Micro Storm Water Drainage Study

Burton Townhomes Lee's Summit

Southwest Corner of NW Olive St and NW Orchard Dr
City of Lee's Summit, Jackson County, Missouri

Created On:

January 18, 2019

Prepared by:

Renaissance Infrastructure Consulting

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GENERAL INFORMATION

A. Project Location

The proposed Burton Townhomes development is in the City of Lee's Summit, Jackson County, MO. The project is located on the southwest corner of NW Olive St and NW Orchard Dr and is 3.52 acres in size. The proposed location is currently 3 lots zoned for single family residential or vacant residential land that are planned to be re-zoned Planned Residential Mixed-Use RP-3. The entire site is located within the Cedar Creek Watershed. Table 1 lists the parcel information for each of the 3 proposed lots and all adjacent properties.

Table 1: Existing Lot Information

Parcel Description	Address	Parcel ID	Land Use Type
Proposed Parcel Information			
NW Corner of Proposed Lot	500 NW Olive St	61-320-01-06-00-0-00-000	1101 – Vacant Residential Land
SE Corner of Proposed Lot	408 NW Olive St	61-310-06-01-00-0-00-000	1110 – Single Family Residence
SW Corner of Proposed Lot	No Address Assigned by City Lee's Summit, MO	61-320-07-01-00-0-00-000	1101-Vacant Residential Land
Adjacent Parcel Information			
N of Proposed Lot	221 NW Chipman Rd	61-320-01-02-00-0-00-000	3216 – Wholesale Trade
NE of Proposed Lot	504 NW Olive St	61-310-05-11-00-0-00-000	1110 – Single Family Residence
NE of Proposed Lot	502 NW Olive St	61-310-05-12-00-0-00-000	1110 – Single Family Residence
SE of Proposed Lot	406 NW Olive St	61-310-06-02-00-0-00-000	1110 – Single Family Residence
S of Proposed Lot	404 NW Olive St	61-310-06-03-00-0-00-000	1110 – Single Family Residence

Activities include the construction of a proposed townhome development and associated infrastructure. The proposed site will not impact downstream infrastructure because none exists. See Exhibit A for a site location map.

B. Federal Emergency Management Agency (FEMA) Classification

According to the Flood Insurance Rate Map (FIRM) panel number 29095C0417G, dated January 20, 2017, the property lies within Zone "X" (future base flood) as defined as areas having a one percent annual chance flood based on future conditions hydrology. See Exhibit B for a site location FEMA FIRM map.

C. Soil Classification

Soil classifications published by the United States Department of Agriculture/Natural Resources Conservation Service (USDA/NRCS) website for Jackson County, MO on October 16, 2018 indicate the existing site is made up of three soil types:

10082 Arisburg-Urban Land Complex, 1 to 5 percent slopes
Hydraulic Soil Group (HSG) Type C

10128 Sharpsburg-Urban Land Complex, 2 to 5 percent slopes
Hydraulic Soils Group (HSG) Type D

7462 Udarents -Urban Land - Sampsel, 5 to 9 percent slopes
Hydraulic Soils Group (HSG) Type C

See Exhibit C for a detailed soil report.

D. Drainage Patterns

Two existing sub basins were identified at the project location. ExNW was identified as the northern drainage area with a discharge point at the northwest corner of the sub basin. The second existing sub basin was identified as ExSE with a discharge point at the southeast corner of the sub basin. No offsite drainage areas were identified at the project location. See Exhibit D for an existing drainage map.

METHODOLOGY

This study was prepared in accordance with the provisions of "Section 5600 – Storm Drainage Systems and Facilities" (February 15, 2006) of the Kansas City Metropolitan Chapter of the American Public Works Association as adopted and modified (City of Lee's Summit Section 5600, August 8, 2011) for use in storm facilities design by the City of Lee's Summit, MO. Pre and post development runoff were determined using the curve number method described in SCS (now NRCS) Technical Release No. 55 "Urban Hydrology for Small Watersheds" (2nd Edition, June 1986) as provided for in APWA Sub-section 5602.2. Storm water management controls included in the post development TR55 analyses were designed to reduce peak discharges to or below pre-development values as stipulated in Sub-section 5601.5. The analyses were performed using the Type II 24-hour storm distribution for 50%, 10% and 1% annual probability storm events. The rainfall depths used in the analyses corresponding to those events are shown in Table 2.

Table 2: Storm Analysis Table

Storm	Percent	Rainfall Depth (in)
2 Year	50%	3.50
10 Year	10%	5.30
100 Year	1%	7.70

EXISTING CONDITIONS ANALYSIS

Existing site drainage patterns are shown in Exhibit D – Existing Drainage Map. Exhibit D shows two drainage areas that were analyzed for existing conditions. The total drainage area of the existing site is 3.52 acres and contains no offsite drainages.

The curve numbers used in the TR55 existing condition analysis are 74.0 (ExNW, >75% grass cover, good) and 83.0 (ExSE, ¼ acre lots, 38% impervious).

The existing drainage map (Exhibit D) identifies each sub basin discharge point and related area shown in Table 3 below. The existing conditions model results have been provided in Exhibit E. The time of concentration determined for each sub basin is shown in Table 4. The sub basin discharge for the three storm events investigated are shown in Table 5 and summarized in Table 6.

