Periodic Inflow Design Flood Control System Plan Lower AQC Impoundment

La Cygne Generating Station

Evergy Metro, Inc.
Project No. 121556

Revision 1
10/1/2021

Periodic Inflow Design Flood Control System Plan Lower AQC Impoundment

prepared for

Evergy Metro, Inc.
La Cygne Generating Station
Linn County, Kansas

Project No. 121556

Revision 1
10/1/2021

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Evergy Metro, Inc.
Periodic Inflow Design Flood
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Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Kansas, that the information in this document was assembled under my direct personal charge and that this periodic run-on and run-off control system plan meets the applicable requirements of 40 CFR 257.82. This report is not intended or represented to be suitable for reuse by Evergy Metro, Inc. or others without specific verification or adaptation by the Engineer.

AUSTIN MUCKENTHALER
LICENSED
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10/1/2021
KANSAS
PROFESSIONAL ENGINEER

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Austin Muckenthaler, P.E.
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Date: 10/1/2021

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LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CN	curve number
EPA	Environmental Protection Agency
Evergy	Evergy Metro, Inc.
KDHE	Kansas Department of Health and Environment
La Cygne	La Cygne Generating Station
NAVD88	North American Vertical Datum of 1988
NDPES	National Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
PFDS	Precipitation Frequency Data Server
RCRA	Resource Conservations and Recovery Act
SCS	Soil Conservation Service
TR-55	SCS Technical Release 55
U.S.C.	United States Code
USDA	United States Department of Agriculture
W.S.E.	Water Surface Elevation

1.0 BACKGROUND

On April 17, 2015, the Environmental Protection Agency (EPA) issued the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of CCR materials generated at operating coal-fired generating stations. The rule is being administered as part of the Resource Conservation and Recovery Act [RCRA, 42 United States Code (U.S.C.) §6901 et seq.], under Subtitle D.

Evergy Metro, Inc. (Evergy) is subject to the CCR Rule and as such must develop an inflow design flood control system plan for the Lower AQC Impoundment at La Cygne Generating Station (La Cygne). The Lower AQC Impoundment is an existing CCR surface impoundment as defined by 40 Code of Federal Regulations (CFR) §257.82. This report serves as the periodic update to the inflow design flood control system plan which was originally developed by Kansas City Power & Light (now Evergy) in 2016, with the support of calculations prepared by AECOM. This inflow design flood control system plan is in addition to, not in place of, any other applicable site permits, environmental standards, or work safety practices.

1.1 Facility Information

Name of Facility:	La Cygne Generating Station
Name of CCR Unit:	Lower AQC Impoundment
Name of Operator:	Evergy Metro, Inc.
Facility Mailing Address:	25166 E 2200th Rd La Cygne, KS 66040
Location:	Approximately seven miles east of La Cygne, KS
Facility Description:	The La Cygne Generating Station has two coal-fired units that produce fly ash, bottom ash, and gypsum. CCR not beneficially used is transported to the on-site landfill for disposal. The Lower AQC Impoundment is no longer actively used for CCR disposal. Related landfill facilities include a groundwater monitoring system, stormwater management systems, and haul/access roads.

1.2 Regulatory Requirements

Per 40 CFR §257.82, the inflow design flood control system plan must contain documentation (including supporting engineering calculations) that the control system has been designed and constructed to meet the applicable requirements of 40 CFR 257.82. The owner or operator of a CCR unit must prepare a written plan that includes the information specified in 40 CFR 257.82 (a) and (b) which is as follows:

(a) Design, construct, operate, and maintain an inflow design flood control system as specified:

(1) The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow 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.

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

Per 40 CFR §257.81(c)(5), Evergy must obtain certification from a qualified professional engineer that the inflow design flood control system plan, and subsequent updates to the plan, meet the requirements of 40 CFR §257.82. This sealed document serves as that certification.

2.0 EXISTING CONDITIONS

The Lower AQC Impoundment was commissioned in 1973. The Impoundment was constructed with embankments having a maximum height of 24 feet high and a crest elevation of 864.0 feet (NAVD88). The embankments have 3H:1V side slopes. The Lower AQC Impoundment is primarily used as a holding basin for formerly sluiced CCR materials, AQC recycling water, and onsite stormwater. The Impoundment watershed includes rainfall directly into the unit, but no longer includes the Upper AQC Impoundment; or the on-site CCR landfill due to recent grading and stormwater system modifications. The Lower AQC Impoundment is operated as a non-discharge unit; however, there is an emergency overflow spillway at the northwest corner of the Lower AQC Impoundment which consists of a 120-foot-wide earth embankment with 5H:1V side slopes and an invert elevation of 862.3 feet. The water from the emergency spillway discharges directly into the discharge canal. The unit is now operated at a level that does not typically exceed 860.0 feet.

3.0 DESIGN BASIS / FLOOD CONTROL SYSTEM

3.1 Inflow Design Flood System Criteria

3.1.1 Capacity Criteria

The CCR Rule requires that CCR surface impoundments have adequate hydrologic and hydraulic capacity to manage flows from the inflow design flood. For this analysis, the criteria were interpreted to mean that the surface impoundment must be able to accept inflows from the design flood event without overtopping.

3.1.2 Freeboard Criteria

The CCR documentation further discusses that operating freeboard must be adequate to meet performance standards, but a specific freeboard is not defined. For this analysis, it was assumed a 1-foot minimum freeboard shall be maintained during the inflow design flood event.

3.1.3 Flood Routing Design Criteria

The La Cygne Lower AQC Impoundment has been categorized by others as a “Low Hazard Potential CCR Impoundment”, therefore the inflow design flood is a 100-year flood event per 40 CFR§257.82 (a)(3)(iii).

3.2 Topographic Survey

Survey data was utilized in this analysis for determining storage volumes, drainage paths, and drainage areas. Survey performed by BHC Rhodes from December 2020 to June 2021 was the primary source for this information. The site coordinate system is based on control established by McClure Engineering Company in the Kansas South Zone, U.S. Feet, State Plane, NAD83 Coordinate System.

4.0 HYDROLOGIC AND HYDRAULIC CAPACITY

Peak flow rates and runoff volumes were determined using the Soil Conservation Service's (SCS) [now known as the Natural Resources Conservation Service (NRCS)] run-off curve number (CN) method with HydroCAD stormwater modeling software. Inputs to the HydroCAD model are discussed in more detail in the following sections.

4.1 Hydrology

4.1.1 Recurrence Interval and Rainfall Duration

The La Cygne Lower AQC Impoundment inflow design flood is a 100-year flood event per 40 CFR§257.82 (a)(3)(iii). A storm duration is not specified under 40 CFR §257.82 or other pertinent inflow flood design sections within the CCR Rule; therefore, a 24-hour storm duration was assumed since this is typically required by RCRA (40 CFR 258.26).

4.1.2 Rainfall Distribution and Depth

The SCS Type II rainfall distribution was used for computations associated with this evaluation. Precipitation data was acquired from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server (PFDS). Precipitation depth for the 100-year, 24-hour storm is 8.55 inches.

4.1.3 Subbasin Characteristics

The drainage areas were delineated using the topographic survey data described in Section 3.2. A sketch is provided in Appendix A which shows the drainage areas and flow paths used in the analysis.

The CN Method was used to estimate runoff from each drainage area. The CN is determined from several site characteristics, including the hydrologic soil group and ground cover type. Typical CN values from SCS Technical Release 55 (TR-55) are preloaded into HydroCAD and were referenced for this analysis. Based on Custom Soils Resource Report from the US Department of Agriculture (USDA) NRCS Web Soil Survey site, soils near the Lower AQC Impoundment are generally from Hydrologic Soil Group D. The common ground cover types of the contributing drainage areas consist of gravel roads, water surface, and CCR. CCR is not a typical ground cover type in TR-55, so a CN of 85 was assumed.

The time of concentration equations from TR-55 were used in HydroCAD to calculate time of concentration for each drainage area. Inputs for the equations were determined with reference to the surface characteristics of each drainage area.

4.1.4 Storage Capacity

When conducting the analysis, it was assumed that the impoundment water surface is at an elevation of 860.0 feet prior to the storm event, below the invert elevation of the emergency spillway (862.3). This is a conservative assumption since the operating level of the pond does not exceed 860.0.

Storage data was only inputted for elevations between the assumed water surface elevation (860.0) and the maximum available storage elevation in the pond (approximately 864.0 feet) using available survey data. There is approximately 240 acre-feet of storage in the impoundment between these levels.

4.2 Impoundment Outflows

The water surface elevation in the Lower AQC Impoundment is controlled by pumps during normal conditions and by the emergency spillway in extreme conditions. For this analysis, it was assumed that there is zero discharge through the pumps and any discharge will go through the emergency spillway.

5.0 RESULTS

The Lower AQC Impoundment was modeled for a 100-year, 24-hour storm event with the initial water surface elevation set at the emergency spillway elevation (862.3 feet). The resulting runoff volume represents the amount of rainwater over the watershed area, reduced by the amount of infiltration that would be expected to occur for the types of soils and vegetation present. A summary of the results from the HydroCAD model have been provided in Table 5-1. The HydroCAD report, which is included in Appendix A, provides a routing diagram, input summary, and more detailed modeling results for the 100-year, 24-hour event.

Table 5-1: Summary of HydroCAD Results

CCR Unit	Initial W.S.E. (feet)	Peak W.S.E. (feet)	Flood Elevation (feet)	Freeboard (feet)
Lower AQC Impoundment	860.0	861.66	864.0	2.34

There are no discharge flows into the Lower AQC Impoundment except for the perimeter road. Under the assumed conditions, the impoundment was able to contain runoff from the 100-year, 24-hour storm event while maintaining at least 1-foot of freeboard; all discharge goes through the emergency spillway and the embankments were not overtopped. It was therefore concluded that the inflow design flood control system of the La Cygne Lower AQC Impoundment both adequately manages flow into the CCR unit during and following the peak discharge of the inflow design flood (40 CFR §257.82 (a)(1)), and adequately manages flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood (40 CFR §257.82 (a)(2)).

Discharges from the Lower AQC Impoundment are directed to a permitted NPDES outfall. Per the current NPDES permit, all discharged water is tested for pollutants and the discharge meets the minimum regulatory requirements of the permit. 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). Discharge from the Lower 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 Lower AQC Impoundment meets the requirements for certification under the CCR Rule.

