Periodic Inflow Design Flood Control System Plan

Upper AQC Impoundment
La Cygne Generating Station

Evergy Metro, Inc.

October 2021

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Appendices

1. Introduction

1.1 Purpose

The purpose of this Periodic Inflow Design Flood Control System Plan is to document that the requirements specified in 40 CFR §257.82 of the Coal Combustion Residual (CCR) Rule[1] have been met for the Upper Air Quality Control (AQC) Impoundment at Evergy Metro, Inc. (Evergy) La Cygne Generating Station. The Upper AQC Impoundment is an existing CCR surface impoundment as defined by 40 CFR §257.53.

1.2 Regulatory Requirements

In accordance with the CCR Rule, this plan documents how the inflow design flood control system has been designed and constructed to meet the requirements of 40 CFR §257.82 referenced below and is supported by appropriate engineering calculations. The Initial Inflow Design Flood Control System Plan was completed October 13, 2016. Periodic inflow design flood control system plans shall be prepared every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first periodic plan. This Periodic Inflow Design Flood Control System Plan has therefore been completed no later than October 13, 2021. This plan shall be amended whenever there is a change in conditions that would substantially affect the written plan in effect.

Regulatory Citation: 40 CFR §257.82 (a); Design, construct, operate, and maintain an inflow design flood control system as specified:

- *(1) Inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflows design flood specified in paragraph (3);*
- *(2) The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood specified in paragraph (3);*
- *(3) The inflow design flood is: (i) For a high hazard potential CCR surface impoundment, the probable maximum flood; (ii) For a significant hazard potential CCR surface impoundment, the 1,000-year flood; (iii) For a low hazard potential CCR surface impoundment, the 100-year flood; or (iv) For an incised CCR surface impoundment, the 25-year flood.*

Regulatory Citation: 40 CFR §257.82 (b); Discharge from the CCR unit must be handled in accordance with the surface water requirements under: §257.3 – 3.

1.3 Brief Description of Impoundment

The La Cygne Generating Station is a coal-fired power plant located near La Cygne in Linn County, Kansas. The Station is located approximately 6.25 miles east of the city of La Cygne and is bordered to the west by La Cygnes Lake. The Upper AQC Impoundment is located on plant property and has initiated closure. A site Location Map showing the area surrounding the station is in **Figure 1** of **Appendix A**.

1.3.1 Design and Construction

The original construction of the Upper AQC Impoundment was substantially completed in 1979. The Impoundment was constructed with embankments having an approximately maximum height of 50 feet and a crest elevation of 890 feet[2]. The embankments have 2.5 horizontal to 1.0 vertical side slopes. The impoundment currently has a water surface area of approximately 17 acres at a current typical operating level of 869.5 feet and a main Upper AQC Impoundment surface area of approximately 98 acres at the zero-freeboard elevation of 889.0 feet. The unit currently has a substantial amount of material above existing water levels, and therefore a smaller water surface area, due to the closure in place process.

1.3.2 Inflow from Plant Operations and Stormwater Runoff

The Upper AQC Impoundment is primarily used as a holding basin for formerly sluiced CCR water and materials from the La Cygne Generating Station and stormwater management for the unit. The watershed for the Upper AQC Impoundment includes the access road around the perimeter of the embankment as well as the entirety of the area within the embankment.

1.3.3 Outlet Structures

The principal spillway for the Upper AQC Impoundment is located at the south side of the impoundment and consists of a 6-foot-wide by 9-foot-long by 22 feet high concrete riser fitted with stop logs. Stop logs are added or removed to manage operational water levels in the impoundment. All stop logs have been removed, lowering the operational water level to facilitate closure activities in the impoundment. The concrete riser is connected to a 30-inch corrugated metal pipe (CMP) that discharges to the Lower AQC Impoundment to the south.

The impoundment also has an auxiliary spillway. The auxiliary spillway is a 50 ft. wide riprap lined channel that extends over the crest of the embankment and along the downstream slope and discharges into a drainage swale as shown in Figure 2. The design plans show that the opening for the spillway is 3 ft. lower than the top of embankment and has a 1 ft. thick, 66 ft. wide, 4 ft. deep seepage cut off wall at the inside crest. The auxiliary spillway does not discharge into the Lower AQC Impoundment, but rather discharges into a drainage swale that slopes downward to the west and discharges into La Cygnes Lake. The auxiliary spillway is functional; however, to be conservative, the auxiliary spillway was not considered when analyzing the outlet from the Upper AQC Impoundment.

1.4 Plan Approach

Analyses and calculations completed for the hydrologic and hydraulic assessments of the Upper AQC Impoundment are described in this plan and included in **Appendix B**. Data and analyses results are based on information shown on design drawings, topographic surveys, information about operational and maintenance procedures provided by Evergy, and field observations by AECOM. The analysis approach and results of the hydrologic and hydraulic analyses are presented in the following sections. The results of this analysis will be used by AECOM to confirm that the Upper AQC Impoundment meets the hydrologic and hydraulic capacity requirements of the rules referenced above for CCR surface impoundments. **Table 1** cross references the Plan sections to the applicable CCR Rule requirements.

Table 1. CCR Rule Cross Reference Table

Plan Section	Title	CCR Rule Reference
4.1	Inflow Analysis	§257.82 (a)(1)
4.2	Outflow Analysis	§257.82 (a)(2)
4.3	Inflow Design Flood	§257.82 (a)(3)
4.4	Discharge handled in accordance with §257.3 - 3	§257.82 (b)

2. Hydraulic Analysis

2.1 Design Storm

The La Cygne Upper AQC Impoundment has been categorized by others[13] as a "Low Hazard Potential CCR Impoundment", which indicates that the inflow design flood is the 100-year return frequency design storm event.

2.2 Rainfall Data

The rainfall information used in the analysis was based on the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2[3] which provides rainfall data for storm events with average recurrence intervals ranging from 1 to 1,000 years and durations ranging from 5 minutes to 60 days. The design storm rainfall depth, obtained from the NOAA website, is 8.6 inches for the 24-hour, 100-year storm The Soil Conservation Service (SCS) Type II rainfall distribution used by AECOM is appropriate to use for storms up to the 1,000-year flood at the project site.

2.3 Runoff Computations

The watershed areas for the Upper AQC Impoundment were determined using a computer-aided design (CAD) analysis of the AECOM design plans for Ponds A and B and the existing ground contours provided by Evergy[4-10]. Design plans were used for Ponds A and B because they have been constructed but as built drawings had not been created at the time this analysis was completed. The existing ground contours were compiled from multiple surveys by third parties dated 2001 through 2021. Survey information can be found in **References**. The total watershed area to the impoundment is approximately 332.4 acres and is subdivided into nine sub-watersheds. Sub-dividing the Upper AQC Impoundment into sub-watersheds more accurately models the upstream storage capacity in the Impoundment and provides a more accurate peak inflow to the main Upper AQC storage area. See **Figure 2** in **Appendix A** for the Watershed Map.

Runoff was calculated using the SCS Curve Number Method, where curve numbers (CN) were assigned to each sub-catchment based on the type of land cover and soil type present. Using the USDA Natural Resources Conservation Service (NRCS) Web Soil Survey[11], the soil type of the site was determined to be almost exclusively hydrologic soil group D. CN values for the land cover were selected from the SCS NRCS Technical Release-55 (TR-55) publication[12]. Gravel roads and Water Surface land covers that are located on site were determined to have a CN value of 89 and 98, respectively. A majority of land cover for the Upper AQC Impoundment watershed consists of CCR. Based on past project experience, a curve number of 85 was selected for the CCR area. A composite CN was calculated for each sub-catchment area by summing the products of each CN multiplied by its percentage of the total area. Calculations for the weighted runoff curve numbers for each sub-watershed were performed in HydroCAD.

The time of concentration is commonly defined as the time required for runoff to travel from the most hydrologically distant point to the point of collection. Calculations for the time of concentration for each sub-watershed were performed in HydroCAD.

Stormwater runoff from the 100-year event into the southernmost watershed (Node P-I) of the Upper AQC Impoundment has a peak runoff inflow of 576.2 cfs and total runoff inflow volume of 159.9 acre-feet. Stormwater runoff from the 100-year event into the Pond A (Node P-A) of the Upper AQC Impoundment has a peak runoff inflow of 211.6 cfs and total runoff inflow volume of 14.7 acre-feet. Stormwater runoff from the 100-year event into the Pond B (Node P-B) of the Upper AQC Impoundment has a peak runoff inflow of 219.0 cfs and total runoff inflow volume of 15.1 acre-feet. Ponds A and B both have finished cover and their discharges are non-contact water.

3. Hydraulic Analyses

3.1 Process Flows

CCR sluicing operations to the Upper AQC Impoundment have been discontinued. Thus, there are no inflows to the impoundment other than precipitation.

3.2 Storage Capacity

The storage volumes for the Upper AQC Impoundment were determined using a CAD analysis of the existing ground contours[4-10]. The calculated volume of the Upper AQC Impoundment is approximately 729 acre-feet of available storage measured from the current typical operating pool elevation of 869.5 feet to the zero-freeboard elevation of 889.0 feet.

3.3 Discharge Analysis

A hydraulic model was created in HydroCAD to assess the capacity of the impoundment to store and convey the stormwater flows. HydroCAD has the capability to evaluate multiple impoundments within a network and to respond to variable tailwater, pumping rates, and reversing flows. HydroCAD routing calculations reevaluate the impoundment's discharge capability at each time increment, making the program an efficient and dynamic tool for this evaluation.

The analyzed scenario assumes the starting water surface elevation of Region 6 of the Upper AQC Impoundment is 869.5 feet, which is the water surface elevation at the Principal Spillway intake weirs. The upstream regions are assumed to have no ponded water. The current conditions are that the stop logs in the principal outlet structure have been removed, making the invert elevation 869.5 feet assuming there is zero discharge out of the system at the start of the simulation. The IDF inflow is stored in the Upper AQC Impoundment and then discharged through the primary spillway into a concrete lined ditch that discharges into La Cygnes Lake.

4. Results

The hydrologic and hydraulic conditions of the Upper AQC Impoundment were modeled with the peak discharge of the 100-year storm event. The hydrologic and hydraulic analyses and calculations for the Upper AQC Impoundment are summarized below and included in **Appendix B**.

4.1 Inflow Analysis – §257.82 (a)(1)

Adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood.

Background and Assessment

Using the HydroCAD model, the total inflow was stored and routed through the various swales, culverts, and dike openings of the Upper AQC Impoundment to determine the peak water surface elevations.

Table 2 summarizes the water surface elevations of the Upper AQC Impoundment prior to and after the inflow design flood. It is important to note that Pond E overtops into Pond G and not outside of the embankment. Pond G discharges into Pond I and not outside of the embankment. No external overtopping of any exterior embankment is predicted in the model.

Table 2. Summary of Hydrologic and Hydraulic Analysis in Upper AQC Impoundment

Subcatchment	Beginning WSE* (feet)	Peak WSE (feet)	Min. Crest Elevation (feet)	Freeboard Above Peak WSE (feet)
Pond A 100-Year, 24-Hour Storm	888.0	893.2	895.8	2.6
Pond B 100-Year, 24-Hour Storm	887.5	892.9	895.8	2.9
Pond C 100-Year, 24-Hour Storm	887.8	889.9	890.8	0.9
Pond D 100-Year, 24-Hour Storm	885.3	887.7	890.4	2.7
Pond E 100-Year, 24-Hour Storm	883.1	884.6	884.1	-0.5[1]
Pond F 100-Year, 24-Hour Storm	883.0	884.2	889.1	4.9
Pond G 100-Year, 24-Hour Storm	881.4	883.4	889.5	6.1[1]
Pond H 100-Year, 24-Hour Storm	888.3	889.1	890.6	1.5
Pond I (Principal Spillway) 100-Year, 24-Hour Storm	869.5	878.6	889.6	11.0

1 - Pond E overtops into Pond G, which are both inside the embankment. Pond G discharges into Pond I and not outside of the embankment. No external overtopping of any exterior embankment is predicted in the model.

Conclusion and Recommendation

As there is adequate storage within the Upper AQC Impoundment to manage the inflow design flood, there is no anticipated overtopping of the embankments, which meets the requirements in §257.82 (a)(1).

4.2 Outflow Analysis – §257.82 (a)(2)

Adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood.

Background and Assessment

Using the HydroCAD model, the total inflow due to rainfall runoff in contributing drainage areas was stored and routed to the outlet riser at the south end of the Upper AQC Impoundment to determine the peak water surface elevations at Pond I, which is the Principal Spillway. The same method was used for Ponds A and B, which have received final cover and discharge non-contact water. The results are summarized in **Table 3**.

Table 3. Summary of Outlet Works

Outlet	Storm Event	Invert Elevation (feet)	Peak Flowrate (cfs)	Velocity at Peak Flowrate (fps)
Pond I (Principal Spillway)	100-Year, 24-Hour	869.5	40.9	8.3
Pond A	100-Year, 24-Hour	888.0	10.3	8.1
Pond B	100-Year, 24-Hour	887.5	10.6	8.3

Conclusion and Recommendation

As the Upper AQC Impoundment outlet manages the discharge of the inflow design flood without the peak water surface elevation overtopping the embankment, the impoundment meets the requirements in §257.82 (a)(2).

4.3 Inflow Design Flood – §257.82 (a)(3)

Required Inflow design flood for Low Hazard Surface Impoundments.

Background and Assessment

The calculations for the inflow design flood are based on the hazard potential of the impoundment. The different classifications of the impoundment hazard potential are high, significant, and low.

Conclusion and Recommendation

As the impoundment hazard potential category is Low[13], the 100-year design storm was utilized in the analysis, which meets the requirements in §257.82 (a)(3).

4.4 Discharge – §257.82 (b)

Discharge from the CCR unit handled in accordance with the surface water requirements under: §257.3 – 3.

Background and Assessment

The discharge from the Upper AQC Impoundment outlet riser enters a discharge pipe that leads to the Lower AQC Impoundment. The discharge must meet the requirements of the NPDES under Section 402 of the Clean Water Act to meet the above requirement of the CCR rule.

Conclusion and Recommendation

Region 1 (Ponds A and B) currently discharges non-contact water. Regions 2 through 6 (Ponds C through I) continue to discharge from the Upper AQC Impoundment and flow to a concrete lined channel that drains to La Cygnes Lake. Therefore, the facility does not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the NPDES under Section 402 of the Clean Water Act, and thereby meets the requirements in §257.82 (b).

5. Conclusions

The hazard classification assessments conducted by others concluded that the Hazard Potential category of the impoundment is Low[13]. The inflow design flood control system of the Upper AQC Impoundment adequately manages flow into the CCR unit during and following the peak discharge of the 100-year, 24-hour frequency storm event inflow design flood. The inflow design flood control system of the Upper AQC Impoundment adequately manages flow from the CCR unit to collect and control the peak discharge resulting from the 100-year, 24-hour frequency storm event inflow design flood. Discharge from the Upper AQC Impoundment is handled in accordance with the surface water requirements of §257.3 – 3 during the 100-year, 24-hour flood event. Therefore, the Upper AQC Impoundment meets the requirements for certification.

The contents of this plan, specifically **Sections 1** through **5**, represent the Periodic Inflow Design Flood Control System Plan for this unit.

6. Limitations

Background information, design basis, and other data have been furnished to AECOM by Evergy, which AECOM has used in preparing this plan. AECOM has relied on this information as furnished and is not responsible for the accuracy of this information. Our recommendations are based on available information from previous and current investigations. These recommendations may be updated as future investigations are performed.

The conclusions presented in this plan are intended only for the purpose, site location, and project indicated. The recommendations presented in this plan should not be used for other projects or purposes. Conclusions or recommendations made from these data by others are their responsibility. The conclusions and recommendations are based on AECOM's understanding of current plant operations, maintenance, stormwater handling, and ash handling procedures at the station, as provided by Evergy. Changes in any of these operations or procedures may invalidate the findings in this plan until AECOM has had the opportunity to review the findings and revise the plan if necessary.

This hydrologic and hydraulic analysis was performed in accordance with the standard of care commonly used as state-of-practice in our profession. Specifically, our services have been performed in accordance with accepted principles and practices of the hydrologic and hydraulic engineering profession. The conclusions presented in this plan are professional opinions based on the indicated project criteria and data available at the time this plan was prepared. Our services were provided in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation is intended.