Comprehensive control was used in accordance with APWA 5608.4 to determine maximum release rates for each post development sub basin. This allows for a maximum discharge (cfs/acre) for 2-yr, 10-yr, and 100-yr storm events. There are no off-site contributors to the drainage area present in the existing condition drainage area. The sub basin allowable release rates for the three storm events investigated are shown in Table 7.

Table 3. Existing Discharge Points

Outfall	Direction
ExNW	Flow travels across the lot from east (NW Olive St) to west (Railroad ROW). Runoff that it discharged across the western property line is conveyed to the NW corner parallel to the railroad.
ExSW	Flow travels across the lot from north to south parallel to NW Olive St. Runoff is discharge in the SE corner of the sub basin.

Table 4. Existing Time of Concentration Calculations

Sub Basin	Overland Flow	Shallow Concentrated Flow	Channel Flow	Tc (Min.)
ExNW	Length=100 ft Slope=3.0% N Value=0.30	Length= 380 ft Slope= 2.6% Short Grass Pasture	Length= n/a Slope= n/a Cross Section Area= n/a Wetted Perimeter= n/a	19.47
ExSE	Length=100 ft Slope=3.0% N Value=0.30	Length=150 ft Slope=3.70% Short Grass Pasture	Length= n/a Slope= n/a Cross Section Area= n/a Wetted Perimeter= n/a	15.72

Table 5: Existing Site Hydrology and Flows

Sub Basin	Discharge Point	Outfall	Outfall Type	Area (Ac.)	T_c (min)	CN Value	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ExNW	A	NW	Low Point	2.61	19.47	74.00	3.51	7.58	13.56
ExSE	B	SE	Low Point	0.91	15.72	83.00	2.05	3.76	6.09

Table 6: Total Outflow Summary

Sub Basin	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ExNW	3.51	7.58	13.56
ExSE	2.05	3.76	6.09

Table 7: Allowable Release Rates per Existing Discharge Point

Sub Basin	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ExNW	1.31	5.22	7.83
ExSE	0.46	1.82	2.73

PROPOSED CONDITIONS ANALYSIS

The overall drainage pattern for the proposed condition has been updated to three sub basins with three separate discharge points. See Exhibit F for a proposed drainage map. The development will not add any area to the existing 3.52 acres, but the area of each sub basin has changed.

The curve number used for the proposed site was 90.0 (1/8 acre lots, 65% impervious) HSG C was assumed for the curve number calculations.

The proposed drainage map (Exhibit F) identifies the sub basin discharge points and related area shown in Table 8 below. The proposed conditions model results have been provided in Exhibit G. The time of concentration assumptions for each sub basin are shown in Table 9. The sub basin discharge for the three storm events investigated are shown in Table 10 and summarized in Table 11. The sub basin allowable release rates for the three storm events investigated are shown in Table 12.

Table 8. Proposed Discharge Points

Outfall	Direction
Northwest (ProNW)	Runoff is conveyed NW across the ProNW sub basin to a discharge point in the NW corner of the proposed lot.
Southeast (ProSE)	Runoff is conveyed SE across the ProSE sub basin to existing roadway ditch and discharge point in the SE corner of the proposed lot.
South (ProS)	Runoff is conveyed SW across the ProS sub basin to a discharge point in the NW corner of the ProS sub basin.

Table 9. Proposed Time of Concentration Calculations

Sub Basin	Overland Flow	Shallow Concentrated Flow	Channel Flow	Tc (Min.)
ProNW	Length= 40 ft Slope= 1.0% N Value= 0.30	Length= 175 ft Slope= 2.5% Paved	Length= 117 Slope= 1.0% Cross Section Area= 1.77 ft_2 Wetted Perimeter= 9.42 ft	11.55
ProSE	Length= 70 ft Slope= 1.0% N Value= 0.015	Length= 120 ft Slope= 2.0% Short Grass	Length= n/a Slope= n/a Cross Section Area= n/a Wetted Perimeter= n/a	9.84
ProS	Length= 40 ft Slope= 1.0% N Value= 0.30	Length= 200 ft Slope= 1.0% Paved	Length= n/a Slope= n/a Cross Section Area= n/a Wetted Perimeter= n/a	11.98

Table 10: Proposed Site Hydrology and Flows

Sub Basin	Discharge Point	Outfall Type	Area (Ac.)	T_c (min)	CN	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ProNW	A	Railroad ROW	1.75	11.55	90.00	5.62	9.31	14.18
ProSE	B	Un-Detained Discharge	0.60	9.84	90.00	2.01	3.33	5.07
ProS	C	Railroad ROW	1.17	11.98	90.00	3.73	6.18	9.41

Table 11: Total Outflow Summary

Sub Basin	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ProNE	5.62	9.31	14.18
ProSE	2.01	3.33	5.07
ProS	3.73	6.18	9.41

Table 12: Allowable Release Rates per Proposed Discharge Point

Sub Basin	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ProNW	0.88	3.45	5.25
ProSE	0.30	1.20	1.80
ProS	0.59	2.34	3.51

DETENTION ANALYSIS

Detention analysis was completed according to APWA Section 5608: Stormwater Detention and Retention. The proposed detention analysis was completed per APWA 5608.4.C.1.a (pg 92) which allows a maximum peak discharge rate of 0.5 (2-yr), 2.0 (10-yr), and 3.0 (100-yr) cfs/acre for any development under runoff control strategies. Criteria from APWA 5608.4.C.1.b (pg 92) was also applied to ensure 40-hour extended detention of runoff for local 90% mean annual event. (1.37"/24-hour rainfall)

All outflow conditions assume free flow. All downstream pipes of the detention basin will be sized using manning's equation to carry the 100-year flow condition to site development. To mitigate this, we are proposing two detention basins on site.