6.0 REVISIONS AND AMENDMENTS

Evergy must place this periodic inflow design flood control system plan in the CCR Operating Record by October 13, 2021. Evergy may amend the plan at any time and is required to do so whenever there is a change in conditions which would substantially affect the written plan in effect. Evergy must prepare a periodic inflow design flood control system plan at least every five years. Each periodic plan or amendment to the written plan shall be certified by a qualified professional engineer in the State of Kansas. All amendments and revisions must be placed on the CCR public website. A record of revisions made to this document is included in Section 8.0.

7.0 REFERENCES

1. U.S. Environmental Protection Agency, Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments, 40 CFR §257, Federal Register 80, Subpart D, April 17, 2015.

2. AECOM, Initial Inflow Design Flood Control System Plan, Lower AQC Impoundment, La Cygne Generating Station, October 13, 2016.

3. BHC, Topographic Survey, December 2020-June 2021.

4. National Oceanic and Atmospheric Administration, NOAA Atlas 14 Point Precipitation Frequency Estimates, Volume 8, Version 2, Accessed: 2/19/2020.

5. USDA Natural Resources Conservation Service, Web Soil Survey, Hydrologic Soil Groups – Linn County, Kansas; Accessed: 2/24/2020.

6. SCS Engineers, Initial Hazard Potential Classification Assessment Report, Lower AQC Impoundment, Kansas City Power & Light Company, La Cygne Generating Station, dated October 7, 2016 (updated October 2021).

7. USDA Natural Resources Conservation Service, Technical Release 55, dated June 1986.

8.0 RECORD OF REVISIONS

Revision Number	Date	Revisions Made	By Whom
0	10/13/2016	Initial Issue	AECOM
1	10/13/2021	Periodic Update	Burns & McDonnell

APPENDIX A – SUPPORTING CALCULATIONS

DRAINAGE AREA NAME	RUNOFF SURFACE AREA (ACRES)
LAQC-1	5.52
LAQC-2	12.10
LAQC-3	16.32
LAQC-4	11.99
LAQC-5	23.28
LAQC-6	23.24
LAQC-7	14.53
LAQC-8	61.61

NOTES:

1. THE NAMES FOR DRAINAGE AREAS AND CULVERT CROSSINGS ON THIS SKETCH CORRESPOND TO THE NODES WITH MATCHING NAMES IN THE HYDROCAD REPORT IN APPENDIX A. DRAINAGE AREA BOUNDARIES ARE APPROXIMATE.
2. SURVEY PERFORMED BY BHC RHODES FROM DECEMBER 2020 TO JUNE 2021

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
0	10/01/21	AJM	-	ISSUED WITH LA CYGNE LOWER AQC PERIODIC INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM LICENSE NO. E-65

designed: A. MUCKENTHALER
detailed: S. NICHOLS

evergy

LA CYGNE GENERATING STATION
LOWER AQC IMPOUNDMENT
LINN COUNTY, KS

LA CYGNE GENERATING STATION
EXISTING CONDITIONS

project: 121556
contract: -
drawing: SKC011
rev.: 0
sheet 1 of 1 sheets
file 125196-SKC011.DGN

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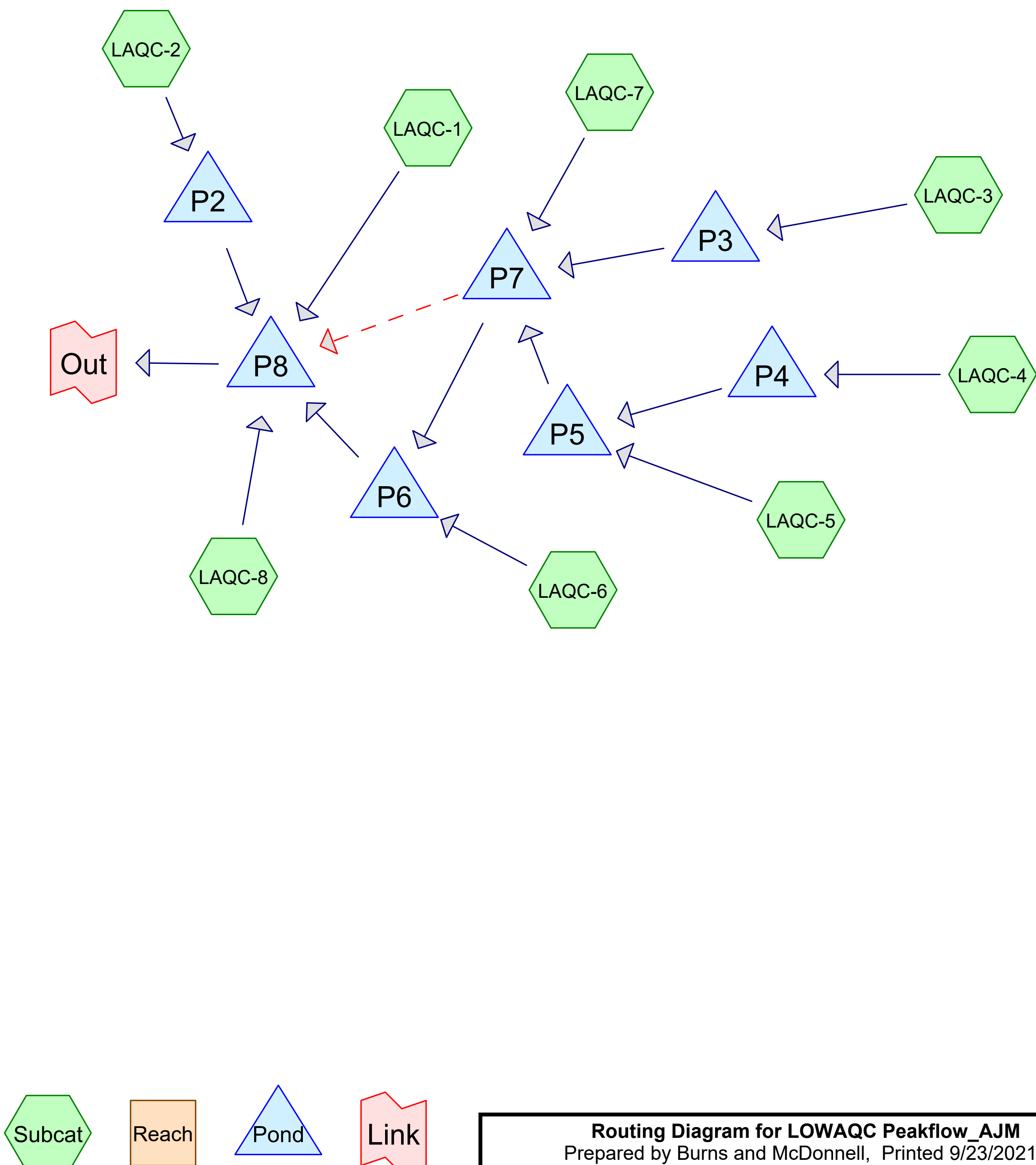


Routing Diagram for LOWAQC Peakflow_AJM
Prepared by Burns and McDonnell, Printed 9/23/2021
HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
125.400	85	CCR HSG D (LAQC-1, LAQC-2, LAQC-3, LAQC-4, LAQC-5, LAQC-6, LAQC-7, LAQC-8)
7.750	91	Gravel roads, HSG D (LAQC-2, LAQC-3, LAQC-4, LAQC-5, LAQC-6, LAQC-7)
35.445	98	Water Surface, HSG D (LAQC-2, LAQC-8)
168.595	**88**	**TOTAL AREA**

Summary for Subcatchment LAQC-1:

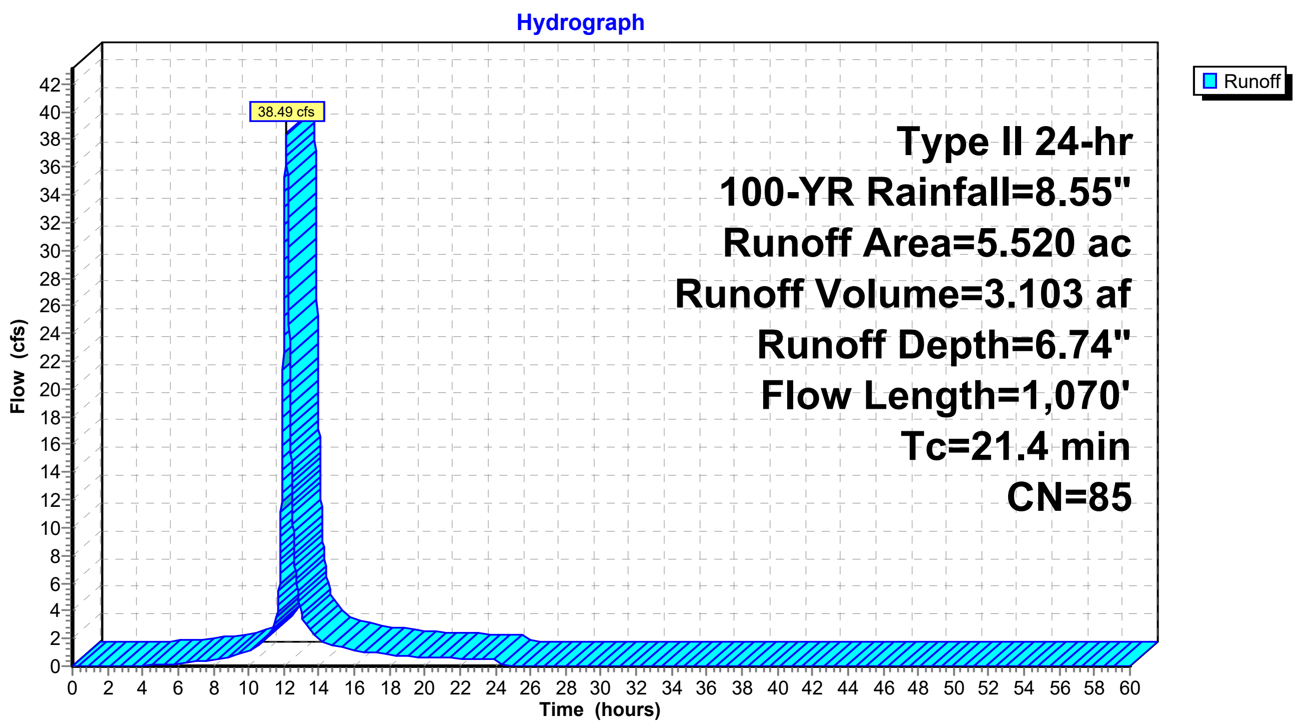
Runoff = 38.49 cfs @ 12.13 hrs, Volume= 3.103 af, Depth= 6.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-YR Rainfall=8.55"

