FINAL STORMWATER REPORT
FOR
Lee's Summit Joint Operations Campus

Project Location:

10 NE Tudor Road, Lee's Summit, MO 64086

BHC Project # 041470.00.01

10/16/2024

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CIVIL ENGINEERING / SURVEYING / UTILITIES

Table of Contents

Table of Appendices

1.0 Introduction

This Final Stormwater Management Study is prepared for the expansion of the existing Lee's Summit Joint Operations Campus located at 10 NE Tudor Road, Lee's Summit, Missouri. The purpose of this study is to evaluate the existing on-site detention pond and the impacts of the expanded development on the existing detention pond and surrounding area. The project will result in the construction of a new Fire Administration building and associated Parking.

Governing design criteria is based on the APWA 5600 comprehensive control and the capacity of the downstream system to convey discharge during the systems design events.

Figure 1: Project Location Aerial

1. 1 Methodology

The unit hydrograph modeling for this report was conducted using TR-55 methodologies within HydroCAD.

Runoff for this report was determined using a SCS Type II 24-Hour rainfall event.

The design storms used for this report were the 2-year (50%), 10-year (10%), and 100-year (1%) events. Rainfall depths for these events were determined from NOAA Atlas 14. The table below contains these rainfall depths.

Table I: Report Design Storms

Report Design Storms	
Storm Event	**Rainfall Depth (in)**
2-Year	3.70
10-Year	5.66
100-Year	9.23

The following documents were used as the design criteria for this report:

- Kansas City Metropolitan Chapter of APWA Standards, Specification and Design Criteria, Section 5600 (2011)

Controlling Design Requirement

APWA 5600 requires that rainfall events are held to the following to the following release rates. 0.5 cfs for the 2-year, 2.0 cfs for the 10-yr, and 3.0 cfs for the 100-yr for any newly developed area. For this site the area considered new development would the eastern third of the site where the Fire Administration be located. BHC and the City of Lee's Summit have been unable to find the existing drainage study for the project and have not quantified release rates. BHC has reached out to the engineer of record (Bartlett and West), but at the submission of this report has not yet received that information.

Additionally, BHC reviewed the receiving system to evaluate potential flooding issues down stream of the site. In this case the down stream system is the proposed storm sewer installed as part of the development of the Douglas Station Multifamily site to the north. This site is not yet developed, therefore BHC has relied on the final development plans prepared by the developer and their engineer, dated March 8, 2024. From that review BHC has determined that the developer has considered release rates from our proposed pond that pass through to the Douglas Station Commercial Park Regional Pond. **From conversations between BHC and City Staff (Gene Williams and Grant White), BHC has determined that the assumed Joint Operations Center pond release rates contained within the Douglas Station Multifamily Final Development Plans should be considered the controlling design requirement.**

2.0 Existing Conditions

2.1 Project Site

The existing project site is currently occupied by the existing Lee's Summit Municipal Court Facility basin on the site grading, the project site has 11.41 acres tributary to the detention pond, and additional 0.78 acres of off-site runoff from the right-of-way of Tudor. Total tributary area is 12.19 acres.

2.2 Hydrology

A majority of the project site drains towards the existing detention pond. This drainage area is summarized below in Table II.

Table II: Existing Drainage Areas

		AREA		PERVIOUS		IMPERVIOUS		CN-Value	C-VALUE
	Total	631,858 SF	(14.51 ac)	294518.55 SF	(6.76 ac)	337,339 SF	(7.74 ac)	90	0.62
To Pond	Onsite	497,121 SF	(11.41 ac)	237177.93 SF	(5.44 ac)	259,943 SF	(5.97 ac)	89	0.61
	Offsite	33,883 SF	(0.78 ac)	12318.70 SF	(0.28 ac)	21,564 SF	(0.50 ac)	91	0.68
Not to Pond	Onsite	26,149 SF	(0.60 ac)	21777.89 SF	(0.50 ac)	4,371 SF	(0.10 ac)	83	0.40
	Offsite	74,704 SF	(1.71 ac)	23244.02 SF	(0.53 ac)	51,460 SF	(1.18 ac)	92	0.71

The drainage area was analyzed in HydroCAD, using TR-55 methodologies to calculate the peak runoff from the existing site in the 2-, 10-, and 100-year storm events to the existing detention pond. These calculations are found in Appendix A1. Table III below summarizes these quantities.

Table III: Existing Site Generated Runoff

Existing Site Generated Runoff (cfs)		
2-Year	**10-Year**	**100-Year**
47.16	78.42	134.50

2.3 Existing Detention

The existing detention pond was evaluated in the all runoff events. The storm events are attenuated through the pond by two existing 30” CMP culvert pipes. During the 2013 modifications to the site a 2-ft plate with multiple orifices was added to detention pond, an image of this control structure is below. The Stormwater Management Study from 2013 modification has not been found at the time this report was submitted, therefore, BHC evaluated the flow through the pond based on the conditions that presently exist. This results in the following pond peak release rates:

Existing Detention Pond				
Storm Event	**Primary Spillway Peak Release (cfs)**	**Overflow Spillway Peak Release (cfs)**	**Combined Peak Release (CFS)**	**Stage Storage Elevation**
2-year	29.89	0	29.89	1002.57
10-year	53.31	1.89	55.21	1003.29
100-year	73.08	42.83	115.91	1003.97

Due to the activation of the overflow spillway in the 10-year event, BHC believes that the existing pond is undersized, based on the established Design Methodology Section 1.1 of this report. Therefore, additional volume is needed with the proposed modification to address the current undersized pond.

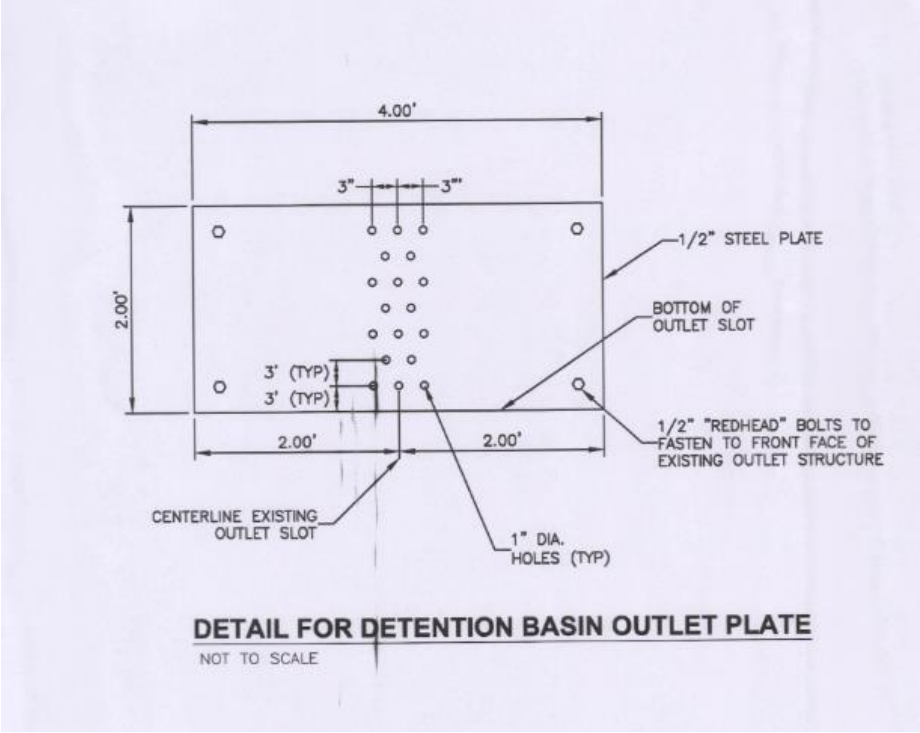


Image: 2013 Pond Modifications

3.0 Proposed Condition

3.1 Project Site

The project will result in the construction of a Fire Administration building, associated parking and site grading changes. This will result in an increase of the tributary area to the detention pond from 12.19 acres to 12.39 (11.59 acres from project site and 0.8 acres from Tudor right-of-way).

3.2 Hydrology

A majority of the project site drains towards the existing detention pond. This drainage area is summarized below in Table IV.

Table IV: Proposed Drainage Areas

		AREA		PERVIOUS		IMPERVIOUS		CN-Value	C-VALUE
	Total	632,704 SF	(14.52 ac)	226,996 SF	(5.21 ac)	405,708 SF	(9.31 ac)	92	0.68
To Pond	Onsite	504,869 SF	(11.59 ac)	175,873 SF	(4.04 ac)	328,996 SF	(7.55 ac)	92	0.69
	Offsite	34,740 SF	(0.80 ac)	13,154 SF	(0.30 ac)	21,586 SF	(0.50 ac)	91	0.67
Not to Pond	Onsite	19,248 SF	(0.44 ac)	15,814 SF	(0.36 ac)	3,434 SF	(0.08 ac)	83	0.41
	Offsite	73,848 SF	(1.70 ac)	22,155 SF	(0.51 ac)	51,692 SF	(1.19 ac)	93	0.72

The drainage area was analyzed in HydroCAD, using TR-55 methodologies to calculate the peak runoff from the existing site in the 2-, 10-, and 100-year storm events. These calculations are found in Appendix A1. Table V below summarizes these quantities.

Table V: Proposed Site Generated Runoff

Proposed Site Generated Runoff (cfs)		
2-Year	**10-Year**	**100-Year**
50.58	82.12	138.64

The proposed development of the site results in an increase in peak runoff rates in all analyzed storm events. To manage runoff to pre-development levels the existing detention pond will need to be expanded.

3.3 Controlling Release Rate

Downstream Analysis

The City of Lee's Summit provided the Final Development Plans submitted by for the multi-family development located north of the project site. BHC has reviewed the plans and sheet C202 indicates that a release rate from the pond located on the Joint Operations Center property considered a release rate of 36 cfs in the 10-year storm, and 54 CFS in the 100-year storm.

Additionally, the current overflow spillway discharges to the proposed Douglas Station Multi-Family Project. The current spillway location creates a potential of flooding of downstream Multi-Family site. Therefore, this proposed design includes raising the top of the north berm elevation of the detention pond to 1005.50. This allows for the construction of spillway to west towards Commerce Drive and minimizes downstream flooding during an emergency overflow event.

3.3 Proposed Detention

Detention will be provided by modification of the existing dry detention pond. Presently, the outlet of the pond includes two 30" CMP outlet pipes, the proposed solutions considers replacing the existing CMP structures an outlet control structure with a weir wall. The weir wall will have a 3" opening for the water quality storm (extended dry detention released over 40 hours). The 10 and 100-yr events will be controlled by 4" wide by 18" tall opening. The depth an area of the pond has been increased to allow for (1) additional detention and (2) a direct connection to the proposed inlet 1-6 located on the development to the north.

Information regarding the downstream system has been provided in Appendix A2.

This controls the release rate to the flows assumed for the project.

Proposed Detention Pond		
Storm Event	**Peak Release (cfs)**	**Stage Storage Elevation**
Water Quality	0.37	997.5
*2-year	23.73	999.49
10-year	34.50	1000.85
100-year	55.61	1002.75
Bottom of Spillway	--	1003.75
**Top of Spillway	--	1004.70
Top of Berm	--	1005.50

*The 2-year event was not defined in the downstream system.
**Spillway sizing is provided in Appendix A3.

Emergency Overflow Spillway

As previously discussed, the current emergency overflow spillway discharges onto property proposed for multifamily construction. This creates potential for downstream flooding during an event that activates the emergency spillway. To prevent this the proposed design raises the top of berm height to 1005.50 and relocates the spillway to the discharge on Commerce Drive. To provide the flow required for the 100-year event the spillway will need to be constructed of concrete and include a retaining wall to stabilize the berm along the northside of the site. This location of the spillway is conceptually located plans. Full detailing of the concrete spillway pad and any retaining walls will be provided with the final development plans.

The current spillway design provides 9” of freeboard between the top of spillway flow elevation and the top of berm. This is 3” less than the 12” required by APWA 5600, therefore, a waiver will be required as the project progress.

4.0 Downstream Analysis

As previously discussed BHC reviewed downstream infrastructure as part of this analysis. The site discharges to a currently undeveloped site that has an active Final Development Plan in review by the City of Lee's Summit. The proposed development includes installation of an enclosed storm sewer system through the property replacing the existing channel. The proposed detention meets the allowed release rates to that system from the on-site pond. However, the site does not have surface flow capacity for the emergency overflow event required by APWA 5600. Therefore, the proposed design relocates the existing overflow spillway to discharge to Commerce Drive. As part of the Stormwater Management Study. Downstream conditions were considered.

Additionally, BHC recommends a direct connection to the Douglas Station Muli-Family system to in lieu of an overland flow.

4.0 Water Quality

Per the Lee Summit design and construction manual “volumetric and/or extended detention control of the 90% mean annual event storm event shall be provided for broad protection of the receiving system, including channel erosion protection and flood peak reductions over a range of return periods.”

This is achieved as described above with the use of the restricted 3” orifice to manage runoff from the 1.37 inch event.

6.0 Permitting

6.1 United State Army Corps of Engineers (USACE)

The National Wetland Inventory and USGS Mapping does not Identify and jurisdictional waters within the site area. There are no known USACE regulated levees with 500-feet of the site.

6.2 Federal Emergency Management Agency (FEMA)

The site is located within the Zone X, and outside of the 1% and 0.2% annual chance flood hazard, as shown on FEMA FIRM Map 29095C0417G, effective 1/20/2017. The FEMA Firmette for the project site can be found in Appendix A4

6.3 Missouri Department of Natural Resources (MoDNR)

The area to be disturbed by the project site exceeds 1-arce; a Notice of Intent (NOI) is required to be submitted to MoDNR and a Stormwater Pollution Prevention Plan (SWPPP) will be prepared for the project.

6.0 Conclusion

Multiple stormwater control criteria were considered for the development of the proposed project. It was also determined that the existing pond is undersized as the overflow spillway is activated in the 10-year event. Therefore, the existing undersize of this pond needs addressed as part of the proposed improvements.

It was determined that limiting release rate criteria is the capacity of the proposed Douglas Station Multifamily storm sewer system. The design rates of the Joint Operations Center to the receiving storm sewer system were considered the controlling design criteria.

The existing overflow spillway discharging to the Douglas Station project is proposed to be relocated to discharge to Commerce Drive.

Additionally, the stormwater design meets the Lee's Summit Design and Construction manual requirements for water quality control through the use of an Extended Dry Detention system.

BHC will continue to work with staff and the neighboring development through the preparation of final development plans and issuance of a permit.

Appendix A – Reference Documents

A1 – HyrdoCAD Output Summary

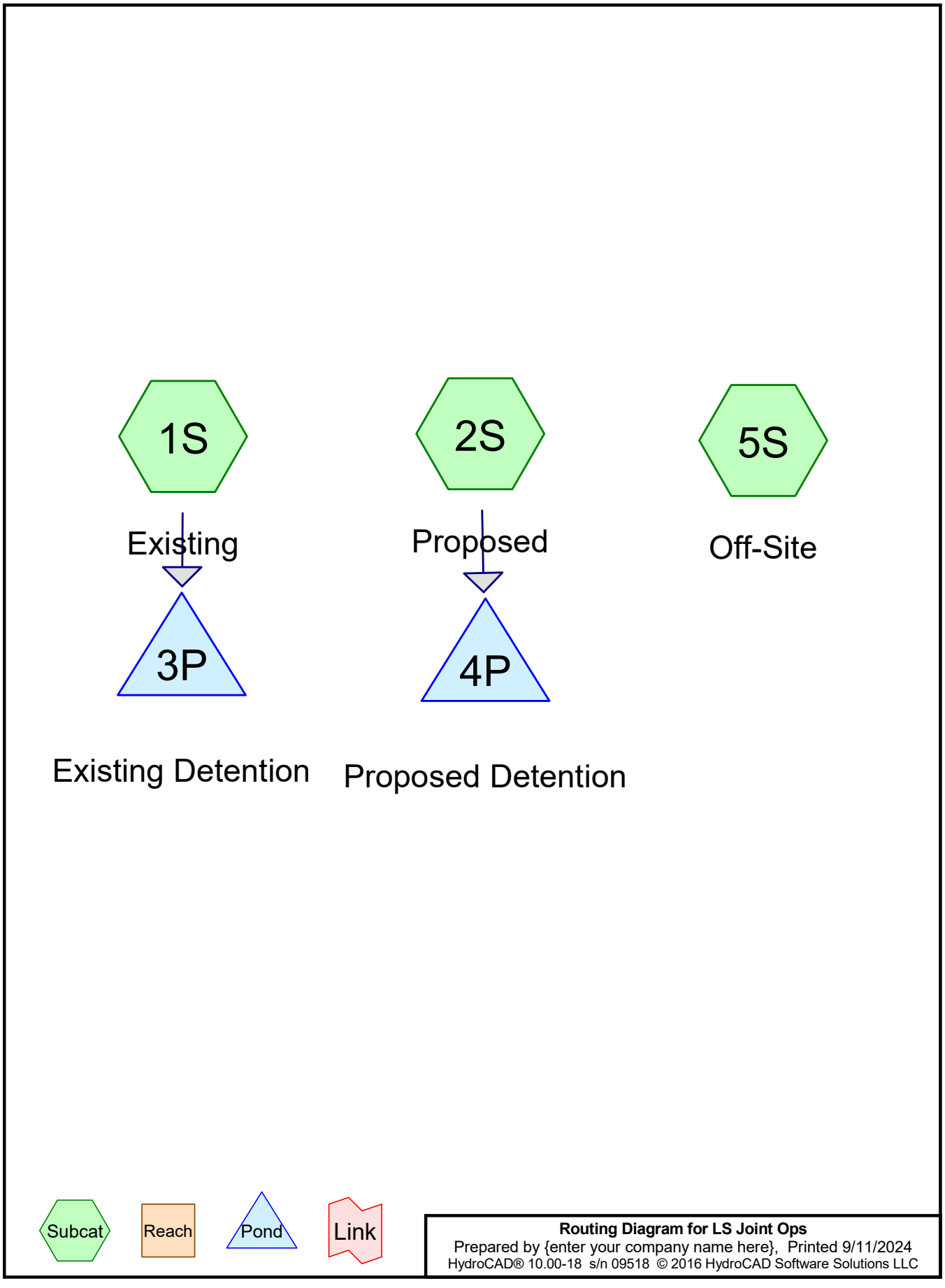
A2 – Douglass Station Commercial Park Reference Documents

A3 – Spillway Design

A4 – FEMA Firmette

A5 – Drainage Maps

Appendix A1


1S
2S
5S
Existing
Proposed
Off-Site
3P
4P
Existing Detention
Proposed Detention
Subcat
Reach
Pond
Link
Routing Diagram for LS Joint Ops
Prepared by {enter your company name here}, Printed 9/11/2024
HydroCAD® 10.00-18 s/n 09518 © 2016 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
12.190	90	(1S)
12.390	92	(2S)
0.500	91	(5S)
25.080	**91**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
25.080	Other	1S, 2S, 5S
25.080		**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	25.080	25.080		1S, 2S, 5S
0.000	**0.000**	**0.000**	**0.000**	**25.080**	**25.080**	**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	3P	999.50	999.00	40.0	0.0125	0.025	30.0	0.0	0.0
2	4P	994.90	994.50	40.0	0.0100	0.012	30.0	0.0	0.0

Time span=5.00-60.00 hrs, dt=0.05 hrs, 1101 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Runoff Area=12.190 ac 0.00% Impervious Runoff Depth>2.64"
Tc=10.0 min CN=90 Runoff=47.16 cfs 2.677 af

