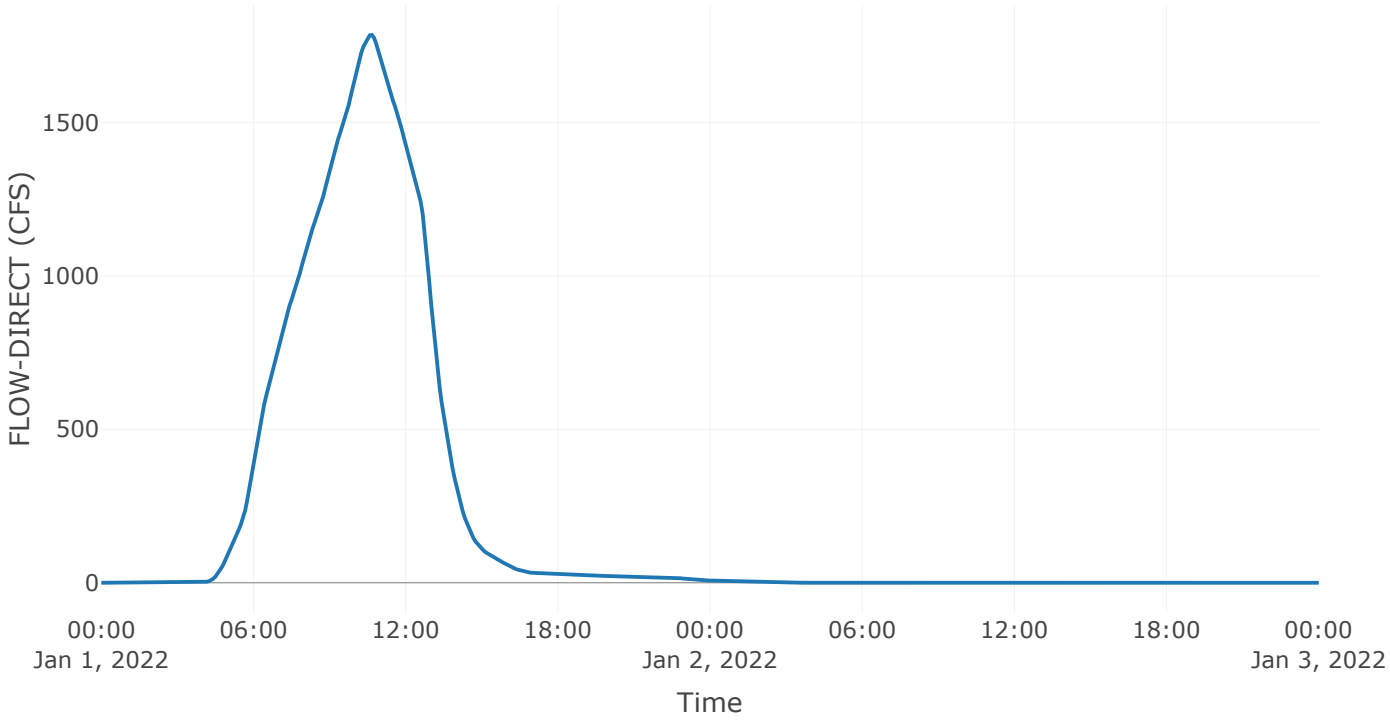
Cumulative Excess Precipitation



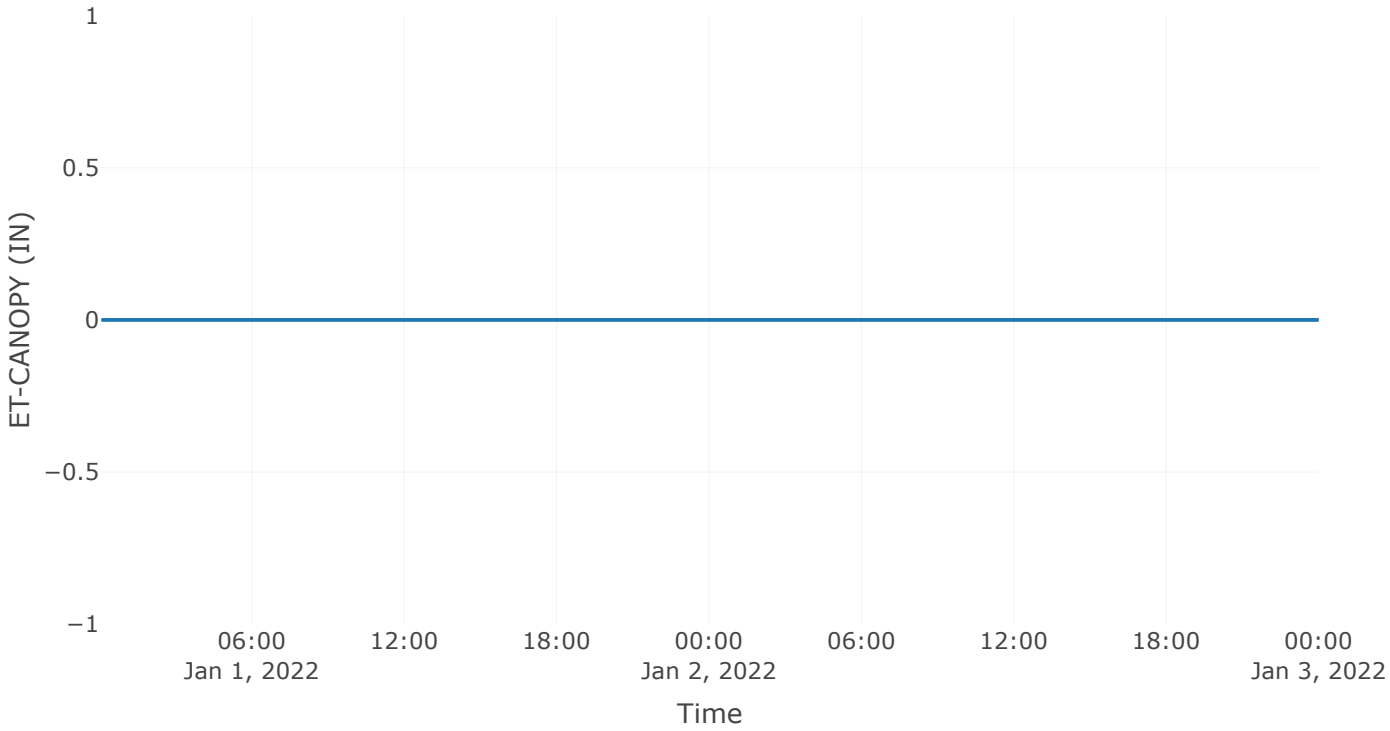

Cumulative Precipitation Loss
PRECIP-LOSS-CUM (IN)
2
1.5
1
0.5
0
00:00
Jan 1, 2022
06:00
12:00
18:00
00:00
Jan 2, 2022
06:00
12:00
18:00
00:00
Jan 3, 2022
Time