	Area (ac)	CN	Description
*	5.520	85	CCR HSG D
	5.520		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.3	150	0.0330	1.94		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.64"
0.8	81	0.0120	1.76		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
4.1	250	0.0040	1.02		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
15.2	589	0.0016	0.64		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
21.4	1,070	Total			

Subcatchment LAQC-1:



Summary for Subcatchment LAQC-2:

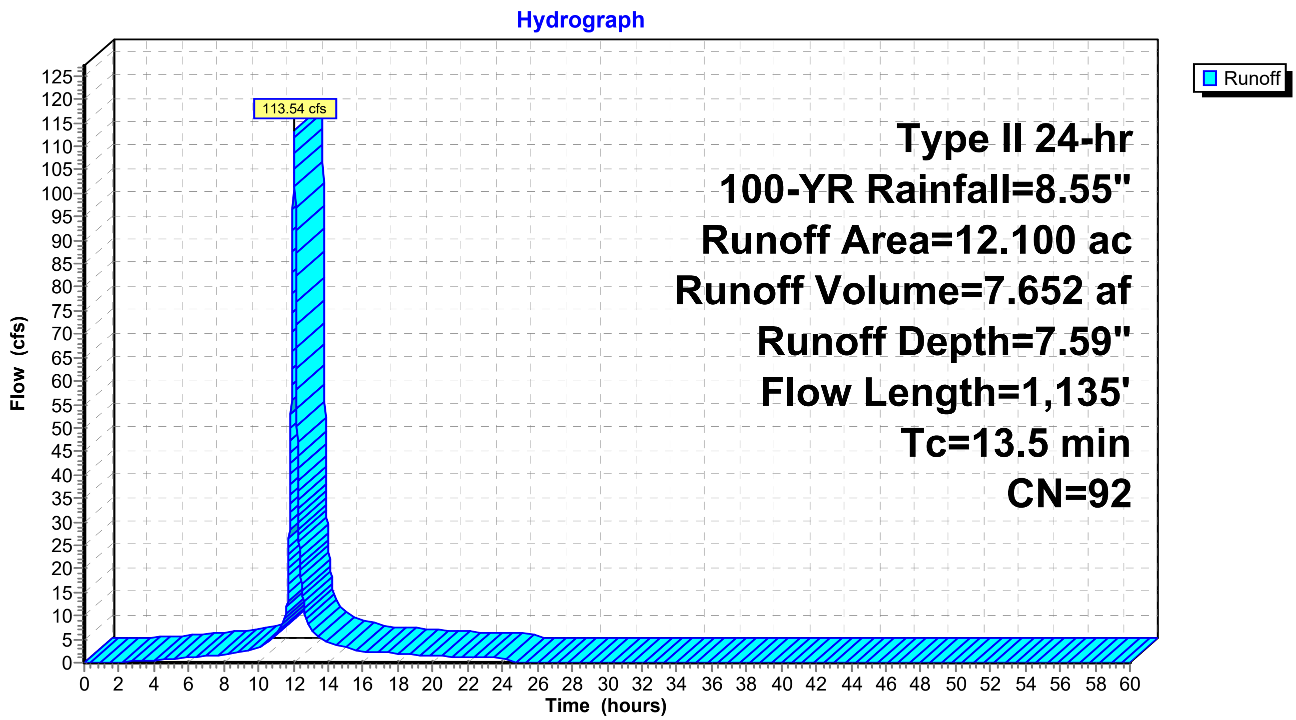
Runoff = 113.54 cfs @ 12.05 hrs, Volume= 7.652 af, Depth= 7.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-YR Rainfall=8.55"

	Area (ac)	CN	Description
	0.430	91	Gravel roads, HSG D
*	5.650	85	CCR HSG D
	6.020	98	Water Surface, HSG D
	12.100	92	Weighted Average
	6.080		50.25% Pervious Area
	6.020		49.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	130	0.3300	4.74		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.64"
2.6	418	0.0280	2.69		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
10.4	587	0.0034	0.94		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
13.5	1,135	Total			

Subcatchment LAQC-2:



Summary for Subcatchment LAQC-3:

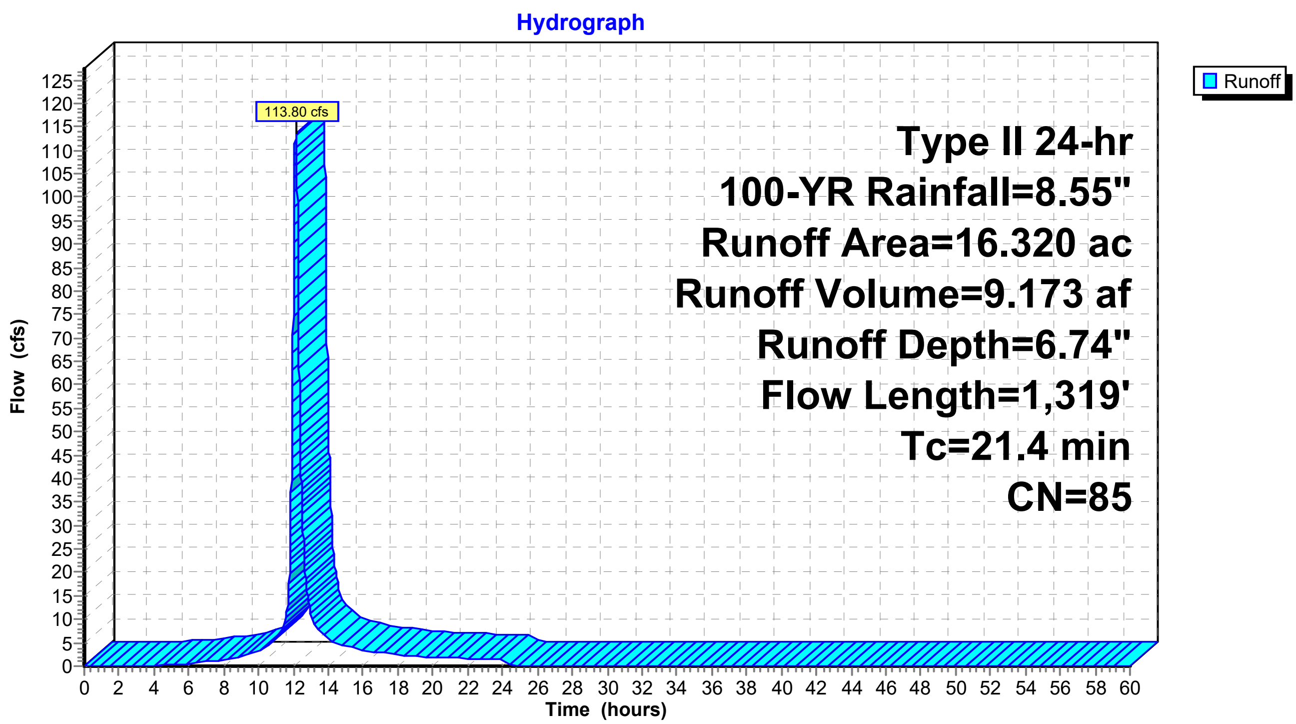
Runoff = 113.80 cfs @ 12.13 hrs, Volume= 9.173 af, Depth= 6.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-YR Rainfall=8.55"

	Area (ac)	CN	Description
*	15.030	85	CCR HSG D
	1.290	91	Gravel roads, HSG D
	16.320	85	Weighted Average
	16.320		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	150	0.0070	1.05		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.64"
2.3	255	0.0130	1.84		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
16.7	914	0.0032	0.91		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
21.4	1,319	Total			

Subcatchment LAQC-3:



Summary for Subcatchment LAQC-4:

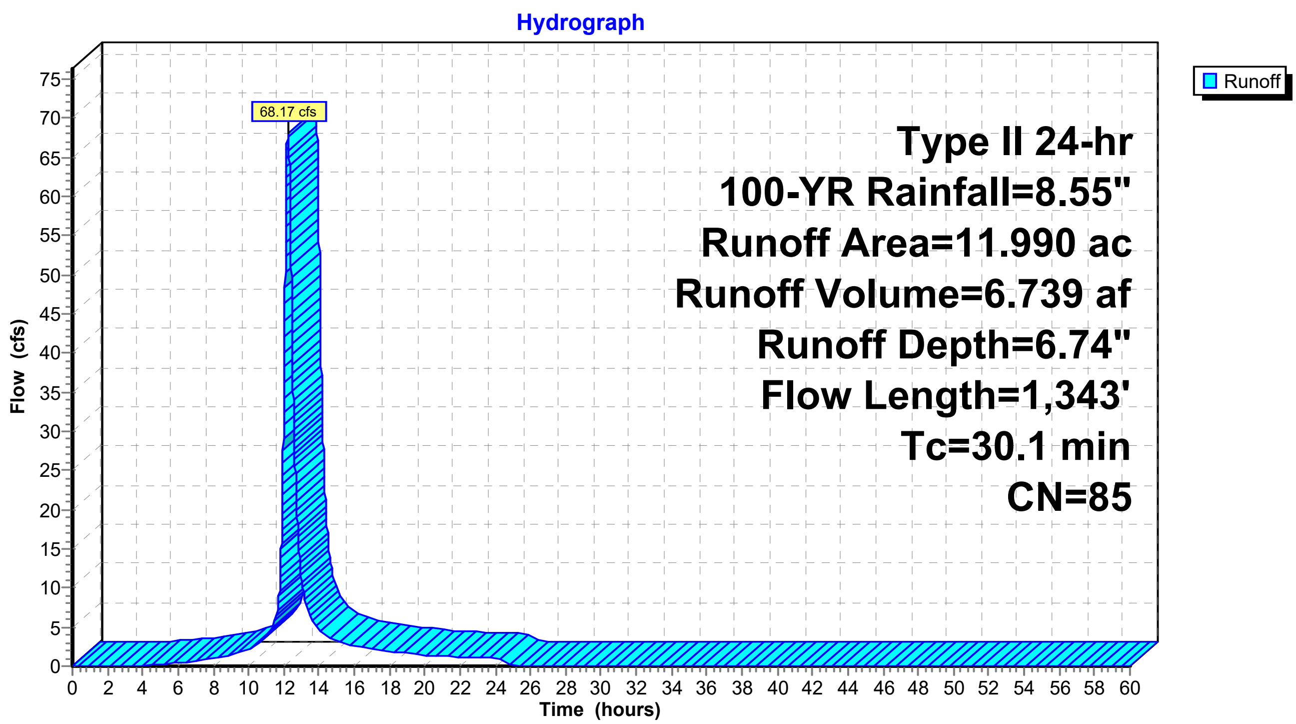
Runoff = 68.17 cfs @ 12.24 hrs, Volume= 6.739 af, Depth= 6.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-YR Rainfall=8.55"