The proposed onsite detention consists of two above ground extended dry detention basins (EDDB) which accommodate wet detention for a 40-hour extended period. A 4" outfall pipe was assumed for the water quality outfall in each detention pond based on the minimum allowable cross-sectional area outlet.

The proposed northwest basin (ProNW) will have an invert elevation of 1007.00', a top of dam of 1012.10', and a 100-year HGL of 1010.50'. The total volume of the storage basin at the 100-year HGL is 0.35 acre-feet. Runoff is to be conveyed through 1-Perforated Riser (Invert = 1007.00', 40-hour extended dry detention outfall) and 1-12" HDPE Pipe (invert = 1009.02'). The 40-linear foot 12" pipe will be built at a 5.0%

slope. Runoff from both outfall pipes will daylight on the existing property (Invert = 1007.00') and flow towards railroad right-of-way.

The emergency overflow structure consists of a 103' wide naturally graded trapezoidal weir at an elevation of 1011.0'. A minimum of 0.50' of freeboard is required between the emergency spillway crest and the maximum 100-year WSE and 0.50' of freeboard has been provided.

The proposed south basin (ProS) will have an invert elevation of 1014.25', a top of dam of 1017.60', and a 100-year HGL of 1016.0'. The total volume of the storage basin at the 100-year HGL is 0.27 acre-feet. Runoff is to be conveyed through 1 – Perforated Riser (Invert = 1014.25', 40-hour extended dry detention outfall) and 1-12" HDPE Pipe (invert = 1014.95'). The 20-linear foot 12" pipe will be built at a 5.00% slope. Runoff from both outfall pipes will daylight on the existing property (Invert = 1014.00') and flow towards railroad right-of-way.

The emergency overflow structure consists of a 75' wide naturally graded trapezoidal weir at an elevation of 1016.50'. A minimum of 0.50' of freeboard is required between the emergency spillway crest and the maximum 100-year WSE and 0.50' of freeboard has been provided.

Please see Table 13 below for a summary of pipe velocities during 2, 10, and 100-year storms, Table 14 for a detention basin inflow/outflow summary, Table 15 for a detention basin summary, and Table 16 for an APWA 5608 peak discharge requirement summary.

Table 13: Summary of Pipe Velocities

Pipe	V_2 (fps)	V_{10} (fps)	V_{100} (fps)
Proposed NE Detention Basin			
12" HDPE	1.11	3.30	5.89
Proposed S Detention Basin			
12" HDPE	0.66	2.10	4.33

Table 14: Detention Basin Inflow/Outflow Summary

Storm Event	Q_{in} (cfs)	Ponding Elevation (ft)	Max Depth Attained (ft)	Q_{out} (cfs)
Proposed NW Pond				
100- Year Storm	14.15	1010.50	3.50	4.62
10-Year Storm	9.30	1009.80	2.80	2.59
2-Year Storm	5.61	1009.23	2.23	0.87
Proposed S Pond				
100- Year Storm	9.41	1016.00	1.75	3.40
10-Year Storm	6.18	1015.53	1.28	1.65
2-Year Storm	3.72	1015.10	0.85	0.52

Table 15: Summary of Detention Basin Design

Proposed NW Detention Basin	
Drainage Area	1.75 AC
Curve Number	90.00
Basin Flow Line Outfall	1007.00'
Pond Base Elevation	1007.00'
Outlet Structure	1 – 12" HDPE Pipes @ 1009.02' 1 – Perforated Pipe @ 1007.00'
Max 100-year HGL	1010.50'
100-Year Emergency Weir Elevation	1011.00'
Top of Dam	1012.10'
Proposed SE Detention Basin	
Drainage Area	1.17 AC
Curve Number	90.00
Basin Flow Line Outfall	1014.00'
Pond Base Elevation	1014.25'
Outlet Structure	1 – 12" HDPE Pipe @ 1014.95' 1 – Perforated Pipe @ 1014.25"
Max 100-year HGL	1016.00'
100-Year Emergency Weir Elevation	1016.50'
Top of Dam	1017.60'

Table 16. Summary of APWA 5608 Peak Discharge Requirements

Outfall Desc.	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ProNW Allowable	0.88	3.45	5.25
ProNW Actual	0.87	2.59	4.62
Difference	-0.01	-0.86	-0.63
ProS Allowable	0.59	2.34	3.51
ProS Actual	0.52	1.65	3.40
Difference	-0.07	-0.69	-0.11

APWA Section 5608.4.F.2 requires that the detention basin emergency spillway performance provides a minimum of 1 ft of freeboard from the design stage to the top of dam, assuming zero available storage in the basin and zero flow through the primary outlet. Table 17 shows a summary of emergency spillway performance for the 100-yr storm event assuming zero flow through the primary outlet.