7. Certification Statement

CCR Unit: Evergy La Cygne Generating Station, Upper AQC Impoundment

I, Joslyn Townsend, being a Registered Professional Engineer in good standing in the State of Kansas, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above referenced CCR Unit, that the Periodic Inflow Design Flood Control System Plan dated October 8, 2021, which includes all pages in Sections 1 through 5, meets the requirements of 40 CFR § 257.82.

Joslyn Townsend

Printed Name

October 8, 2021

Date

AECOM
2380 McGee Street, Suite 200
Kansas City, Missouri 64108
1-816-561-4443

8. References

1. U.S. Environmental Protection Agency, Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments, 40 CFR §257.82 Federal Register 80, Subpart D, April 17, 2015.
2. AECOM, History of Construction Report, Upper AQC Impoundment, La Cygne Generating Station, Kansas City Power & Light Company, dated October 2016.
3. National Oceanic and Atmospheric Administration, NOAA Atlas 14 Point Precipitation Frequency Estimates, Volume 8, Version 2, https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=il, dated 2021.
4. Western Air Mapping, Topographic Survey Plans for the La Cygne Generating Station, dated 2001.
5. Tukuh Technologies, LLC, Topographic Survey Plans for the La Cygne Generating Station, dated 2017.
6. Tukuh Technologies, LLC, Topographic Survey Plans for the La Cygne Generating Station, dated 2018.
7. AECOM, Alternative Cover Design Test Site – Upper AQC Impoundment, La Cygne Generating Station, Kansas City Power & Light Company, dated September 2019.
8. BHC RHODES, Topographic Survey Plans for the La Cygne Generating Station, dated 2020.
9. BHC RHODES, Topographic Survey Plans for the La Cygne Generating Station, dated 2021.
10. No Author, Bathymetric Survey Plans for the La Cygne Generating Station, undated.
11. USDA Natural Resources Conservation Service, Web Soil Survey, http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm, dated 2021.
12. USDA Natural Resources Conservation Service, Technical Release 55, dated June 1986.
13. SCS Engineers, Periodic Hazard Potential Classification Assessment Report, Upper AQC Impoundment, Evergy Metro, Inc., La Cygne Generating Station, dated October 2021.

Appendix A Figures

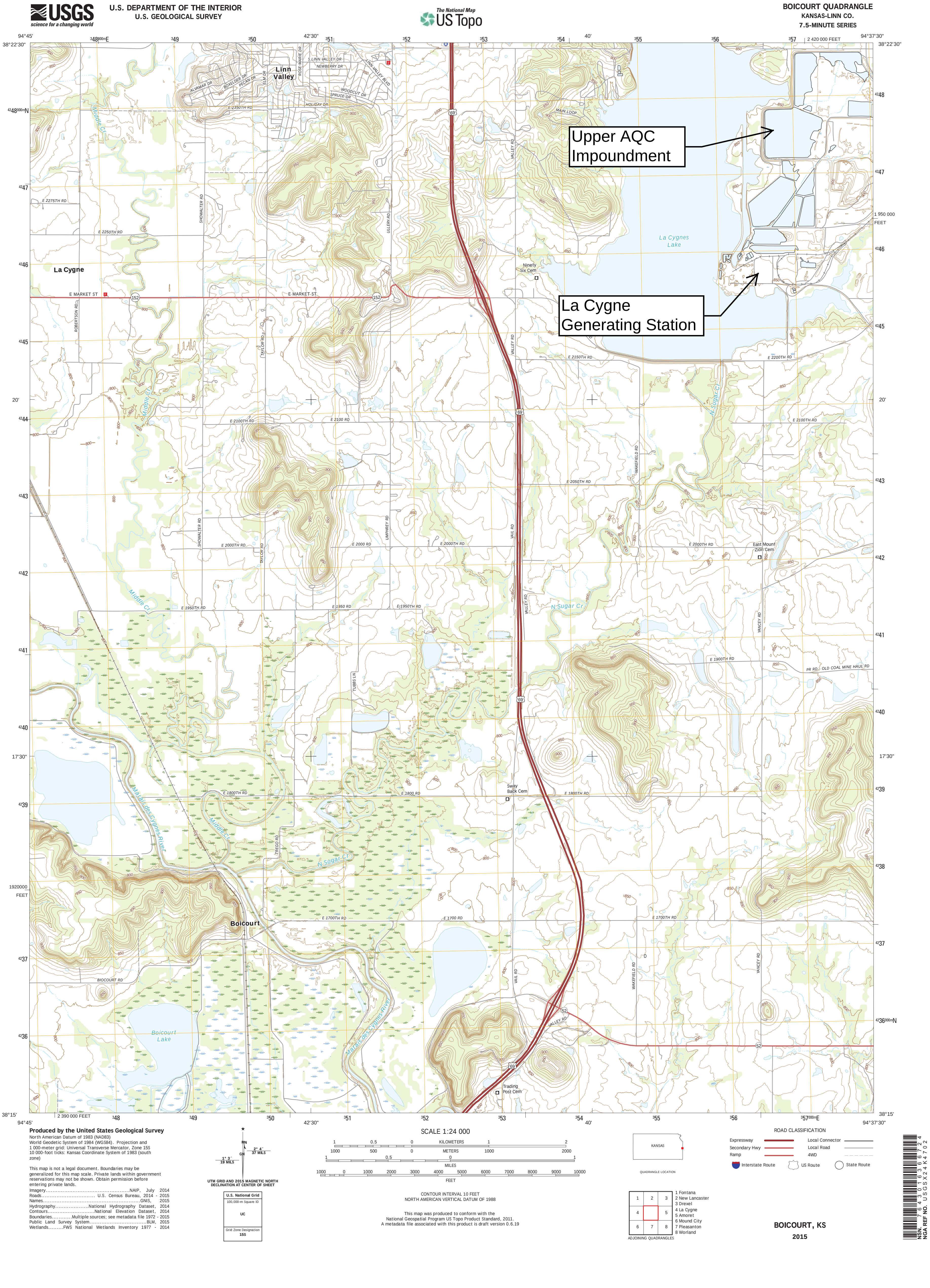

Figure 1 - Location Map

N

300 0 300

SCALE IN FEET

September 13, 2021 6:51:05 pm (mlk)
J:\Evergy La Cygne Phase 4\Plan Sheets\Drainage Area Map – Existing.dwg

PROJECT NUMBER AND TASK: 60663586		REV. NO.	BY	DATE	REVISIONS DESCRIPTION
DRAWN BY: TMS	DESIGNED BY: -				
CHECKED BY: JCA	APPROVED BY: -				
DATE: AUGUST 31, 2021					

AECOM

2380 McGee Street, Suite 200
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DRAFT – PRELIMINARY
NOT FOR CONSTRUCTION

EVERGY METRO, INC.
LA CYGNE GENERATING STATION
UPPER AQC IMPOUNDMENT
COVER PLAN

FIGURE 2 DRAINAGE AREA MAP
EXISTING CONDITION

SHEET NO.
1
1

Appendix B Hydrologic and Hydraulic Support Calculations

B.1 NOAA Rainfall Depths

B.2 NRCS Web Soil Survey Map

B.3 Hydrologic Parameter Calculations

B.4 Existing Surface Contours

B.1 NOAA Rainfall Depths

NOAA Atlas 14, Volume 8, Version 2
Location name: La Cygne, Kansas, USA*
Latitude: 38.3556°, Longitude: -94.6385°
Elevation: 859.74 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.398** (0.315-0.507)	**0.468** (0.371-0.596)	**0.581** (0.459-0.742)	**0.674** (0.530-0.863)	**0.799** (0.609-1.04)	**0.895** (0.669-1.18)	**0.989** (0.718-1.33)	**1.08** (0.759-1.48)	**1.21** (0.817-1.68)	**1.30** (0.861-1.84)
10-min	**0.582** (0.462-0.742)	**0.685** (0.543-0.873)	**0.851** (0.672-1.09)	**0.986** (0.775-1.26)	**1.17** (0.891-1.53)	**1.31** (0.979-1.73)	**1.45** (1.05-1.94)	**1.59** (1.11-2.17)	**1.77** (1.20-2.46)	**1.90** (1.26-2.69)
15-min	**0.710** (0.563-0.905)	**0.835** (0.662-1.07)	**1.04** (0.819-1.33)	**1.20** (0.946-1.54)	**1.43** (1.09-1.86)	**1.60** (1.19-2.11)	**1.77** (1.28-2.37)	**1.94** (1.36-2.65)	**2.15** (1.46-3.00)	**2.32** (1.54-3.28)
30-min	**1.04** (0.825-1.33)	**1.23** (0.972-1.56)	**1.53** (1.21-1.95)	**1.77** (1.39-2.27)	**2.10** (1.60-2.74)	**2.35** (1.76-3.10)	**2.60** (1.88-3.48)	**2.84** (1.99-3.88)	**3.15** (2.13-4.39)	**3.39** (2.25-4.78)
60-min	**1.39** (1.10-1.77)	**1.63** (1.30-2.08)	**2.04** (1.61-2.60)	**2.37** (1.86-3.03)	**2.82** (2.15-3.69)	**3.17** (2.37-4.18)	**3.51** (2.55-4.71)	**3.86** (2.70-5.28)	**4.31** (2.92-6.02)	**4.66** (3.09-6.58)
2-hr	**1.73** (1.39-2.19)	**2.04** (1.63-2.58)	**2.54** (2.03-3.22)	**2.96** (2.35-3.76)	**3.54** (2.72-4.59)	**3.98** (3.00-5.21)	**4.43** (3.24-5.90)	**4.88** (3.45-6.62)	**5.48** (3.74-7.58)	**5.93** (3.96-8.31)
3-hr	**1.95** (1.57-2.45)	**2.29** (1.84-2.88)	**2.86** (2.29-3.60)	**3.34** (2.66-4.22)	**4.01** (3.10-5.18)	**4.53** (3.44-5.91)	**5.06** (3.73-6.72)	**5.60** (3.98-7.58)	**6.33** (4.35-8.74)	**6.89** (4.62-9.62)
6-hr	**2.32** (1.88-2.89)	**2.73** (2.21-3.40)	**3.42** (2.77-4.26)	**4.01** (3.23-5.02)	**4.86** (3.80-6.24)	**5.53** (4.23-7.16)	**6.22** (4.62-8.20)	**6.94** (4.97-9.33)	**7.92** (5.49-10.9)	**8.69** (5.87-12.0)
12-hr	**2.69** (2.20-3.31)	**3.17** (2.60-3.91)	**4.00** (3.26-4.93)	**4.71** (3.82-5.83)	**5.74** (4.54-7.33)	**6.57** (5.08-8.46)	**7.44** (5.58-9.74)	**8.35** (6.04-11.2)	**9.61** (6.71-13.1)	**10.6** (7.22-14.6)
24-hr	**3.11** (2.57-3.79)	**3.64** (3.00-4.43)	**4.55** (3.74-5.56)	**5.36** (4.39-6.57)	**6.55** (5.24-8.30)	**7.52** (5.88-9.61)	**8.55** (6.48-11.1)	**9.65** (7.04-12.8)	**11.2** (7.87-15.1)	**12.4** (8.50-16.9)
2-day	**3.61** (3.01-4.35)	**4.16** (3.47-5.03)	**5.14** (4.27-6.22)	**6.02** (4.97-7.31)	**7.33** (5.93-9.23)	**8.42** (6.65-10.7)	**9.58** (7.33-12.4)	**10.8** (7.98-14.3)	**12.6** (8.95-16.9)	**14.0** (9.68-18.9)
3-day	**3.93** (3.29-4.71)	**4.55** (3.81-5.46)	**5.64** (4.70-6.78)	**6.60** (5.48-7.96)	**8.02** (6.51-10.0)	**9.19** (7.28-11.6)	**10.4** (8.00-13.4)	**11.7** (8.68-15.4)	**13.6** (9.69-18.2)	**15.1** (10.5-20.3)
4-day	**4.21** (3.54-5.03)	**4.89** (4.11-5.84)	**6.05** (5.07-7.25)	**7.08** (5.90-8.50)	**8.57** (6.97-10.6)	**9.79** (7.78-12.3)	**11.1** (8.52-14.1)	**12.4** (9.21-16.2)	**14.3** (10.2-19.0)	**15.8** (11.0-21.2)
7-day	**5.00** (4.24-5.93)	**5.75** (4.87-6.82)	**7.02** (5.93-8.34)	**8.13** (6.83-9.69)	**9.72** (7.95-11.9)	**11.0** (8.80-13.7)	**12.3** (9.56-15.6)	**13.7** (10.2-17.8)	**15.7** (11.3-20.7)	**17.2** (12.1-22.9)
10-day	**5.73** (4.88-6.76)	**6.53** (5.56-7.70)	**7.88** (6.69-9.31)	**9.04** (7.63-10.7)	**10.7** (8.79-13.1)	**12.0** (9.66-14.8)	**13.4** (10.4-16.9)	**14.9** (11.1-19.1)	**16.8** (12.1-22.1)	**18.4** (12.9-24.4)
20-day	**7.80** (6.71-9.10)	**8.80** (7.56-10.3)	**10.5** (8.96-12.2)	**11.8** (10.1-13.9)	**13.8** (11.4-16.6)	**15.3** (12.3-18.6)	**16.8** (13.1-20.8)	**18.3** (13.8-23.3)	**20.4** (14.8-26.5)	**22.0** (15.6-28.9)
30-day	**9.48** (8.20-11.0)	**10.7** (9.23-12.4)	**12.6** (10.9-14.7)	**14.2** (12.2-16.6)	**16.4** (13.6-19.6)	**18.1** (14.7-21.8)	**19.7** (15.5-24.3)	**21.4** (16.2-26.9)	**23.5** (17.1-30.3)	**25.1** (17.9-32.9)
45-day	**11.6** (10.1-13.3)	**13.0** (11.3-15.0)	**15.4** (13.3-17.8)	**17.3** (14.9-20.1)	**19.8** (16.5-23.4)	**21.7** (17.7-26.0)	**23.5** (18.5-28.7)	**25.3** (19.2-31.6)	**27.5** (20.1-35.2)	**29.1** (20.8-38.0)
60-day	**13.3** (11.6-15.3)	**15.0** (13.1-17.3)	**17.8** (15.5-20.4)	**19.9** (17.2-23.0)	**22.7** (19.0-26.7)	**24.8** (20.3-29.5)	**26.7** (21.2-32.5)	**28.6** (21.8-35.6)	**30.9** (22.7-39.4)	**32.6** (23.4-42.3)

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

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

Please refer to NOAA Atlas 14 document for more information.