	Area (ac)	CN	Description
*	11.170	85	CCR HSG D
	0.820	91	Gravel roads, HSG D
	11.990	85	Weighted Average
	11.990		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	150	0.0070	1.05		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.64"
21.4	744	0.0013	0.58		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
6.3	449	0.0055	1.19		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
30.1	1,343	Total			

Subcatchment LAQC-4:



Summary for Subcatchment LAQC-5:

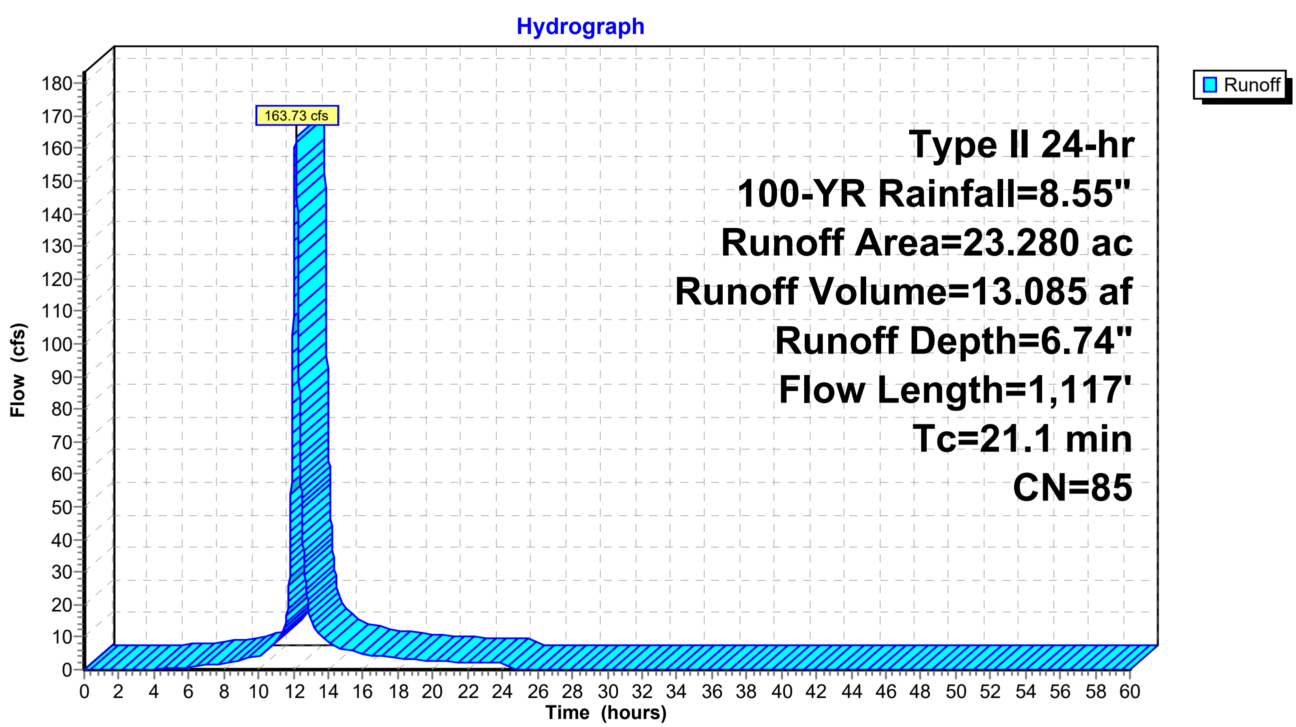
Runoff = 163.73 cfs @ 12.12 hrs, Volume= 13.085 af, Depth= 6.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-YR Rainfall=8.55"

	Area (ac)	CN	Description
*	22.430	85	CCR HSG D
	0.850	91	Gravel roads, HSG D
	23.280	85	Weighted Average
	23.280		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	150	0.0060	0.98		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.64"
18.6	967	0.0029	0.87		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
21.1	1,117	Total			

Subcatchment LAQC-5:



Summary for Subcatchment LAQC-6:

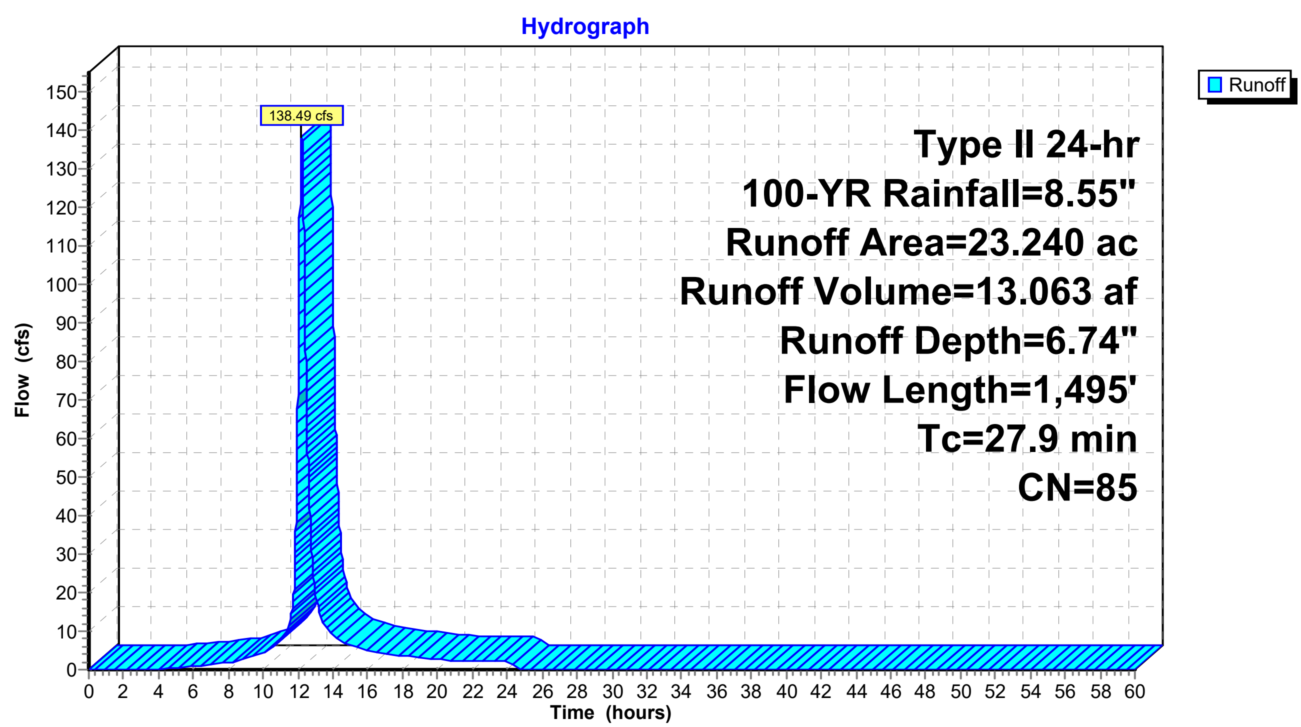
Runoff = 138.49 cfs @ 12.21 hrs, Volume= 13.063 af, Depth= 6.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-YR Rainfall=8.55"

	Area (ac)	CN	Description
*	21.530	85	CCR HSG D
	1.710	91	Gravel roads, HSG D
	23.240	85	Weighted Average
	23.240		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	150	0.0060	0.98		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.64"
25.4	1,345	0.0030	0.88		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
27.9	1,495	Total			

Subcatchment LAQC-6:



Summary for Subcatchment LAQC-7:

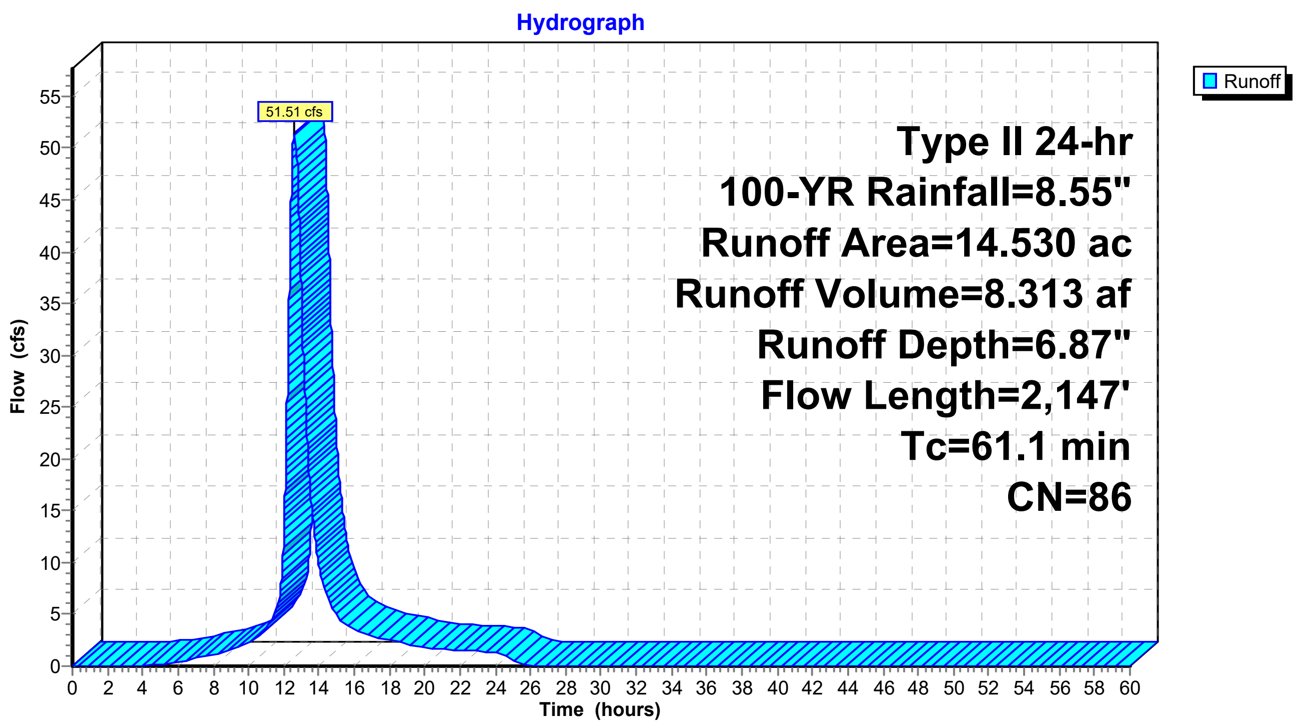
Runoff = 51.51 cfs @ 12.62 hrs, Volume= 8.313 af, Depth= 6.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-YR Rainfall=8.55"