Subcatchment 2S: Proposed Runoff Area=12.390 ac 0.00% Impervious Runoff Depth>2.83"
Tc=10.0 min CN=92 Runoff=50.58 cfs 2.918 af

Subcatchment 5S: Off-Site Runoff Area=0.500 ac 0.00% Impervious Runoff Depth>2.73"
Tc=5.0 min CN=91 Runoff=2.33 cfs 0.114 af

Pond 3P: Existing Detention Peak Elev=1,002.57' Storage=33,368 cf Inflow=47.16 cfs 2.677 af
Primary=29.89 cfs 2.670 af Secondary=0.00 cfs 0.000 af Outflow=29.89 cfs 2.670 af

Pond 4P: Proposed Detention Peak Elev=999.49' Storage=49,259 cf Inflow=50.58 cfs 2.918 af
Outflow=23.73 cfs 2.918 af

Total Runoff Area = 25.080 ac Runoff Volume = 5.709 af Average Runoff Depth = 2.73"
100.00% Pervious = 25.080 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Existing

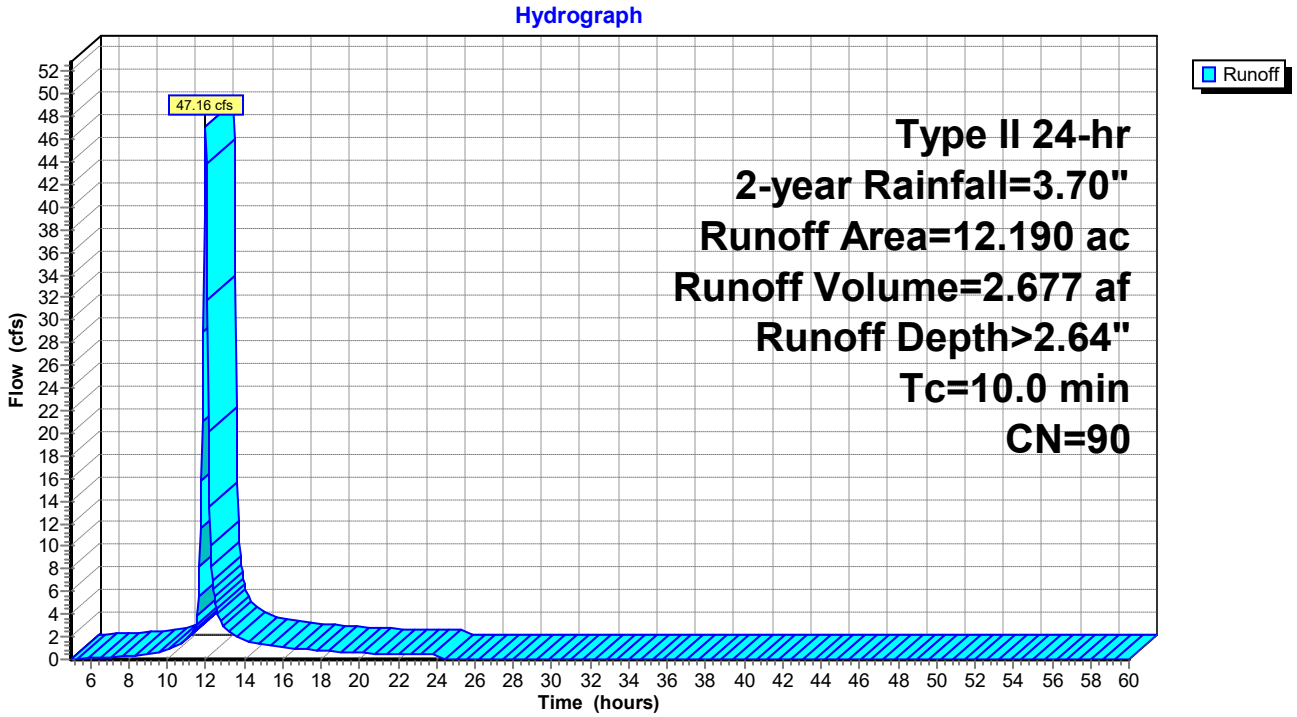
Runoff = 47.16 cfs @ 12.01 hrs, Volume= 2.677 af, Depth> 2.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-year Rainfall=3.70"

	Area (ac)	CN	Description
*	12.190	90	
	12.190		100.00% Pervious Area

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

Subcatchment 1S: Existing



Summary for Subcatchment 2S: Proposed

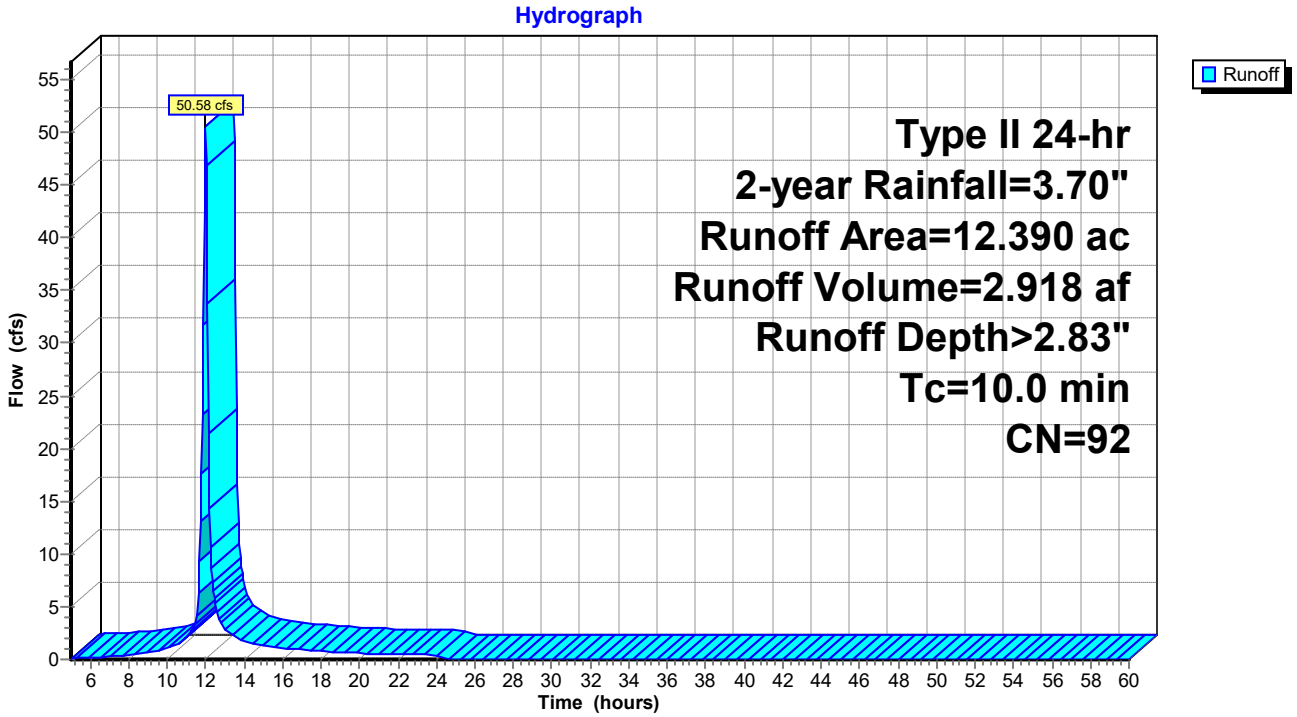
Runoff = 50.58 cfs @ 12.01 hrs, Volume= 2.918 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-year Rainfall=3.70"

	Area (ac)	CN	Description
*	12.390	92	
	12.390		100.00% Pervious Area

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

Subcatchment 2S: Proposed



Summary for Subcatchment 5S: Off-Site

[49] Hint: Tc<2dt may require smaller dt

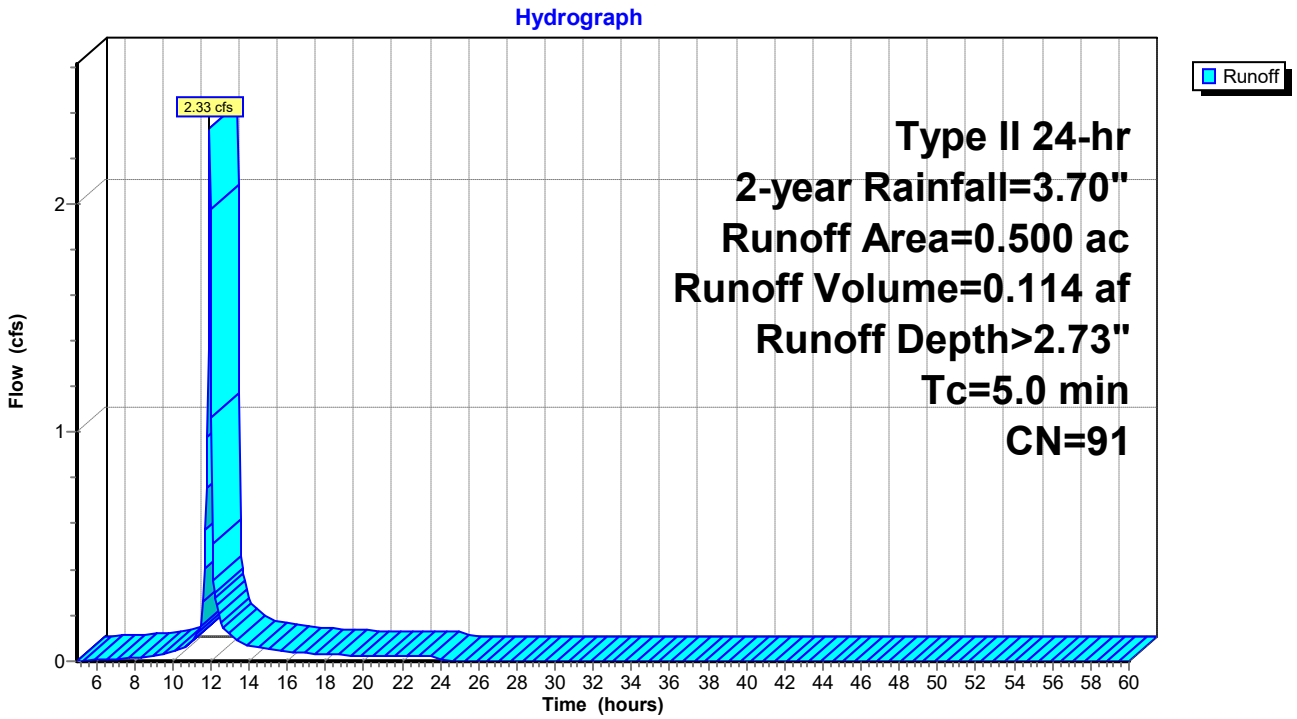
Runoff = 2.33 cfs @ 11.95 hrs, Volume= 0.114 af, Depth> 2.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-year Rainfall=3.70"

	Area (ac)	CN	Description
*	0.500	91	
	0.500		100.00% Pervious Area

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

Subcatchment 5S: Off-Site



Summary for Pond 3P: Existing Detention

Inflow Area = 12.190 ac, 0.00% Impervious, Inflow Depth > 2.64" for 2-year event
Inflow = 47.16 cfs @ 12.01 hrs, Volume= 2.677 af
Outflow = 29.89 cfs @ 12.11 hrs, Volume= 2.670 af, Atten= 37%, Lag= 6.0 min
Primary = 29.89 cfs @ 12.11 hrs, Volume= 2.670 af
Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Peak Elev= 1,002.57' @ 12.11 hrs Surf.Area= 18,484 sf Storage= 33,368 cf

Plug-Flow detention time= 87.9 min calculated for 2.668 af (100% of inflow)
Center-of-Mass det. time= 86.7 min (888.6 - 802.0)

Volume	Invert	Avail.Storage	Storage Description
#1	999.00'	88,385 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

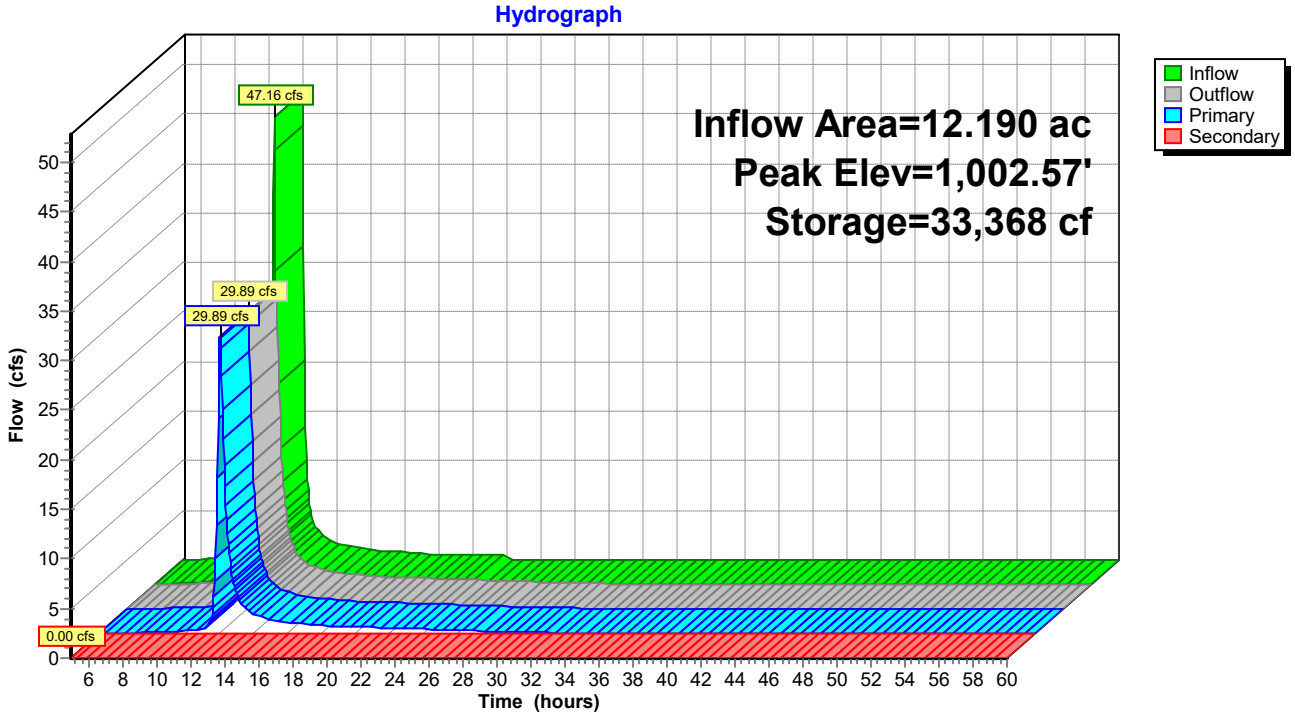
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
999.00	10	0	0
1,000.00	2,580	1,295	1,295
1,001.00	12,035	7,308	8,603
1,002.00	17,125	14,580	23,183
1,003.00	19,500	18,313	41,495
1,004.00	22,140	20,820	62,315
1,005.00	30,000	26,070	88,385

Device	Routing	Invert	Outlet Devices
#1	Primary	999.50'	**30.0" Round CMP_Round 30" X 2.00** L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 999.50' / 999.00' S= 0.0125 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	999.25'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#3	Device 1	999.50'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Device 1	999.75'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#5	Device 1	1,000.00'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#6	Device 1	1,000.25'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#7	Device 1	1,000.50'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#8	Device 1	1,000.75'	**3.0" Vert. Orifice/Grate X 3.00** C= 0.600
#9	Secondary	1,003.20'	**24.0' long x 22.0' 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
#10	Device 1	1,001.00'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height

Primary OutFlow Max=29.57 cfs @ 12.11 hrs HW=1,002.56' (Free Discharge)
└─**1=CMP_Round 30"** (Passes 29.57 cfs of 52.84 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.14 cfs @ 8.42 fps)
  ├─**3=Orifice/Grate** (Orifice Controls 0.09 cfs @ 8.37 fps)
  ├─**4=Orifice/Grate** (Orifice Controls 0.13 cfs @ 8.01 fps)
  ├─**5=Orifice/Grate** (Orifice Controls 0.08 cfs @ 7.64 fps)
  ├─**6=Orifice/Grate** (Orifice Controls 0.12 cfs @ 7.25 fps)
  ├─**7=Orifice/Grate** (Orifice Controls 0.07 cfs @ 6.84 fps)
  ├─**8=Orifice/Grate** (Orifice Controls 0.92 cfs @ 6.25 fps)
  └─**10=Sharp-Crested Rectangular Weir** (Weir Controls 28.01 cfs @ 4.87 fps)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=999.00' (Free Discharge)
└─**9=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 3P: Existing Detention



Summary for Pond 4P: Proposed Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.390 ac, 0.00% Impervious, Inflow Depth > 2.83" for 2-year event
Inflow = 50.58 cfs @ 12.01 hrs, Volume= 2.918 af
Outflow = 23.73 cfs @ 12.15 hrs, Volume= 2.918 af, Atten= 53%, Lag= 8.2 min
Primary = 23.73 cfs @ 12.15 hrs, Volume= 2.918 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Peak Elev= 999.49' @ 12.15 hrs Surf.Area= 17,706 sf Storage= 49,259 cf

Plug-Flow detention time= 238.1 min calculated for 2.915 af (100% of inflow)
Center-of-Mass det. time= 239.1 min (1,032.7 - 793.6)

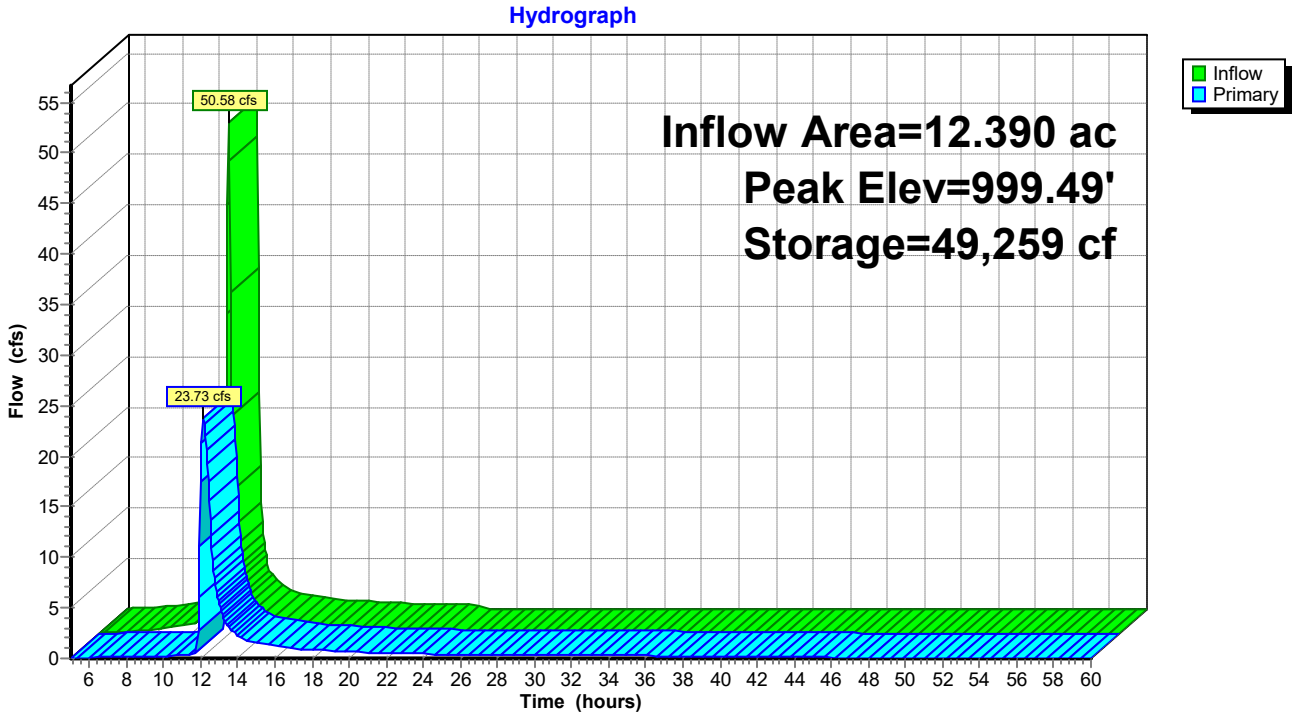
Volume	Invert	Avail.Storage	Storage Description
#1	995.00'	153,448 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
995.00	50	0	0
996.00	8,213	4,132	4,132
997.00	10,000	9,107	13,238
998.00	14,340	12,170	25,408
999.00	16,580	15,460	40,868
1,000.00	18,880	17,730	58,598
1,001.00	21,240	20,060	78,658
1,002.00	23,640	22,440	101,098
1,003.00	26,110	24,875	125,973
1,004.00	28,840	27,475	153,448