Table 17. Summary of Emergency Spillway Performance (100-Yr Event)

Outfall Desc.	Crest Elev (ft)	Length (ft)	Top of Dam Elev (ft)	Max WSE (ft)	Freeboard (ft)
ProNW	1011.00	103	1012.10	1011.10	1.00
ProS	1016.50	75	1017.60	1016.56	1.04

The proposed southeast sub basin (ProSE) is an un-detained drainage area. The existing discharge point (Discharge point B on Exhibits D & F) will remain the same for the ProSE sub basin but the drainage area has decreased. The decreased area will be un-detained and discharge at existing discharge point B. Updated curve number and drainage area for the SE basin show an overall reduction in runoff conveyed to discharge point B. See Table 18 below for a summary of existing and proposed conditions at discharge point B.

Table 18. Summary of Discharge Point B Conditions

Outfall Desc.	Area (AC)	CN	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ExSE	0.91	83.00	2.07	3.78	6.13
ProSE	0.60	90.00	2.01	3.33	5.07

WATER QUALITY ANALYSIS

MARC BMP Manual Section 4.0 was used to determine BMP requirements for the proposed site. Worksheet 1A (Required level of Service – Developed Site) was used to determine the existing site value rating based on the current single-family residential land use. An existing value rating of 18.37 was calculated based on the existing impervious area for the site. See Exhibit H for Worksheet 1A calculations.

MARC BMP Manual Section 4.0, Worksheet 2 was used to analyze the proposed site BMP mitigation package. Extended-dry detention was added to the 1.75-acre ProNW sub basin. Extended-dry detention to native vegetation swale was added to the 1.17-acres ProS sub basin. Preserved native vegetation was added to the ProSE sub basin. See Exhibit J for a BMP location plan of the proposed BMP mitigation package. A total value rating of 20.74 was calculated for the proposed site. See Exhibit I for Worksheet 2 calculations.

APWA 5608.4 and Chapter 6 of the MARC/APWA BMP Manual require 40-hour extended detention to treat the Water Quality Storm. MARC BMP Manual Chapter 6 section 6.2 Short-Cut Method (pg 6-1) was used to determine the water quality volume for a proposed drainage area of less than 10 acres. Table 19 lists rainfall event, percent impervious area, and volumetric runoff coefficient assumptions made for the ProNW and ProS detention basin design. Table 20 lists the water quality volume calculations for each sub basin. EDDB calculations have been provided in Exhibit I.

Table 19. APWA/MARC Water Quality Volume

Rainfall Event (P, in/24-hrs)	1.37
Percent Site Imperviousness (I, %)	65
Volumetric Runoff Coefficient (Rv)	0.635

Table 20. APWA/MARC Water Quality Volume

Detention Basin	Area (AC)	Water Quality Volume (ac-ft)	Q_{out} (cfs)
ProNW	1.75	0.13	0.04
ProS	1.17	0.09	0.03

Note: Q_{out} (cfs) assumes full 40-hr extended detention of total design volume.

SUMMARY

The proposed site will require stormwater detention because of an increased runoff from the existing conditions. Table 21 summarizes the existing and proposed peak flows from the entire site with no stormwater detention.

Table 21. Summary of Existing and Proposed Peak Flows

Outfall Desc.	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
Total Existing Site	5.56	11.34	19.65
Total Proposed Site w/ out Detention	11.36	18.82	28.66

Two above ground extended dry detention basins, a native vegetation swale, and native vegetation have been added to the proposed site (ProNW and ProS) to reduce the proposed site peak runoff, improve water quality, and control release rates for all required design storms. Table 22 summarizes the existing and proposed peak flowrate decrease with the included stormwater detention. The proposed detention meets all APWA 5608 peak discharge requirements. Table 23 summarizes allowable and actual proposed site peak discharge requirements.

Table 22. Summary of Total Existing and Proposed Peak Discharges

Outfall Desc.	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
Total Existing Site	5.56	11.34	19.65
Total Proposed Site w/ Detention	3.33	7.46	12.92

Table 23. Summary of Proposed Peak Discharge Requirements

Outfall Desc.	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ProNW Allowable	0.88	3.45	5.25
ProNW Actual	0.87	2.59	4.62
ProS Allowable	0.59	2.34	3.51
ProS Actual	0.52	1.65	3.40

The proposed site will also have a third un-detained sub basin (ProSE). A request for waiver from the City of Lee' Summit Design and Construction Manual requirement has been proposed based on an overall decrease in peak flowrate discharging to outlet point B. Table 24 summarizes the existing and proposed peak flowrates at discharge point B.