	Area (ac)	CN	Description
*	11.880	85	CCR HSG D
	2.650	91	Gravel roads, HSG D
	14.530	86	Weighted Average
	14.530		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1	150	0.0100	1.21		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.64"
1.3	147	0.0130	1.84		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
57.7	1,850	0.0011	0.53		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
61.1	2,147	Total			

Subcatchment LAQC-7:



Summary for Subcatchment LAQC-8:

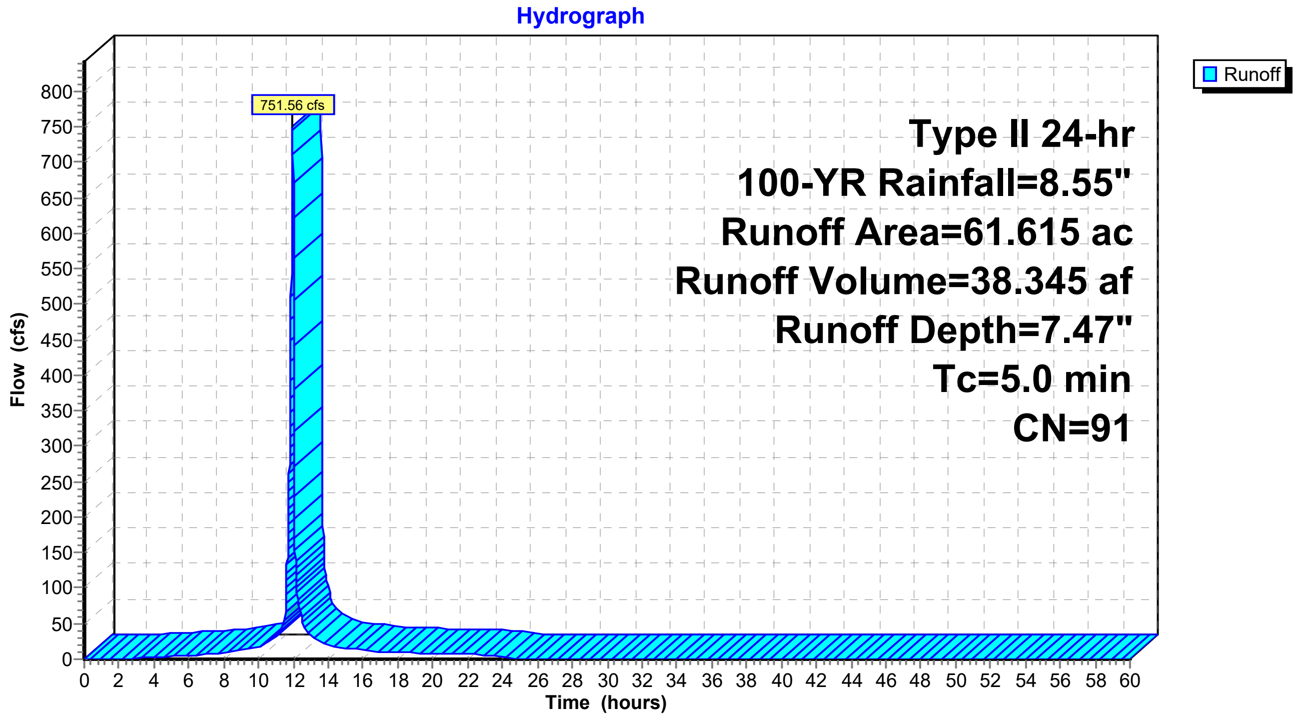
Runoff = 751.56 cfs @ 11.96 hrs, Volume= 38.345 af, Depth= 7.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-YR Rainfall=8.55"

	Area (ac)	CN	Description
*	32.190	85	CCR HSG D
	29.425	98	Water Surface, HSG D
	61.615	91	Weighted Average
	32.190		52.24% Pervious Area
	29.425		47.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment LAQC-8:



Summary for Pond P2:

Inflow Area = 12.100 ac, 49.75% Impervious, Inflow Depth = 7.59" for 100-YR event
Inflow = 113.54 cfs @ 12.05 hrs, Volume= 7.652 af
Outflow = 45.56 cfs @ 12.21 hrs, Volume= 3.965 af, Atten= 60%, Lag= 9.7 min
Primary = 45.56 cfs @ 12.21 hrs, Volume= 3.965 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 861.58' @ 24.71 hrs Surf.Area= 160,055 sf Storage= 160,604 cf

Plug-Flow detention time= 57.2 min calculated for 3.965 af (52% of inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

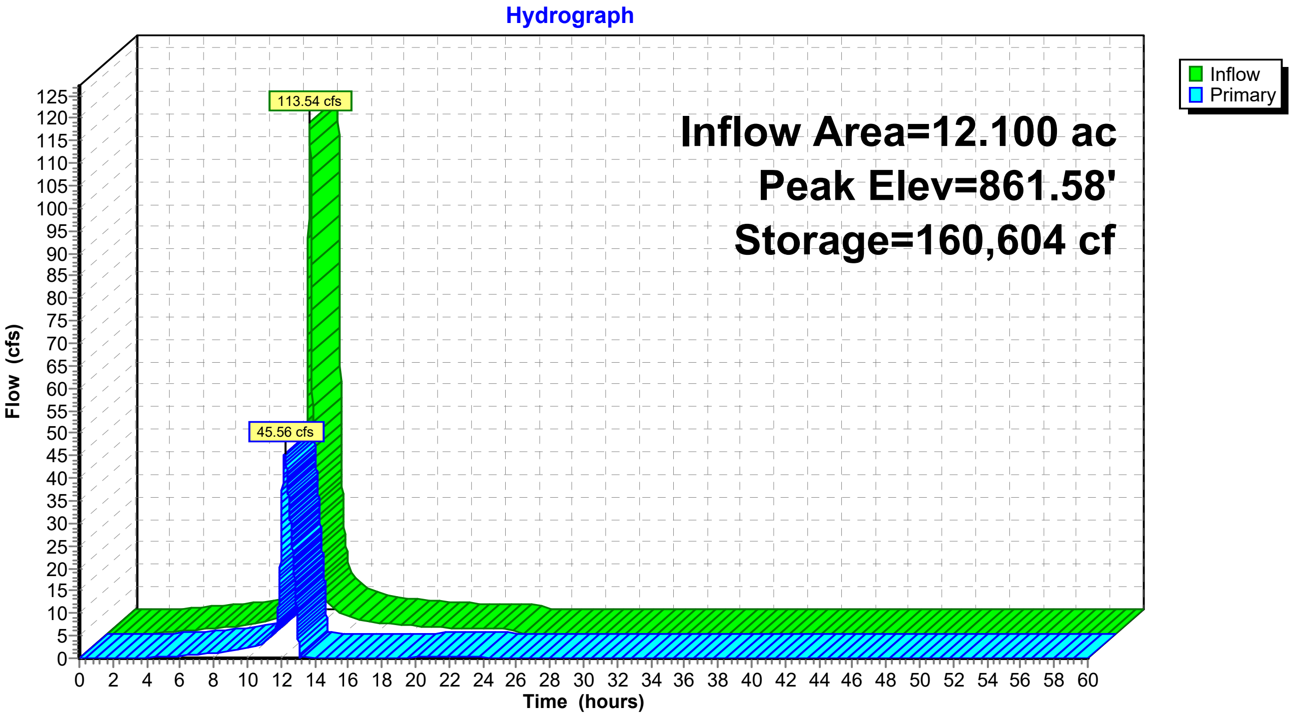
Volume	Invert	Avail.Storage	Storage Description
#1	860.00'	1,166,273 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
860.00	69,010	0	0
861.00	100,770	84,890	84,890
863.00	305,000	405,770	490,660
865.00	370,613	675,613	1,166,273

Device	Routing	Invert	Outlet Devices
#1	Primary	860.00'	**15.0' long x 105.0' 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=45.55 cfs @ 12.21 hrs HW=861.22' TW=860.60' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 45.55 cfs @ 2.48 fps)

Pond P2:


Hydrograph
113.54 cfs
45.56 cfs
Inflow Area=12.100 ac
Peak Elev=861.58'
Storage=160,604 cf
Inflow
Primary
Flow (cfs)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
Time (hours)
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 50 52 54 56 58 60

Summary for Pond P3:

Inflow Area = 16.320 ac, 0.00% Impervious, Inflow Depth = 6.74" for 100-YR event
Inflow = 113.80 cfs @ 12.13 hrs, Volume= 9.173 af
Outflow = 49.72 cfs @ 12.27 hrs, Volume= 9.171 af, Atten= 56%, Lag= 8.2 min
Primary = 49.72 cfs @ 12.27 hrs, Volume= 9.171 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 868.68' @ 12.40 hrs Surf.Area= 85,514 sf Storage= 102,793 cf