Device	Routing	Invert	Outlet Devices
#1	Primary	994.90'	**30.0" Round Culvert** L= 40.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 994.90' / 994.50' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	995.00'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	997.62'	**42.0" W x 15.0" H Vert. Orifice/Grate** C= 0.600
#4	Primary	1,001.10'	**24.0" W x 12.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=23.70 cfs @ 12.15 hrs HW=999.49' (Free Discharge)
- **1=Culvert** (Passes 23.70 cfs of 43.17 cfs potential flow)
  - **2=Orifice/Grate** (Orifice Controls 0.49 cfs @ 10.05 fps)
  - **3=Orifice/Grate** (Orifice Controls 23.20 cfs @ 5.30 fps)
- **4=Orifice/Grate** (Controls 0.00 cfs)

Pond 4P: Proposed Detention



Time span=5.00-60.00 hrs, dt=0.05 hrs, 1101 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Runoff Area=12.190 ac 0.00% Impervious Runoff Depth>4.50"
Tc=10.0 min CN=90 Runoff=78.42 cfs 4.575 af

Subcatchment 2S: Proposed Runoff Area=12.390 ac 0.00% Impervious Runoff Depth>4.71"
Tc=10.0 min CN=92 Runoff=82.12 cfs 4.862 af

Subcatchment 5S: Off-Site Runoff Area=0.500 ac 0.00% Impervious Runoff Depth>4.61"
Tc=5.0 min CN=91 Runoff=3.81 cfs 0.192 af

Pond 3P: Existing Detention Peak Elev=1,003.29' Storage=47,320 cf Inflow=78.42 cfs 4.575 af
Primary=53.31 cfs 4.559 af Secondary=1.89 cfs 0.009 af Outflow=55.21 cfs 4.568 af

Pond 4P: Proposed Detention Peak Elev=1,000.85' Storage=75,559 cf Inflow=82.12 cfs 4.862 af
Outflow=34.50 cfs 4.862 af

Total Runoff Area = 25.080 ac Runoff Volume = 9.629 af Average Runoff Depth = 4.61"
100.00% Pervious = 25.080 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Existing

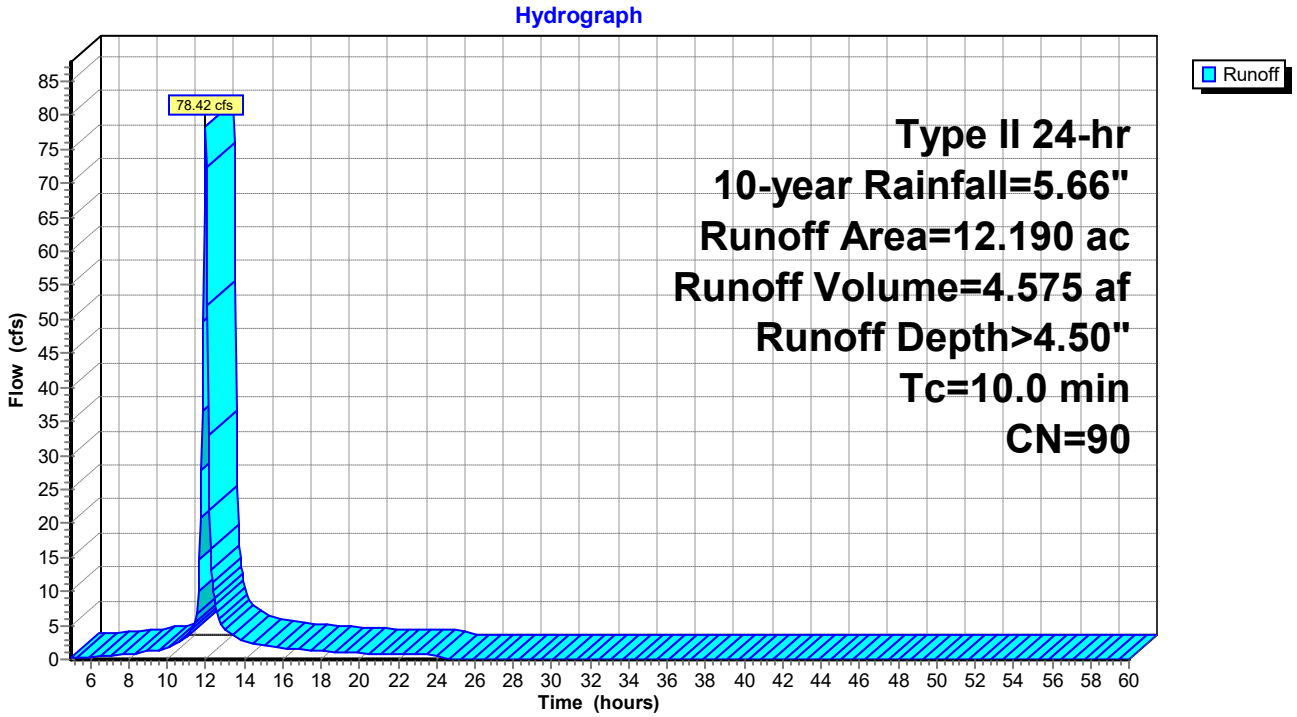
Runoff = 78.42 cfs @ 12.01 hrs, Volume= 4.575 af, Depth> 4.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-year Rainfall=5.66"

	Area (ac)	CN	Description
*	12.190	90	
	12.190		100.00% Pervious Area

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

Subcatchment 1S: Existing



Summary for Subcatchment 2S: Proposed

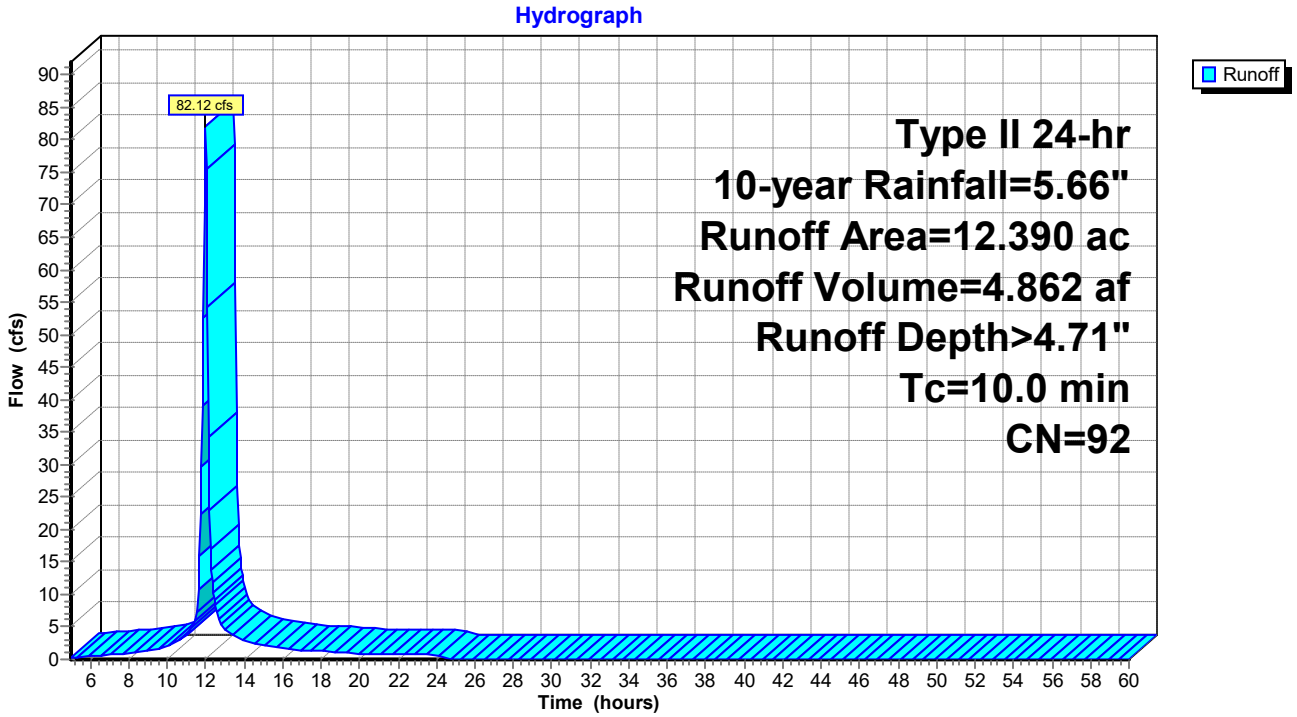
Runoff = 82.12 cfs @ 12.01 hrs, Volume= 4.862 af, Depth> 4.71"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-year Rainfall=5.66"

	Area (ac)	CN	Description
*	12.390	92	
	12.390		100.00% Pervious Area

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

Subcatchment 2S: Proposed



Summary for Subcatchment 5S: Off-Site

[49] Hint: Tc<2dt may require smaller dt

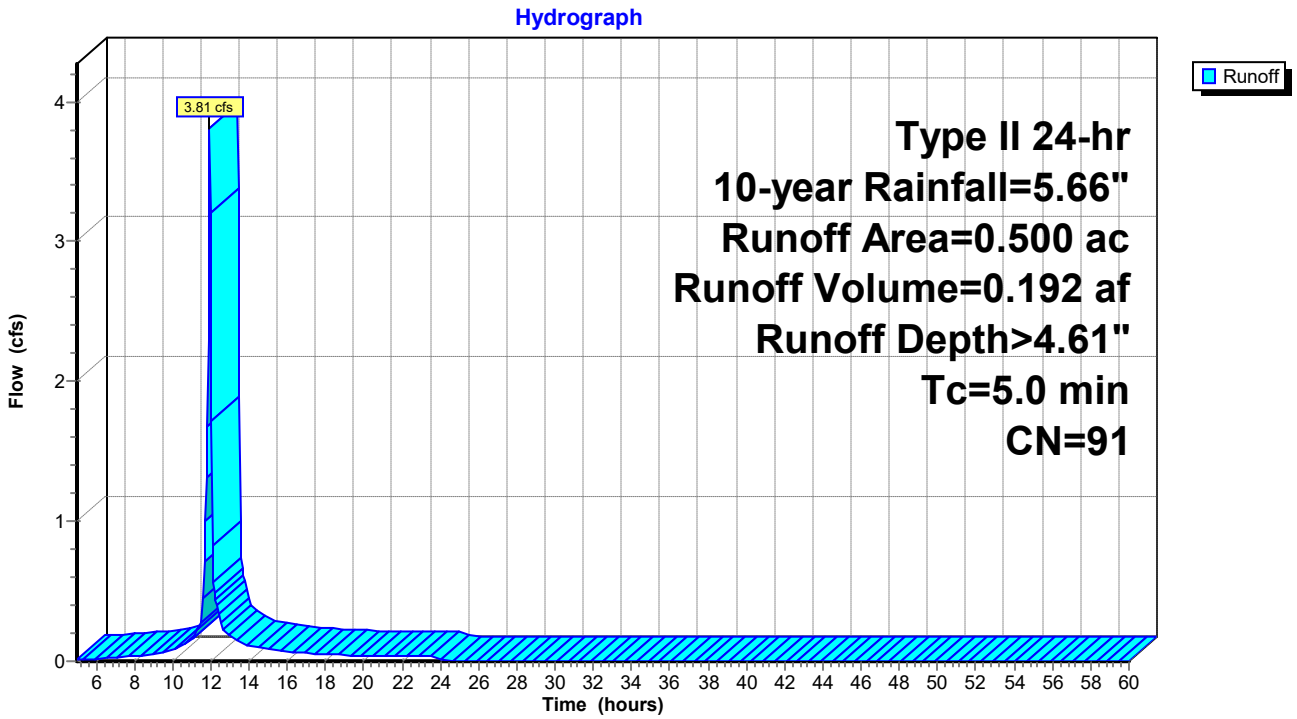
Runoff = 3.81 cfs @ 11.95 hrs, Volume= 0.192 af, Depth> 4.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-year Rainfall=5.66"

	Area (ac)	CN	Description
*	0.500	91	
	0.500		100.00% Pervious Area

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

Subcatchment 5S: Off-Site



Summary for Pond 3P: Existing Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.190 ac, 0.00% Impervious, Inflow Depth > 4.50" for 10-year event
Inflow = 78.42 cfs @ 12.01 hrs, Volume= 4.575 af
Outflow = 55.21 cfs @ 12.10 hrs, Volume= 4.568 af, Atten= 30%, Lag= 5.4 min
Primary = 53.31 cfs @ 12.10 hrs, Volume= 4.559 af
Secondary = 1.89 cfs @ 12.10 hrs, Volume= 0.009 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Peak Elev= 1,003.29' @ 12.10 hrs Surf.Area= 20,273 sf Storage= 47,320 cf

Plug-Flow detention time= 66.2 min calculated for 4.567 af (100% of inflow)
Center-of-Mass det. time= 64.4 min (852.7 - 788.3)

Volume	Invert	Avail.Storage	Storage Description
#1	999.00'	88,385 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

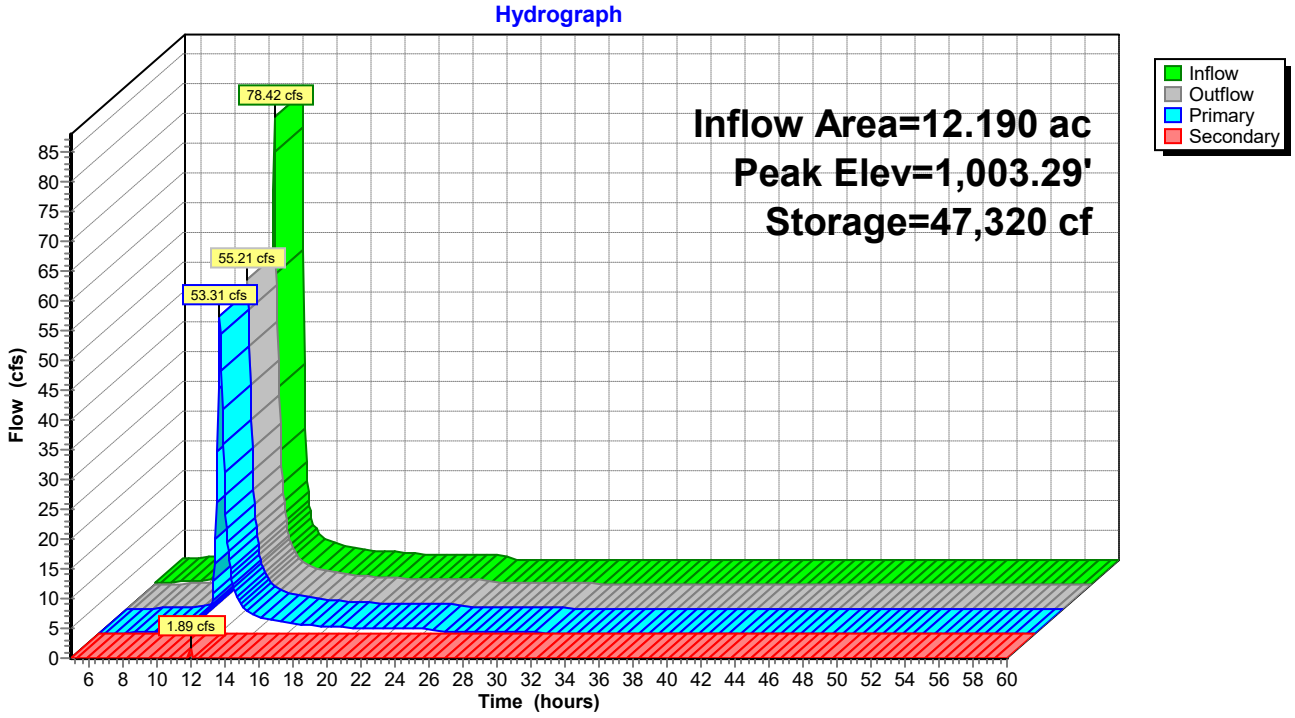
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
999.00	10	0	0
1,000.00	2,580	1,295	1,295
1,001.00	12,035	7,308	8,603
1,002.00	17,125	14,580	23,183
1,003.00	19,500	18,313	41,495
1,004.00	22,140	20,820	62,315
1,005.00	30,000	26,070	88,385

Device	Routing	Invert	Outlet Devices
#1	Primary	999.50'	**30.0" Round CMP_Round 30" X 2.00** L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 999.50' / 999.00' S= 0.0125 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	999.25'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#3	Device 1	999.50'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Device 1	999.75'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#5	Device 1	1,000.00'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#6	Device 1	1,000.25'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#7	Device 1	1,000.50'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#8	Device 1	1,000.75'	**3.0" Vert. Orifice/Grate X 3.00** C= 0.600
#9	Secondary	1,003.20'	**24.0' long x 22.0' 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
#10	Device 1	1,001.00'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height

Primary OutFlow Max=53.25 cfs @ 12.10 hrs HW=1,003.29' (Free Discharge)
└─**1=CMP_Round 30"** (Passes 53.25 cfs of 62.25 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.15 cfs @ 9.38 fps)
  ├─**3=Orifice/Grate** (Orifice Controls 0.10 cfs @ 9.32 fps)
  ├─**4=Orifice/Grate** (Orifice Controls 0.15 cfs @ 9.01 fps)
  ├─**5=Orifice/Grate** (Orifice Controls 0.09 cfs @ 8.68 fps)
  ├─**6=Orifice/Grate** (Orifice Controls 0.14 cfs @ 8.34 fps)
  ├─**7=Orifice/Grate** (Orifice Controls 0.09 cfs @ 7.98 fps)
  ├─**8=Orifice/Grate** (Orifice Controls 1.10 cfs @ 7.48 fps)
  └─**10=Sharp-Crested Rectangular Weir** (Weir Controls 51.43 cfs @ 6.34 fps)

Secondary OutFlow Max=1.79 cfs @ 12.10 hrs HW=1,003.29' (Free Discharge)
└─**9=Broad-Crested Rectangular Weir** (Weir Controls 1.79 cfs @ 0.81 fps)

Pond 3P: Existing Detention



Summary for Pond 4P: Proposed Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.390 ac, 0.00% Impervious, Inflow Depth > 4.71" for 10-year event
Inflow = 82.12 cfs @ 12.01 hrs, Volume= 4.862 af
Outflow = 34.50 cfs @ 12.16 hrs, Volume= 4.862 af, Atten= 58%, Lag= 8.9 min
Primary = 34.50 cfs @ 12.16 hrs, Volume= 4.862 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Peak Elev= 1,000.85' @ 12.16 hrs Surf.Area= 20,893 sf Storage= 75,559 cf