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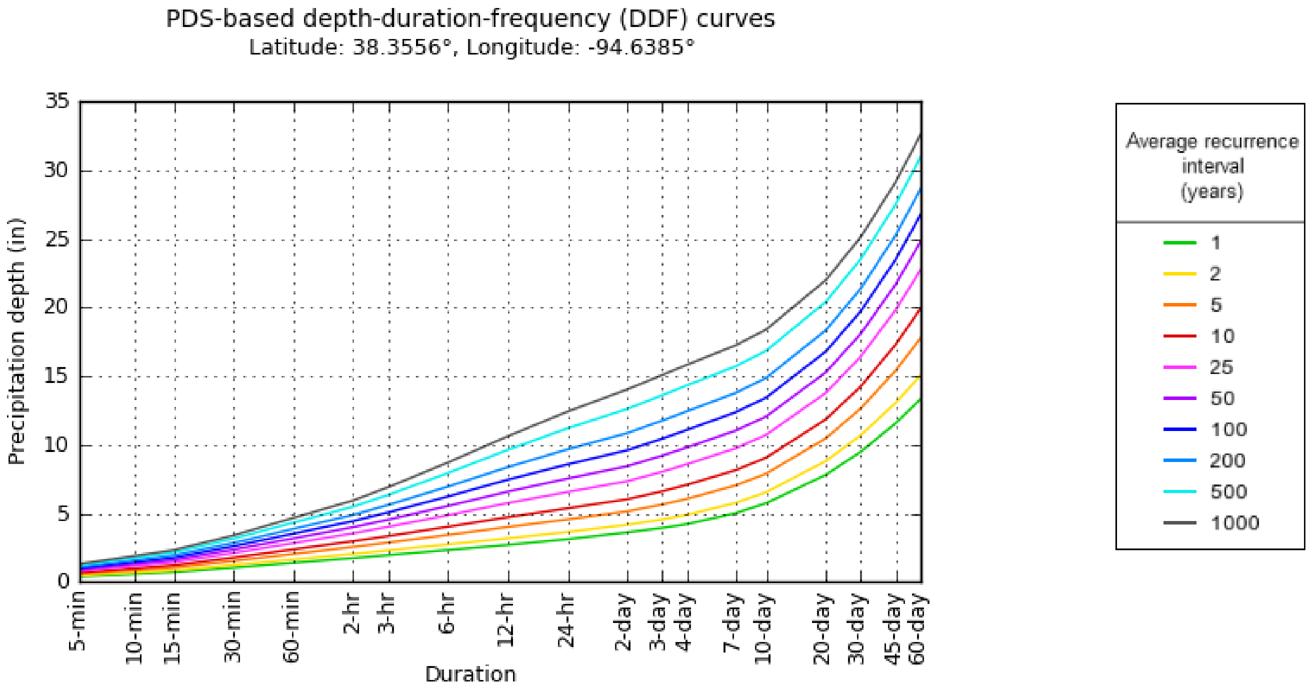
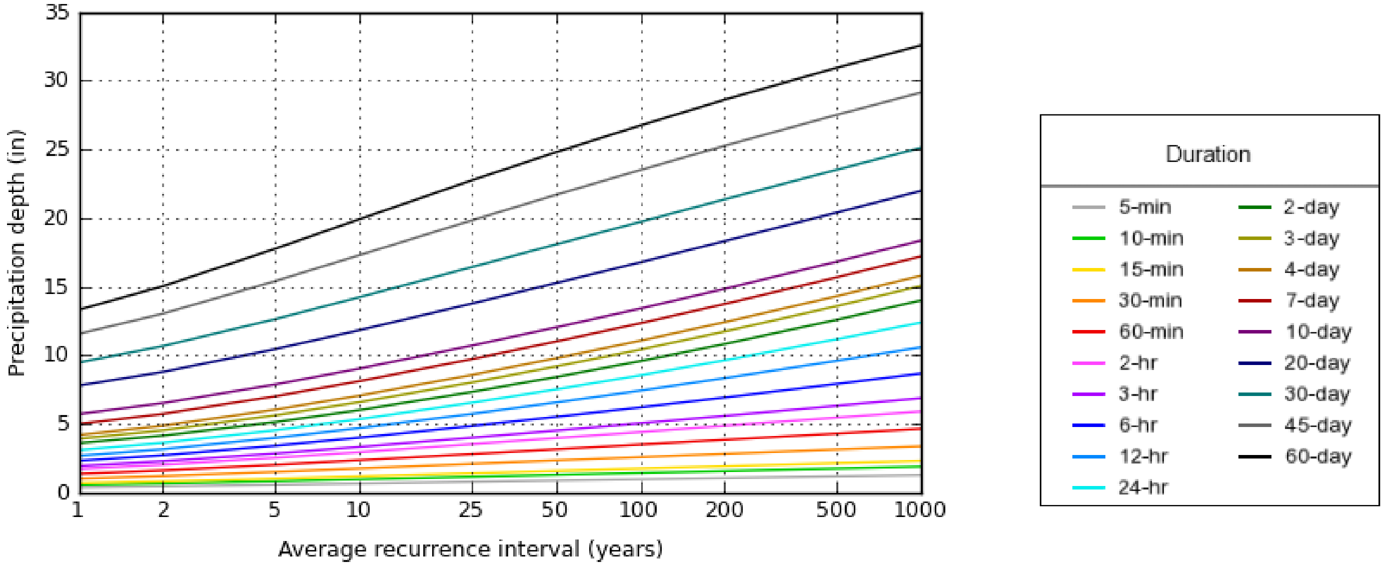
PF graphical





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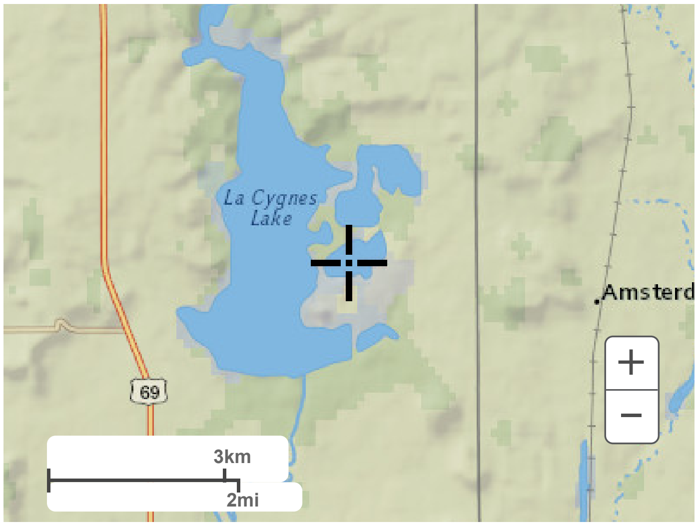
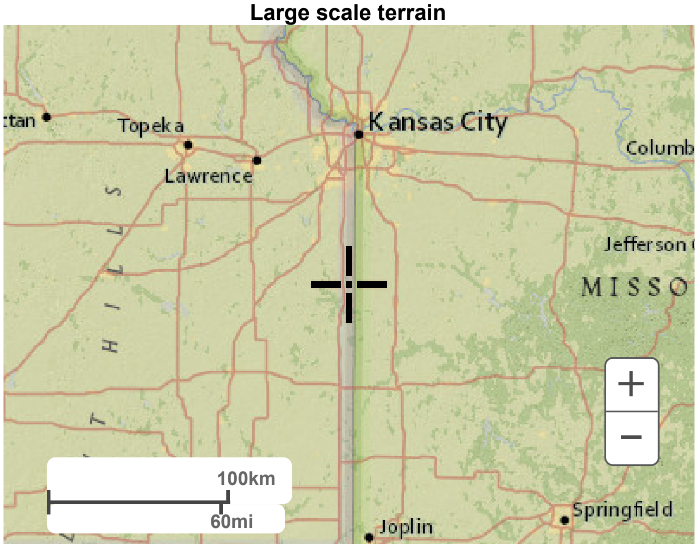
Maps & aerials

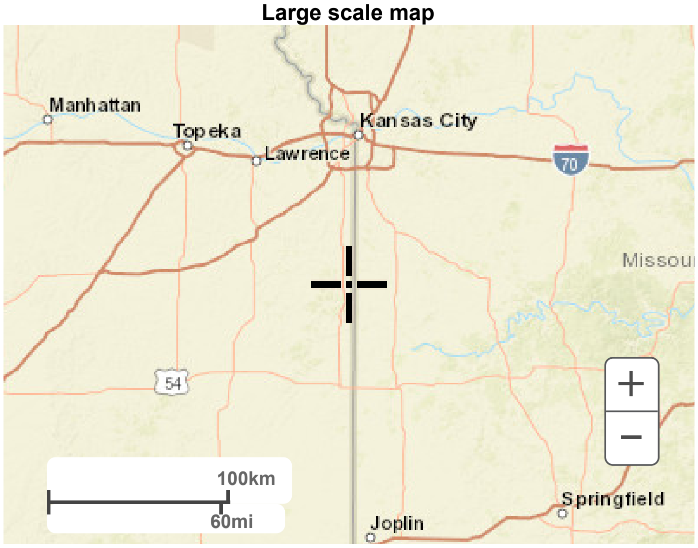
Small scale terrain



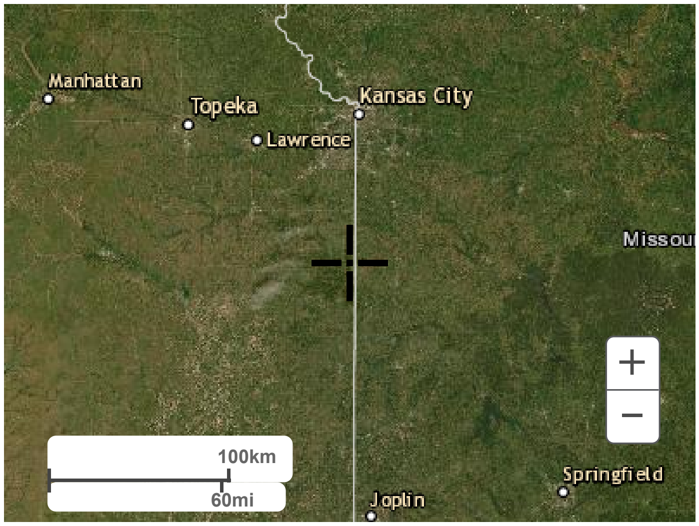
Large scale terrain



Large scale map



Large scale aerial



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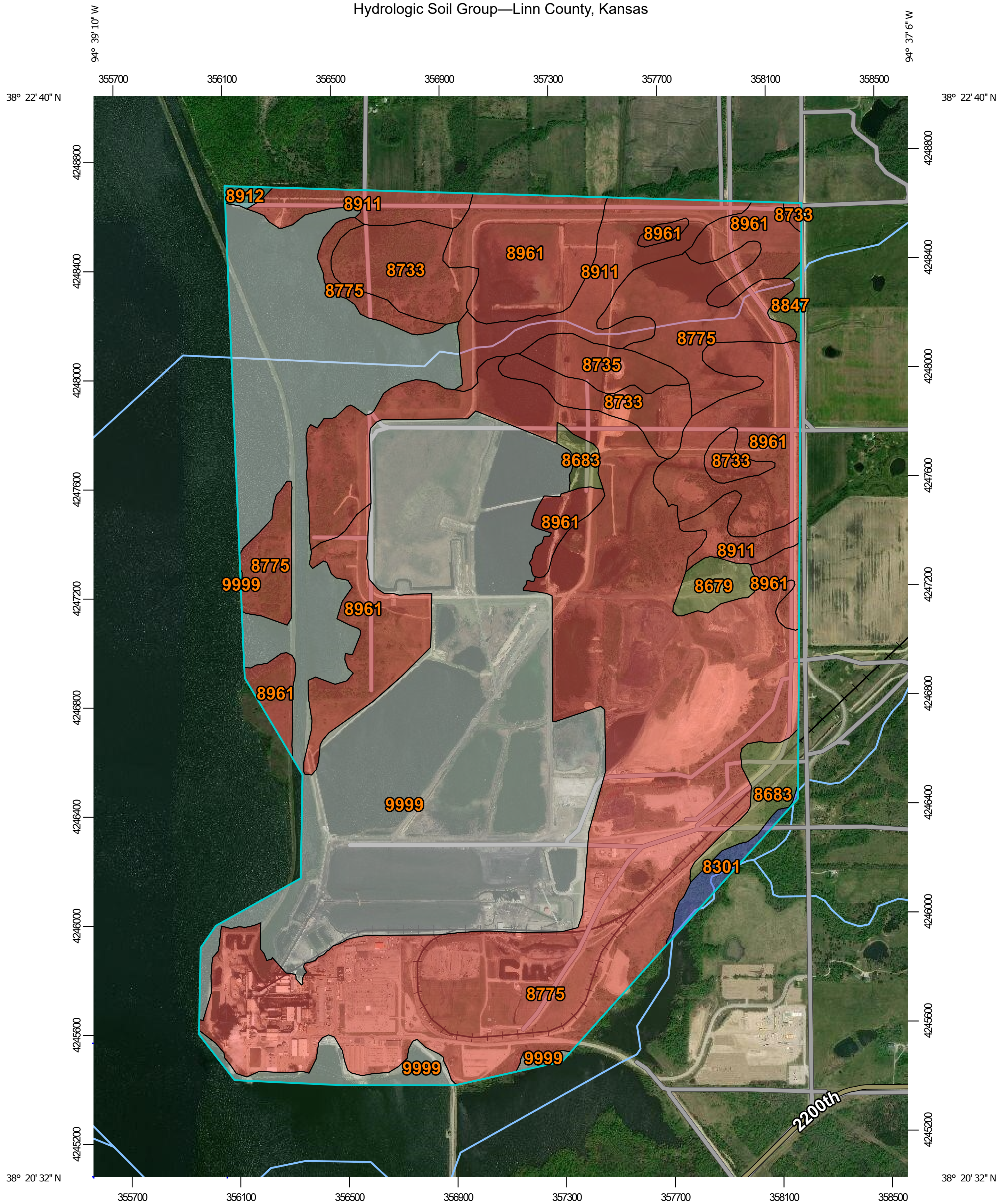
[US Department of Commerce](#)
[National Oceanic and Atmospheric Administration](#)
[National Weather Service](#)
[National Water Center](#)
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

B.2 NRCS Web Soil Survey Map

Hydrologic Soil Group—Linn County, Kansas



Map Scale: 1:19,300 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 250, 500, 1000, 1500

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

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: Linn County, Kansas
Survey Area Data: Version 20, 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: Oct 20, 2014—Jun 14, 2017

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.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
8301	Verdigris silt loam, 0 to 1 percent slopes, frequently flooded	B	9.0	0.6%
8679	Dennis silt loam, 1 to 3 percent slopes	C/D	11.0	0.7%
8683	Dennis silt loam, 3 to 7 percent slopes	C/D	22.4	1.5%
8733	Eram silty clay loam, 1 to 3 percent slopes	D	63.9	4.2%
8735	Eram silty clay loam, 3 to 7 percent slopes	D	18.2	1.2%
8775	Kenoma silt loam, 1 to 3 percent slopes	D	548.8	35.8%
8847	Okemah silt loam, 0 to 3 percent slopes	C/D	3.9	0.3%
8911	Summit silty clay loam, 1 to 3 percent slopes	D	81.4	5.3%
8912	Summit silty clay loam, 3 to 7 percent slopes	C	2.5	0.2%
8961	Woodson silt loam, 0 to 1 percent slopes	D	203.7	13.3%
9999	Water		566.3	37.0%
Totals for Area of Interest			**1,531.1**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

B.3 Hydrologic Parameter Calculations

I, Joslyn Townsend, being a Registered Professional Engineer in good standing in the State of Kansas, do hereby certify that the following calculations, which include all pages in Appendix B.3, were made to satisfy the requirements specified in 40 CFR §257.82 and were prepared by me or under my direct personal supervision.