Table 24. Summary of Discharge Point B Conditions

Outfall Desc.	Area (AC)	CN	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
ExSE	0.91	83.00	2.05	3.76	6.09
ProSE	0.60	90.00	2.01	3.33	5.07

CONCLUSION

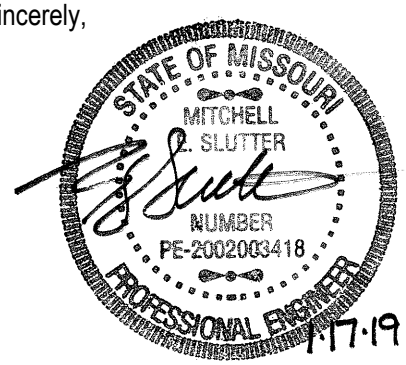
The proposed Burton Townhomes development is a 3.52 acre site in Lee's Summit, MO that will include the construction of 9 townhome units and associated infrastructure. Two above ground extended-dry detention basins have been proposed to control the increase runoff produced by the development.

The proposed development meets all stormwater criteria set forth by the City of Lee's Summit, Missouri and APWA 5600 design criteria. These requirements include an overall decrease in post development peak flowrates, 40-hour water quality extended detention, and a maximum allowable sub basin discharge rate.

A request for waiver from the City of Lee's Summit Design and Construction Manual requirement has been proposed for the un-detained sub basin ProSE based on a peak flowrate discharge decrease under proposed conditions.

Based on this information, Renaissance Infrastructure Consulting recommends approval of this storm study. If you have any questions or need additional information, please contact me.

Sincerely,



Mick Slutter, PE

Jonathan Daldalian, EI

RENAISSANCE INFRASTRUCTURE CONSULTING

Exhibit A

Project Location Map

Exhibit A: Burton Townhomes Lee's Summit

Scale: 1" = 1000'

Location Map
18-0251
Prepared: 10/16/18

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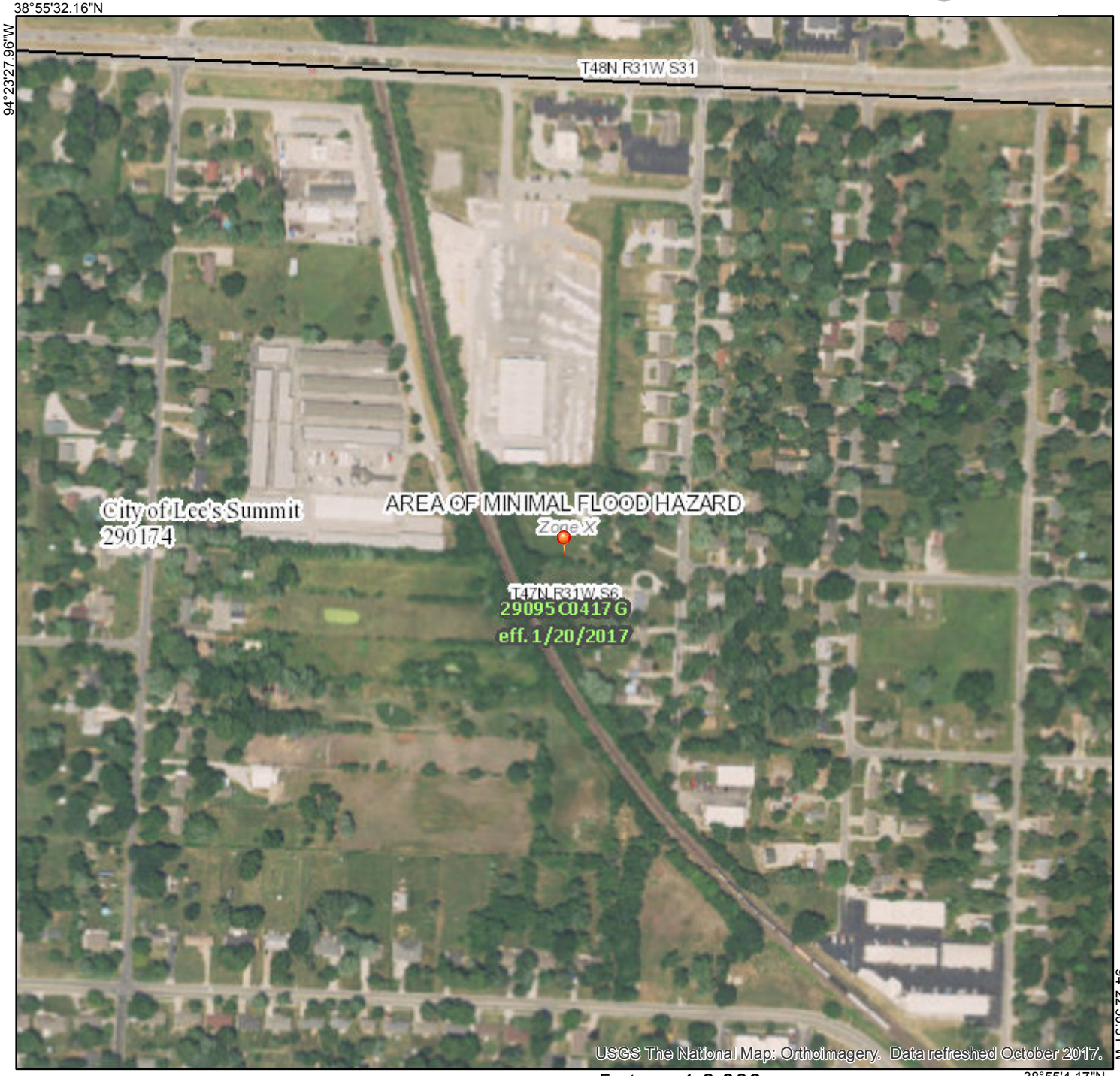
Exhibit B

FEMA FIRM Map

National Flood Hazard Layer FIRMette

FEMA



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 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- 513 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 10/24/2018 at 10:40:52 AM 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.