Plug-Flow detention time= 164.0 min calculated for 4.857 af (100% of inflow)
Center-of-Mass det. time= 164.9 min (947.0 - 782.2)

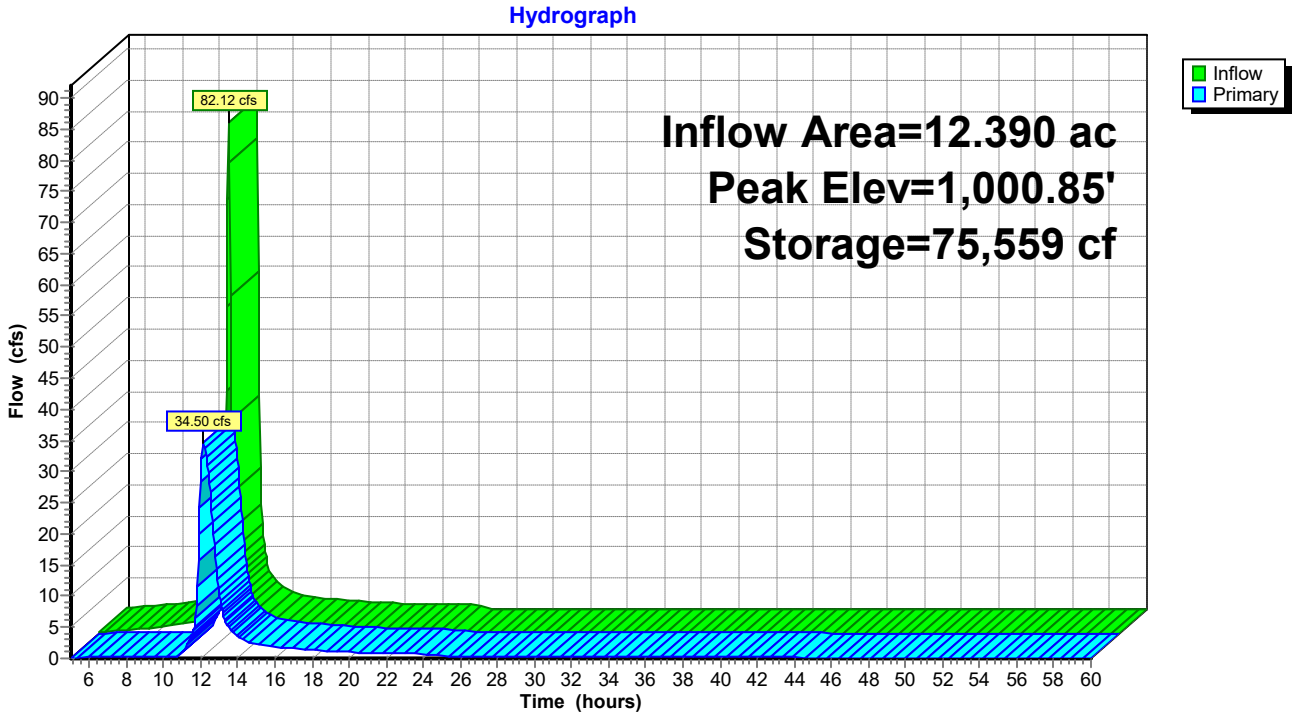
Volume	Invert	Avail.Storage	Storage Description
#1	995.00'	153,448 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
995.00	50	0	0
996.00	8,213	4,132	4,132
997.00	10,000	9,107	13,238
998.00	14,340	12,170	25,408
999.00	16,580	15,460	40,868
1,000.00	18,880	17,730	58,598
1,001.00	21,240	20,060	78,658
1,002.00	23,640	22,440	101,098
1,003.00	26,110	24,875	125,973
1,004.00	28,840	27,475	153,448

Device	Routing	Invert	Outlet Devices
#1	Primary	994.90'	**30.0" Round Culvert** L= 40.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 994.90' / 994.50' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	995.00'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	997.62'	**42.0" W x 15.0" H Vert. Orifice/Grate** C= 0.600
#4	Primary	1,001.10'	**24.0" W x 12.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=34.45 cfs @ 12.16 hrs HW=1,000.84' (Free Discharge)
- **1=Culvert** (Passes 34.45 cfs of 51.21 cfs potential flow)
  - **2=Orifice/Grate** (Orifice Controls 0.57 cfs @ 11.52 fps)
  - **3=Orifice/Grate** (Orifice Controls 33.88 cfs @ 7.74 fps)
- **4=Orifice/Grate** (Controls 0.00 cfs)

Pond 4P: Proposed Detention



Time span=5.00-60.00 hrs, dt=0.05 hrs, 1101 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Runoff Area=12.190 ac 0.00% Impervious Runoff Depth>7.94"
Tc=10.0 min CN=90 Runoff=134.50 cfs 8.068 af

Subcatchment 2S: Proposed Runoff Area=12.390 ac 0.00% Impervious Runoff Depth>8.15"
Tc=10.0 min CN=92 Runoff=138.64 cfs 8.411 af

Subcatchment 5S: Off-Site Runoff Area=0.500 ac 0.00% Impervious Runoff Depth>8.04"
Tc=5.0 min CN=91 Runoff=6.47 cfs 0.335 af

Pond 3P: Existing Detention Peak Elev=1,003.97' Storage=61,626 cf Inflow=134.50 cfs 8.068 af
Primary=73.08 cfs 7.468 af Secondary=42.83 cfs 0.592 af Outflow=115.91 cfs 8.060 af

Pond 4P: Proposed Detention Peak Elev=1,002.75' Storage=119,612 cf Inflow=138.64 cfs 8.411 af
Outflow=55.61 cfs 8.411 af

Total Runoff Area = 25.080 ac Runoff Volume = 16.814 af Average Runoff Depth = 8.04"
100.00% Pervious = 25.080 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Existing

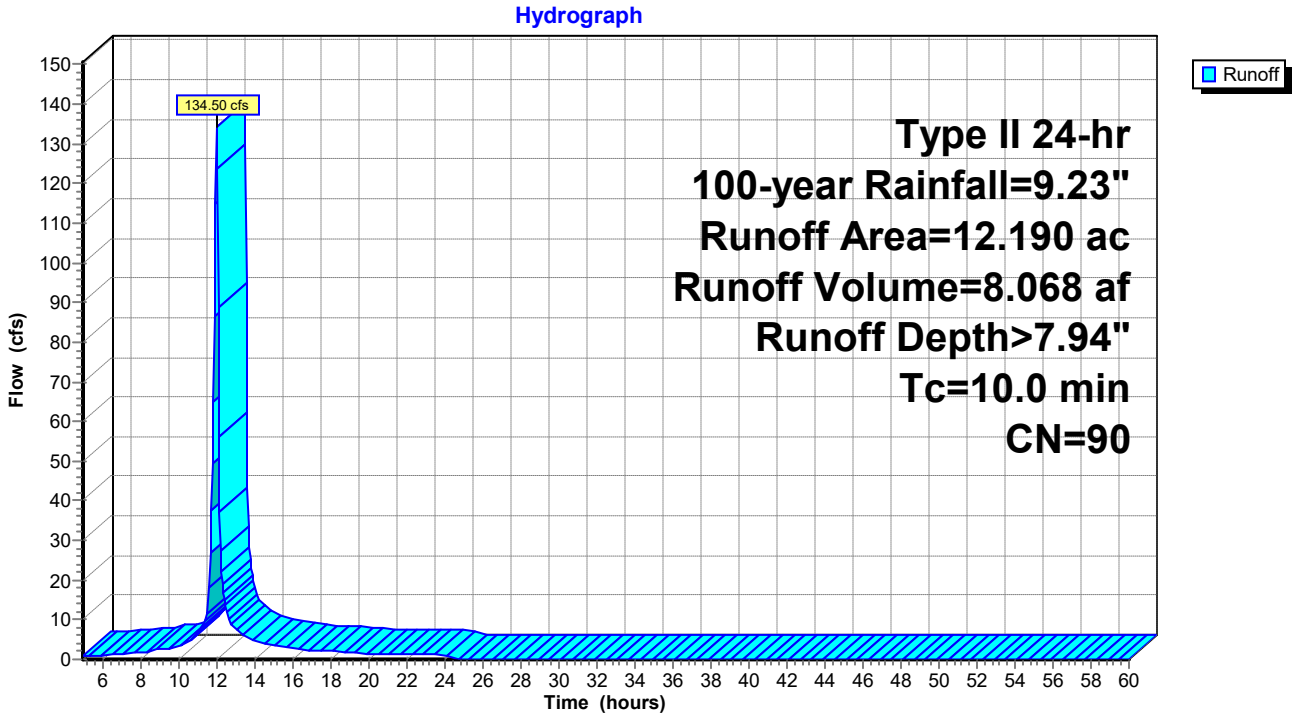
Runoff = 134.50 cfs @ 12.01 hrs, Volume= 8.068 af, Depth> 7.94"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=9.23"

	Area (ac)	CN	Description
*	12.190	90	
	12.190		100.00% Pervious Area

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

Subcatchment 1S: Existing



Summary for Subcatchment 2S: Proposed

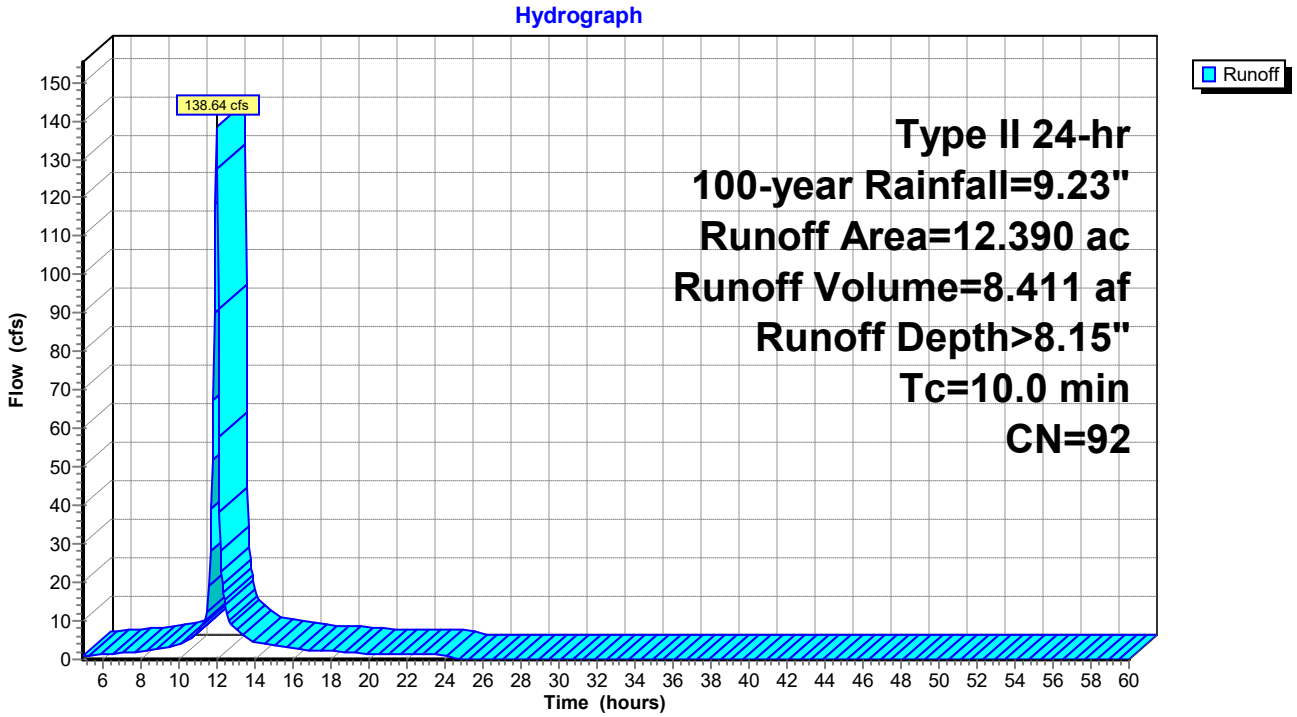
Runoff = 138.64 cfs @ 12.01 hrs, Volume= 8.411 af, Depth> 8.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=9.23"

	Area (ac)	CN	Description
*	12.390	92	
	12.390		100.00% Pervious Area

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

Subcatchment 2S: Proposed



Summary for Subcatchment 5S: Off-Site

[49] Hint: Tc<2dt may require smaller dt

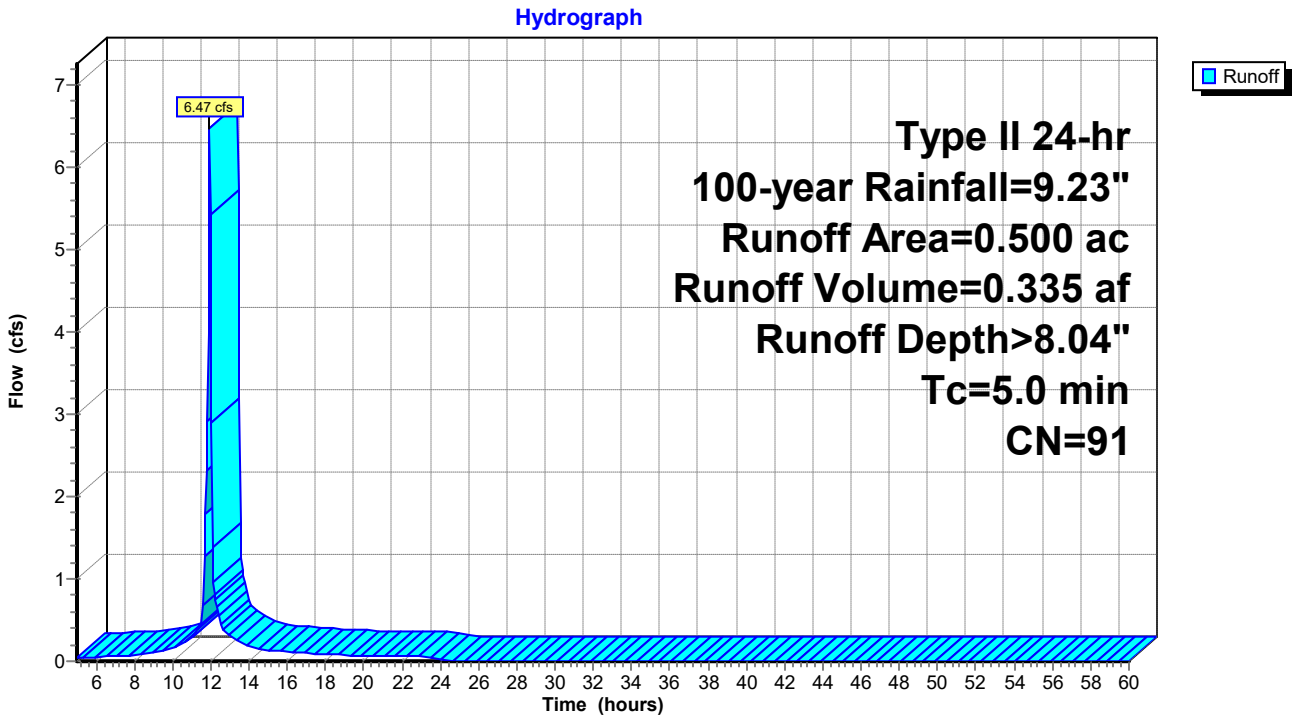
Runoff = 6.47 cfs @ 11.95 hrs, Volume= 0.335 af, Depth> 8.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=9.23"

	Area (ac)	CN	Description
*	0.500	91	
	0.500		100.00% Pervious Area

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

Subcatchment 5S: Off-Site



Summary for Pond 3P: Existing Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.190 ac, 0.00% Impervious, Inflow Depth > 7.94" for 100-year event
Inflow = 134.50 cfs @ 12.01 hrs, Volume= 8.068 af
Outflow = 115.91 cfs @ 12.06 hrs, Volume= 8.060 af, Atten= 14%, Lag= 3.4 min
Primary = 73.08 cfs @ 12.06 hrs, Volume= 7.468 af
Secondary = 42.83 cfs @ 12.06 hrs, Volume= 0.592 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Peak Elev= 1,003.97' @ 12.06 hrs Surf.Area= 22,058 sf Storage= 61,626 cf

Plug-Flow detention time= 46.9 min calculated for 8.059 af (100% of inflow)
Center-of-Mass det. time= 45.4 min (822.5 - 777.1)

Volume	Invert	Avail.Storage	Storage Description
#1	999.00'	88,385 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

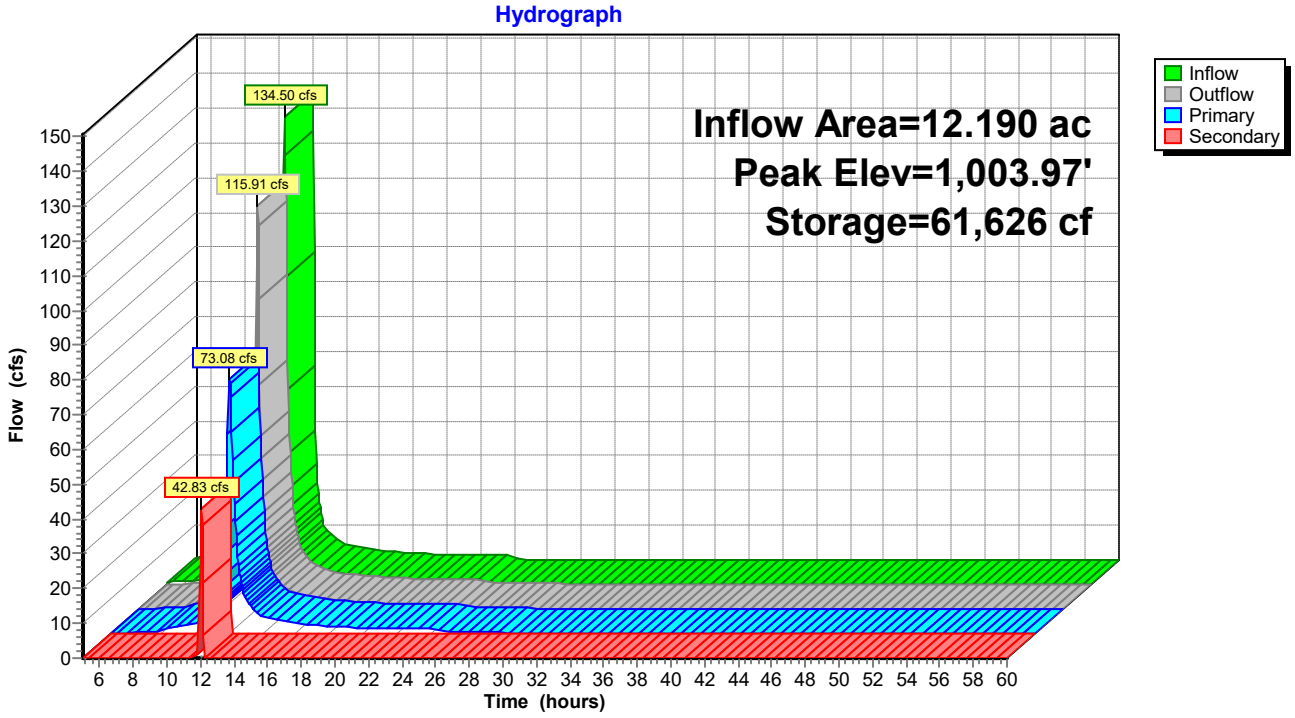
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
999.00	10	0	0
1,000.00	2,580	1,295	1,295
1,001.00	12,035	7,308	8,603
1,002.00	17,125	14,580	23,183
1,003.00	19,500	18,313	41,495
1,004.00	22,140	20,820	62,315
1,005.00	30,000	26,070	88,385