Joslyn Townsend
Printed Name

October 8, 2021
Date

AECOM
2380 McGee Street, Suite 200
Kansas City, Missouri 64108
1-816-561-4443

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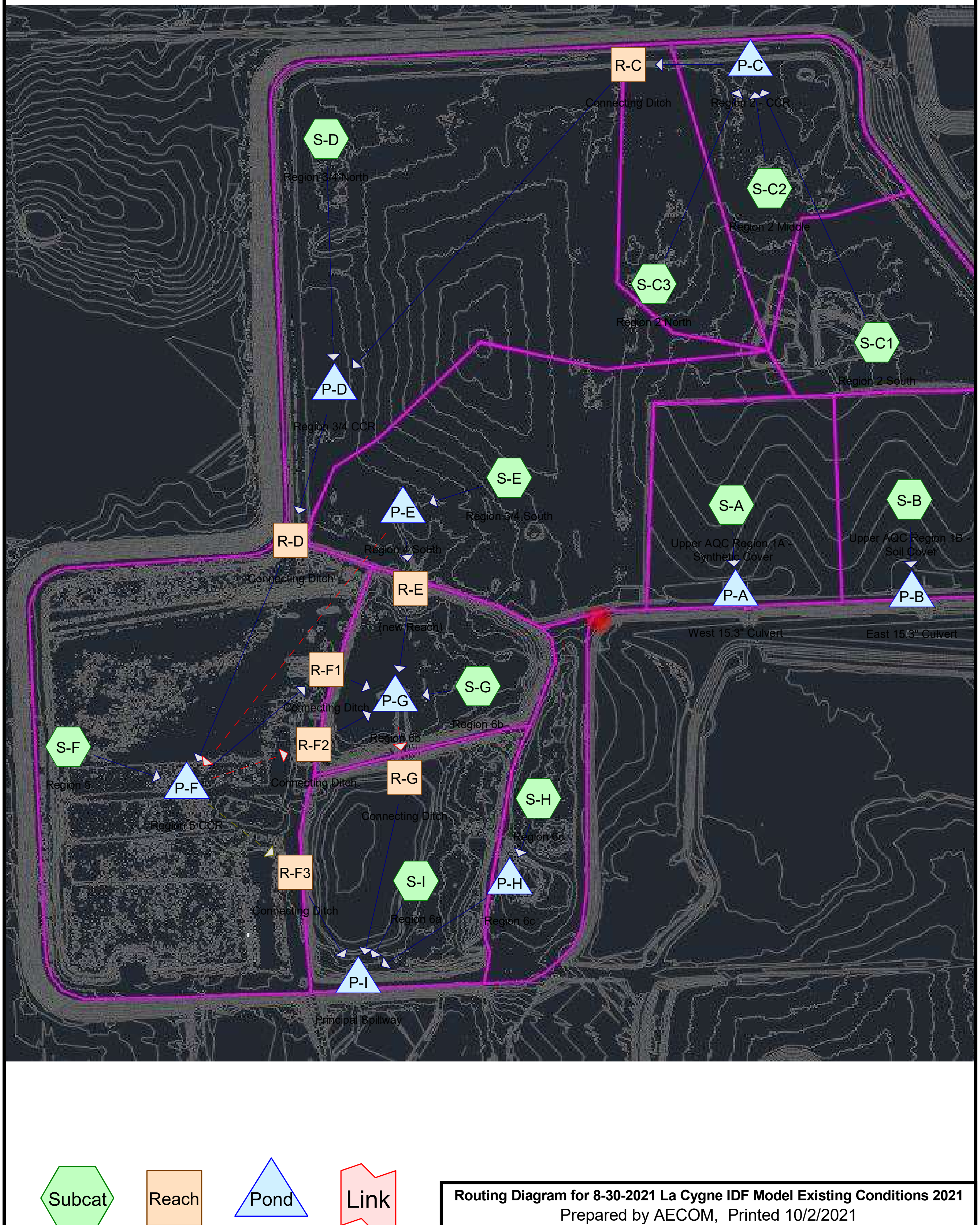


Routing Diagram for 8-30-2021 La Cygne IDF Model Existing Conditions 2021
Prepared by AECOM, Printed 10/2/2021

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	100-Year	Type II 24-hr		Default	24.00	1	8.55	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
20.720	98	Artificial Turf (S-A)
281.940	85	CCR (S-C1, S-C2, S-C3, S-D, S-E, S-F, S-G, S-H, S-I)
8.760	91	Gravel roads, HSG D (S-A, S-B, S-C1, S-C2, S-C3, S-D, S-F, S-H, S-I)
20.930	98	Soil Cover (S-B)
332.350	**87**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
8.760	HSG D	S-A, S-B, S-C1, S-C2, S-C3, S-D, S-F, S-H, S-I
323.590	Other	S-A, S-B, S-C1, S-C2, S-C3, S-D, S-E, S-F, S-G, S-H, S-I
332.350		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	20.720	20.720	Artificial Turf	S-A
0.000	0.000	0.000	0.000	281.940	281.940	CCR	S-C1, S-C2, S-C3, S-D, S-E, S-F, S-G, S-H, S-I
0.000	0.000	0.000	8.760	0.000	8.760	Gravel roads	S-A, S-B, S-C1, S-C2, S-C3, S-D, S-F, S-H, S-I
0.000	0.000	0.000	0.000	20.930	20.930	Soil Cover	S-B
0.000	**0.000**	**0.000**	**8.760**	**323.590**	**332.350**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	P-A	888.00	887.08	92.0	0.0100	0.013	15.3	0.0	0.0
2	P-B	887.50	886.54	96.0	0.0100	0.013	15.3	0.0	0.0
3	P-H	888.30	887.40	60.0	0.0150	0.014	18.0	0.0	0.0
4	P-H	888.40	887.10	60.0	0.0217	0.014	18.0	0.0	0.0
5	P-I	865.46	864.60	268.0	0.0032	0.025	30.0	0.0	0.0

Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Pond P-A: West 15.3" Culvert Peak Elev=893.18' Storage=7.369 af Inflow=211.58 cfs 14.653 af
Primary=10.34 cfs 14.653 af Secondary=0.00 cfs 0.000 af Tertiary=0.00 cfs 0.000 af Outflow=10.34 cfs 14.653 af

Pond P-B: East 15.3" Culvert Peak Elev=892.92' Storage=7.398 af Inflow=218.97 cfs 15.082 af
Primary=10.61 cfs 15.082 af Secondary=0.00 cfs 0.000 af Tertiary=0.00 cfs 0.000 af Outflow=10.61 cfs 15.082 af

Pond P-C: Region 2 - CCR Peak Elev=889.89' Storage=8.072 af Inflow=537.35 cfs 30.993 af
Primary=341.47 cfs 30.992 af Secondary=0.00 cfs 0.000 af Outflow=341.47 cfs 30.992 af

Pond P-D: Region 3/4 CCR Peak Elev=887.70' Storage=17.328 af Inflow=813.83 cfs 69.848 af
Primary=425.50 cfs 69.826 af Secondary=0.00 cfs 0.000 af Outflow=425.50 cfs 69.826 af

Pond P-E: Region 4 South Peak Elev=884.62' Storage=0.163 af Inflow=438.21 cfs 23.090 af
Primary=397.01 cfs 22.623 af Secondary=40.10 cfs 0.467 af Outflow=437.12 cfs 23.090 af

Pond P-F: Region 5 CCR Peak Elev=884.19' Storage=2.402 af Inflow=760.16 cfs 108.481 af
imary=76.82 cfs 10.995 af Secondary=425.32 cfs 60.875 af Tertiary=255.77 cfs 36.608 af Outflow=757.90 cfs 108.478 af

Pond P-G: Region 6b Peak Elev=883.44' Storage=209.730 af Inflow=786.92 cfs 104.352 af
Primary=277.62 cfs 103.696 af Secondary=0.00 cfs 0.000 af Outflow=277.62 cfs 103.696 af

Pond P-H: Region 6c Peak Elev=889.07' Storage=27.569 af Inflow=134.52 cfs 7.941 af
Primary=3.81 cfs 5.766 af Secondary=0.00 cfs 0.000 af Outflow=3.81 cfs 5.766 af

Pond P-I: Principal Spillway Peak Elev=878.60' Storage=127.623 af Inflow=576.23 cfs 159.947 af
Primary=40.88 cfs 114.548 af Secondary=0.00 cfs 0.000 af Outflow=40.88 cfs 114.548 af

Summary for Pond P-A: West 15.3" Culvert

Finished cap in 2021, discharge is non-contact water.
Lowest road point at 895.8.

Inflow Area = 21.160 ac, 97.92% Impervious, Inflow Depth = 8.31" for 100-Year event
Inflow = 211.58 cfs @ 12.03 hrs, Volume= 14.653 af
Outflow = 10.34 cfs @ 13.34 hrs, Volume= 14.653 af, Atten= 95%, Lag= 78.7 min
Primary = 10.34 cfs @ 13.34 hrs, Volume= 14.653 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 893.18' @ 13.34 hrs Storage= 7.369 af

Plug-Flow detention time= 291.2 min calculated for 14.653 af (100% of inflow)
Center-of-Mass det. time= 290.7 min (1,032.4 - 741.7)

Volume	Invert	Avail.Storage	Storage Description
#1	888.00'	25.316 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
888.00	0.000
888.50	0.029
889.00	0.120
890.00	0.564
891.00	1.616
892.00	3.543
893.00	6.578
894.00	10.979
895.00	17.018
896.00	25.316

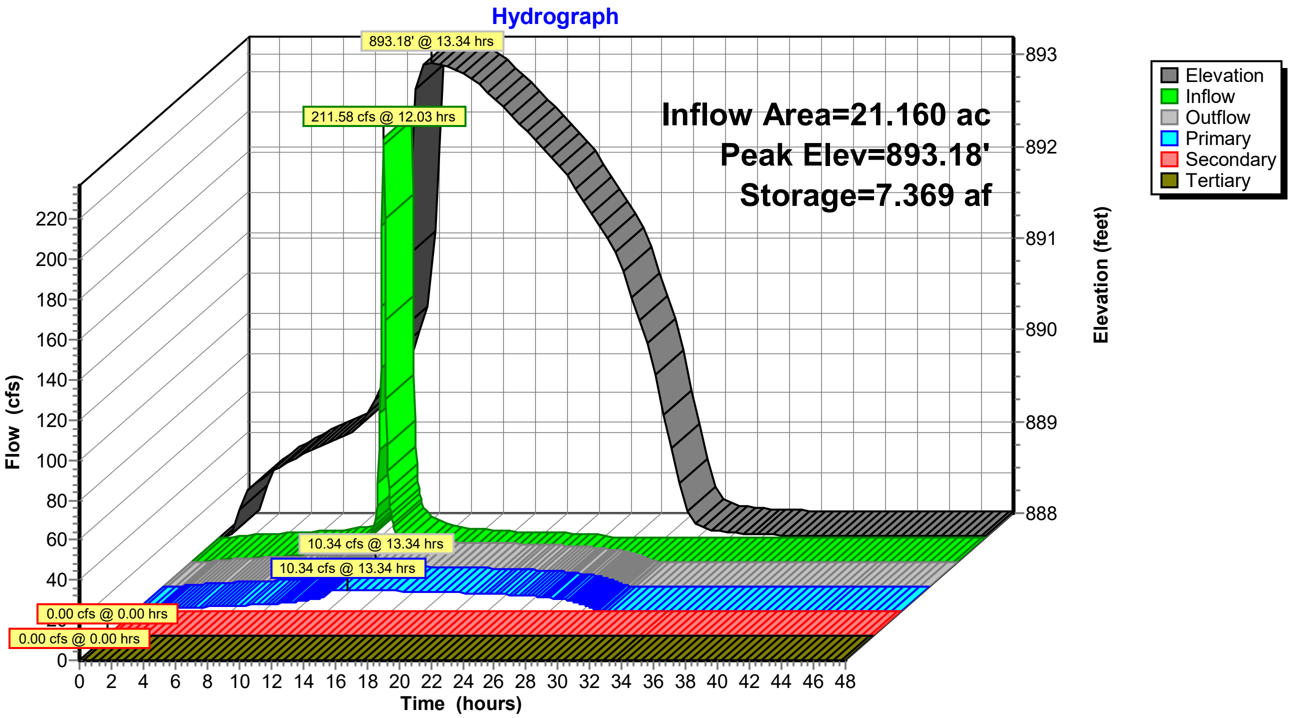
Device	Routing	Invert	Outlet Devices
#1	Primary	888.00'	**15.3" Round Culvert** L= 92.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 888.00' / 887.08' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.28 sf
#2	Secondary	894.00'	**50.0' long x 40.0' breadth Auxilliary Spillway** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#3	Tertiary	895.80'	**40.0' long x 20.0' breadth Road Overtop** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=10.34 cfs @ 13.34 hrs HW=893.18' (Free Discharge)
↑**1=Culvert** (Inlet Controls 10.34 cfs @ 8.10 fps)

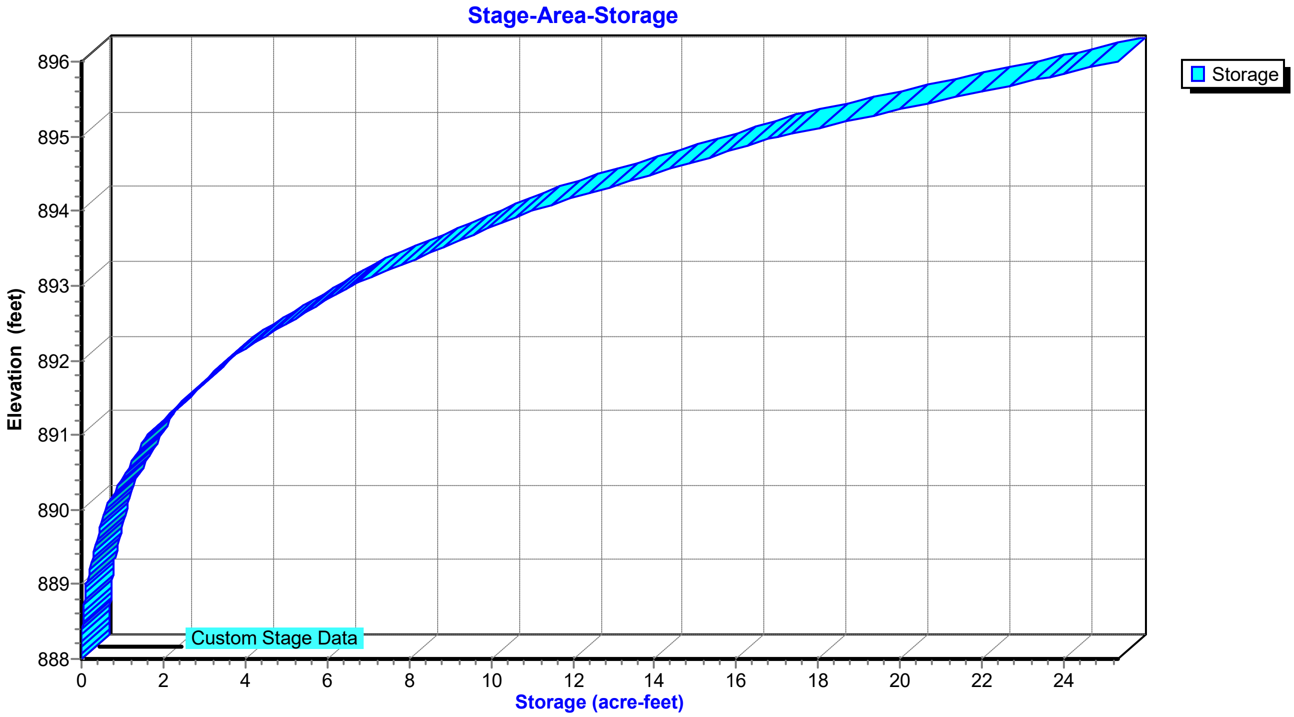
Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=888.00' (Free Discharge)
↑**2=Auxilliary Spillway** (Controls 0.00 cfs)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=888.00' (Free Discharge)
↑**3=Road Overtop** (Controls 0.00 cfs)

Pond P-A: West 15.3" Culvert



Pond P-A: West 15.3" Culvert



Summary for Pond P-B: East 15.3" Culvert

Finished cap in 2021, discharge is non-contact water.
Lowest road point at 895.8.