Exhibit C

NRCS Web Soil Survey

Soil Map—Jackson County, Missouri
(Proposed Burton Townhomes Lee's Summit)

Map Scale: 1:1,280 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 15 30 60 90

Feet
0 50 100 200 300

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

MAP LEGEND

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

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Jackson County, Missouri
Survey Area Data: Version 19, Sep 13, 2018

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

Date(s) aerial images were photographed: Jun 11, 2017—Sep 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10082	Arisburg-Urban land complex, 1 to 5 percent slopes	0.7	17.9%
10128	Sharpsburg-Urban land complex, 2 to 5 percent slopes	3.1	81.6%
10181	Udarents-Urban land-Sampsel complex, 5 to 9 percent slopes	0.0	0.5%
Totals for Area of Interest		**3.8**	**100.0%**

Exhibit D

Existing Drainage Map

Property Line

ExNW Discharge Point (A)

ExNW Sub Basin
Area = 2.61AC
CN = 74.00
Tc = 19.47 min
Q_{100} = 13.56 cfs
Q_{10} = 7.58 cfs
Q_2 = 3.51 cfs

Property Line

Property Line

Property Line

Existing House

Property Line

Property Line

Existing House

ExSE Discharge Point (B)

ExSE Sub Basin
Area = 0.91 AC
CN = 83.00
Tc = 15.72 min
Q_{100} = 6.09 cfs
Q_{10} = 3.76 cfs
Q_2 = 2.05 cfs

NW Orchard Dr

NW Olive St

Property Line

S27°33'40"E 230.08'

417.50'

Field for Line

NORTH
1" = 30'
0 15' 30'

Sheet
Exhibit D

Storm Report
18-0251
Lee's Summit, Jackson County, MO

Existing Drainage Map

NO.	BY	DATE	REVISION
1	JGD	MES 01/16/19	ORIGINAL SUBMISSION

Renaissance Infrastructure Consulting
815 McGee Street, Suite 200
Kansas City, Missouri 64108
816.800.0950
www.ric-consult.com

MO Certificate of Authority: E-2010033630

Jan 16, 2019-3:22pm
Z:\RIC Design\2018\18-0251 Burton Townhomes Lees Summit\Office\Storm Report\18-0251 - SWR.dwg

Exhibit E

Existing Conditions Analysis

Project Description

File Name ..... Existing.SPF

Project Options

Flow Units ..... CFS
Elevation Type ..... Elevation
Hydrology Method ..... SCS TR-55
Time of Concentration (TOC) Method ..... SCS TR-55
Link Routing Method ..... Kinematic Wave
Enable Overflow Ponding at Nodes ..... YES
Skip Steady State Analysis Time Periods ... NO

Analysis Options

Start Analysis On ..... Oct 16, 2018 00:00:00
End Analysis On ..... Oct 17, 2018 00:00:00
Start Reporting On ..... Oct 16, 2018 00:00:00
Antecedent Dry Days ..... 0 days
Runoff (Dry Weather) Time Step ..... 0 01:00:00 days hh:mm:ss
Runoff (Wet Weather) Time Step ..... 0 00:05:00 days hh:mm:ss
Reporting Time Step ..... 0 00:05:00 days hh:mm:ss
Routing Time Step ..... 30 seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	2
Nodes	2
Junctions	0
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	2-Year	Cumulative	inches	Missouri	Jackson	2	3.50	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	ExNW	2.62	74.00	3.50	1.24	3.25	3.51	0 00:19:28
2	ExSE	0.90	83.00	3.50	1.86	1.67	2.05	0 00:15:43

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Out-01	Outfall	0.00					0.00	0.00					
2	Out-03	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : ExNW

Input Data

Area (ac) 2.62
Weighted Curve Number 74.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
> 75% grass cover, Good	2.62	C	74.00
Composite Area & Weighted CN	2.62		74.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.12	0.00	0.00
Computed Flow Time (min) :	13.87	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	380	0.00	0.00
Slope (%) :	2.6	0.00	0.00
Surface Type :	Grass pasture	Unpaved	Unpaved
Velocity (ft/sec) :	1.13	0.00	0.00
Computed Flow Time (min) :	5.60	0.00	0.00