Device	Routing	Invert	Outlet Devices
#1	Primary	999.50'	**30.0" Round CMP_Round 30" X 2.00** L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 999.50' / 999.00' S= 0.0125 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	999.25'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#3	Device 1	999.50'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Device 1	999.75'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#5	Device 1	1,000.00'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#6	Device 1	1,000.25'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#7	Device 1	1,000.50'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#8	Device 1	1,000.75'	**3.0" Vert. Orifice/Grate X 3.00** C= 0.600
#9	Secondary	1,003.20'	**24.0' long x 22.0' 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
#10	Device 1	1,001.00'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height

Primary OutFlow Max=72.73 cfs @ 12.06 hrs HW=1,003.95' (Free Discharge)
└─**1=CMP_Round 30"** (Barrel Controls 72.73 cfs @ 7.41 fps)
  ├─**2=Orifice/Grate** (Passes < 0.17 cfs potential flow)
  ├─**3=Orifice/Grate** (Passes < 0.11 cfs potential flow)
  ├─**4=Orifice/Grate** (Passes < 0.16 cfs potential flow)
  ├─**5=Orifice/Grate** (Passes < 0.10 cfs potential flow)
  ├─**6=Orifice/Grate** (Passes < 0.15 cfs potential flow)
  ├─**7=Orifice/Grate** (Passes < 0.10 cfs potential flow)
  ├─**8=Orifice/Grate** (Passes < 1.24 cfs potential flow)
  └─**10=Sharp-Crested Rectangular Weir** (Passes < 76.70 cfs potential flow)

Secondary OutFlow Max=41.07 cfs @ 12.06 hrs HW=1,003.95' (Free Discharge)
└─**9=Broad-Crested Rectangular Weir** (Weir Controls 41.07 cfs @ 2.29 fps)

Pond 3P: Existing Detention



Summary for Pond 4P: Proposed Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.390 ac, 0.00% Impervious, Inflow Depth > 8.15" for 100-year event
Inflow = 138.64 cfs @ 12.01 hrs, Volume= 8.411 af
Outflow = 55.61 cfs @ 12.16 hrs, Volume= 8.411 af, Atten= 60%, Lag= 9.3 min
Primary = 55.61 cfs @ 12.16 hrs, Volume= 8.411 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Peak Elev= 1,002.75' @ 12.16 hrs Surf.Area= 25,501 sf Storage= 119,612 cf

Plug-Flow detention time= 113.0 min calculated for 8.402 af (100% of inflow)
Center-of-Mass det. time= 113.9 min (886.8 - 773.0)

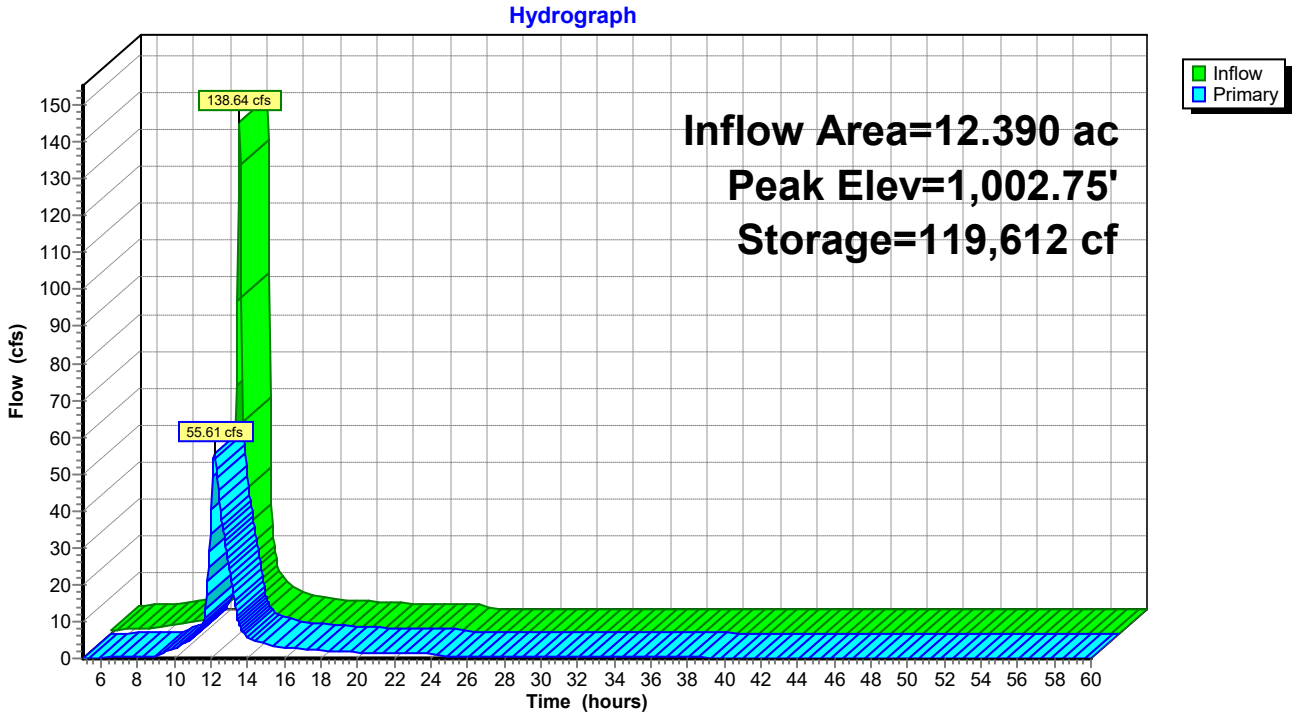
Volume	Invert	Avail.Storage	Storage Description
#1	995.00'	153,448 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
995.00	50	0	0
996.00	8,213	4,132	4,132
997.00	10,000	9,107	13,238
998.00	14,340	12,170	25,408
999.00	16,580	15,460	40,868
1,000.00	18,880	17,730	58,598
1,001.00	21,240	20,060	78,658
1,002.00	23,640	22,440	101,098
1,003.00	26,110	24,875	125,973
1,004.00	28,840	27,475	153,448

Device	Routing	Invert	Outlet Devices
#1	Primary	994.90'	**30.0" Round Culvert** L= 40.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 994.90' / 994.50' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	995.00'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	997.62'	**42.0" W x 15.0" H Vert. Orifice/Grate** C= 0.600
#4	Primary	1,001.10'	**24.0" W x 12.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=55.44 cfs @ 12.16 hrs HW=1,002.74' (Free Discharge)
- **1=Culvert** (Passes 45.26 cfs of 60.66 cfs potential flow)
  - **2=Orifice/Grate** (Orifice Controls 0.65 cfs @ 13.28 fps)
  - **3=Orifice/Grate** (Orifice Controls 44.61 cfs @ 10.20 fps)
- **4=Orifice/Grate** (Orifice Controls 10.18 cfs @ 5.09 fps)

Pond 4P: Proposed Detention



Time span=5.00-60.00 hrs, dt=0.05 hrs, 1101 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Runoff Area=12.190 ac 0.00% Impervious Runoff Depth=0.58"
Tc=10.0 min CN=90 Runoff=10.74 cfs 0.592 af

Subcatchment 2S: Proposed Runoff Area=12.390 ac 0.00% Impervious Runoff Depth=0.69"
Tc=10.0 min CN=92 Runoff=13.00 cfs 0.715 af

Subcatchment 5S: Off-Site Runoff Area=0.500 ac 0.00% Impervious Runoff Depth=0.64"
Tc=5.0 min CN=91 Runoff=0.57 cfs 0.026 af

Pond 3P: Existing Detention Peak Elev=1,001.18' Storage=10,894 cf Inflow=10.74 cfs 0.592 af
Primary=1.88 cfs 0.585 af Secondary=0.00 cfs 0.000 af Outflow=1.88 cfs 0.585 af

Pond 4P: Proposed Detention Peak Elev=997.52' Storage=18,980 cf Inflow=13.00 cfs 0.715 af
Outflow=0.37 cfs 0.715 af

Total Runoff Area = 25.080 ac Runoff Volume = 1.334 af Average Runoff Depth = 0.64"
100.00% Pervious = 25.080 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Existing

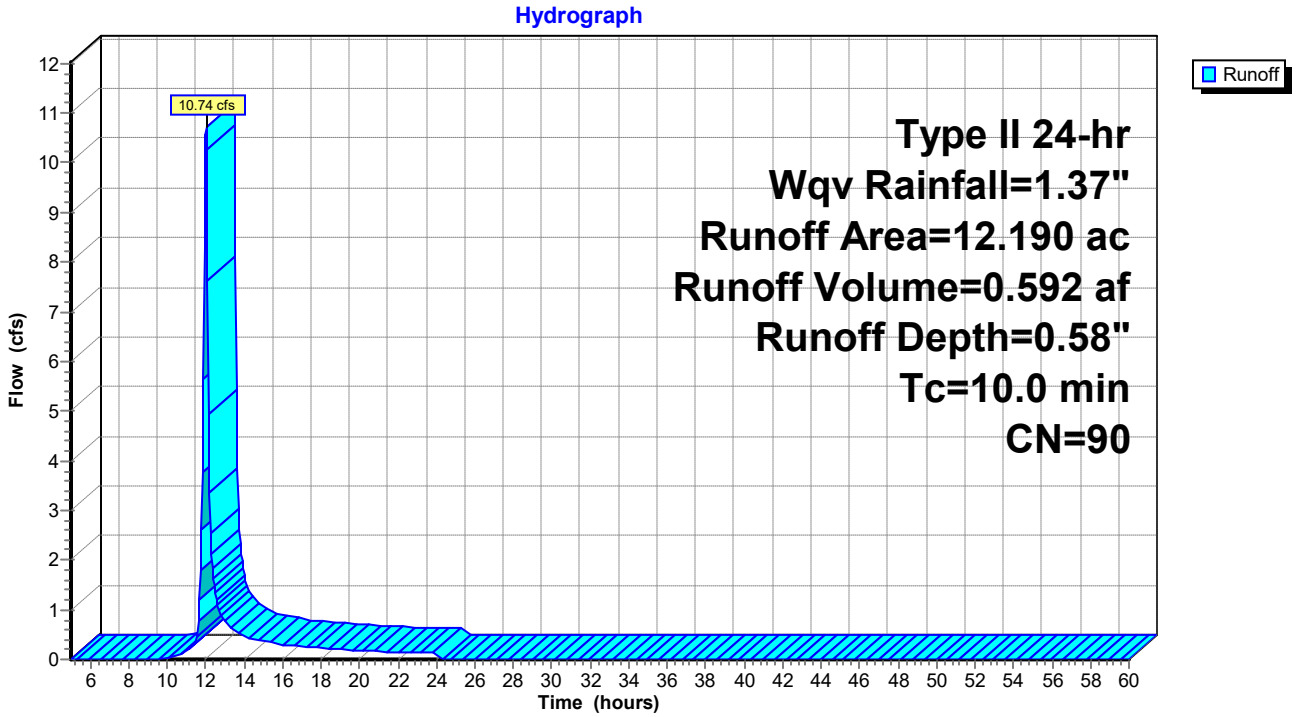
Runoff = 10.74 cfs @ 12.02 hrs, Volume= 0.592 af, Depth= 0.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr Wqv Rainfall=1.37"

	Area (ac)	CN	Description
*	12.190	90	
	12.190		100.00% Pervious Area

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

Subcatchment 1S: Existing



Summary for Subcatchment 2S: Proposed

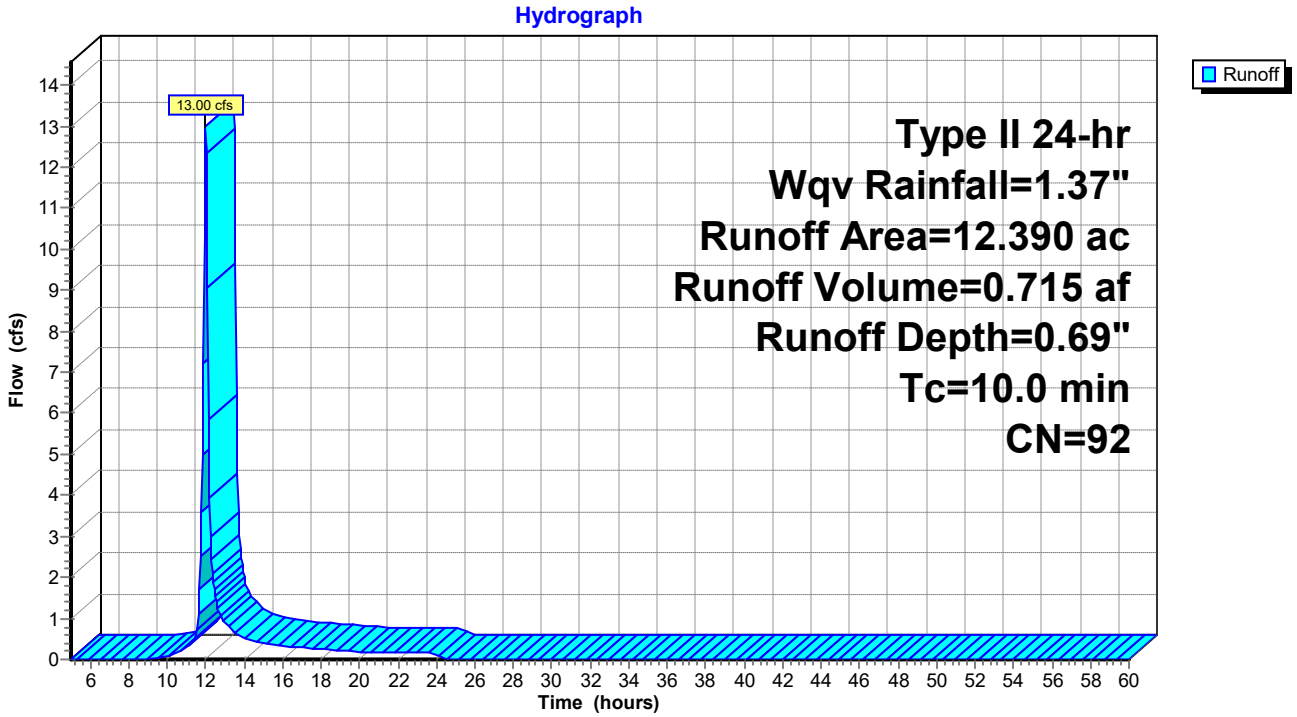
Runoff = 13.00 cfs @ 12.02 hrs, Volume= 0.715 af, Depth= 0.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr Wqv Rainfall=1.37"

	Area (ac)	CN	Description
*	12.390	92	
	12.390		100.00% Pervious Area

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

Subcatchment 2S: Proposed



Summary for Subcatchment 5S: Off-Site

[49] Hint: Tc<2dt may require smaller dt

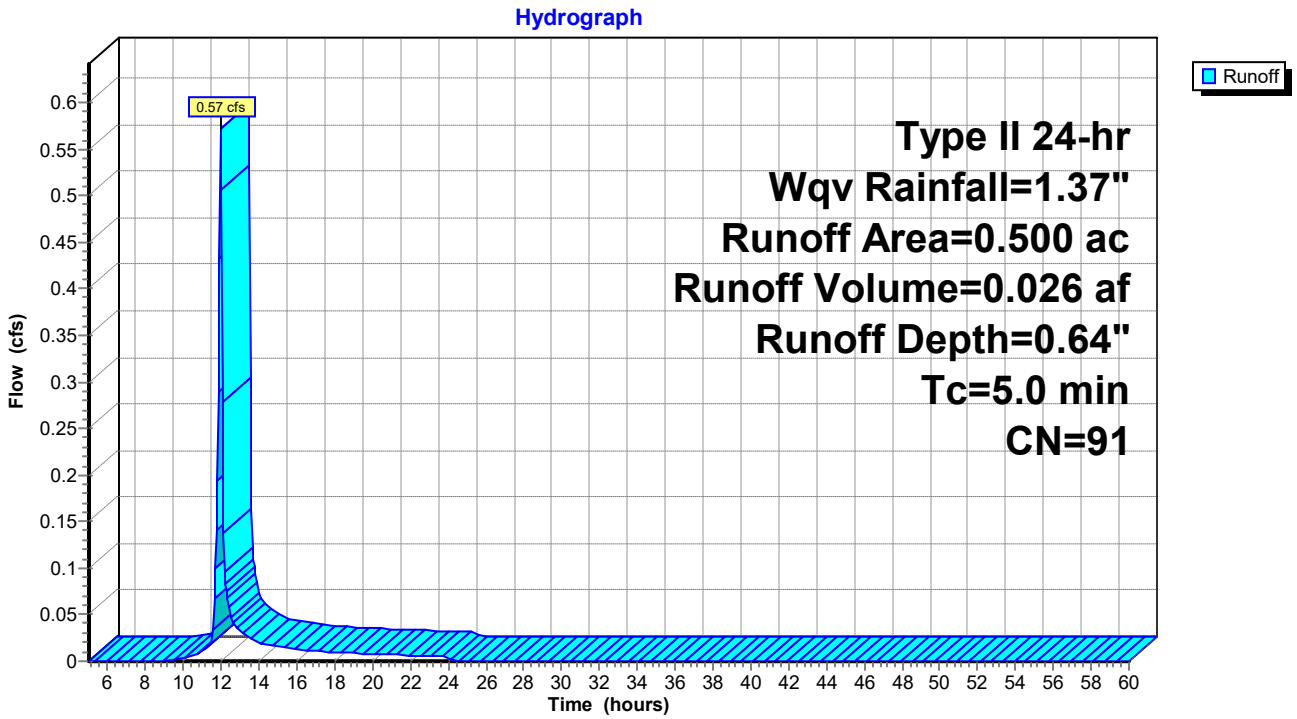
Runoff = 0.57 cfs @ 11.96 hrs, Volume= 0.026 af, Depth= 0.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr Wqv Rainfall=1.37"

	Area (ac)	CN	Description
*	0.500	91	
	0.500		100.00% Pervious Area

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

Subcatchment 5S: Off-Site



Summary for Pond 3P: Existing Detention

Inflow Area = 12.190 ac, 0.00% Impervious, Inflow Depth = 0.58" for Wqv event
Inflow = 10.74 cfs @ 12.02 hrs, Volume= 0.592 af
Outflow = 1.88 cfs @ 12.34 hrs, Volume= 0.585 af, Atten= 83%, Lag= 19.5 min
Primary = 1.88 cfs @ 12.34 hrs, Volume= 0.585 af
Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Peak Elev= 1,001.18' @ 12.34 hrs Surf.Area= 12,968 sf Storage= 10,894 cf

Plug-Flow detention time= 201.2 min calculated for 0.585 af (99% of inflow)
Center-of-Mass det. time= 193.0 min (1,038.2 - 845.1)

Volume	Invert	Avail.Storage	Storage Description
#1	999.00'	88,385 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