Precipitation Loss
PRECIP-LOSS (IN)
0.04
0.03
0.02
0.01
0
06:00
Jan 1, 2022
12:00
18:00
00:00
Jan 2, 2022
06:00
12:00
18:00
00:00
Jan 3, 2022
Time

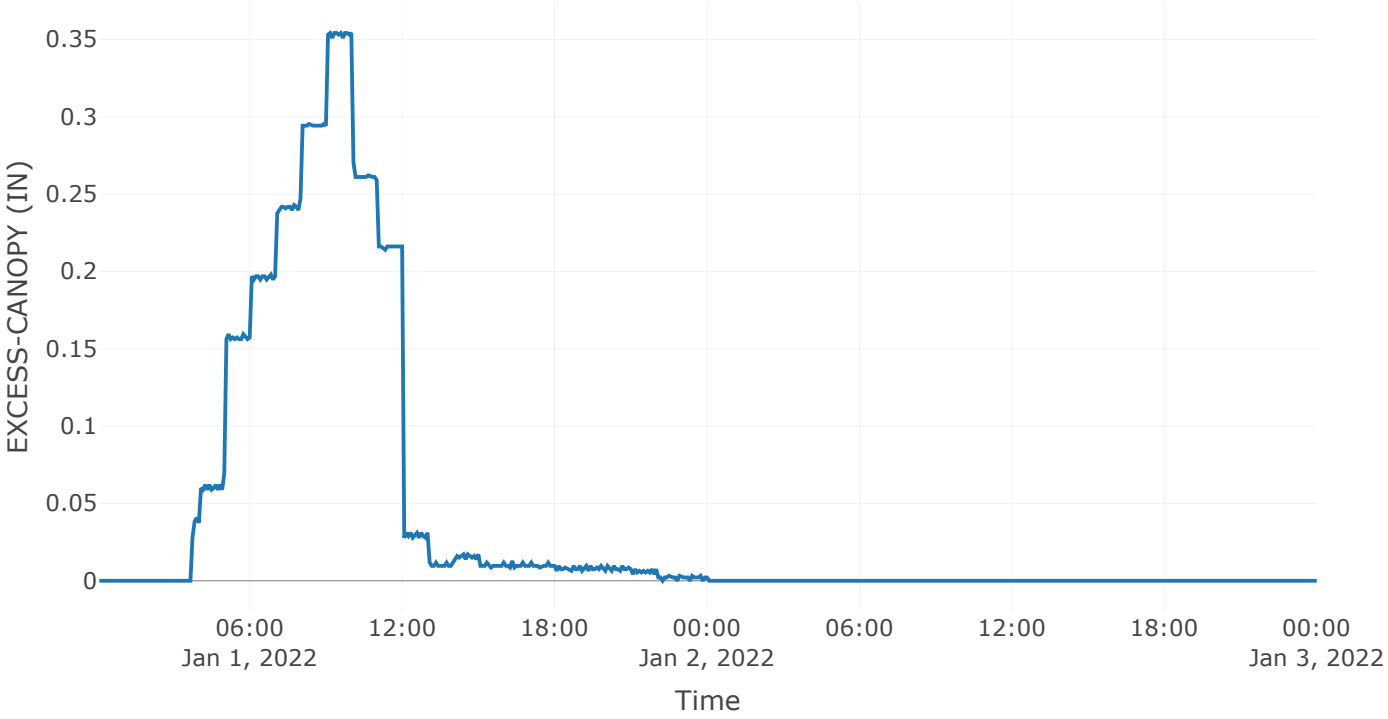
Direct Runoff