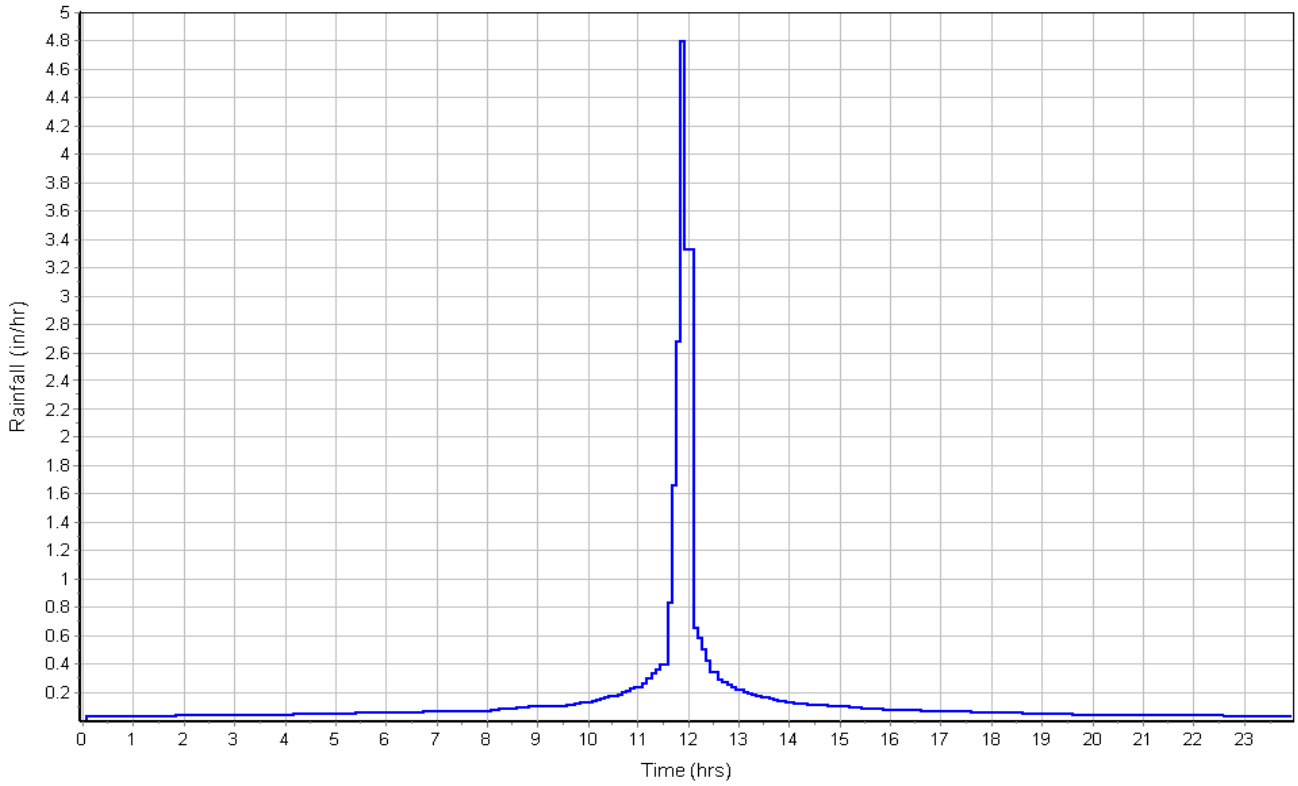
Total TOC (min) 19.47

Subbasin Runoff Results

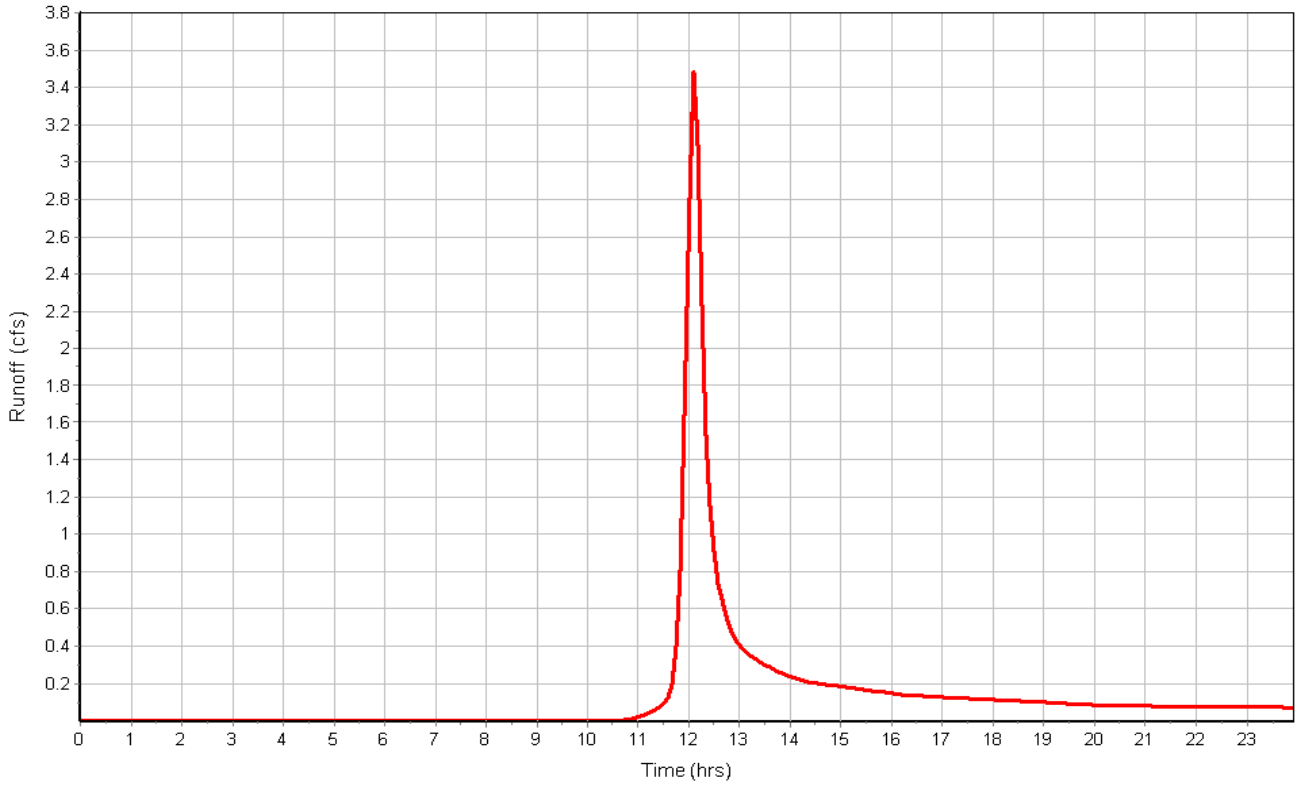
Total Rainfall (in)	3.50
Total Runoff (in)	1.24
Peak Runoff (cfs)	3.51
Weighted Curve Number	74.00
Time of Concentration (days hh:mm:ss)	0 00:19:28