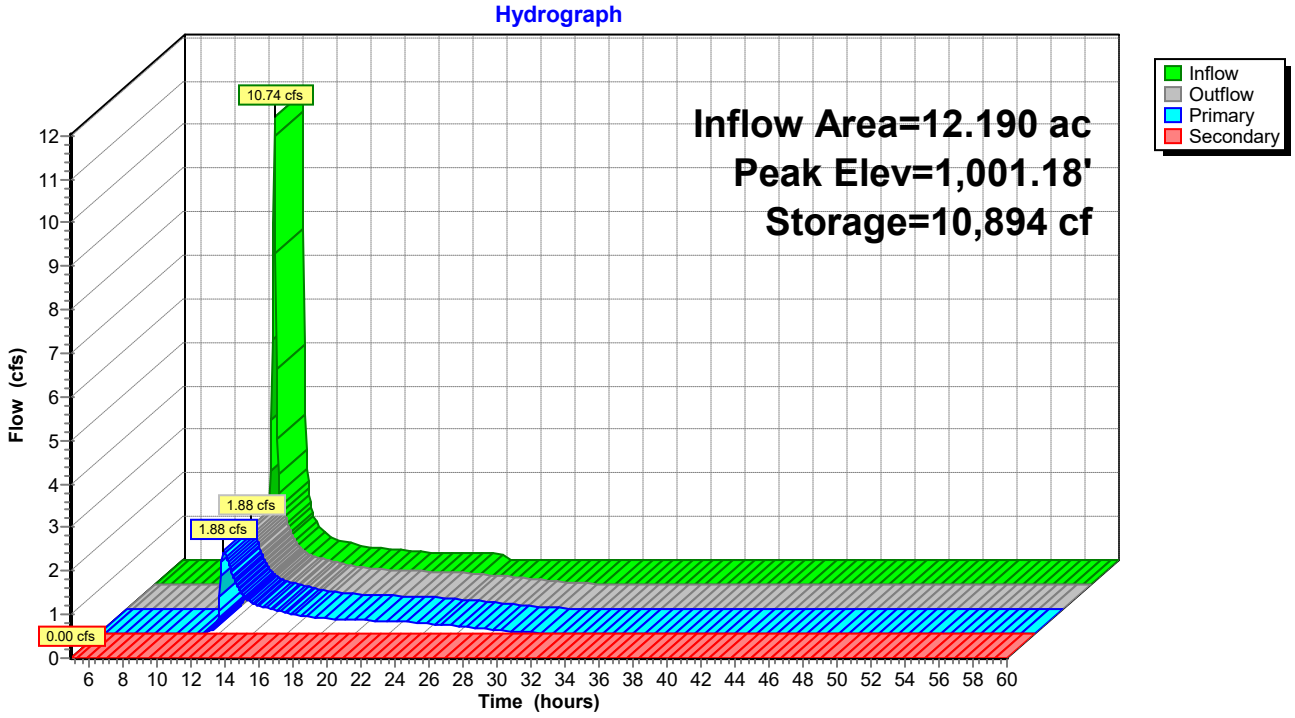
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
999.00	10	0	0
1,000.00	2,580	1,295	1,295
1,001.00	12,035	7,308	8,603
1,002.00	17,125	14,580	23,183
1,003.00	19,500	18,313	41,495
1,004.00	22,140	20,820	62,315
1,005.00	30,000	26,070	88,385

Device	Routing	Invert	Outlet Devices
#1	Primary	999.50'	**30.0" Round CMP_Round 30" X 2.00** L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 999.50' / 999.00' S= 0.0125 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	999.25'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#3	Device 1	999.50'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Device 1	999.75'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#5	Device 1	1,000.00'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#6	Device 1	1,000.25'	**1.0" Vert. Orifice/Grate X 3.00** C= 0.600
#7	Device 1	1,000.50'	**1.0" Vert. Orifice/Grate X 2.00** C= 0.600
#8	Device 1	1,000.75'	**3.0" Vert. Orifice/Grate X 3.00** C= 0.600
#9	Secondary	1,003.20'	**24.0' long x 22.0' 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
#10	Device 1	1,001.00'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height

Primary OutFlow Max=1.87 cfs @ 12.34 hrs HW=1,001.18' (Free Discharge)
└─**1=CMP_Round 30"** (Passes 1.87 cfs of 22.64 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.10 cfs @ 6.25 fps)
  ├─**3=Orifice/Grate** (Orifice Controls 0.07 cfs @ 6.17 fps)
  ├─**4=Orifice/Grate** (Orifice Controls 0.09 cfs @ 5.68 fps)
  ├─**5=Orifice/Grate** (Orifice Controls 0.06 cfs @ 5.14 fps)
  ├─**6=Orifice/Grate** (Orifice Controls 0.07 cfs @ 4.55 fps)
  ├─**7=Orifice/Grate** (Orifice Controls 0.04 cfs @ 3.86 fps)
  ├─**8=Orifice/Grate** (Orifice Controls 0.39 cfs @ 2.67 fps)
  └─**10=Sharp-Crested Rectangular Weir** (Weir Controls 1.04 cfs @ 1.43 fps)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=999.00' (Free Discharge)
└─**9=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 3P: Existing Detention



Summary for Pond 4P: Proposed Detention

Inflow Area = 12.390 ac, 0.00% Impervious, Inflow Depth = 0.69" for Wqv event
Inflow = 13.00 cfs @ 12.02 hrs, Volume= 0.715 af
Outflow = 0.37 cfs @ 15.56 hrs, Volume= 0.715 af, Atten= 97%, Lag= 212.6 min
Primary = 0.37 cfs @ 15.56 hrs, Volume= 0.715 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Peak Elev= 997.52' @ 15.56 hrs Surf.Area= 12,241 sf Storage= 18,980 cf

Plug-Flow detention time= 617.6 min calculated for 0.714 af (100% of inflow)
Center-of-Mass det. time= 618.1 min (1,451.1 - 833.1)

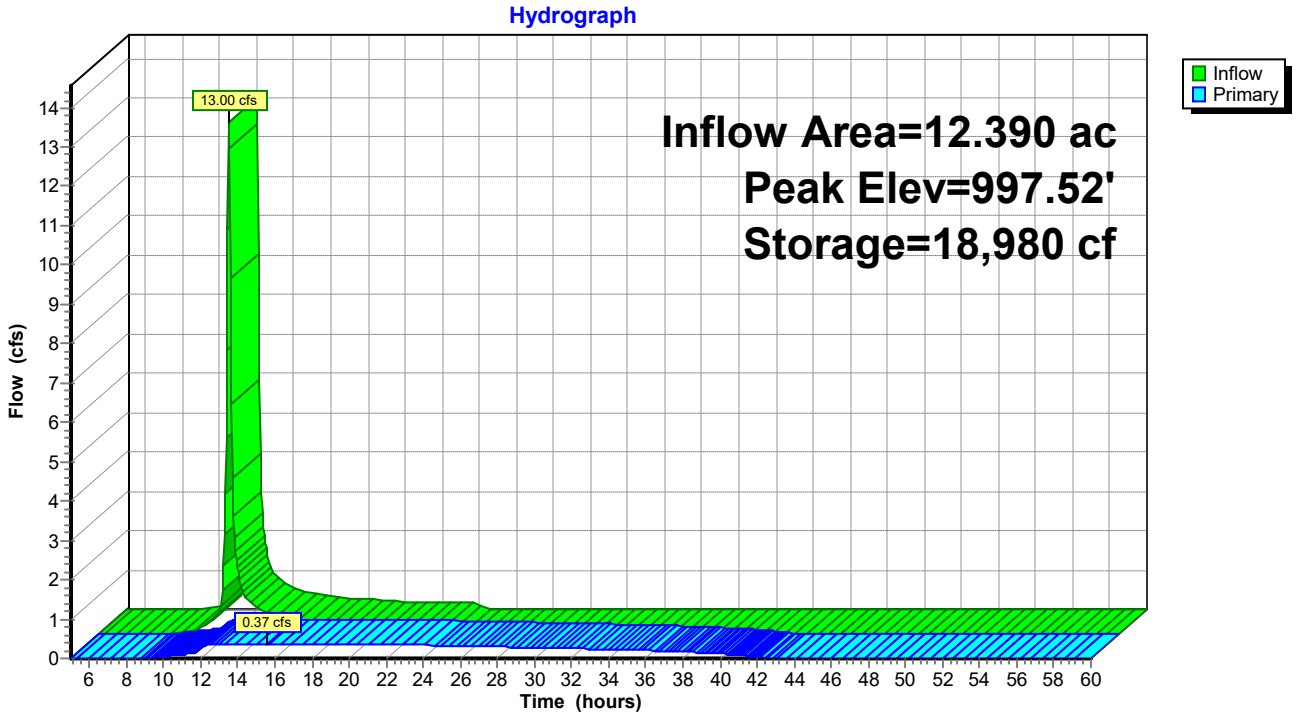
Volume	Invert	Avail.Storage	Storage Description
#1	995.00'	153,448 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
995.00	50	0	0
996.00	8,213	4,132	4,132
997.00	10,000	9,107	13,238
998.00	14,340	12,170	25,408
999.00	16,580	15,460	40,868
1,000.00	18,880	17,730	58,598
1,001.00	21,240	20,060	78,658
1,002.00	23,640	22,440	101,098
1,003.00	26,110	24,875	125,973
1,004.00	28,840	27,475	153,448

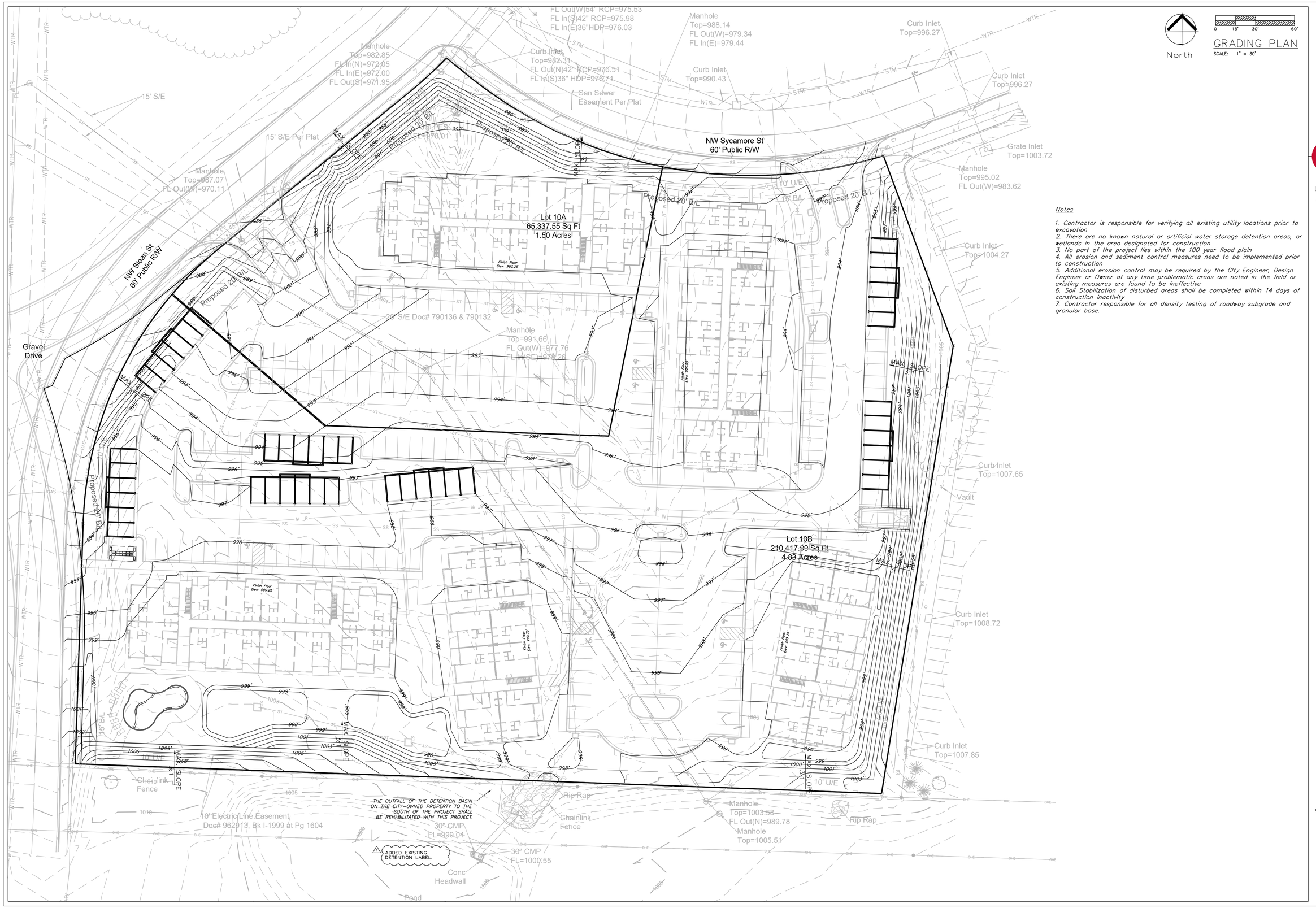
Device	Routing	Invert	Outlet Devices
#1	Primary	994.90'	**30.0" Round Culvert** L= 40.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 994.90' / 994.50' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	995.00'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	997.62'	**42.0" W x 15.0" H Vert. Orifice/Grate** C= 0.600
#4	Primary	1,001.10'	**24.0" W x 12.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.37 cfs @ 15.56 hrs HW=997.52' (Free Discharge)
- **1=Culvert** (Passes 0.37 cfs of 25.79 cfs potential flow)
  - **2=Orifice/Grate** (Orifice Controls 0.37 cfs @ 7.45 fps)
  - **3=Orifice/Grate** (Controls 0.00 cfs)
- **4=Orifice/Grate** (Controls 0.00 cfs)

Pond 4P: Proposed Detention



Appendix A2



Notes

1. Contractor is responsible for verifying all existing utility locations prior to excavation
2. There are no known natural or artificial water storage detention areas, or wetlands in the area designated for construction
3. No part of the project lies within the 100 year flood plain
4. All erosion and sediment control measures need to be implemented prior to construction
5. Additional erosion control may be required by the CIty Engineer, Design Engineer or Owner at any time problematic areas are noted in the field or existing measures are found to be ineffective
6. Soil Stabilization of disturbed areas shall be completed within 14 days of construction inactivity
7. Contractor responsible for all density testing of roadway subgrade and granular base.

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Surveying 2005000319-D
Kansas
Engineering E-1695
Surveying LS-218
Oklahoma
Engineering 6254
Nebraska
Engineering CA2821

Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

Project: DOUGLAS STATION LSMO
Issue Date: August 11, 2023

Grading Plan
Construction Plans for:
Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

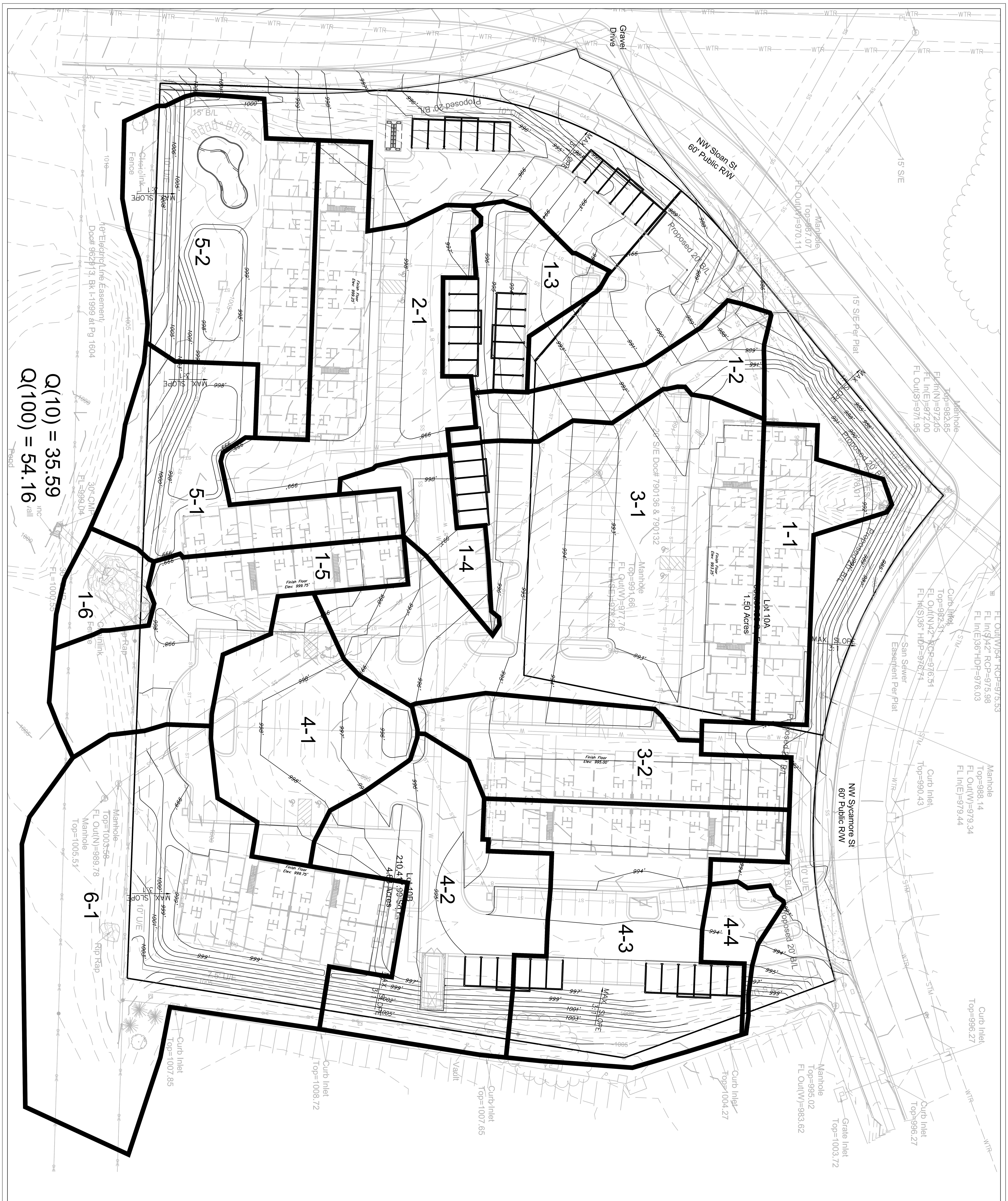
STATE OF MISSOURI
MATTHEW J. SCHLICHT
NUMBER PE-2006019708
PROFESSIONAL ENGINEER

Matthew J. Schlicht
MO PE 2006019708
KS PE 19071
OK PE 25226
NE PE E-14335

REVISIONS

1 REV. 3/7/2024

C.200



APWA STORM DRAINAGE "TC" COMPUTATIONS FOR: DOUGLAS STATION (LSMO)

yellow areas are self computing / overwrite if necessary

Surface types: Asph/ConcBus/Com (SURFACE CODE A, "C" Value 0.90); B (0.87); Dirt (D, 0.60); Grass/Park (G, 0.30); Lake (L, 0.90); MultFam (M, 0.66); SnglFam (S, 0.51); Undev (U, 0.3); Other (Z)