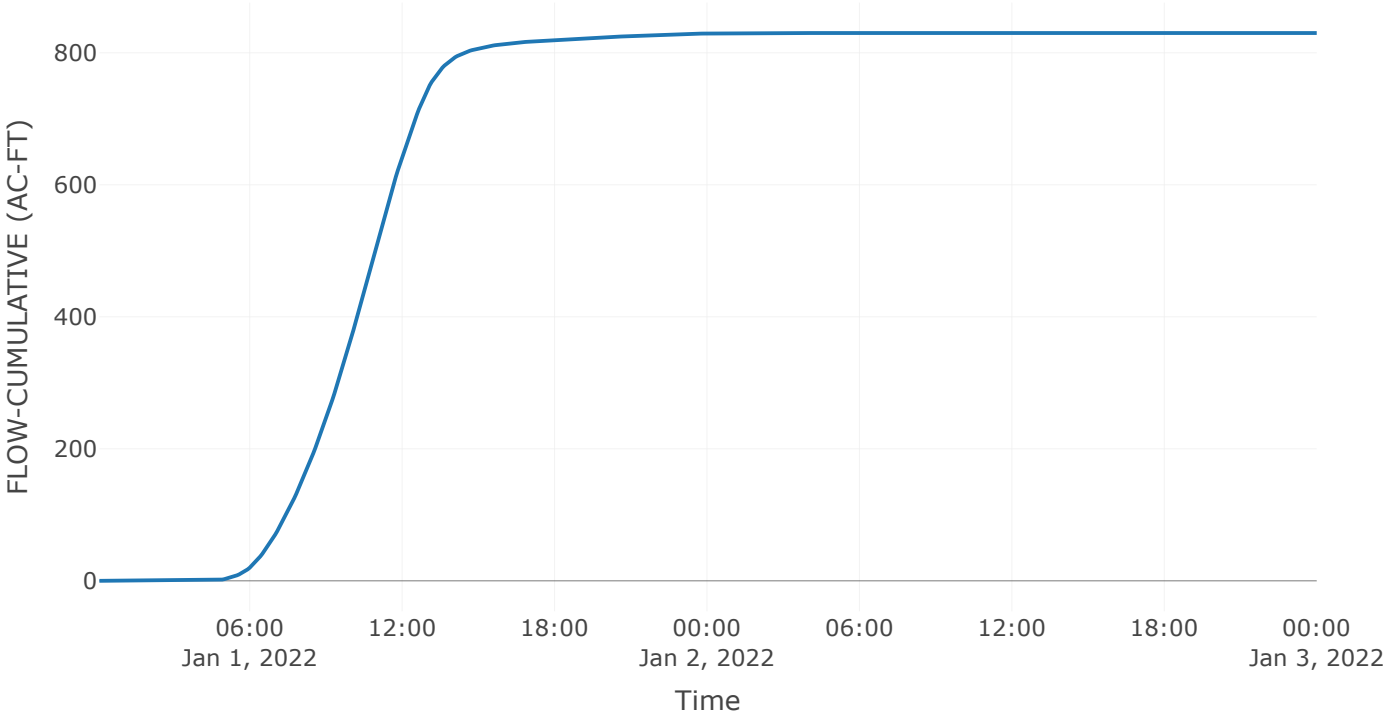
Canopy Evapotranspiration

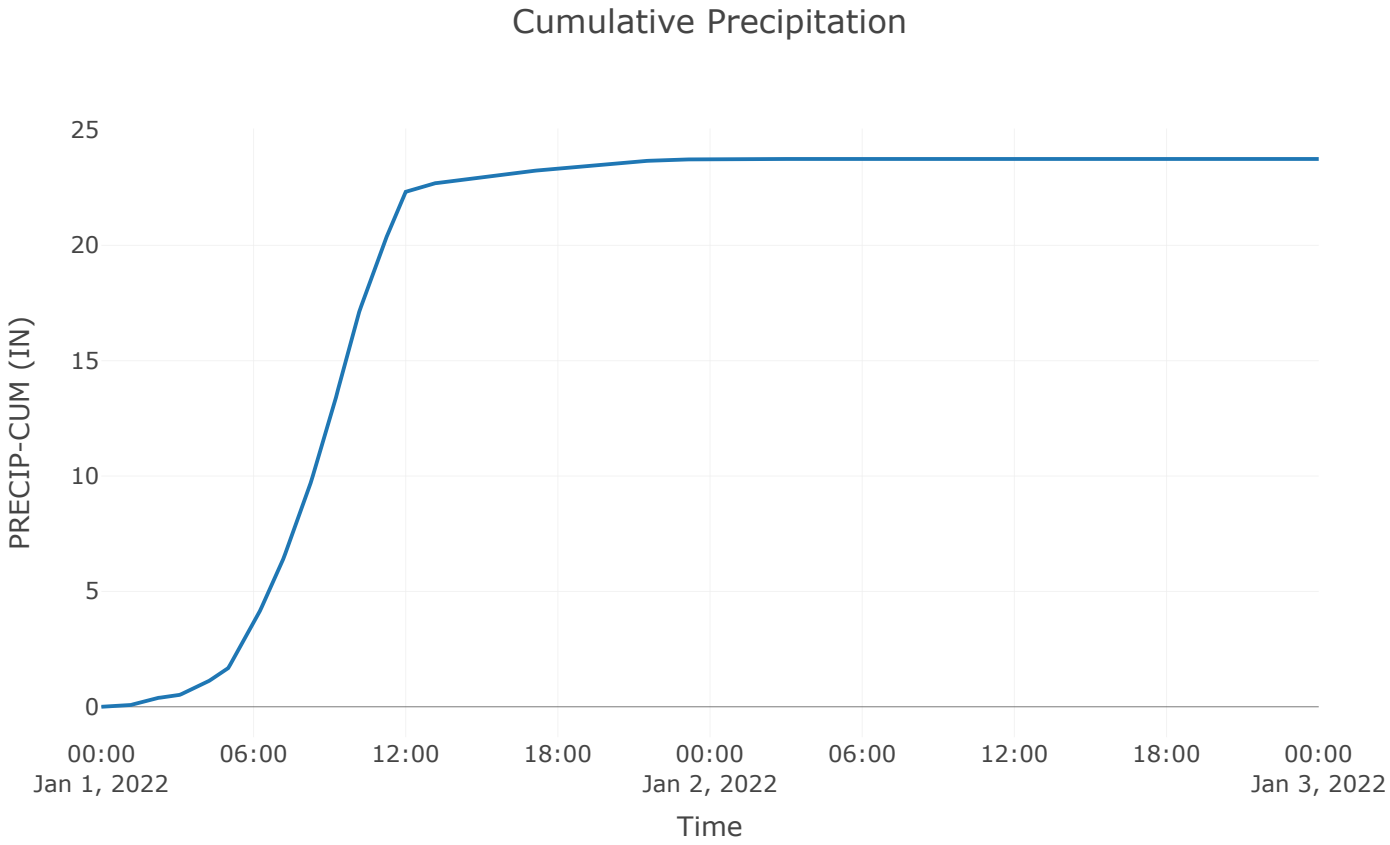


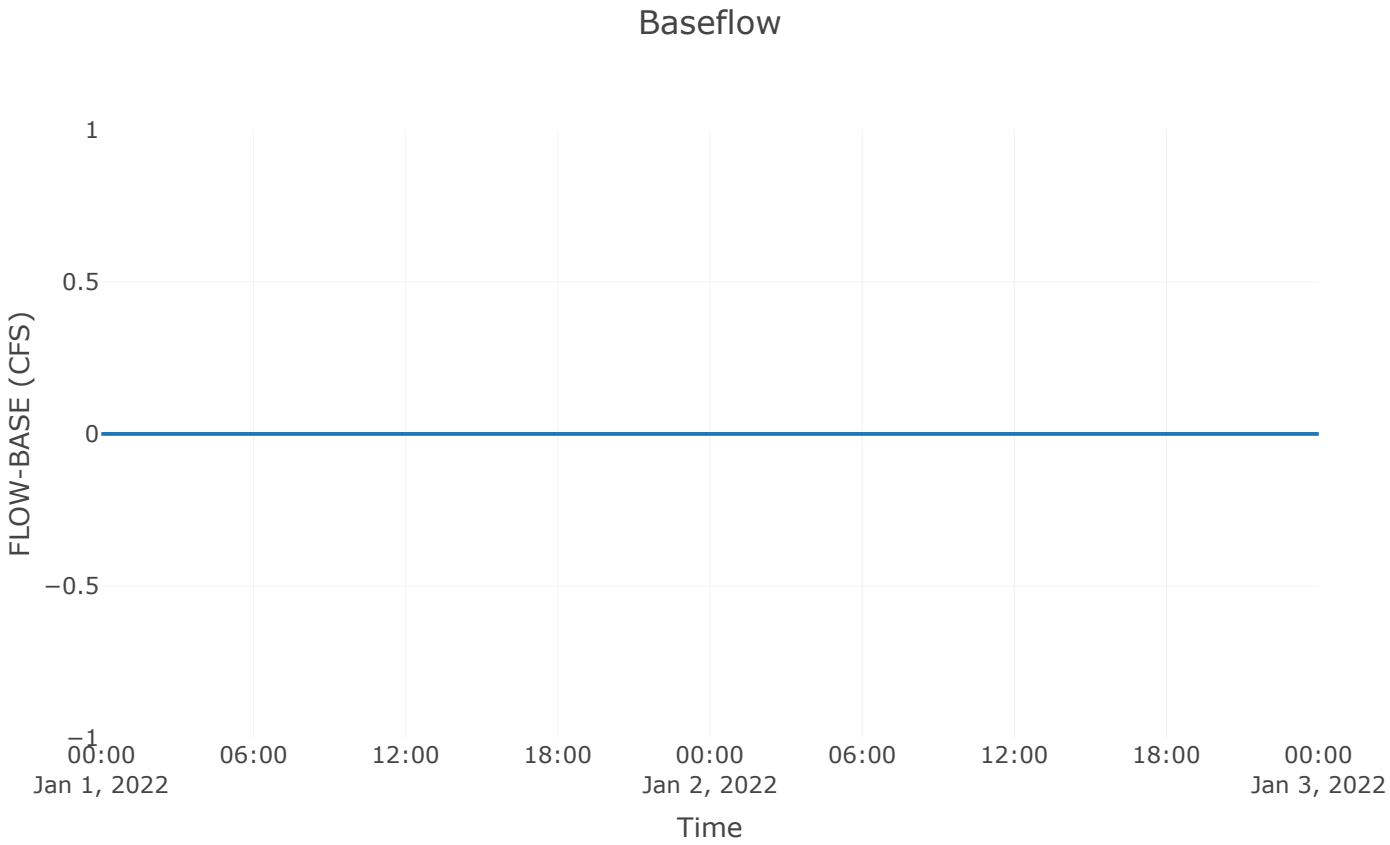
Canopy Overflow



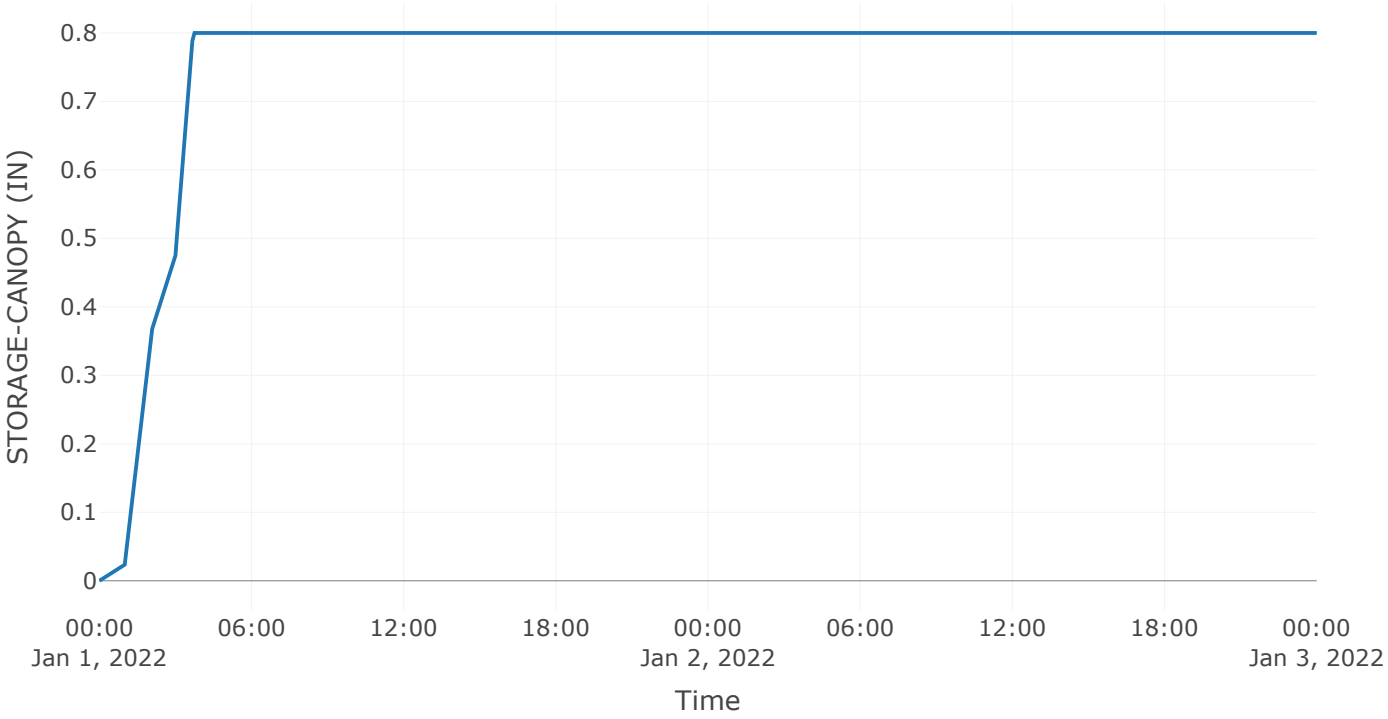