Plug-Flow detention time= 44.8 min calculated for 9.171 af (100% of inflow)
Center-of-Mass det. time= 44.7 min (843.9 - 799.3)

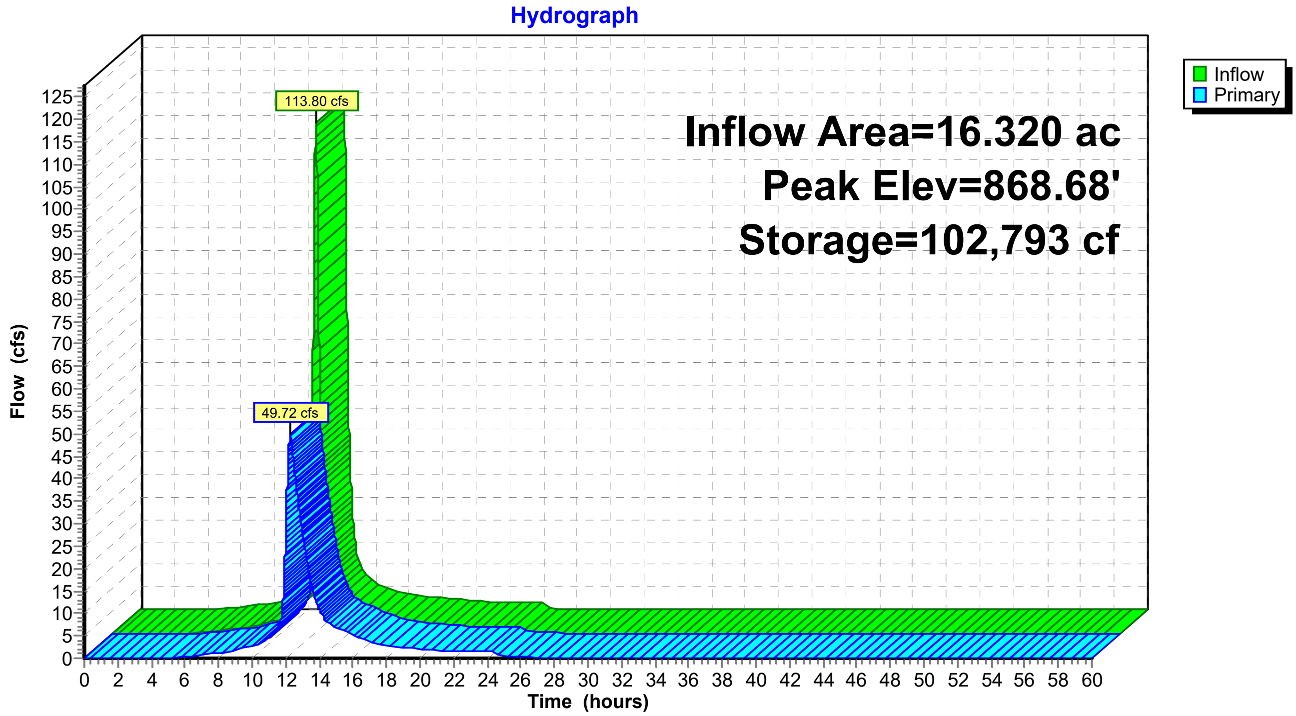
Volume	Invert	Avail.Storage	Storage Description
#1	865.00'	266,628 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
865.00	7,040	0	0
866.00	8,909	7,975	7,975
867.00	22,985	15,947	23,922
868.00	45,499	34,242	58,164
870.00	162,965	208,464	266,628

Device	Routing	Invert	Outlet Devices
#1	Primary	865.00'	**48.0" Round Culvert** L= 98.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 865.00' / 863.85' S= 0.0117 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 12.57 sf
#2	Primary	869.00'	**100.0' long x 85.0' 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=49.72 cfs @ 12.27 hrs HW=868.60' TW=867.02' (Dynamic Tailwater)
—**1=Culvert** (Outlet Controls 49.72 cfs @ 5.51 fps)
—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond P3:


Hydrograph
Inflow
Primary
113.80 cfs
49.72 cfs
Inflow Area=16.320 ac
Peak Elev=868.68'
Storage=102,793 cf
Flow (cfs)
Time (hours)

Summary for Pond P4:

Inflow Area = 11.990 ac, 0.00% Impervious, Inflow Depth = 6.74" for 100-YR event
Inflow = 68.17 cfs @ 12.24 hrs, Volume= 6.739 af
Outflow = 63.46 cfs @ 12.31 hrs, Volume= 6.739 af, Atten= 7%, Lag= 4.6 min
Primary = 63.46 cfs @ 12.31 hrs, Volume= 6.739 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 869.46' @ 12.31 hrs Surf.Area= 32,493 sf Storage= 38,552 cf

Plug-Flow detention time= 14.6 min calculated for 6.739 af (100% of inflow)
Center-of-Mass det. time= 14.5 min (821.8 - 807.3)

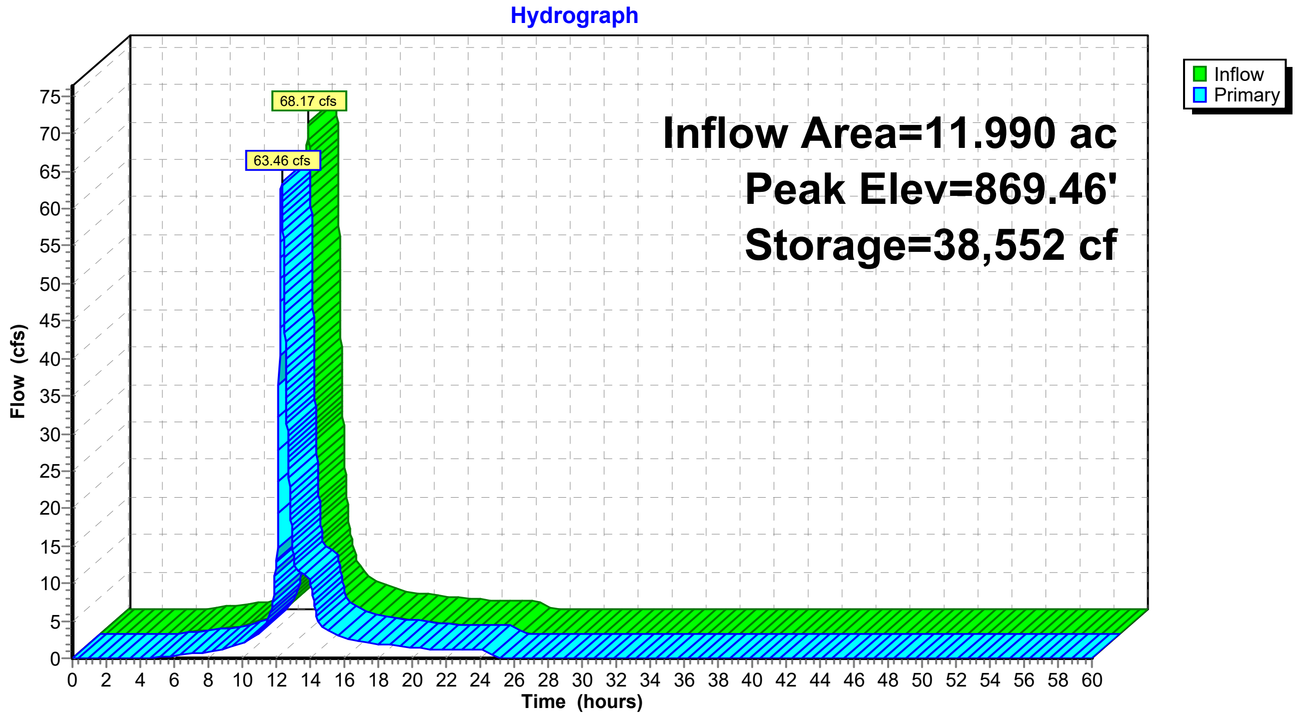
Volume	Invert	Avail.Storage	Storage Description
#1	866.92'	57,454 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
866.92	100	0	0
868.00	9,801	5,347	5,347
869.00	28,698	19,250	24,596
870.00	37,018	32,858	57,454

Device	Routing	Invert	Outlet Devices
#1	Primary	866.92'	**15.0" Round Culvert X 3.00** L= 90.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 866.92' / 865.57' S= 0.0150 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 1.23 sf
#2	Primary	869.00'	**60.0' long x 30.0' 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=63.45 cfs @ 12.31 hrs HW=869.46' TW=867.42' (Dynamic Tailwater)
1=Culvert (Outlet Controls 13.56 cfs @ 3.68 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 49.89 cfs @ 1.82 fps)

Pond P4:


Hydrograph
Inflow
Primary
68.17 cfs
63.46 cfs
Inflow Area=11.990 ac
Peak Elev=869.46'
Storage=38,552 cf
Flow (cfs)
Time (hours)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
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 50 52 54 56 58 60

Summary for Pond P5:

Inflow Area = 35.270 ac, 0.00% Impervious, Inflow Depth = 6.74" for 100-YR event
Inflow = 196.36 cfs @ 12.19 hrs, Volume= 19.825 af
Outflow = 111.46 cfs @ 12.28 hrs, Volume= 19.825 af, Atten= 43%, Lag= 5.4 min
Primary = 111.46 cfs @ 12.28 hrs, Volume= 19.825 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 867.68' @ 12.70 hrs Surf.Area= 95,075 sf Storage= 191,984 cf

Plug-Flow detention time= 67.7 min calculated for 19.825 af (100% of inflow)
Center-of-Mass det. time= 67.7 min (874.5 - 806.7)