SURFACE CODE: P=Paved, U=Unpaved

AREA ID	TOTAL SQ.FT.	TOTAL ACRES (TOTAL WATERSHED)	WTRSHD LENGTH	UP ELEV	DN ELEV	SURFACE CODE	"C" VALUE (OVERLAND FLOW - 100' MAX; Overwrite Length - DnElev or Slope if necessary)	OVRLND LENGTH	UP ELEV	DN ELEV	SLOPE %	P or U	CHANNEL LENGTH (FLOW - FIRST REACH; Overwrite Slope or Elevations if necessary)	UP ELEV	DN ELEV	SLOPE %	VELOCITY F/S	Cal Overland Flow T(I) (TC COMPUTATION)	Used Min 5 Max 15 T(I)	Cal Channel One T(T)	Cal Channel Two T(T)	Total T© 10	Intensity 10 I	Intensity 100 I	CFS 10 Q	K 1.25 CFS 100 Q	AREA ID
POST																											POST
1-1	8941	0.21	232.00	993.75	989.00	M	0.66	35.0	993.8	993.25	1.4	P	197.0	993.3	989.0	2.16	3.0	4.2	5.0	1.1	0.0	6.1	7.0	9.9	0.95	1.67	1-1
1-2	7710	0.18	205.00	997.25	986.25	M	0.66	100.0	997.3	992.00	5.3	P	105.0	992.0	986.3	5.48	4.8	4.6	5.0	0.4	0.0	5.4	7.2	10.2	0.85	1.49	1-2
1-3	8221	0.19	150.00	997.00	992.00	M	0.66	28.0	997.0	995.00	7.1	P	122.0	995.0	992.0	2.46	3.2	2.2	5.0	0.6	0.0	5.6	7.2	10.1	0.89	1.57	1-3
1-4	4385	0.10	158.00	999.00	996.00	M	0.66	48.0	999.0	998.00	2.1	P	110.0	998.0	996.0	1.82	2.7	4.3	5.0	0.7	0.0	5.7	7.2	10.1	0.48	0.83	1-4
1-5	14772	0.34	121.00	1005.00	998.00	M	0.66	80.0	1005.0	999.00	7.5	P	41.0	999.0	998.0	2.44	3.2	3.6	5.0	0.2	0.0	5.2	7.3	10.2	1.63	2.86	1-5
1-6	3575	0.08	65.00	1026.25	999.00	M	0.66	65.0	1026.3	1025.50	1.2	U	0.0	1025.5	999.0		0.0	6.1	6.1		0.0	6.1	7.0	9.9	0.38	0.67	1-6
2-1	20721	0.48	293.00	999.50	996.00	M	0.66	100.0	999.5	997.50	2.0	P	193.0	997.5	996.0	0.78	1.8	6.3	6.3	1.8	0.0	8.1	6.5	9.2	2.04	3.60	2-1
3-1	44340	1.02	390.00	999.50	990.50	M	0.66	100.0	999.5	995.60	3.9	P	290.0	995.6	990.5	1.76	2.7	5.0	5.0	1.8	0.0	6.8	6.8	9.6	4.59	8.07	3-1
3-2	12979	0.30	164.00	996.00	993.80	M	0.66	100.0	996.0	995.00	1.0	P	64.0	995.0	993.8	1.88	2.8	7.9	7.9	0.4	0.0	8.3	6.5	9.1	1.27	2.24	3-2
4-1	15058	0.35	138.00	999.00	995.00	M	0.66	100.0	999.0	996.25	2.8	P	38.0	996.3	995.0	3.29	3.7	5.7	5.7	0.2	0.0	5.8	7.1	10.0	1.62	2.85	4-1
4-2	20476	0.47	157.00	999.50	993.50	M	0.66	100.0	999.5	995.00	4.5	P	57.0	995.0	993.5	2.63	3.3	4.8	5.0	0.3	0.0	5.3	7.3	10.2	2.25	3.96	4-2
4-3	24522	0.56	165.00	1006.00	993.50	M	0.66	87.0	1006.0	997.00	10.3	P	78.0	997.0	993.5	4.49	4.3	3.4	5.0	0.3	0.0	5.3	7.3	10.2	2.70	4.74	4-3
4-4	2438	0.06	65.00	995.00	993.25	M	0.66	65.0	995.0	993.25	2.7	P	0.0	993.3	993.3		0.0	4.6	5.0		0.0	5.0	7.4	10.3	0.27	0.48	4-4
5-1	14125	0.32	75.00	999.25	997.00	M	0.66	75.0	999.3	997.00	3.0	P	0.0	997.0	997.0		0.0	4.8	5.0		0.0	5.0	7.4	10.3	1.57	2.76	5-1
5-2	21986	0.50	125.00	1000.50	996.50	M	0.66	100.0	1000.5	998.50	2.0	P	25.0	998.5	996.5	8.00	5.7	6.3	6.3	0.1	0.0	6.4	7.0	9.8	2.32	4.08	5-2
6-1	41482	0.95	233.00	1009.00	998.00	M	0.66	100.0	1009.0	1003.50	5.5	U	133.0	1003.5	998.0	4.14	3.3	4.5	5.0	0.7	0.0	5.7	7.1	10.0	4.49	7.89	6-1

C.202

REV. 3/7/2024

REVISIONS

Matthew J. Schlicht
MO PE 2006019708
KS PE 19071
OK PE 25226
NE PE E-14335

Drainage Map
Construction Plans for:
Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

Project: DOUGLAS STATION LSMO

Issue Date: August 11, 2023

Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

Professional Registration
Missouri
Engineering 2005002186-D
Surveying 2005008319-D
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Engineering E-1695
Surveying LS-218
Oklahoma
Engineering 6254
Nebraska
Engineering CA2821

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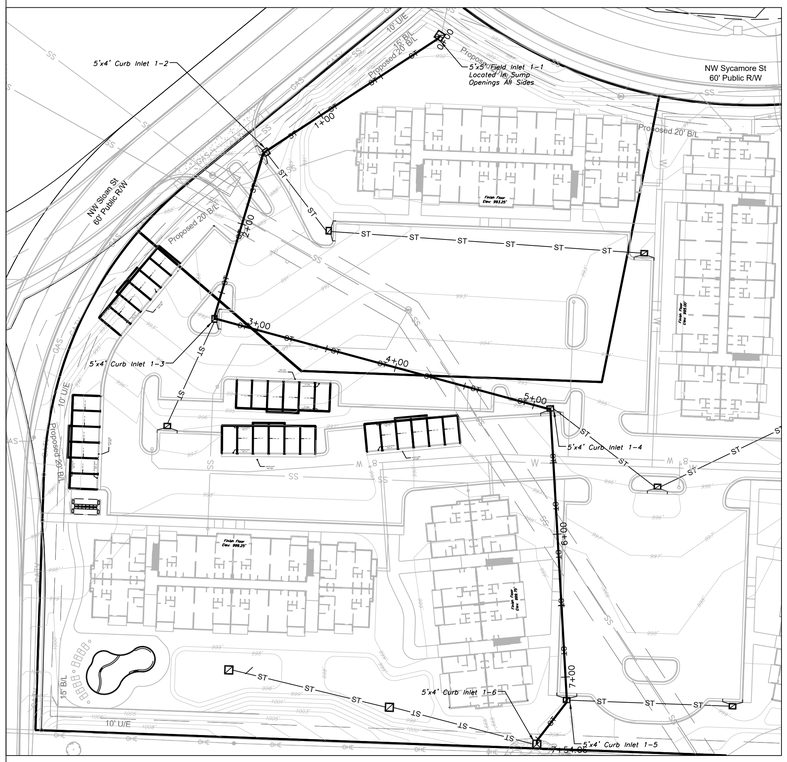
STORM SEWER PLAN AND PROFILE

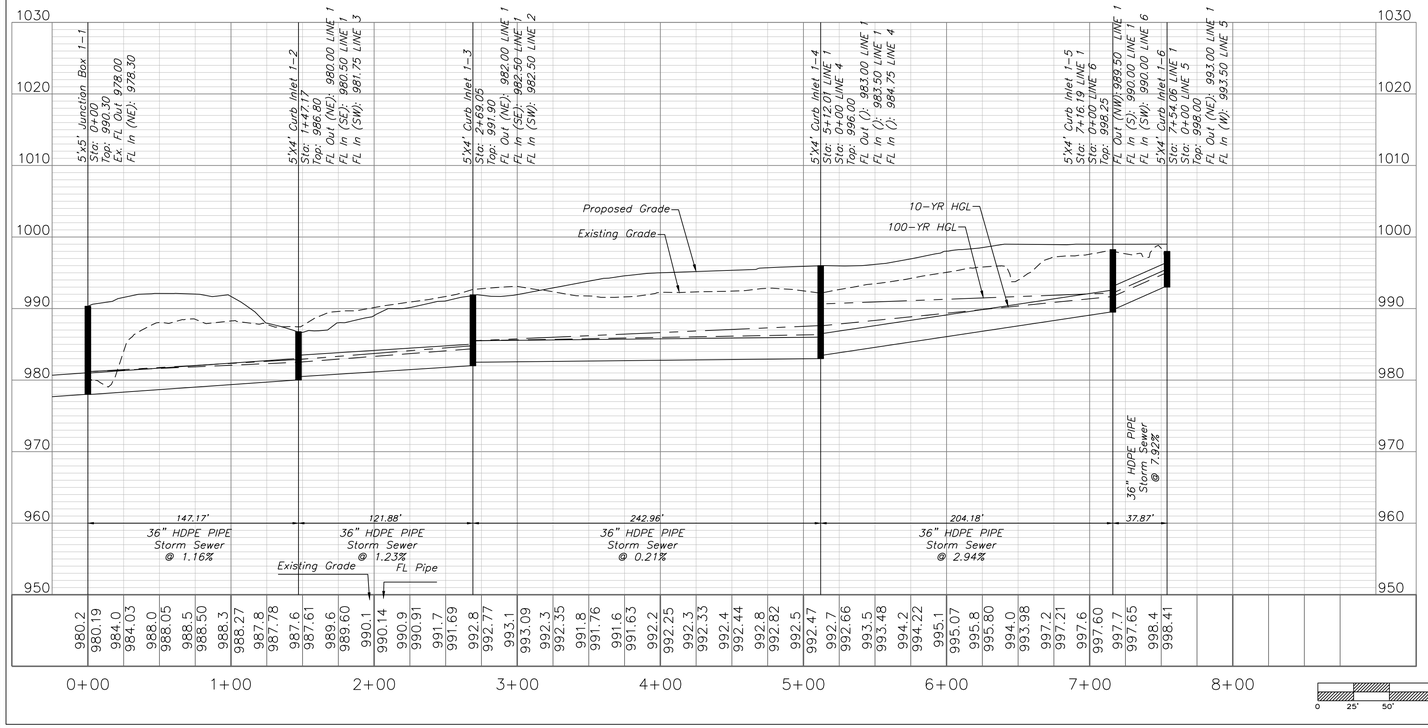
SCALE: 1" = 50'

0 25' 50' 100'

North



STORM LINE 1



STORM SEWER PLAN AND PROFILE

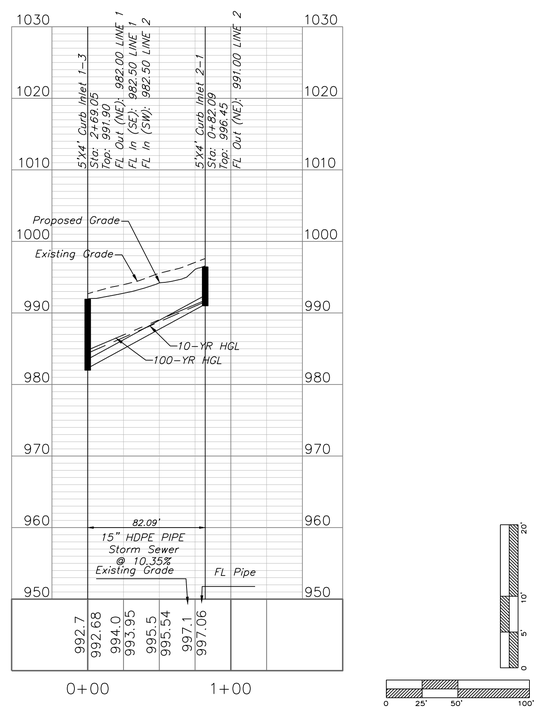
SCALE: 1" = 50'

0 25' 50' 100'

North

REVISED SCALE.

STORM LINE 2



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Surveying 2005000319-D
Kansas
Engineering E-1695
Surveying LS-218
Oklahoma
Engineering 6254
Nebraska
Engineering CA2821

Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

Project: DOUGLAS STATION LSMO

Issue Date: August 11, 2023

Storm Sewer Plan and Profile
Construction Plans for:
Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

STATE OF MISSOURI
MATTHEW J. SCHLICHT
NUMBER PE-2006019708
PROFESSIONAL ENGINEER

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NE PE E-14335

REVISIONS

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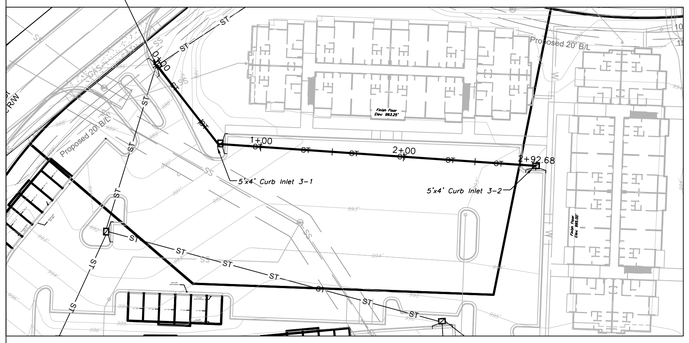
STORM SEWER PLAN AND PROFILE

SCALE: 1" = 50'

0 25' 50' 100'

North

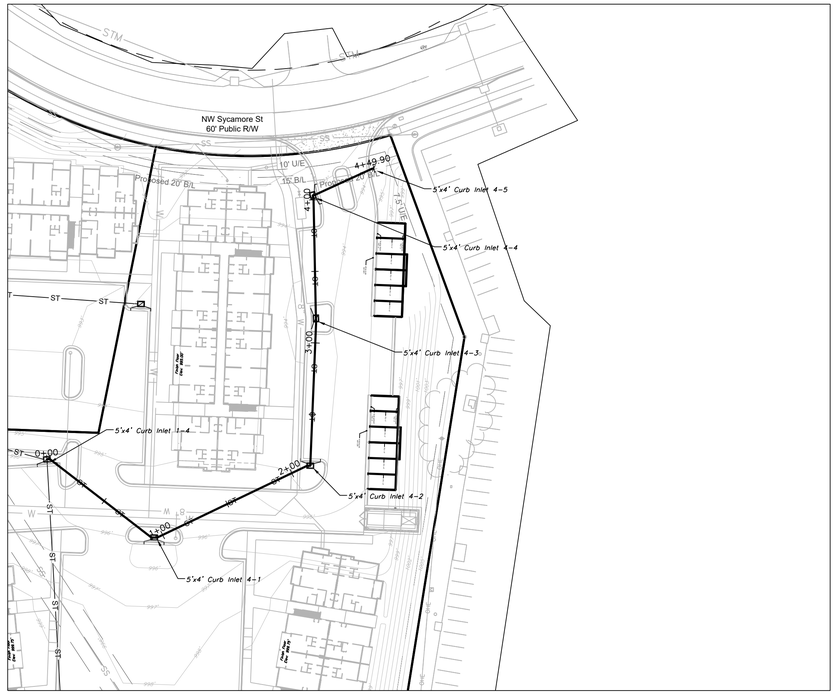


STORM SEWER PLAN AND PROFILE

SCALE: 1" = 50'

0 25' 50' 100'

North



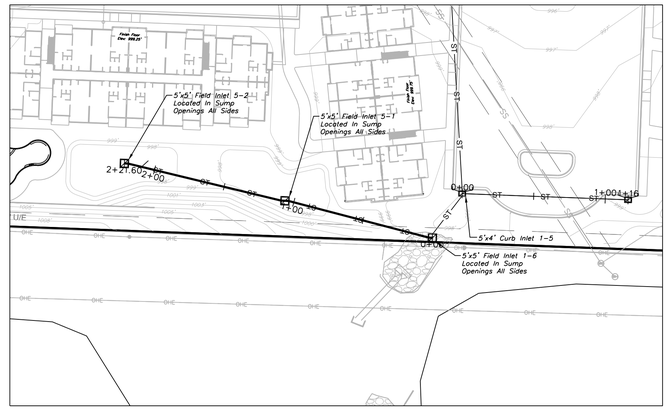
STORM SEWER PLAN AND PROFILE

SCALE: 1" = 50'

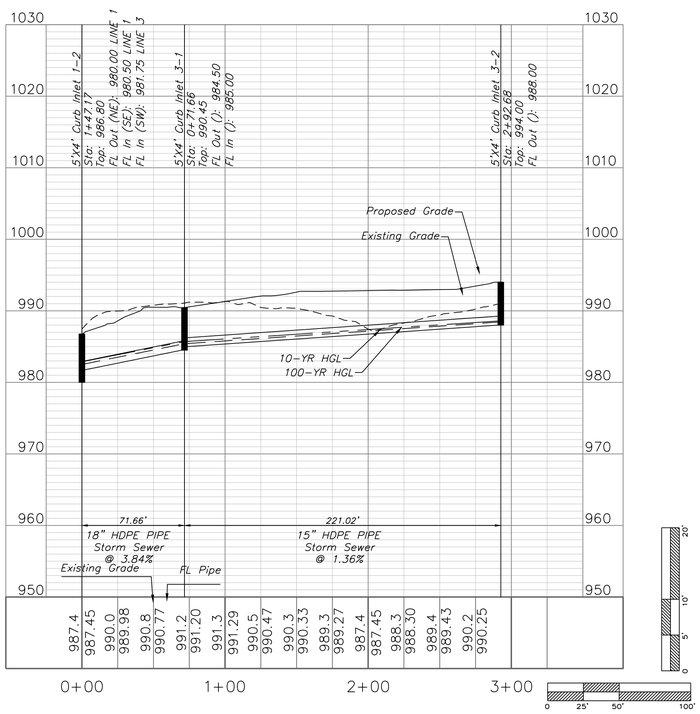
0 25' 50' 100'

North

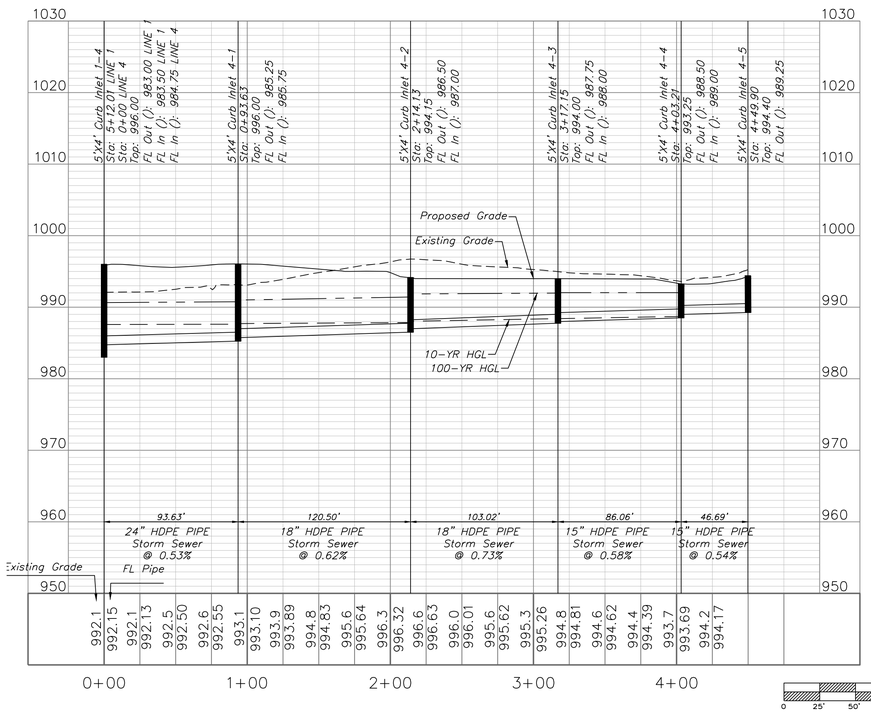
REVISED SCALE.