Inflow Area = 21.780 ac, 96.10% Impervious, Inflow Depth = 8.31" for 100-Year event
Inflow = 218.97 cfs @ 12.03 hrs, Volume= 15.082 af
Outflow = 10.61 cfs @ 13.35 hrs, Volume= 15.082 af, Atten= 95%, Lag= 79.1 min
Primary = 10.61 cfs @ 13.35 hrs, Volume= 15.082 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 892.92' @ 13.35 hrs Storage= 7.398 af

Plug-Flow detention time= 273.2 min calculated for 15.082 af (100% of inflow)
Center-of-Mass det. time= 272.6 min (1,014.1 - 741.5)

Volume	Invert	Avail.Storage	Storage Description
#1	887.50'	33.070 af	**Custom Stage Data** Listed below

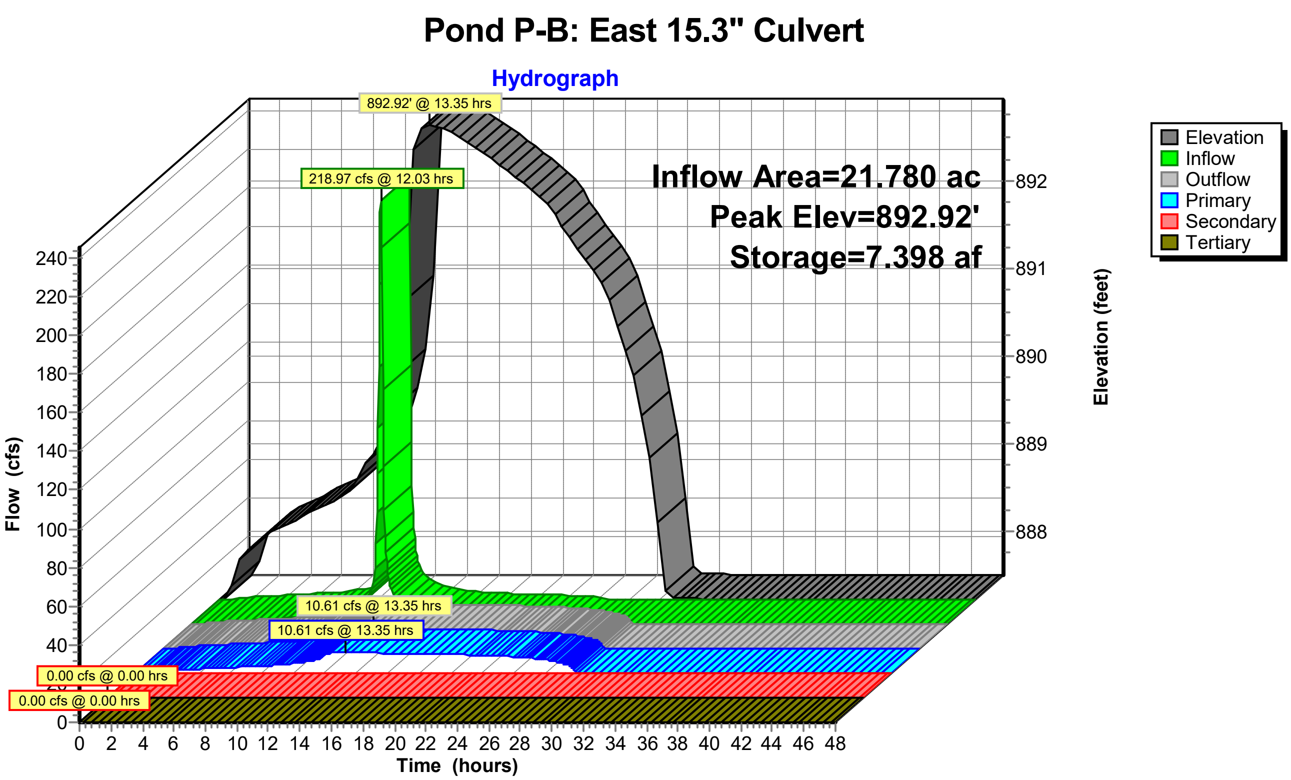
Elevation (feet)	Cum.Store (acre-feet)
887.50	0.000
888.00	0.004
888.50	0.039
889.00	0.136
890.00	0.599
891.00	1.678
892.00	3.839
893.00	7.723
894.00	13.662
895.00	22.025
896.00	33.070

Device	Routing	Invert	Outlet Devices
#1	Primary	887.50'	**15.3" Round Culvert** L= 96.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 887.50' / 886.54' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.28 sf
#2	Secondary	894.00'	**50.0' long x 40.0' breadth Auxilliary Spillway** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#3	Tertiary	895.80'	**40.0' long x 20.0' breadth Road Overtop** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

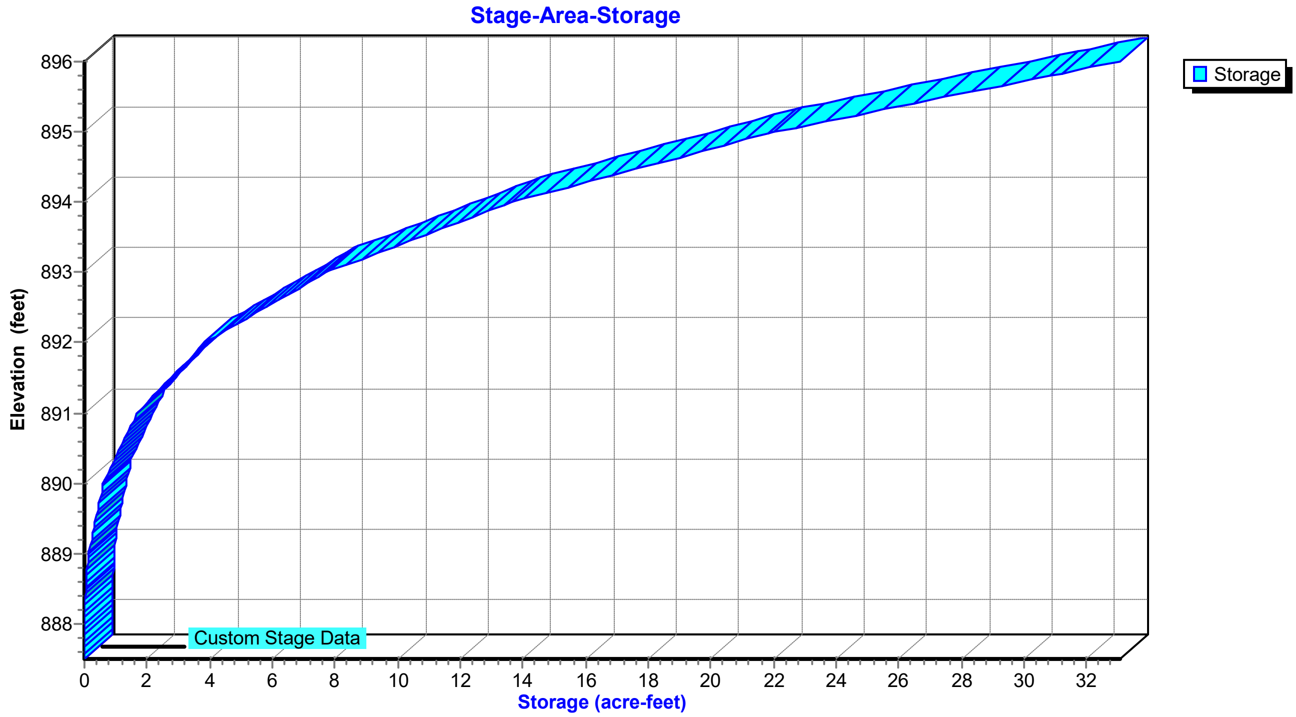
Primary OutFlow Max=10.61 cfs @ 13.35 hrs HW=892.92' (Free Discharge)
└─**1=Culvert** (Inlet Controls 10.61 cfs @ 8.31 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=887.50' (Free Discharge)
└─**2=Auxilliary Spillway** (Controls 0.00 cfs)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=887.50' (Free Discharge)
└─**3=Road Overtop** (Controls 0.00 cfs)



Pond P-B: East 15.3" Culvert



Summary for Pond P-C: Region 2 - CCR

Lowest road point at 890.8

Inflow Area = 55.140 ac, 0.00% Impervious, Inflow Depth = 6.74" for 100-Year event
Inflow = 537.35 cfs @ 11.97 hrs, Volume= 30.993 af
Outflow = 341.47 cfs @ 12.07 hrs, Volume= 30.992 af, Atten= 36%, Lag= 5.7 min
Primary = 341.47 cfs @ 12.07 hrs, Volume= 30.992 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 887.83' Storage= 1.663 af
Peak Elev= 889.89' @ 12.07 hrs Storage= 8.072 af (6.409 af above start)

Plug-Flow detention time= 70.4 min calculated for 29.299 af (95% of inflow)
Center-of-Mass det. time= 22.0 min (808.8 - 786.7)

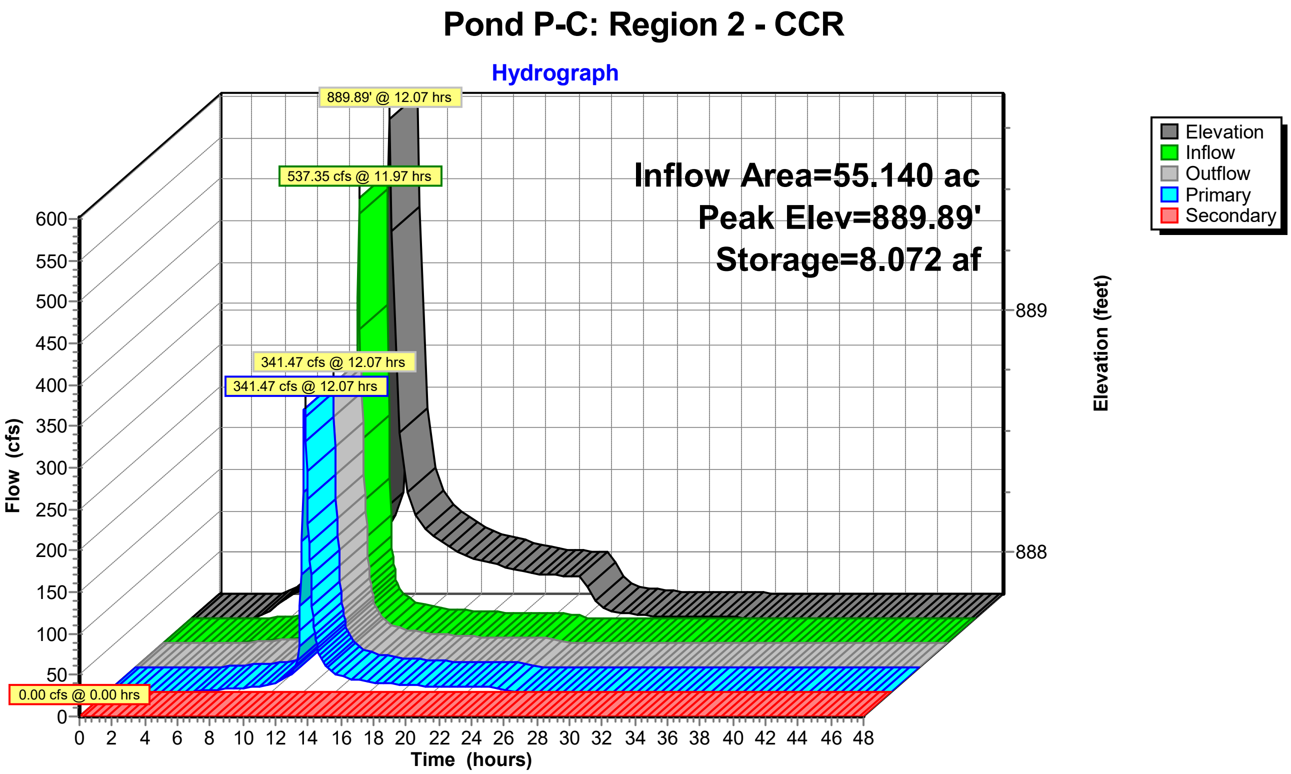
Volume	Invert	Avail.Storage	Storage Description
#1	885.00'	13.843 af	**Custom Stage Data** Listed below

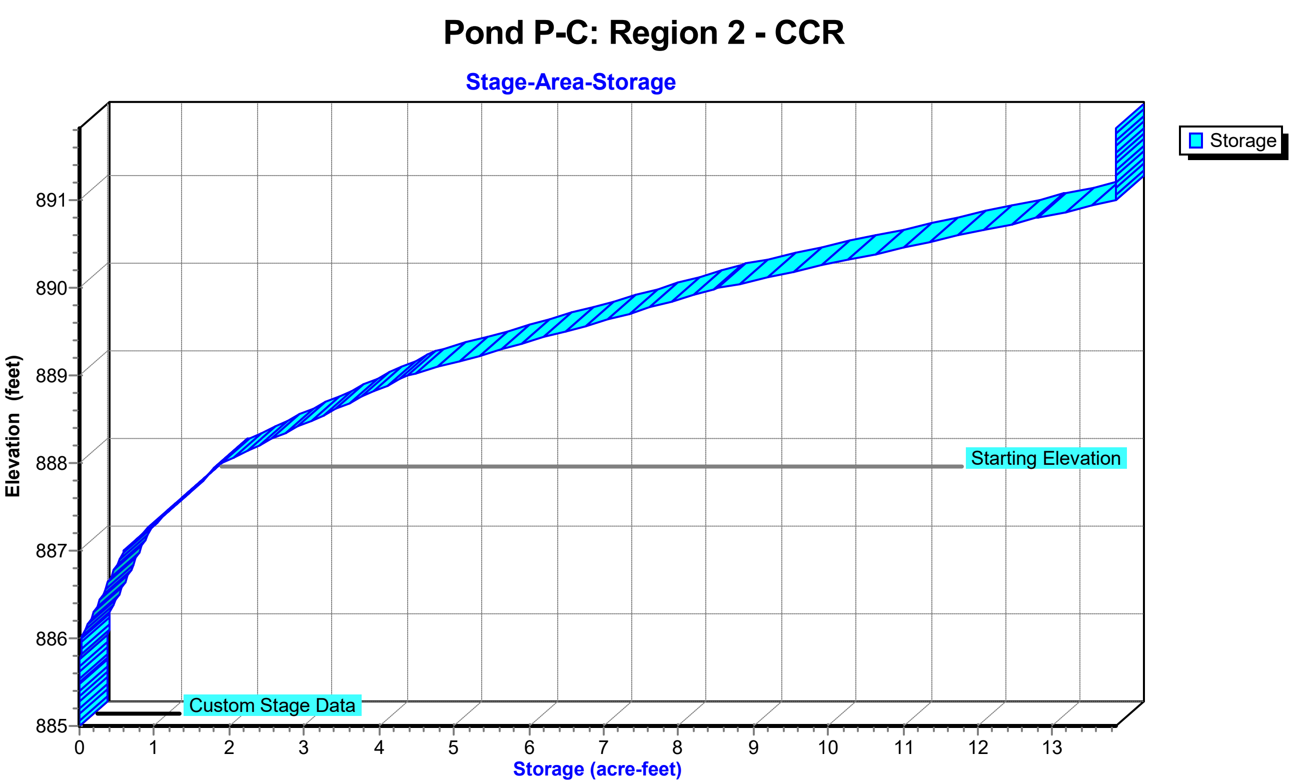
Elevation (feet)	Cum.Store (acre-feet)
885.00	0.000
885.50	0.001
886.00	0.021
887.00	0.592
888.00	1.882
889.00	4.375
890.00	8.534
891.00	13.843

Device	Routing	Invert	Outlet Devices
#1	Primary	887.83'	**Channel/Reach** using Reach R-C: Connecting Ditch
#2	Secondary	890.80'	**40.0' long x 20.0' breadth Road Overtop** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=336.82 cfs @ 12.07 hrs HW=889.87' TW=889.36' (Dynamic Tailwater)
└─**1=Channel/Reach** (Channel Controls 336.82 cfs @ 2.70 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=887.83' (Free Discharge)
└─**2=Road Overtop** (Controls 0.00 cfs)


Pond P-C: Region 2 - CCR
Hydrograph
889.89' @ 12.07 hrs
537.35 cfs @ 11.97 hrs
341.47 cfs @ 12.07 hrs
341.47 cfs @ 12.07 hrs
0.00 cfs @ 0.00 hrs
Inflow Area=55.140 ac
Peak Elev=889.89'
Storage=8.072 af
Elevation
Inflow
Outflow
Primary
Secondary
Flow (cfs)
Elevation (feet)
Time (hours)
0
50
100
150
200
250
300
350
400
450
500
550
600
888
889
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48


Pond P-C: Region 2 - CCR
Stage-Area-Storage
Storage
Starting Elevation
Custom Stage Data
Elevation (feet)
Storage (acre-feet)
885
886
887
888
889
890
891
0 1 2 3 4 5 6 7 8 9 10 11 12 13

Summary for Pond P-D: Region 3/4 CCR

Lowest road point at 890.4

Inflow Area = 124.270 ac, 0.00% Impervious, Inflow Depth = 6.74" for 100-Year event
Inflow = 813.83 cfs @ 12.05 hrs, Volume= 69.848 af
Outflow = 425.50 cfs @ 12.27 hrs, Volume= 69.826 af, Atten= 48%, Lag= 13.0 min
Primary = 425.50 cfs @ 12.27 hrs, Volume= 69.826 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 885.30' Storage= 2.058 af
Peak Elev= 887.70' @ 12.27 hrs Storage= 17.328 af (15.269 af above start)

Plug-Flow detention time= 68.0 min calculated for 67.767 af (97% of inflow)
Center-of-Mass det. time= 37.6 min (849.4 - 811.8)

Volume	Invert	Avail.Storage	Storage Description
#1	881.00'	71.292 af	**Custom Stage Data** Listed below