Cumulative Outflow



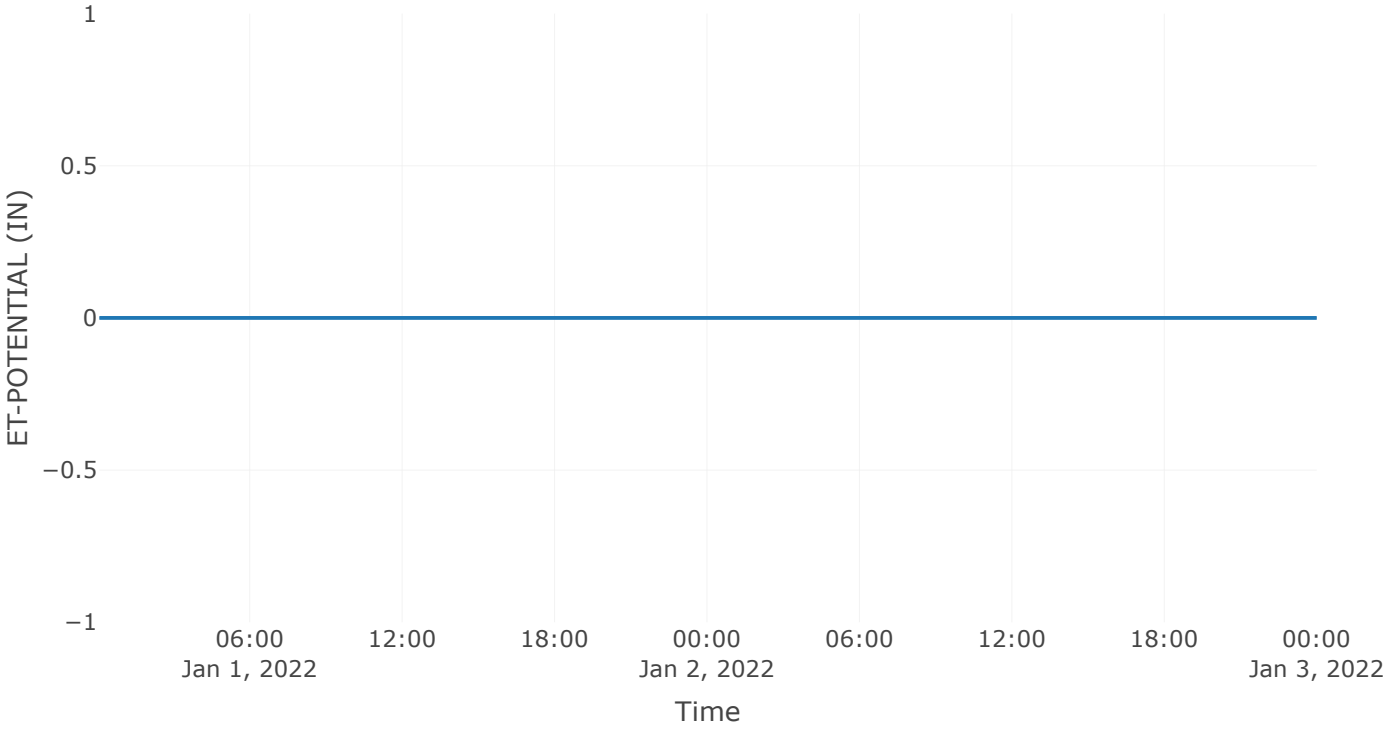

Cumulative Precipitation
PRECIP-CUM (IN)
25
20
15
10
5
0
00:00
Jan 1, 2022
06:00
12:00
18:00
00:00
Jan 2, 2022
06:00
12:00
18:00
00:00
Jan 3, 2022
Time