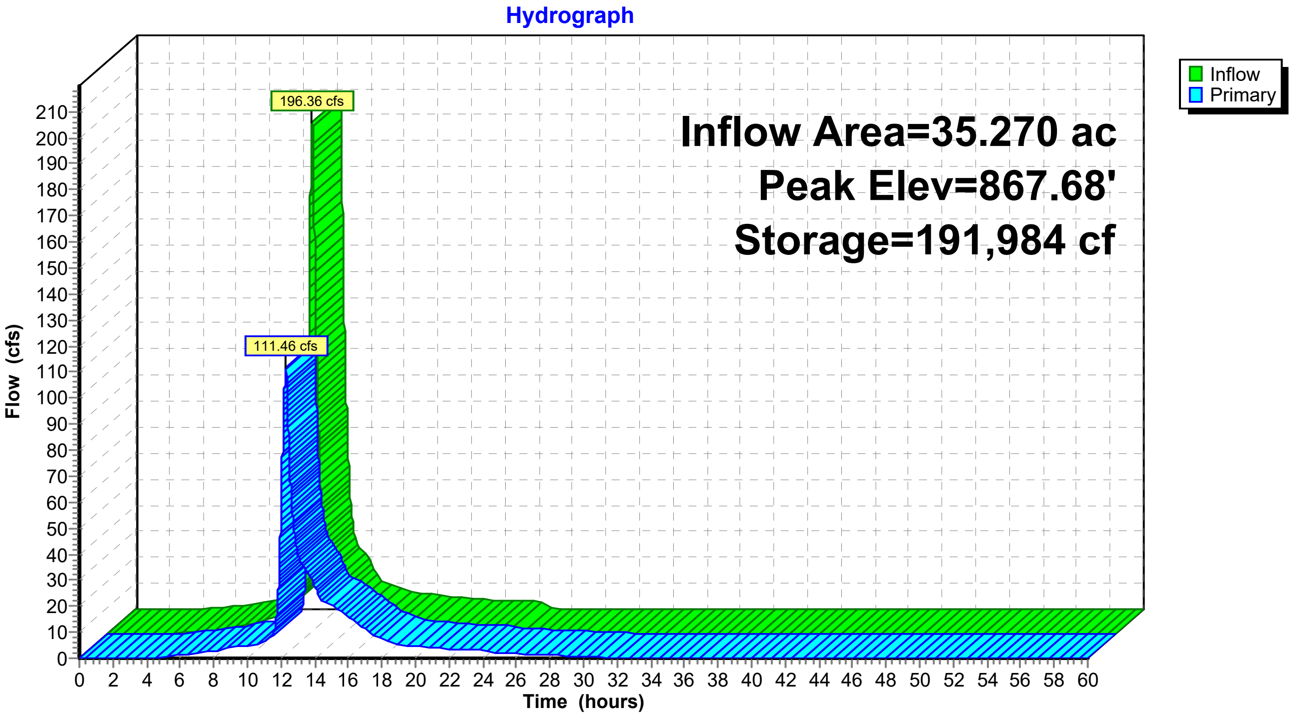
Volume	Invert	Avail.Storage	Storage Description
#1	864.00'	418,235 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
864.00	1,850	0	0
865.00	22,155	12,003	12,003
867.00	93,631	115,786	127,789
870.00	100,000	290,447	418,235

Device	Routing	Invert	Outlet Devices
#1	Primary	864.00'	**15.0' long x 130.0' 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=111.46 cfs @ 12.28 hrs HW=867.35' TW=867.05' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 111.46 cfs @ 2.22 fps)

Pond P5:


Hydrograph
Inflow
Primary
196.36 cfs
111.46 cfs
Inflow Area=35.270 ac
Peak Elev=867.68'
Storage=191,984 cf
Flow (cfs)
Time (hours)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
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 50 52 54 56 58 60

Summary for Pond P6:

Inflow Area = 89.360 ac, 0.00% Impervious, Inflow Depth > 6.73" for 100-YR event
Inflow = 188.70 cfs @ 12.24 hrs, Volume= 50.083 af
Outflow = 188.44 cfs @ 12.24 hrs, Volume= 50.082 af, Atten= 0%, Lag= 0.3 min
Primary = 188.44 cfs @ 12.24 hrs, Volume= 50.082 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 865.75' @ 12.24 hrs Surf.Area= 57,152 sf Storage= 50,652 cf

Plug-Flow detention time= 18.2 min calculated for 50.074 af (100% of inflow)
Center-of-Mass det. time= 18.2 min (958.8 - 940.6)

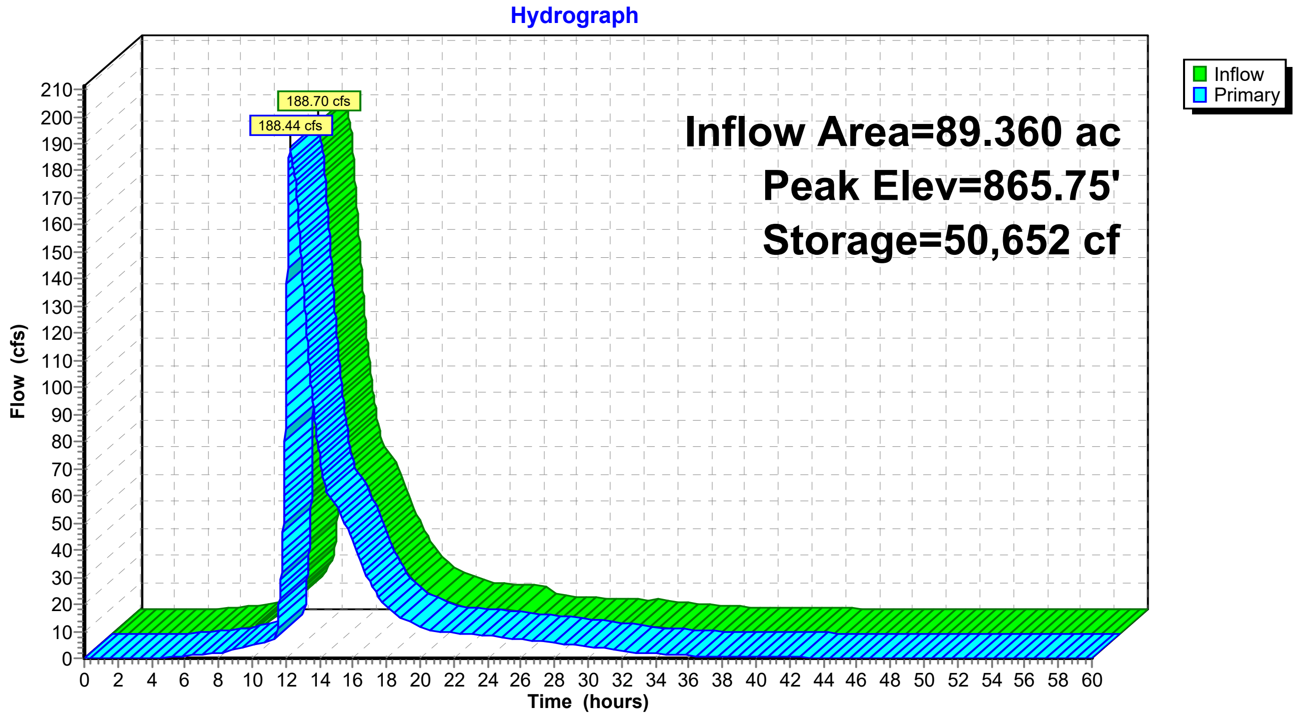
Volume	Invert	Avail.Storage	Storage Description
#1	862.30'	631,357 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
862.30	100	0	0
863.00	250	123	123
864.00	500	375	498
865.00	32,737	16,619	17,116
866.00	65,457	49,097	66,213
870.00	217,115	565,144	631,357

Device	Routing	Invert	Outlet Devices
#1	Primary	862.30'	**18.0" Round Culvert** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 862.30' / 862.30' S= 0.0000 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 1.77 sf
#2	Primary	865.50'	**550.0' long x 50.0' 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=188.41 cfs @ 12.24 hrs HW=865.75' TW=860.62' (Dynamic Tailwater)
1=Culvert (Barrel Controls 8.10 cfs @ 4.59 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 180.30 cfs @ 1.33 fps)

Pond P6:


Hydrograph
188.70 cfs
188.44 cfs
Inflow Area=89.360 ac
Peak Elev=865.75'
Storage=50,652 cf
Inflow
Primary
Flow (cfs)
Time (hours)

Summary for Pond P7:

Inflow Area = 66.120 ac, 0.00% Impervious, Inflow Depth = 6.77" for 100-YR event
Inflow = 195.99 cfs @ 12.31 hrs, Volume= 37.308 af
Outflow = 135.51 cfs @ 12.74 hrs, Volume= 37.271 af, Atten= 31%, Lag= 25.6 min
Primary = 127.81 cfs @ 12.74 hrs, Volume= 37.020 af
Secondary = 7.70 cfs @ 12.74 hrs, Volume= 0.265 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 867.65' @ 12.74 hrs Surf.Area= 168,369 sf Storage= 379,768 cf

Plug-Flow detention time= 130.3 min calculated for 37.271 af (100% of inflow)
Center-of-Mass det. time= 129.2 min (987.0 - 857.8)

Volume	Invert	Avail.Storage	Storage Description
#1	862.30'	439,161 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