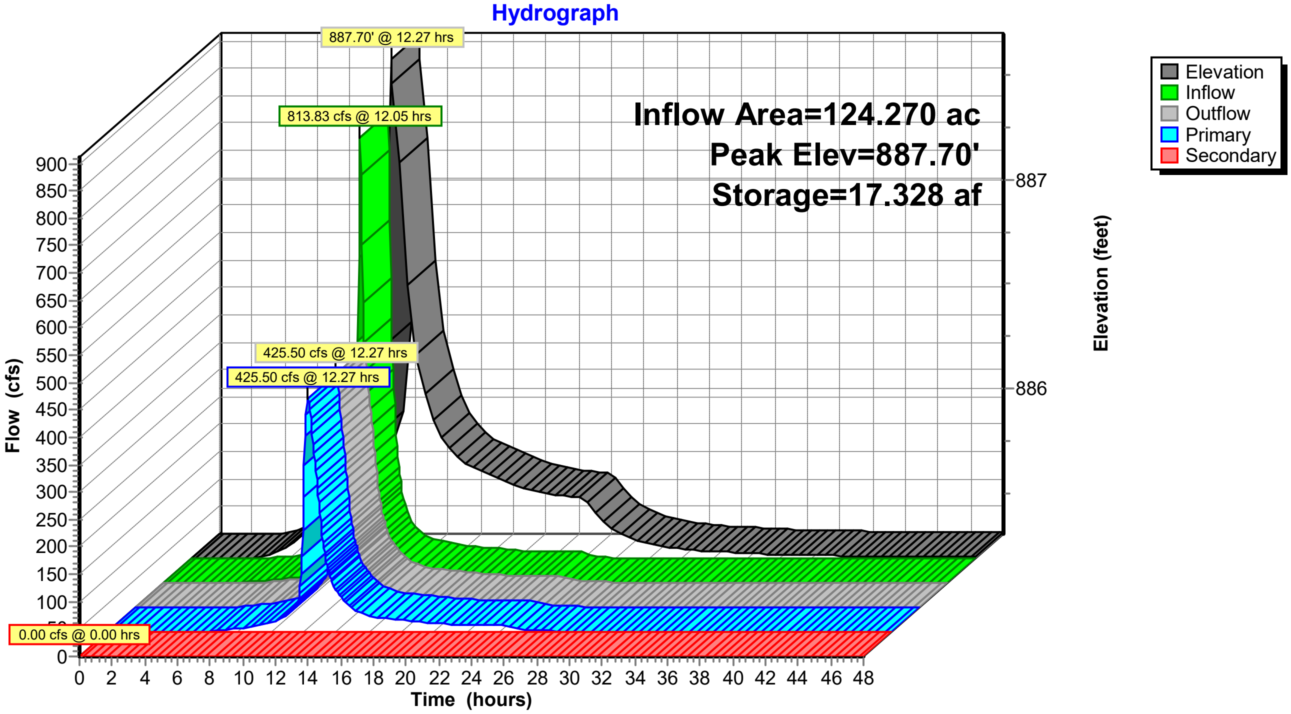
Elevation (feet)	Cum.Store (acre-feet)
881.00	0.000
883.00	0.001
884.00	0.022
885.00	0.977
886.00	4.582
887.00	10.796
888.00	20.116
889.00	32.641
890.00	49.091
891.00	71.292

Device	Routing	Invert	Outlet Devices
#1	Primary	885.30'	**Channel/Reach** using Reach R-D: Connecting Ditch
#2	Secondary	890.40'	**40.0' long x 20.0' breadth Road Overtop** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

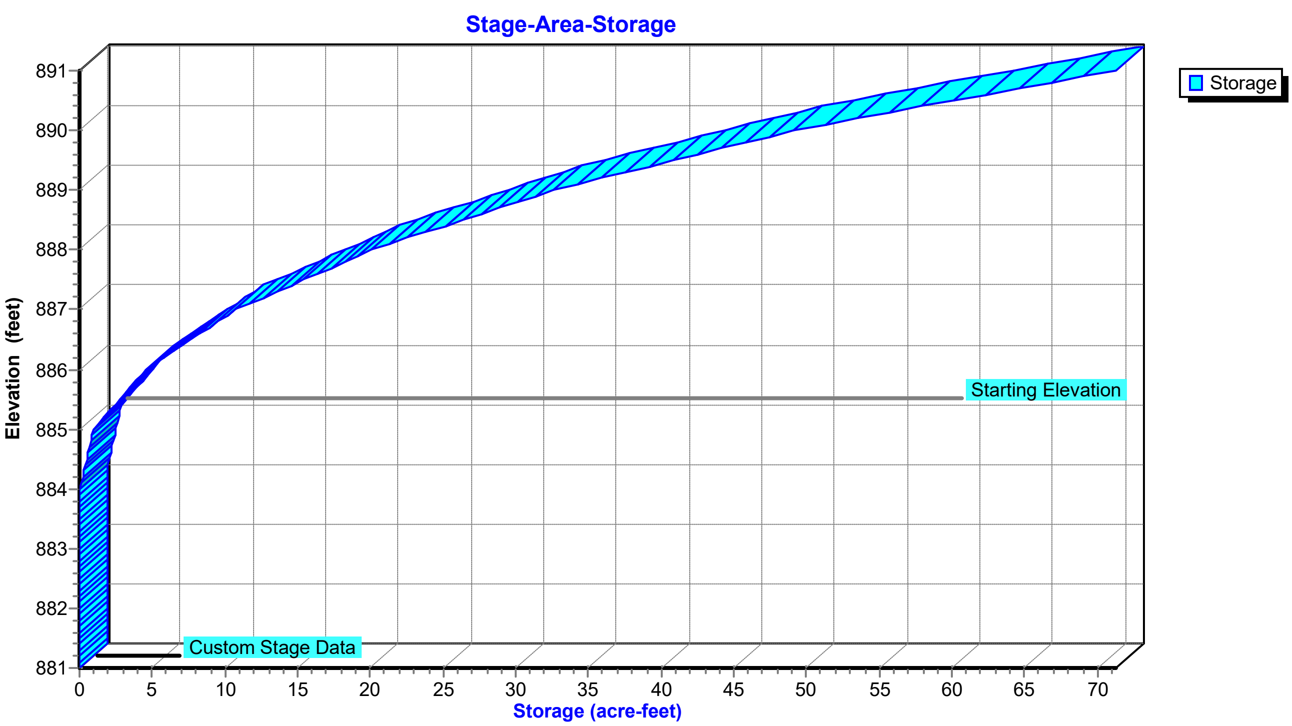
Primary OutFlow Max=424.58 cfs @ 12.27 hrs HW=887.70' TW=887.49' (Dynamic Tailwater)
└─**1=Channel/Reach** (Channel Controls 424.58 cfs @ 2.85 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=885.30' (Free Discharge)
└─**2=Road Overtop** (Controls 0.00 cfs)

Pond P-D: Region 3/4 CCR



Pond P-D: Region 3/4 CCR



Summary for Pond P-E: Region 4 South

Lowest road point at 884.1. NOTE: This is not an exterior road, it overtops into Pond 3P.

Inflow Area =	41.080 ac,	0.00% Impervious, Inflow Depth = 6.74"	for 100-Year event
Inflow =	438.21 cfs @	11.97 hrs, Volume=	23.090 af
Outflow =	437.12 cfs @	11.97 hrs, Volume=	23.090 af, Atten= 0%, Lag= 0.2 min
Primary =	397.01 cfs @	11.97 hrs, Volume=	22.623 af
Secondary =	40.10 cfs @	11.97 hrs, Volume=	0.467 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 883.13' Storage= 0.052 af
Peak Elev= 884.62' @ 11.97 hrs Storage= 0.163 af (0.111 af above start)

Plug-Flow detention time= 3.5 min calculated for 23.038 af (100% of inflow)
Center-of-Mass det. time= 0.5 min (785.8 - 785.4)

Volume	Invert	Avail.Storage	Storage Description
#1	878.00'	16.070 af	**Custom Stage Data** Listed below

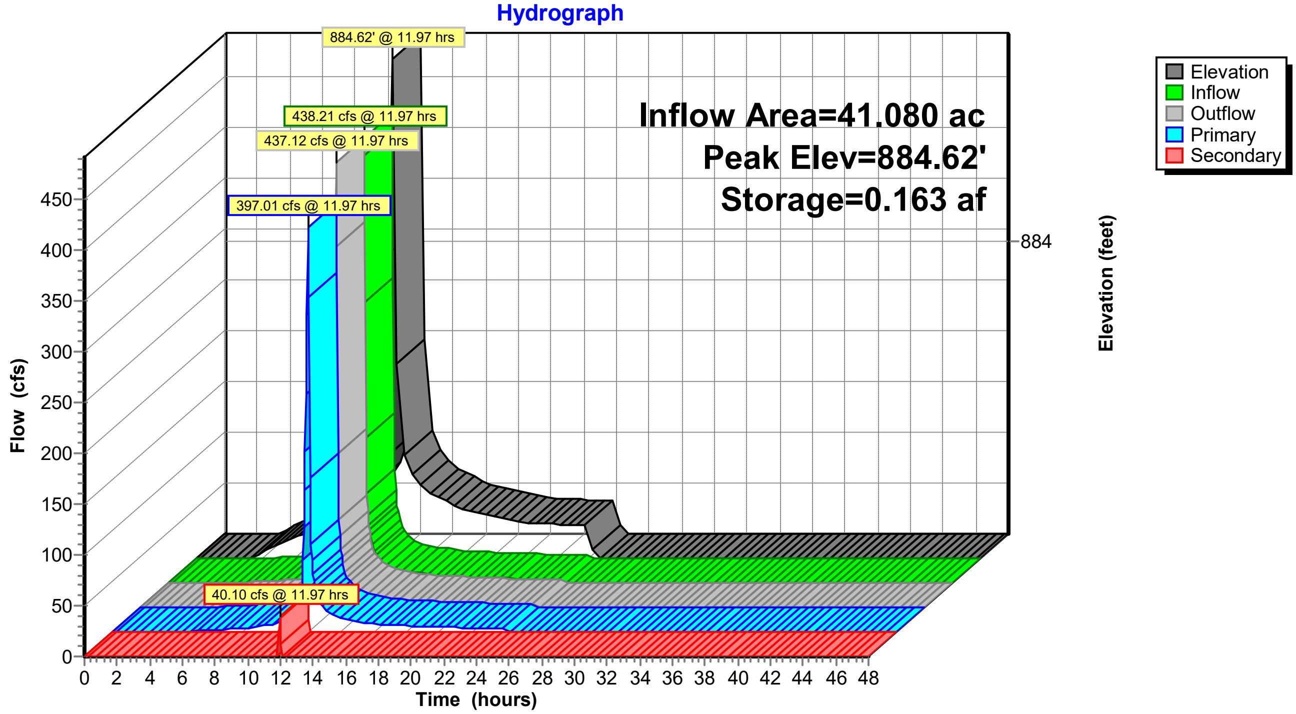
Elevation (feet)	Cum.Store (acre-feet)
878.00	0.000
879.00	0.001
880.00	0.003
881.00	0.011
882.00	0.024
883.00	0.045
884.00	0.101
885.00	0.201
886.00	0.338
887.00	0.526
888.00	0.828
889.00	1.652
890.00	4.829
891.00	10.808
892.00	13.774
893.00	16.070

Device	Routing	Invert	Outlet Devices
#1	Primary	883.13'	**Channel/Reach** using Reach R-E: (new Reach)
#2	Secondary	884.10'	**40.0' long x 20.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

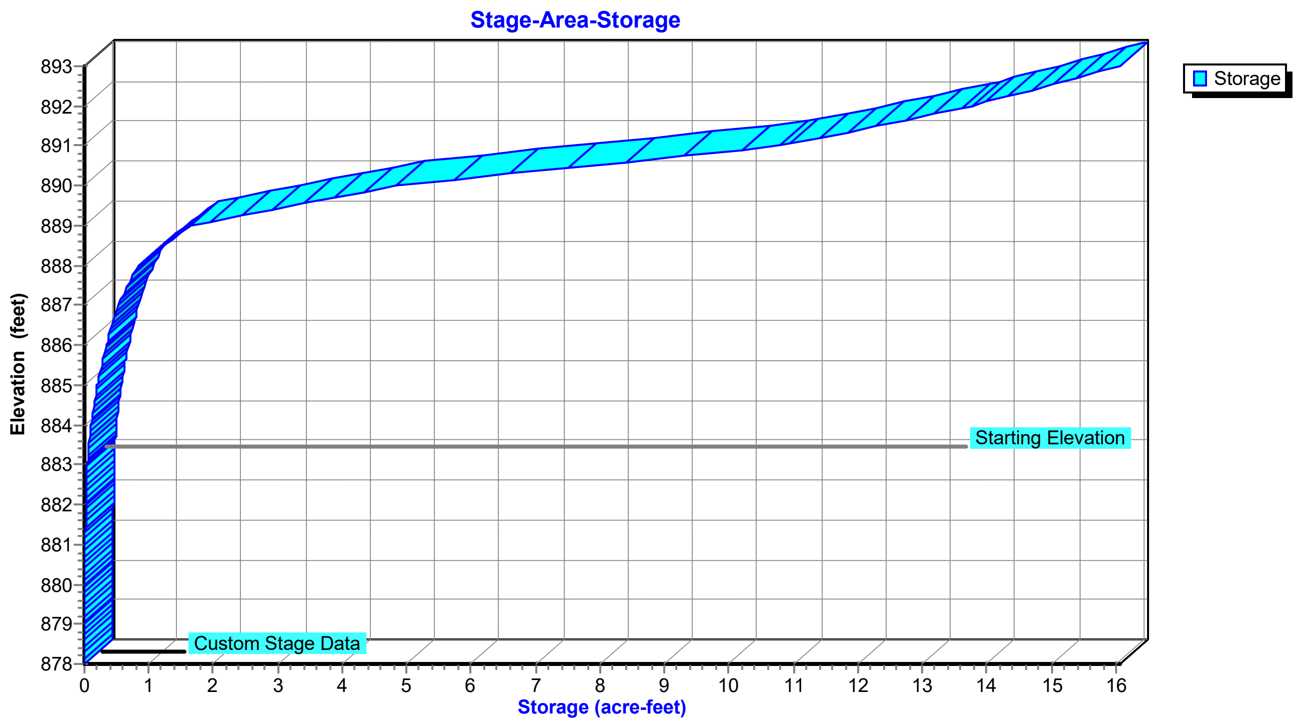
Primary OutFlow Max=387.14 cfs @ 11.97 hrs HW=884.60' TW=884.60' (Dynamic Tailwater)
└─**1=Channel/Reach** (Channel Controls 387.14 cfs @ 20.41 fps)

Secondary OutFlow Max=37.80 cfs @ 11.97 hrs HW=884.60' TW=883.96' (Dynamic Tailwater)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 37.80 cfs @ 1.90 fps)

Pond P-E: Region 4 South



Pond P-E: Region 4 South



Summary for Pond P-F: Region 5 CCR

Lowest road point at 889.1

Inflow Area = 192.220 ac, 0.00% Impervious, Inflow Depth = 6.77" for 100-Year event
Inflow = 760.16 cfs @ 12.10 hrs, Volume= 108.481 af
Outflow = 757.90 cfs @ 12.12 hrs, Volume= 108.478 af, Atten= 0%, Lag= 1.0 min
Primary = 76.82 cfs @ 12.12 hrs, Volume= 10.995 af
Secondary = 425.32 cfs @ 12.12 hrs, Volume= 60.875 af
Tertiary = 255.77 cfs @ 12.12 hrs, Volume= 36.608 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 883.00' Storage= 1.163 af
Peak Elev= 884.19' @ 12.12 hrs Storage= 2.402 af (1.239 af above start)

Plug-Flow detention time= 17.2 min calculated for 107.315 af (99% of inflow)
Center-of-Mass det. time= 2.4 min (844.4 - 841.9)

Volume	Invert	Avail.Storage	Storage Description
#1	876.00'	272.722 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
876.00	0.000
876.50	0.004
877.00	0.007
878.00	0.015
879.00	0.032
880.00	0.066
881.00	0.158
882.00	0.489
883.00	1.163
884.00	2.133
885.00	3.512
886.00	5.428
887.00	8.037
888.00	15.115
889.00	34.979
890.00	64.460
891.00	104.306
892.00	153.039
893.00	209.642
894.00	272.722