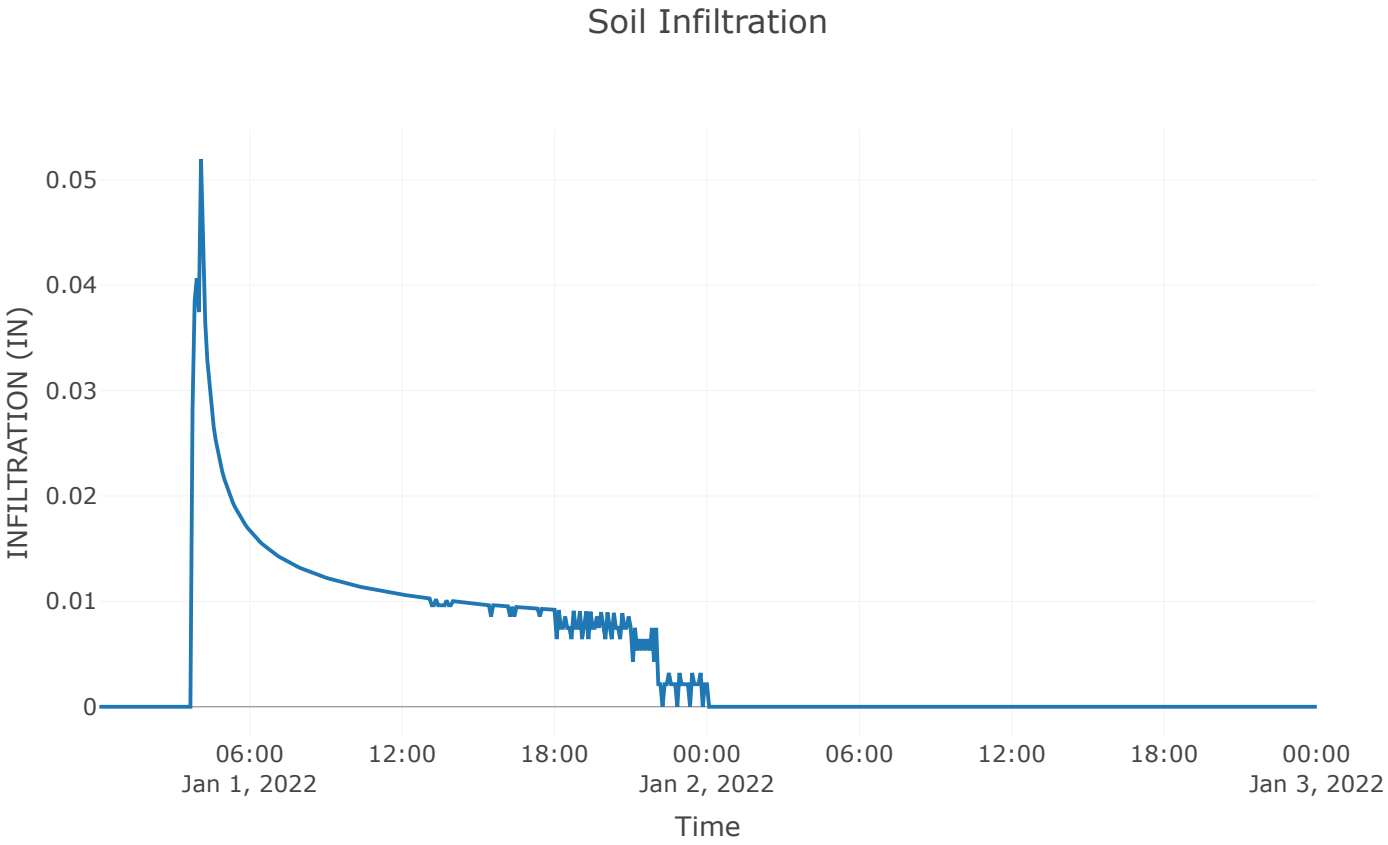

Baseflow
FLOW-BASE (CFS)
1
0.5
0
−0.5
−1
00:00
Jan 1, 2022
06:00
12:00
18:00
00:00
Jan 2, 2022
06:00
12:00
18:00
00:00
Jan 3, 2022
Time

Canopy Storage



Potential Evapotranspiration




Soil Infiltration
INFILTRATION (IN)
0.05
0.04
0.03
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0.01
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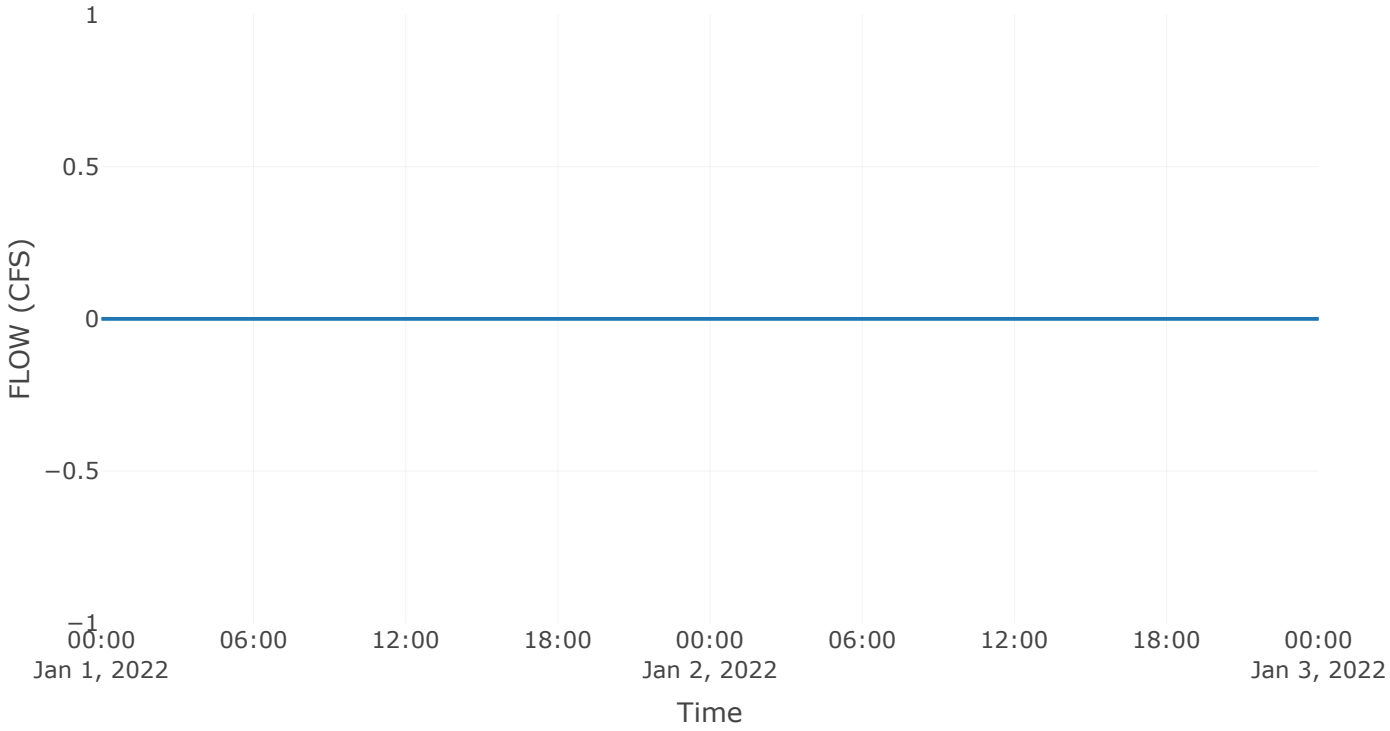
06:00
Jan 1, 2022
12:00
18:00
00:00
Jan 2, 2022
06:00
12:00
18:00
00:00
Jan 3, 2022
Time