STORM LINE 3



STORM LINE 4



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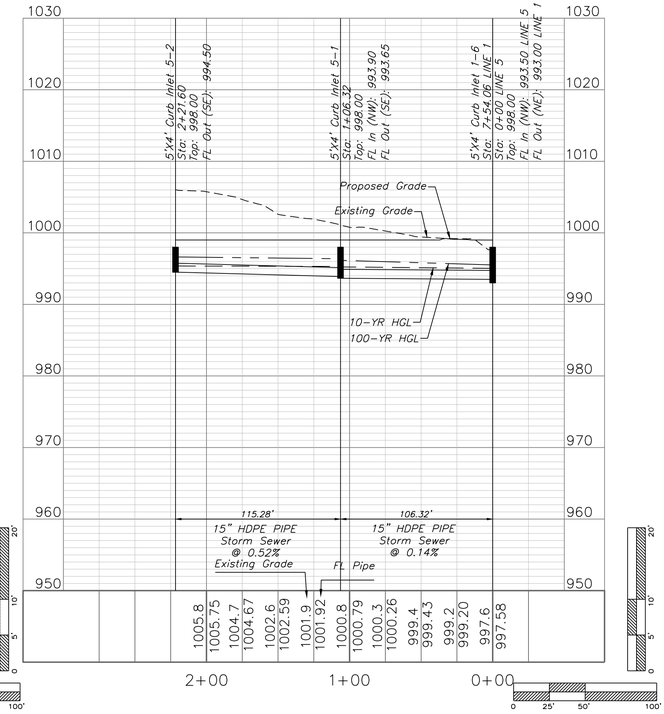

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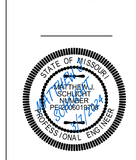
Surveying 2005008319-D
Kansas
Engineering E-1695
Surveying LS-218
Oklahoma
Engineering 6254
Nebraska
Engineering CA2821

Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

Project: DOUGLAS STATION LSMO

Issue Date: August 11, 2023

Storm Sewer Plan and Profile
Construction Plans for:
Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri



Matthew J. Schlicht
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KS PE 19071
OK PE 25226
NE PE E-14335

REVISIONS

⚠ REV. 3/7/2024

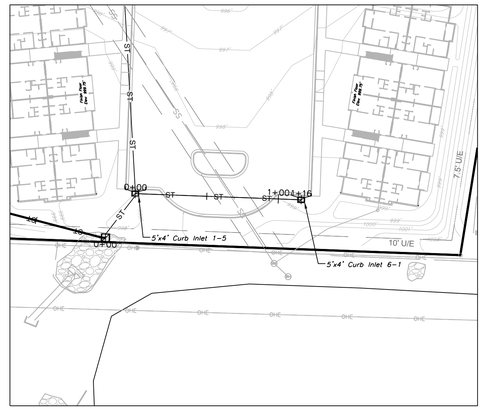
STORM SEWER PLAN AND PROFILE

SCALE: 1" = 50'

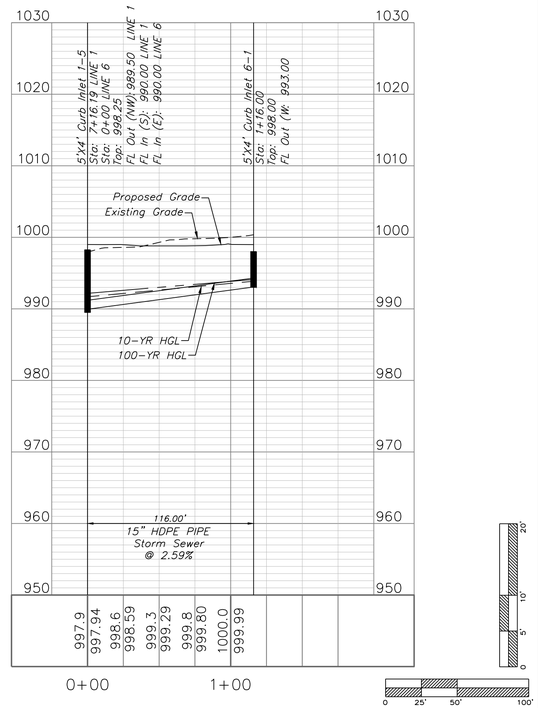
0 25' 50' 100'

1 REVISED SCALE.

North



STORM LINE 6



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STATE OF MISSOURI
MATTHEW J. SCHLICHT
NUMBER PE-2006019708
PROFESSIONAL ENGINEER

Matthew J. Schlicht
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KS PE 19071
OK PE 25226
NE PE E-14335

REVISIONS

1 REV. 3/7/2024

Channel Report

Appendix A3

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Sep 11 2024

Overflow Spillway

Trapezoidal

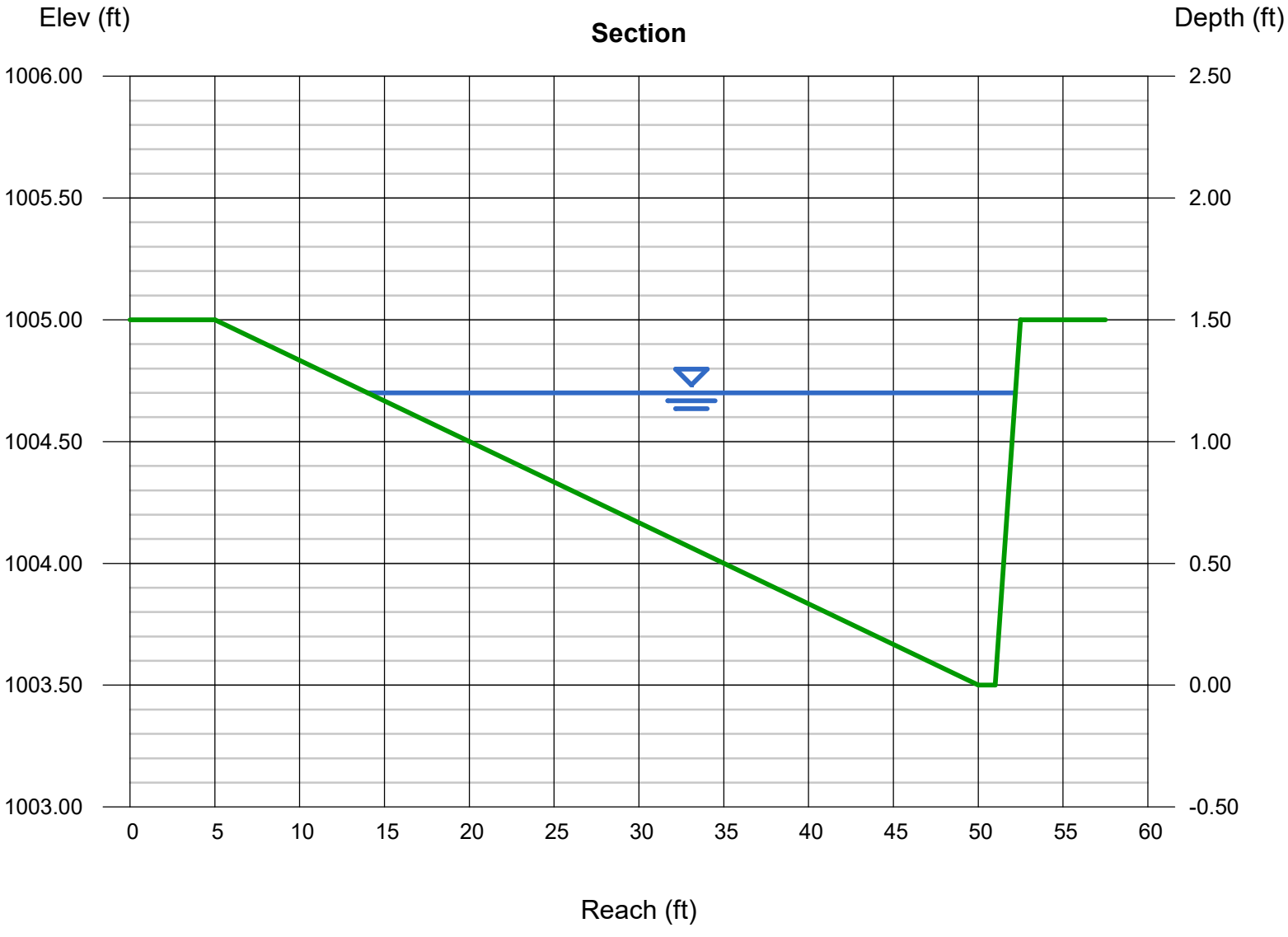
Bottom Width (ft)	= 1.00
Side Slopes (z:1)	= 30.00, 1.00
Total Depth (ft)	= 1.50
Invert Elev (ft)	= 1003.50
Slope (%)	= 1.00
N-Value	= 0.015

Calculations

Compute by:	Q vs Depth
No. Increments	= 10

Highlighted

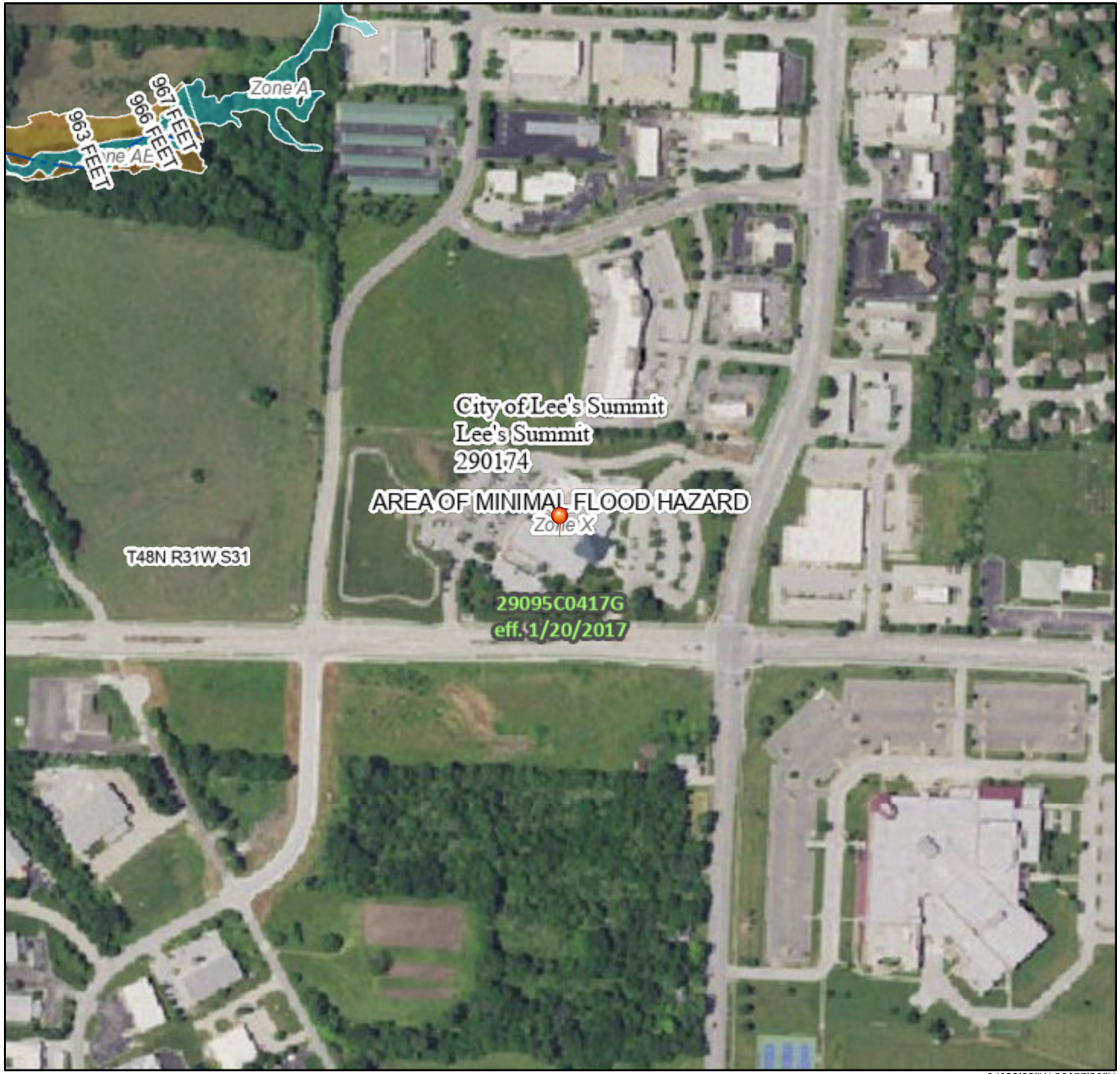
Depth (ft)	= 1.20
Q (cfs)	= 167.10
Area (sqft)	= 23.52
Velocity (ft/s)	= 7.10
Wetted Perim (ft)	= 38.72
Crit Depth, Yc (ft)	= 1.46
Top Width (ft)	= 38.20
EGL (ft)	= 1.98



National Flood Hazard Layer FIRMette

FEMA

94°23'11"W 38°56'7"N



94°22'33"W 38°55'39"N

Feet

0 250 500 1,000 1,500 2,000

1:6,000

Basemap Imagery Source: USGS National Map 2023

Appendix A4

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN — Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 — Cross Sections with 1% Annual Chance
- 17.5 — Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

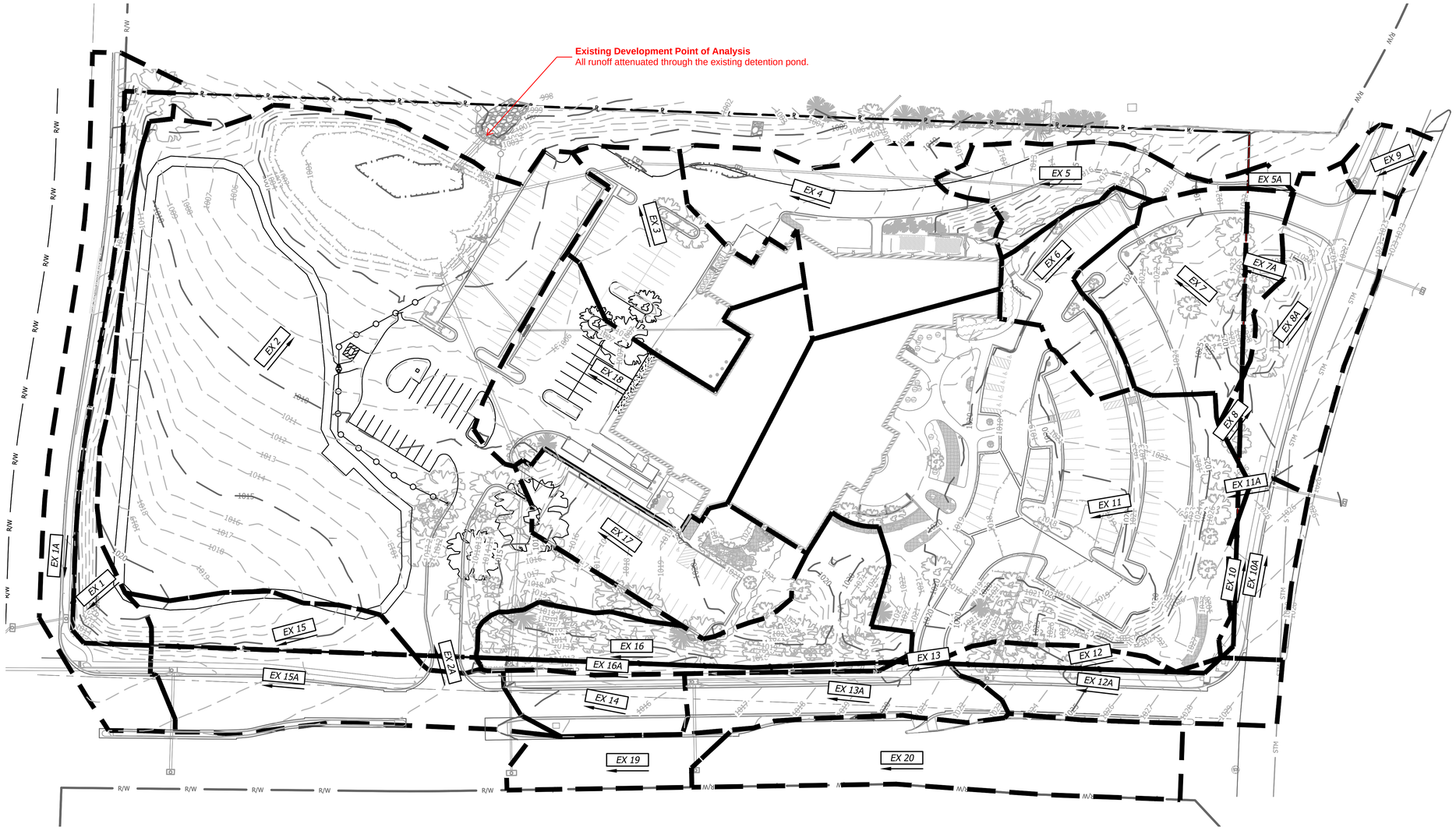
N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 8/27/2024 at 1:29 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.



DRAINAGE LEGEND

- DRAINAGE AREA BOUNDARY
- Field — AREA/DIRECTION OF DRAINAGE BOUNDARY
- 980 — EXISTING GRADE MAJOR CONTOUR
- 982 — EXISTING GRADE MINOR CONTOUR
- ℄ — PROPERTY LINE
- R/W — RIGHT-OF-WAY LINE

N

GRAPHIC SCALE
50 0 50

EXISTING DRAINAGE MAP

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2 NE TUDOR RD
LEE'S SUMMIT, MISSOURI 64086

PRELIMINARY DEVELOPMENT PLAN

REVISION DATES:
REV 1: 2024-08-27

INTERIM REVIEW ONLY
(Document Incomplete)
Not to be used for regulatory approval, permit, or construction.

Architect Of Record:
Hoefer Welker

PROFESSIONAL SEAL

C5.0

ISSUE DATE: JULY 25, 2024
HOEFER WELKER #: 138191

Propesed Development Point of Analysis
All runoff attenuated through the proposed detention pond.

PROP 1A
PROP 1
PROP 2
PROP 3
PROP 4
PROP 5
PROP 5B
PROP 6
PROP 7
PROP 7A
PROP 8
PROP 8A
PROP 9
PROP 10
PROP 10A
PROP 11
PROP 12
PROP 13
PROP 13A
PROP 14
PROP 15
PROP 16
PROP 16A
PROP 17
PROP 18
PROP 18A
PROP 19
PROP 19A
PROP 20
PROP 21
PROP 21A
PROP 22
PROP 22A
PROP 23
PROP 23A
PROP 24
PROP 24A
PROP 25
PROP 26

DRAINAGE LEGEND

- DRAINAGE AREA BOUNDARY
- Field — AREA/DIRECTION OF DRAINAGE BOUNDARY
- 980 — PROPOSED FINISH GRADE MAJOR CONTOUR
- 982 — PROPOSED FINISH GRADE MINOR CONTOUR
- 980 — EXISTING GRADE MAJOR CONTOUR
- 982 — EXISTING GRADE MINOR CONTOUR
- STM — PROPOSED STORM SEWER LINE
- RD — PROPOSED ROOF LINE DRAIN
- PL — PROPERTY LINE
- R/W — RIGHT-OF-WAY LINE

N

GRAPHIC SCALE
50 0 50

PROPOSED DRAINAGE MAP

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