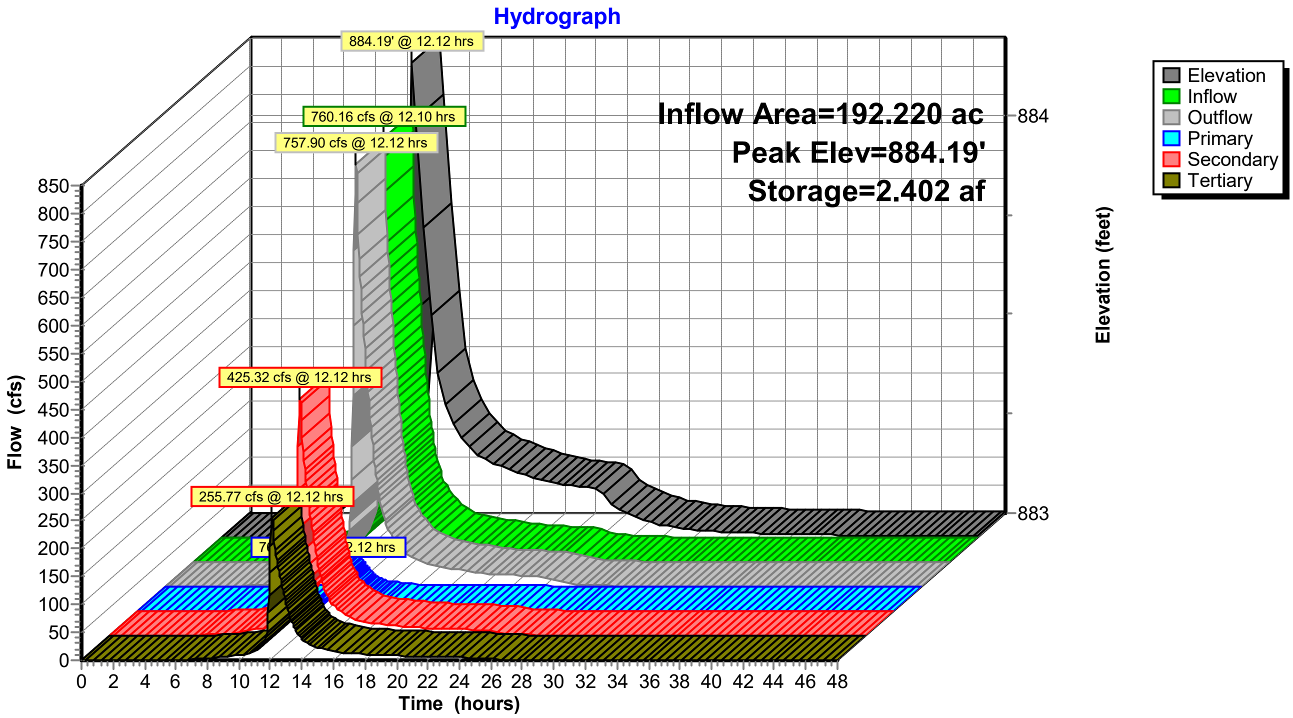
Device	Routing	Invert	Outlet Devices
#1	Primary	883.00'	**Channel/Reach** using Reach R-F1: Connecting Ditch
#2	Secondary	883.00'	**Channel/Reach X 3.00** using Reach R-F2: Connecting Ditch
#3	Tertiary	883.00'	**Channel/Reach** using Reach R-F3: Connecting Ditch

Primary OutFlow Max=76.13 cfs @ 12.12 hrs HW=884.19' TW=884.18' (Dynamic Tailwater)
└─**1=Channel/Reach** (Channel Controls 76.13 cfs @ 9.72 fps)

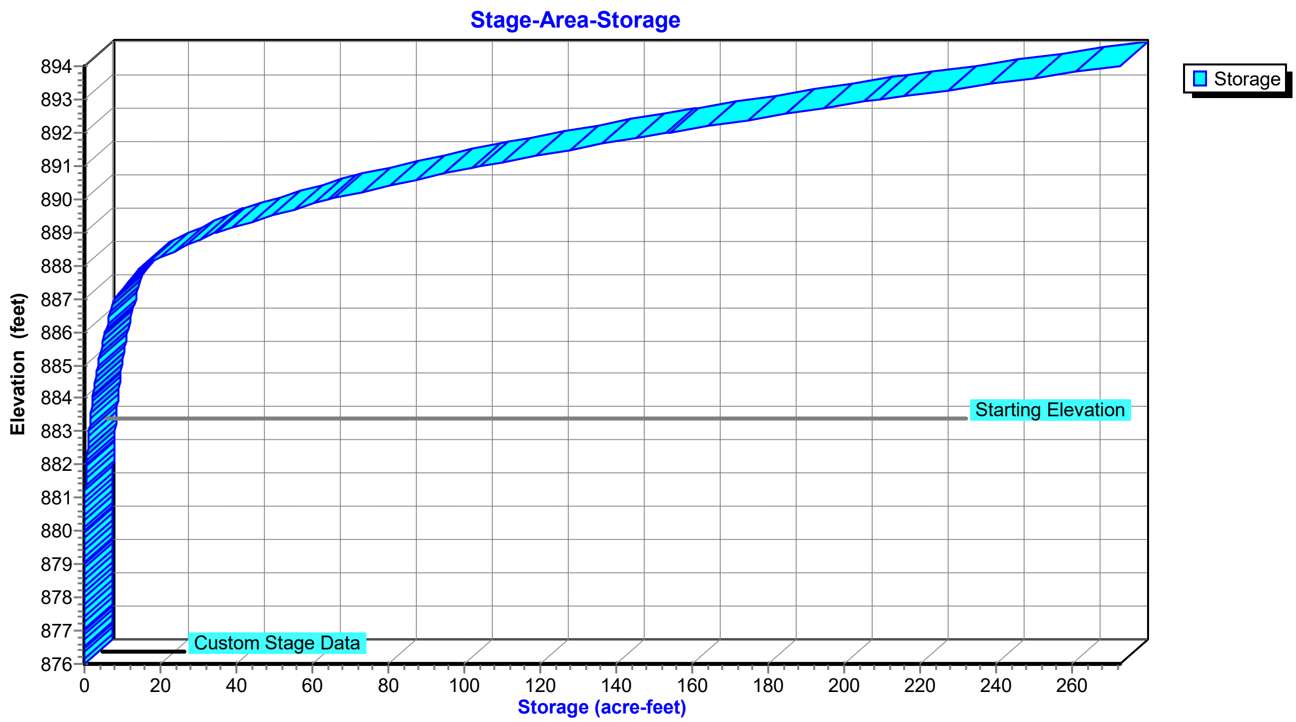
Secondary OutFlow Max=421.51 cfs @ 12.12 hrs HW=884.19' TW=885.34' (Dynamic Tailwater)
└─**2=Channel/Reach** (Channel Controls 421.51 cfs @ 17.93 fps)

Tertiary OutFlow Max=253.48 cfs @ 12.12 hrs HW=884.19' TW=884.19' (Dynamic Tailwater)
└─**3=Channel/Reach** (Channel Controls 253.48 cfs @ 32.36 fps)

Pond P-F: Region 5 CCR



Pond P-F: Region 5 CCR



Summary for Pond P-G: Region 6b

Lowest road point at 889.5. NOTE: This is not an exterior road, it overtops into Pond 6.

Inflow Area = 250.840 ac, 0.00% Impervious, Inflow Depth = 4.99" for 100-Year event
Inflow = 786.92 cfs @ 12.01 hrs, Volume= 104.352 af
Outflow = 277.62 cfs @ 12.80 hrs, Volume= 103.696 af, Atten= 65%, Lag= 47.3 min
Primary = 277.62 cfs @ 12.80 hrs, Volume= 103.696 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 881.37' Storage= 176.931 af
Peak Elev= 883.44' @ 12.80 hrs Storage= 209.730 af (32.800 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 134.6 min (981.0 - 846.4)

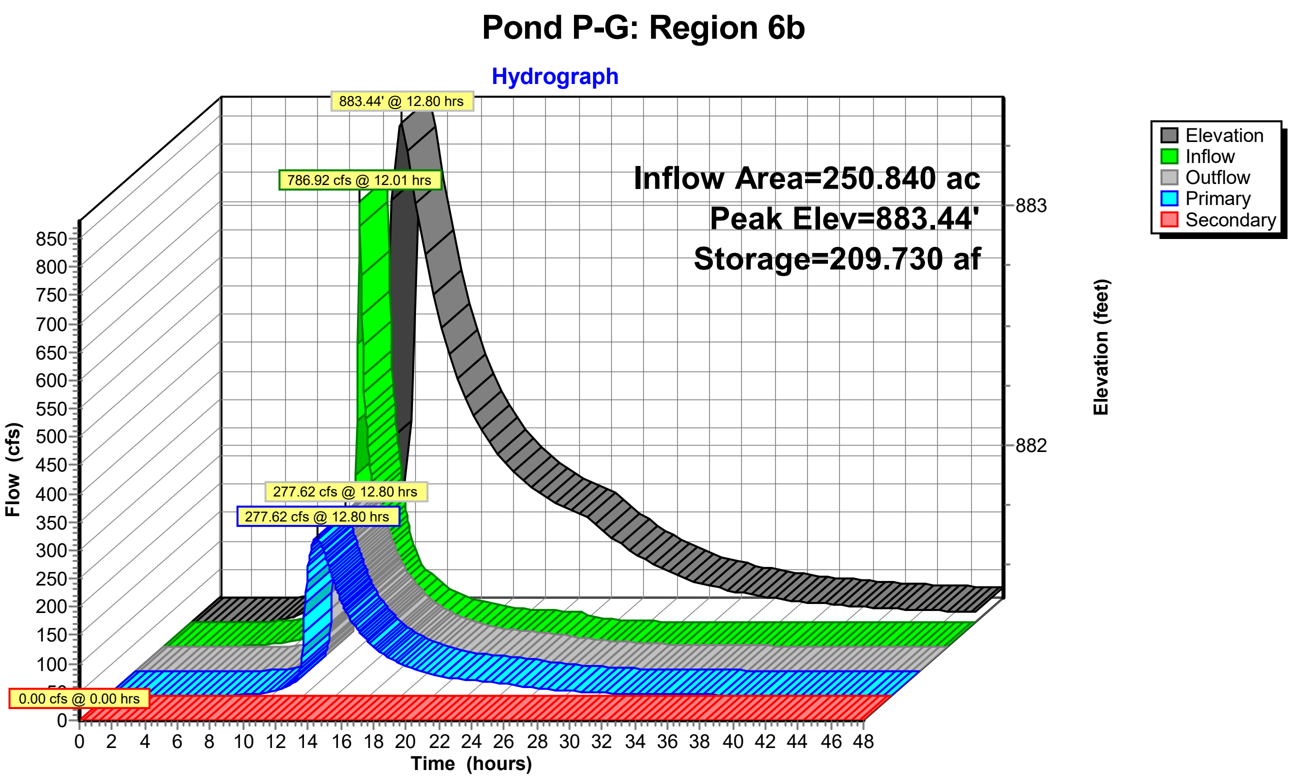
Volume	Invert	Avail.Storage	Storage Description
#1	870.00'	505.051 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
870.00	0.000
870.46	30.466
871.00	36.024
872.00	47.226
873.00	59.249
874.00	71.877
875.00	84.928
876.00	98.345
877.00	112.120
878.00	126.297
879.00	140.863
880.00	155.824
881.00	171.142
882.00	186.787
883.00	202.642
884.00	218.659
885.00	234.836
886.00	251.172
887.00	267.671
888.00	284.341
889.00	301.206
890.00	318.293
891.00	335.593
892.00	367.309
893.00	505.051

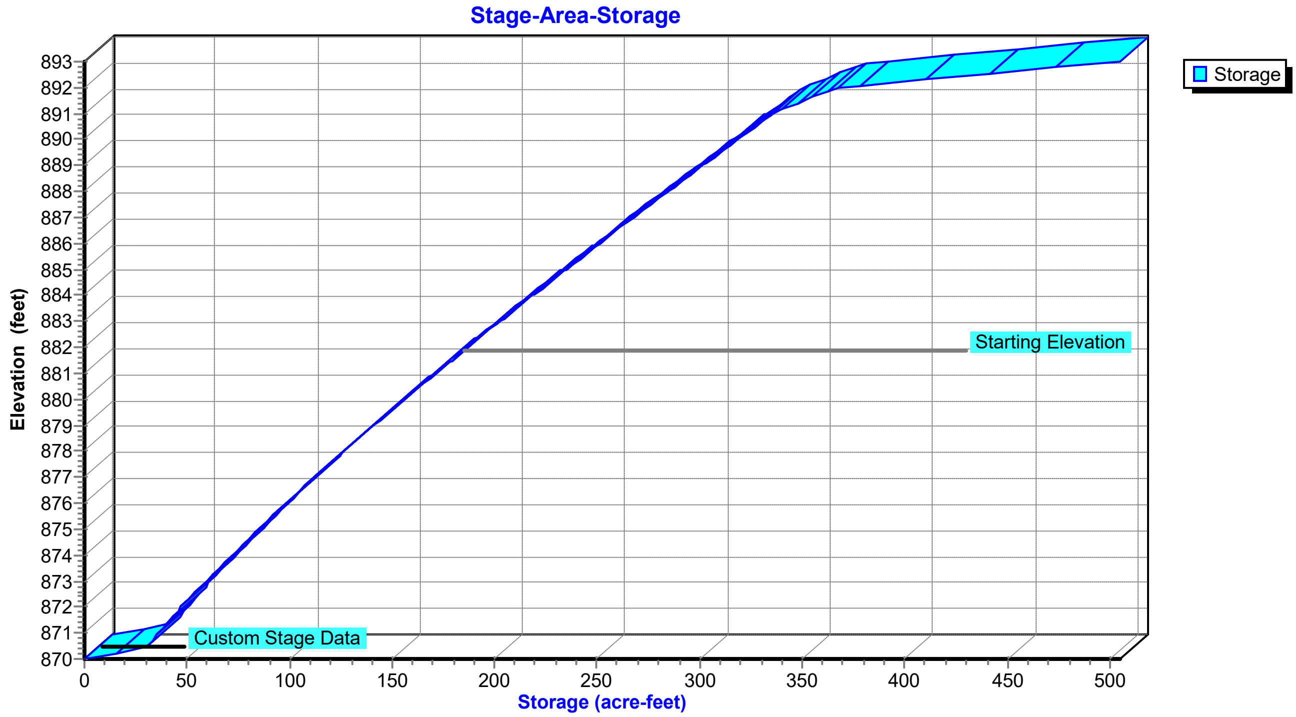
Device	Routing	Invert	Outlet Devices
#1	Primary	881.37'	**Channel/Reach** using Reach R-G: Connecting Ditch
#2	Secondary	889.50'	**40.0' long x 20.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=277.60 cfs @ 12.80 hrs HW=883.44' TW=883.44' (Dynamic Tailwater)
└─**1=Channel/Reach** (Channel Controls 277.60 cfs @ 12.14 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=881.37' TW=881.37' (Dynamic Tailwater)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)



Pond P-G: Region 6b



Summary for Pond P-H: Region 6c

Lowest road point at 890.6

Inflow Area = 13.880 ac, 0.00% Impervious, Inflow Depth = 6.87" for 100-Year event
Inflow = 134.52 cfs @ 12.01 hrs, Volume= 7.941 af
Outflow = 3.81 cfs @ 14.72 hrs, Volume= 5.766 af, Atten= 97%, Lag= 162.7 min
Primary = 3.81 cfs @ 14.72 hrs, Volume= 5.766 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 888.30' Storage= 21.975 af
Peak Elev= 889.07' @ 14.72 hrs Storage= 27.569 af (5.594 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 658.4 min (1,444.6 - 786.2)