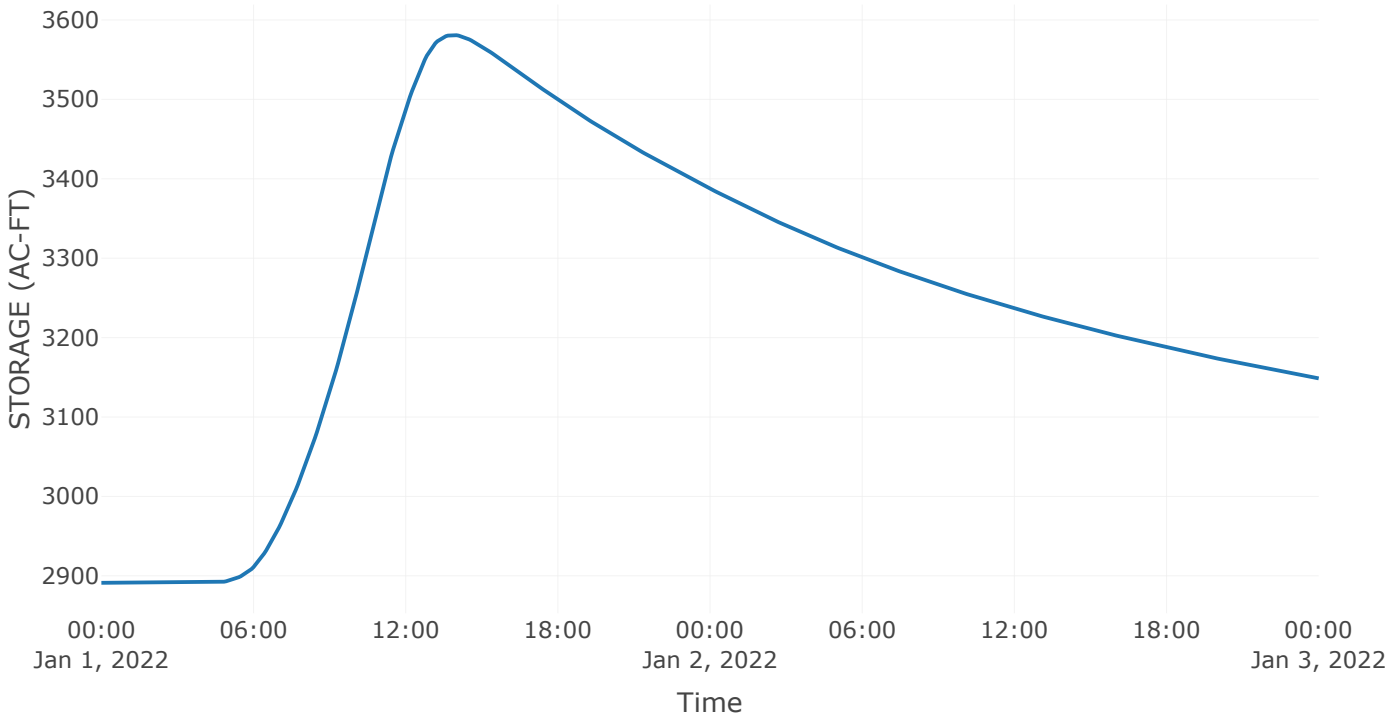
Reservoir: MS Reservoir

Results: MS Reservoir	
Peak Discharge (CFS)	364.53
Time of Peak Discharge	01Jan2022, 13:50
Volume (IN)	14.81
Peak Inflow (CFS)	1785.6
Time of Peak Inflow	01Jan2022, 10:40
Inflow Volume (AC - FT)	829.98
Maximum Storage (AC - FT)	3581.07
Peak Elevation (FT)	5923.91
Discharge Volume (AC - FT)	572.51