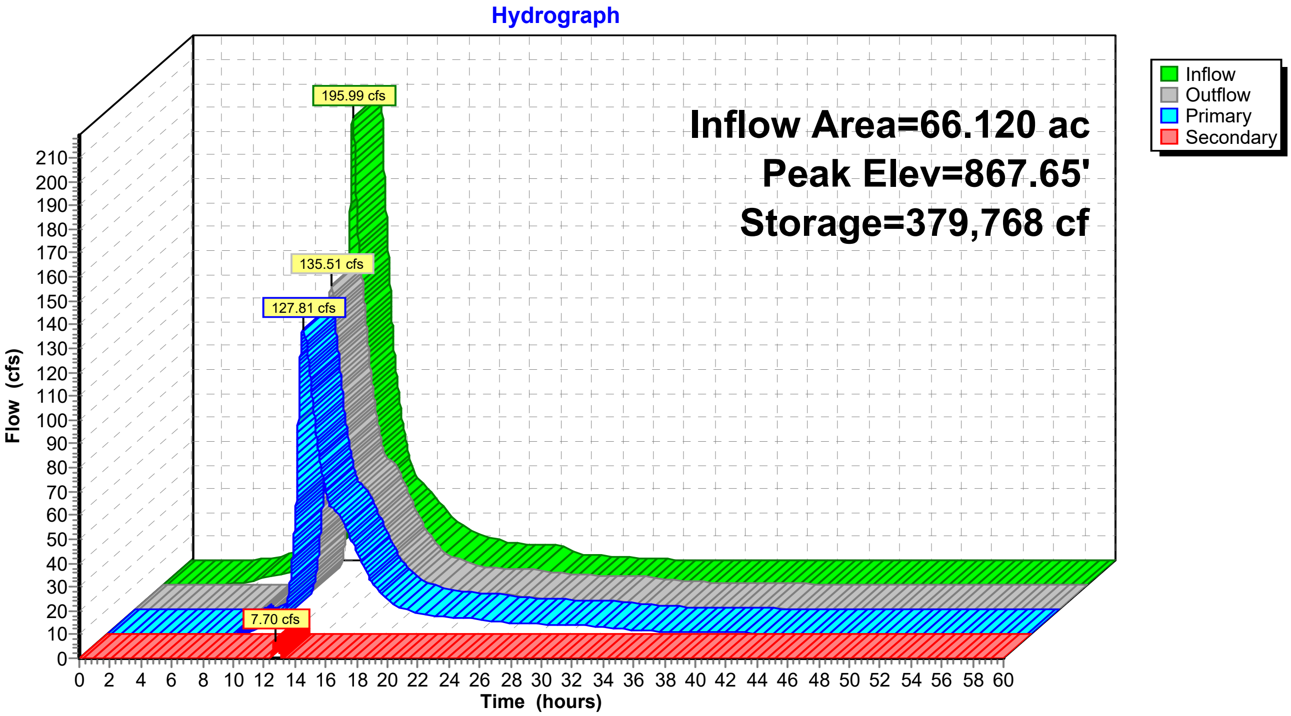
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
862.30	100	0	0
863.00	40,920	14,357	14,357
865.00	41,280	82,200	96,557
866.00	71,610	56,445	153,002
867.00	165,354	118,482	271,484
868.00	170,000	167,677	439,161

Device	Routing	Invert	Outlet Devices
#1	Primary	862.30'	**48.0" Round Culvert** L= 122.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 862.30' / 862.30' S= 0.0000 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 12.57 sf
#2	Secondary	867.50'	**50.0' long x 50.0' 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
#3	Primary	867.00'	**50.0' long x 50.0' 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=127.80 cfs @ 12.74 hrs HW=867.65' TW=865.72' (Dynamic Tailwater)
1=Culvert (Barrel Controls 57.62 cfs @ 4.59 fps)
3=Broad-Crested Rectangular Weir (Weir Controls 70.19 cfs @ 2.16 fps)

Secondary OutFlow Max=7.70 cfs @ 12.74 hrs HW=867.65' TW=860.82' (Dynamic Tailwater)
2=Broad-Crested Rectangular Weir (Weir Controls 7.70 cfs @ 1.03 fps)

Pond P7:


Hydrograph
195.99 cfs
135.51 cfs
127.81 cfs
7.70 cfs
Inflow Area=66.120 ac
Peak Elev=867.65'
Storage=379,768 cf
Inflow
Outflow
Primary
Secondary
Flow (cfs)
Time (hours)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
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 50 52 54 56 58 60

Summary for Pond P8:

Inflow Area = 168.595 ac, 21.02% Impervious, Inflow Depth = 6.82" for 100-YR event
Inflow = 872.76 cfs @ 11.96 hrs, Volume= 95.759 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 861.66' @ 60.00 hrs Surf.Area= 2,610,044 sf Storage= 4,171,266 cf

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

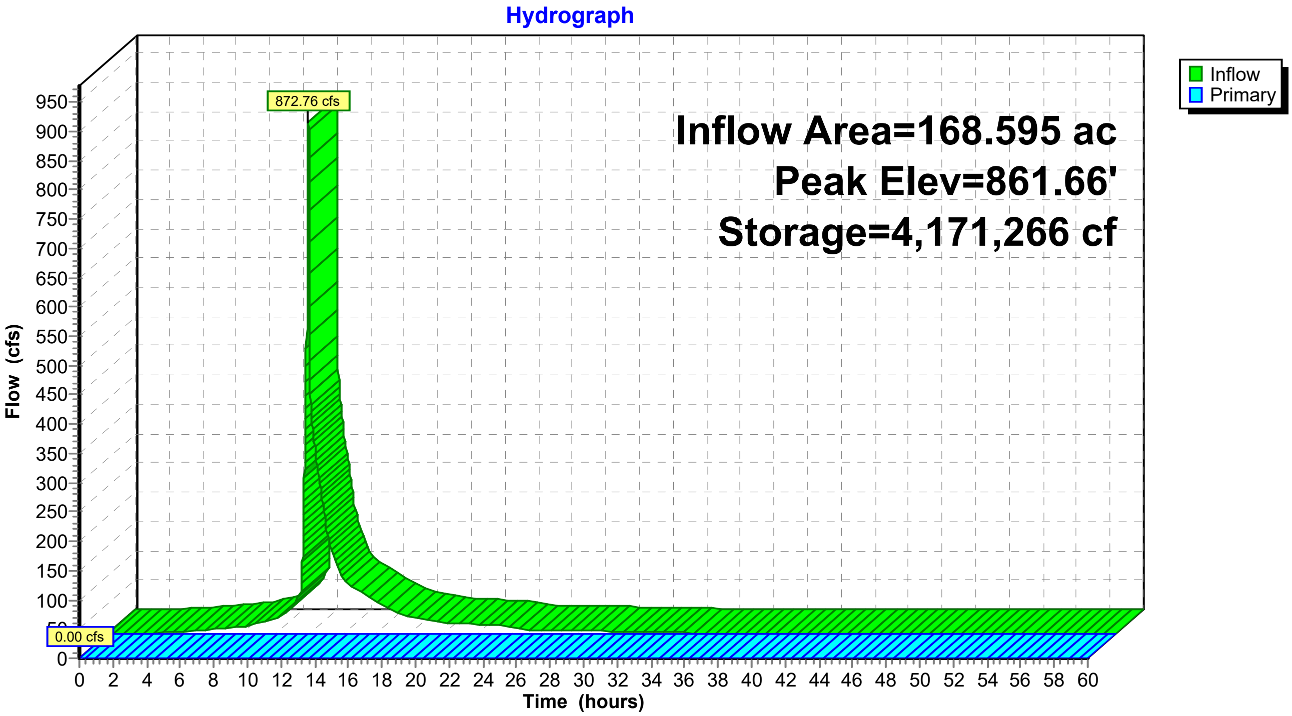
Volume	Invert	Avail.Storage	Storage Description
#1	860.00'	13,243,271 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
860.00	2,421,915	0	0
862.30	2,682,905	5,870,543	5,870,543
863.00	2,710,412	1,887,661	7,758,204
864.00	2,737,920	2,724,166	10,482,370
865.00	2,783,883	2,760,902	13,243,271

Device	Routing	Invert	Outlet Devices
#1	Primary	862.30'	**120.0' 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=0.00 cfs @ 0.00 hrs HW=860.00' TW=0.00' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond P8:

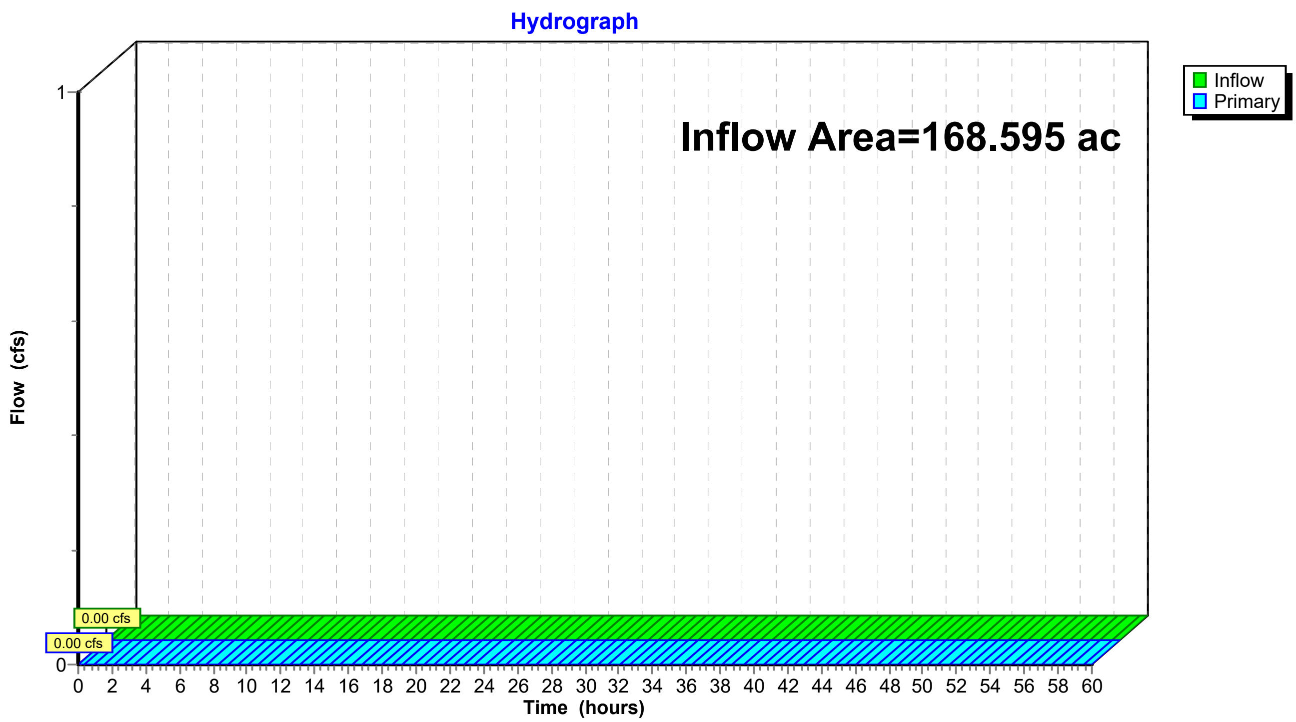

Hydrograph
872.76 cfs
0.00 cfs
Inflow Area=168.595 ac
Peak Elev=861.66'
Storage=4,171,266 cf
Inflow
Primary
Flow (cfs)
Time (hours)
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

Summary for Link Out:

Inflow Area =	168.595 ac,	21.02% Impervious,	Inflow Depth = 0.00"	for 100-YR event	
Inflow =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af	
Primary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs

Link Out:



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