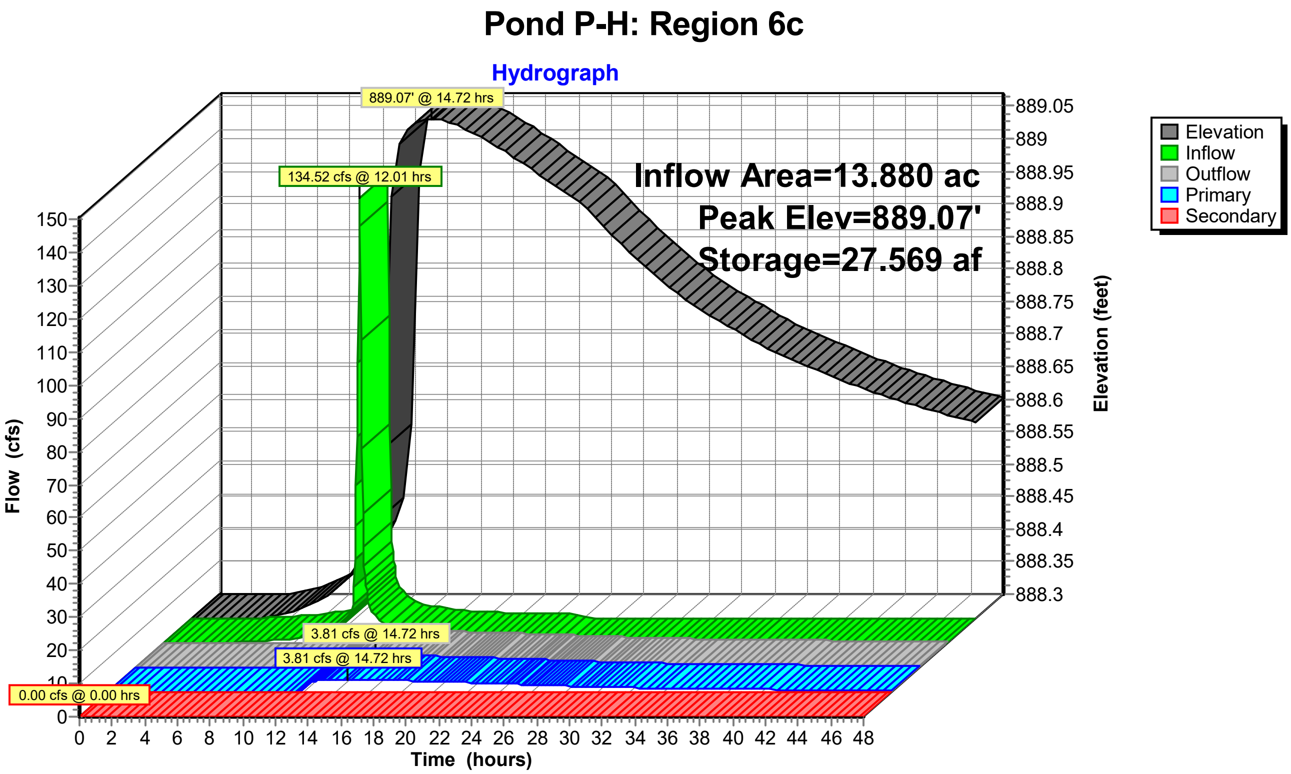
Volume	Invert	Avail.Storage	Storage Description
#1	877.00'	45.073 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
877.00	0.000
878.00	0.041
879.00	0.446
880.00	0.981
881.00	1.579
882.00	2.236
883.00	2.960
884.00	3.949
885.00	5.881
886.00	8.985
887.00	13.694
888.00	19.815
889.00	27.015
890.00	35.263
891.00	45.073

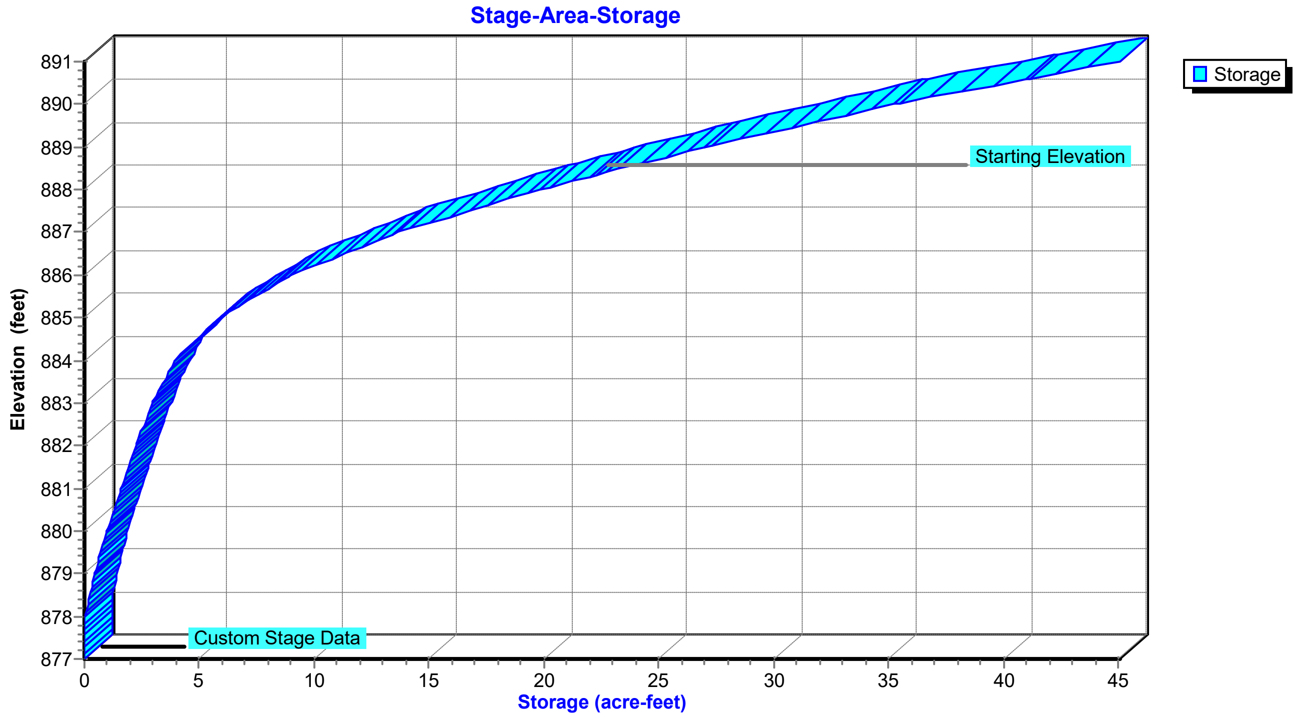
Device	Routing	Invert	Outlet Devices
#1	Primary	888.30'	**18.0" Round Culvert** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 888.30' / 887.40' S= 0.0150 '/' Cc= 0.900 n= 0.014 Ductile Iron Pipe, Flow Area= 1.77 sf
#2	Primary	888.40'	**18.0" Round Culvert** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 888.40' / 887.10' S= 0.0217 '/' Cc= 0.900 n= 0.014 Ductile Iron Pipe, Flow Area= 1.77 sf
#3	Secondary	890.60'	**40.0' long x 20.0' breadth Exterior Road** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=3.81 cfs @ 14.72 hrs HW=889.07' TW=877.08' (Dynamic Tailwater)
1=Culvert (Inlet Controls 2.14 cfs @ 2.35 fps)
2=Culvert (Inlet Controls 1.67 cfs @ 2.20 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=888.30' (Free Discharge)
3=Exterior Road (Controls 0.00 cfs)



Pond P-H: Region 6c



Summary for Pond P-I: Principal Spillway

Extra 0.46 ft added to elevations taken from 1979 plansheets to correct for change from 1929 datum to 1988. See coords.pdf in Resources folder.

Current starting elevation at 869.46 is the principal spillway.

Lowest road point at 889.6

Inflow Area = 289.410 ac, 0.00% Impervious, Inflow Depth > 6.63" for 100-Year event
Inflow = 576.23 cfs @ 12.03 hrs, Volume= 159.947 af
Outflow = 40.88 cfs @ 21.89 hrs, Volume= 114.548 af, Atten= 93%, Lag= 591.3 min
Primary = 40.88 cfs @ 21.89 hrs, Volume= 114.548 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 869.46' Storage= 19.635 af
Peak Elev= 878.60' @ 21.89 hrs Storage= 127.623 af (107.987 af above start)

Plug-Flow detention time= 1,173.3 min calculated for 94.913 af (59% of inflow)
Center-of-Mass det. time= 807.1 min (1,757.0 - 949.9)

Volume	Invert	Avail.Storage	Storage Description
#1	868.00'	436.530 af	**Custom Stage Data** Listed below

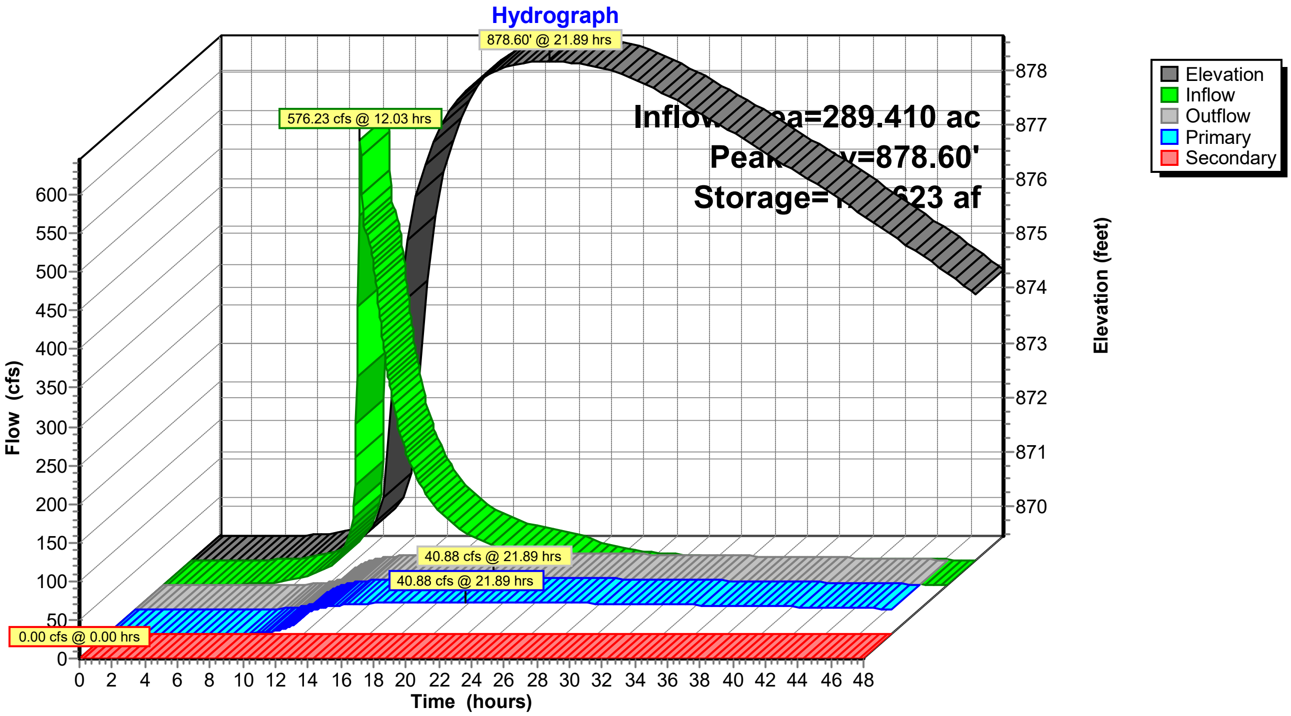
Elevation (feet)	Cum.Store (acre-feet)
868.00	0.000
869.00	15.830
870.46	27.908
871.00	32.593
872.00	41.584
873.00	50.981
874.00	60.904
875.00	73.040
876.00	86.620
877.00	101.569
878.00	117.543
879.00	134.404
880.00	152.070
881.00	170.490
882.00	189.798
883.00	209.994
884.00	230.761
885.00	252.069
886.00	273.771
887.00	295.800
888.00	318.133
889.00	340.747
890.00	363.691
891.00	387.389
892.00	411.911
893.00	436.530

Device	Routing	Invert	Outlet Devices
#1	Primary	865.46'	**30.0" Round Culvert** L= 268.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 865.46' / 864.60' S= 0.0032 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	869.46'	**3.2' long x 0.7' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 Coef. (English) 2.76 2.82 2.93 3.09 3.18 3.22 3.27 3.30 3.32 3.31 3.32
#3	Secondary	889.60'	**40.0' long x 20.0' breadth Road Overtop** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

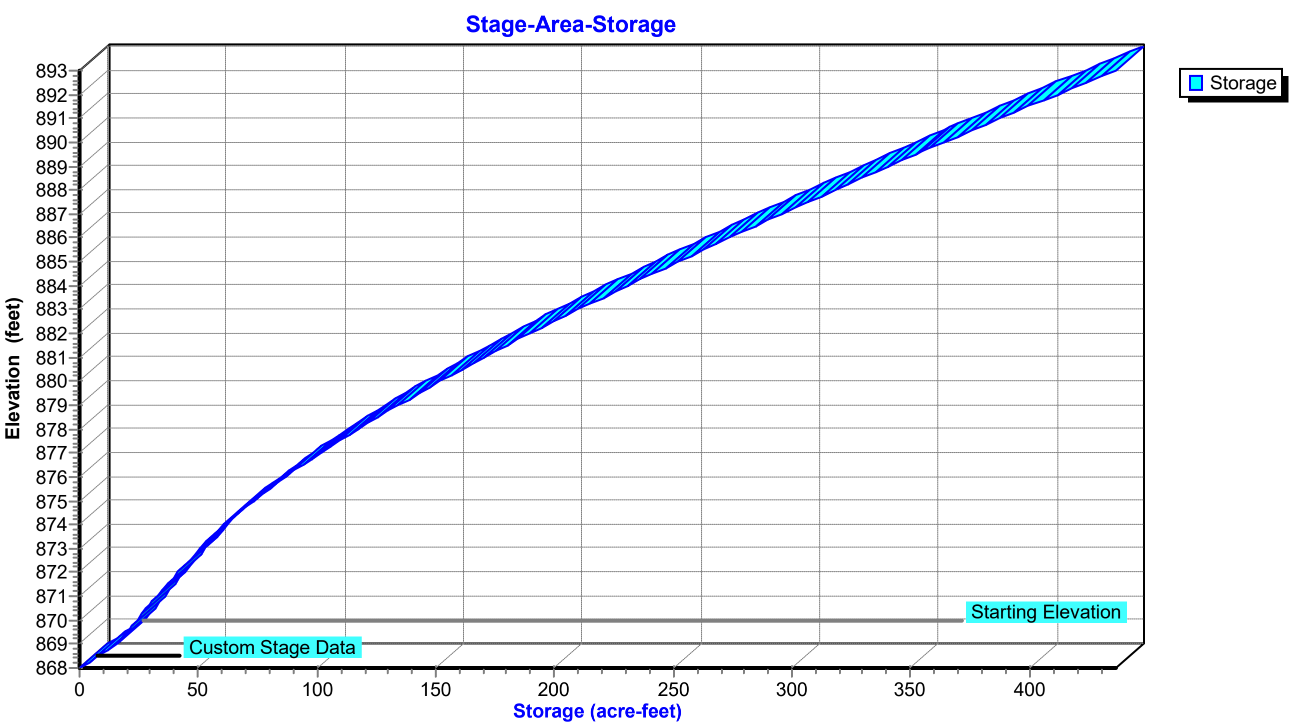
Primary OutFlow Max=40.88 cfs @ 21.89 hrs HW=878.60' (Free Discharge)
└─**1=Culvert** (Barrel Controls 40.88 cfs @ 8.33 fps)
  └─**2=Broad-Crested Rectangular Weir** (Passes 40.88 cfs of 586.92 cfs potential flow)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=869.46' (Free Discharge)
└─**3=Road Overtop** (Controls 0.00 cfs)

Pond P-I: Principal Spillway



Pond P-I: Principal Spillway



B.4 Existing Surface Contours

1. Western Air Mapping, Topographic Survey Plans for the La Cygne Generating Station, dated 2001.
2. Tukuh Technologies, LLC, Topographic Survey Plans for the La Cygne Generating Station, dated 2017.
3. Tukuh Technologies, LLC, Topographic Survey Plans for the La Cygne Generating Station, dated 2018.
4. AECOM, Phase 2 Design Surface, dated 2019.
5. BHC RHODES, Topographic Survey Plans for the La Cygne Generating Station, dated 2020.
6. BHC RHODES, Topographic Survey Plans for the La Cygne Generating Station, dated 2021.
7. No Author, Bathymetric Survey Plans for the La Cygne Generating Station, undated.

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