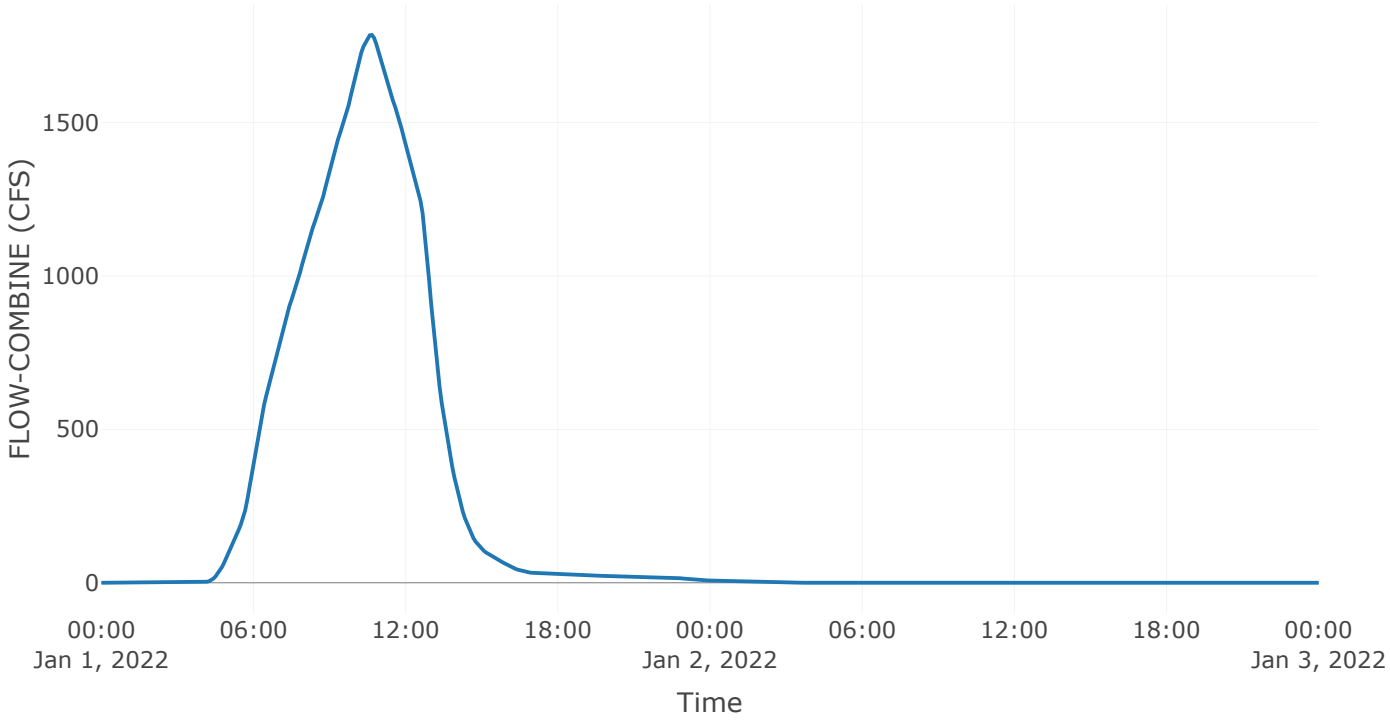
Dam Top 1



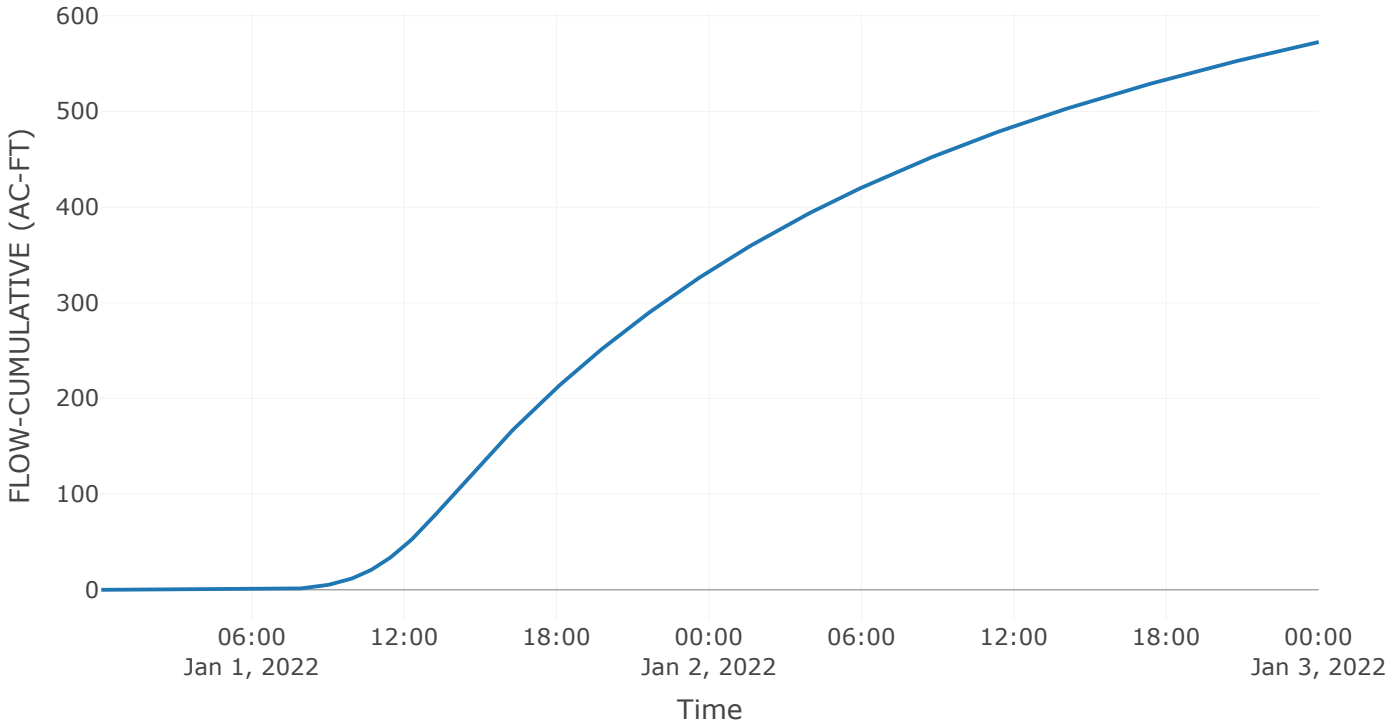
Storage



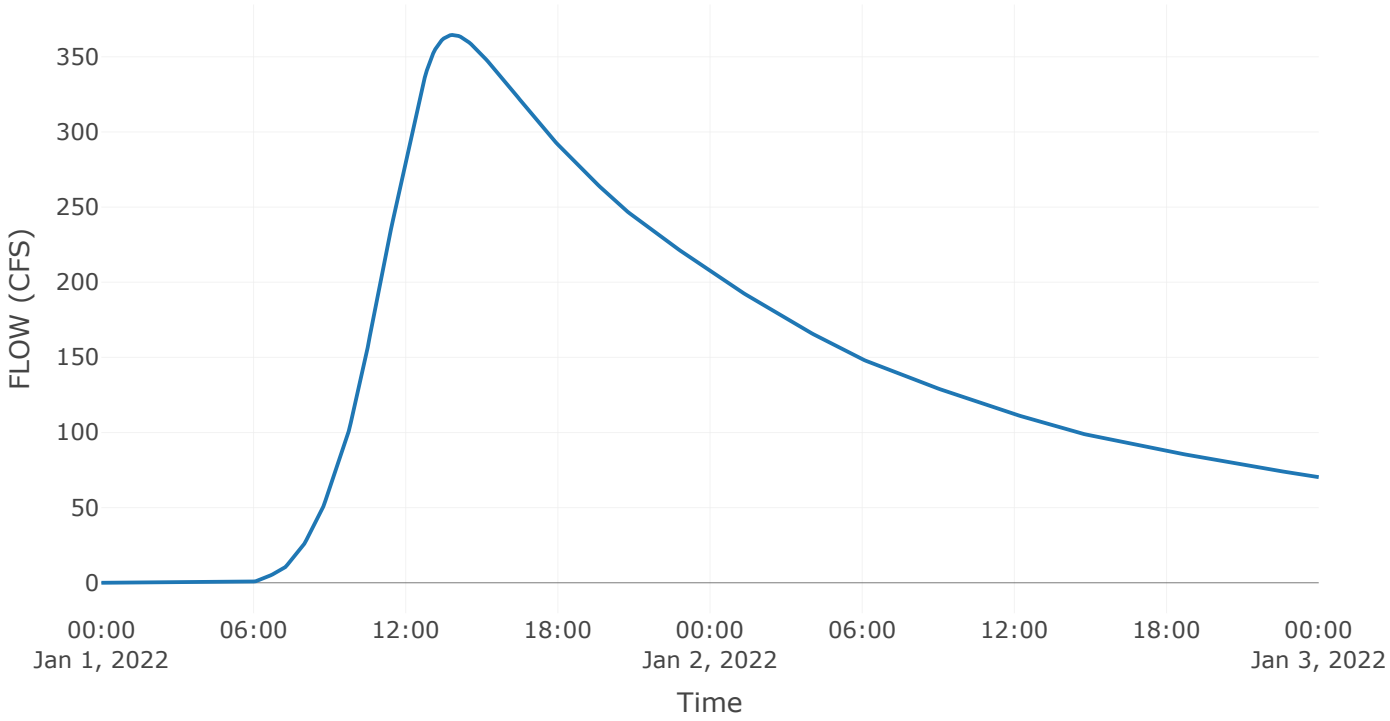
Combined Inflow



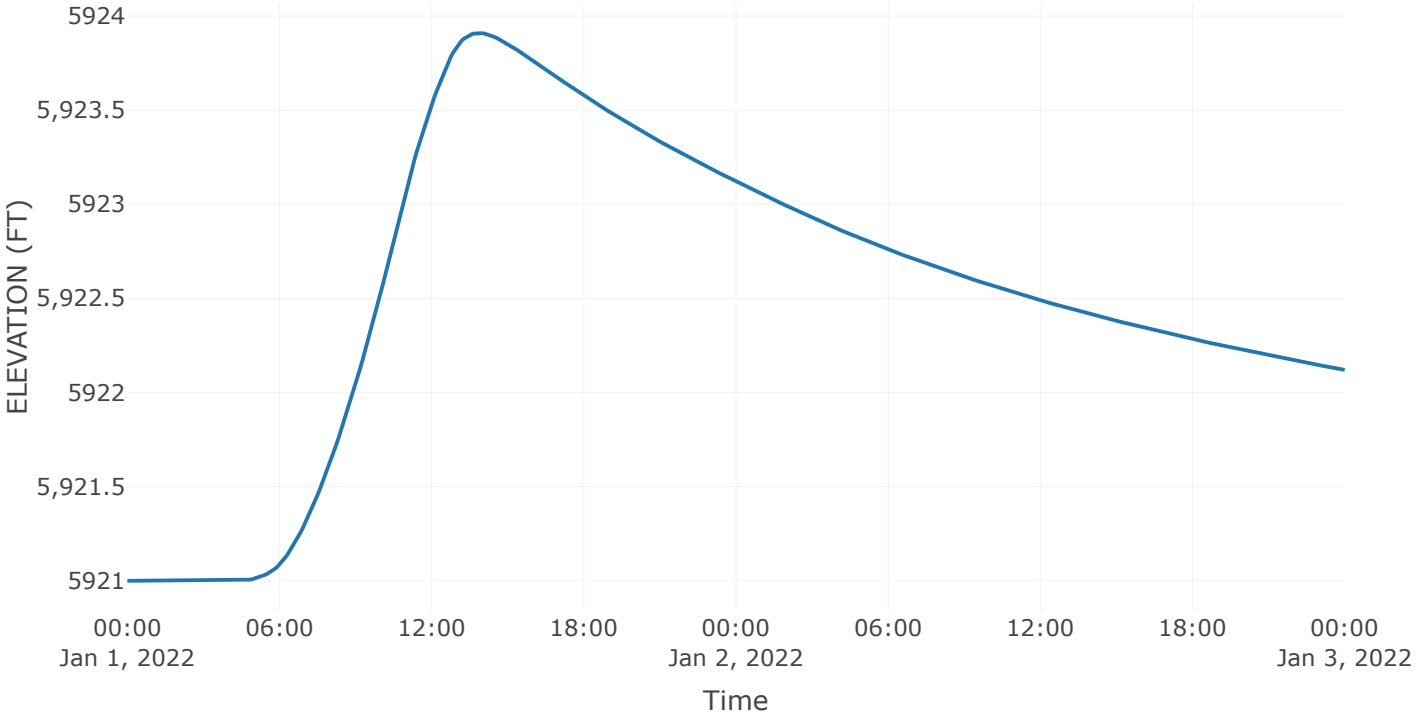
Cumulative Outflow



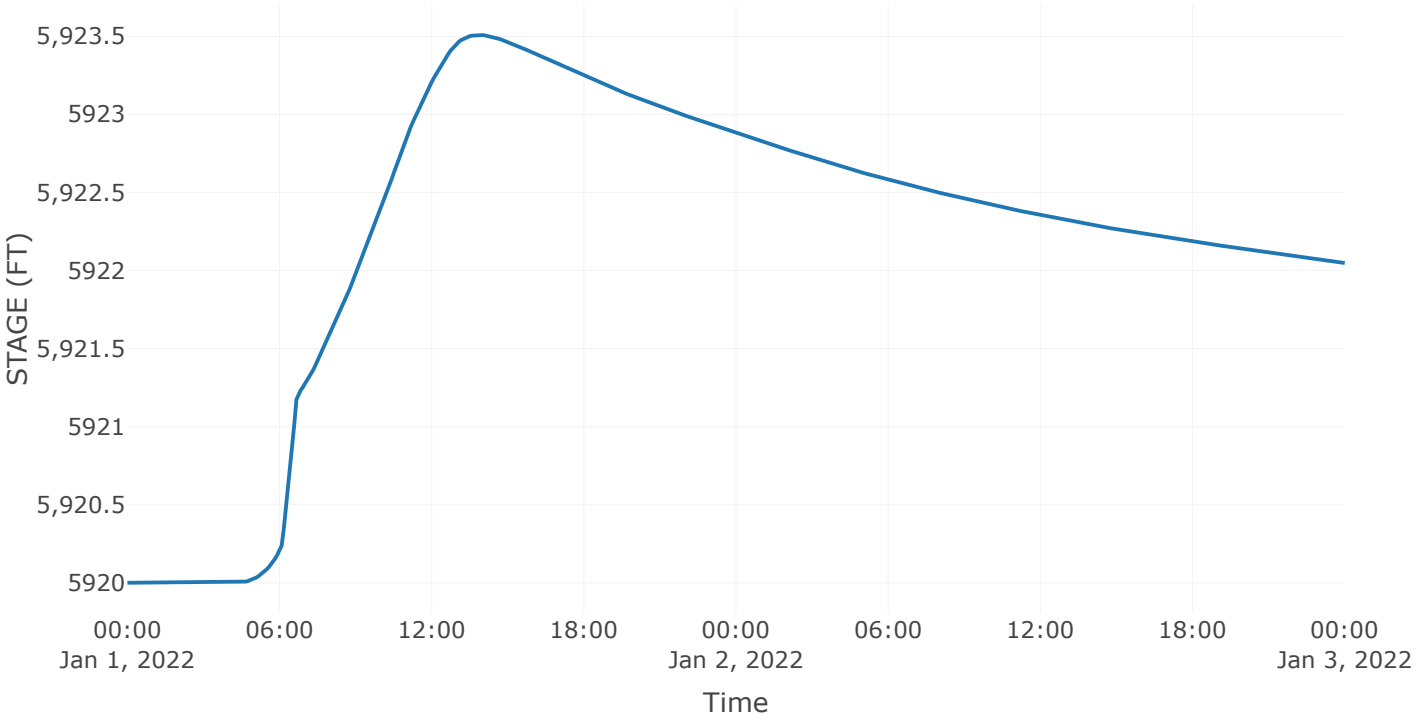
Spillway 1



Pool Elevation



Stage



Outflow