Subbasin : ExNW

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ExSE

Input Data

Area (ac) 0.90
Weighted Curve Number 83.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/4 acre lots, 38% impervious	0.90	C	83.00
Composite Area & Weighted CN	0.90		83.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.12	0.00	0.00
Computed Flow Time (min) :	13.87	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	150	0.00	0.00
Slope (%) :	3.7	0.00	0.00
Surface Type :	Grass pasture	Unpaved	Unpaved
Velocity (ft/sec) :	1.35	0.00	0.00
Computed Flow Time (min) :	1.85	0.00	0.00

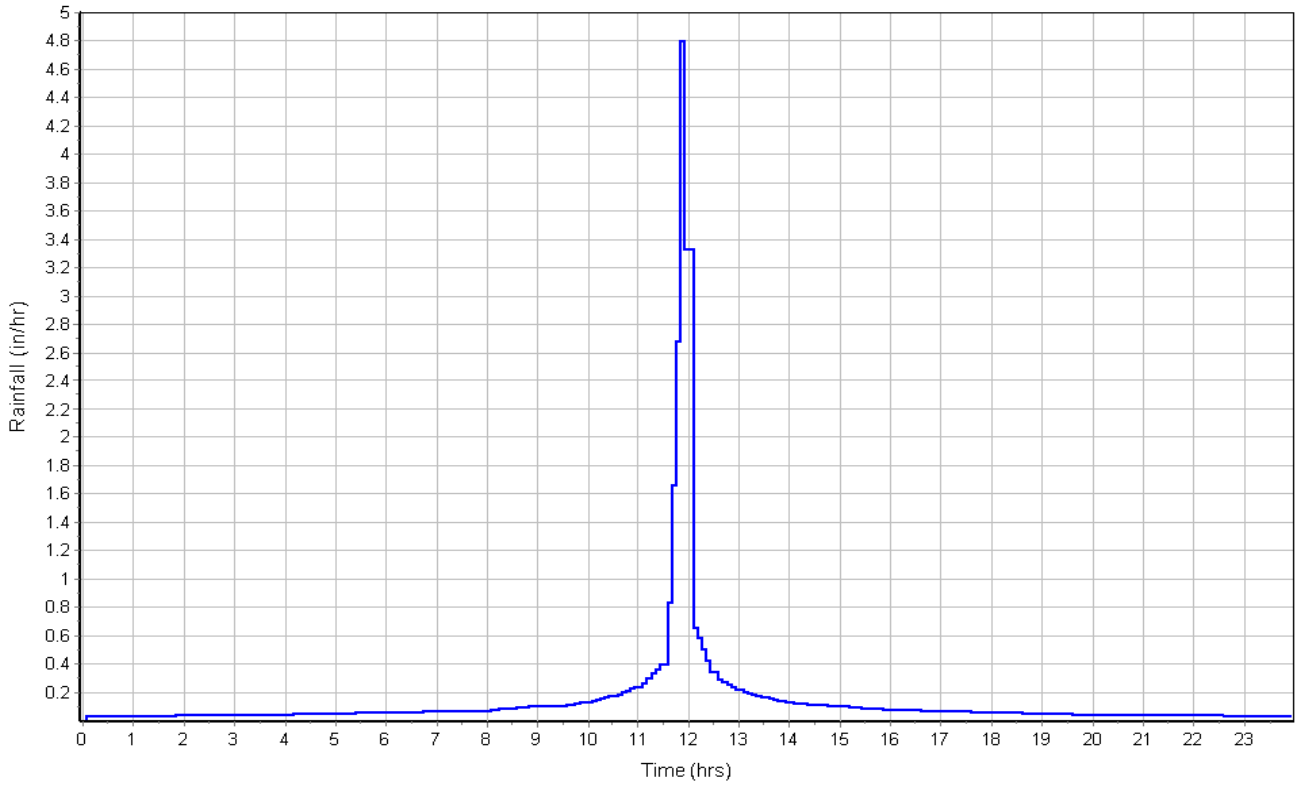
Total TOC (min) 15.72

Subbasin Runoff Results

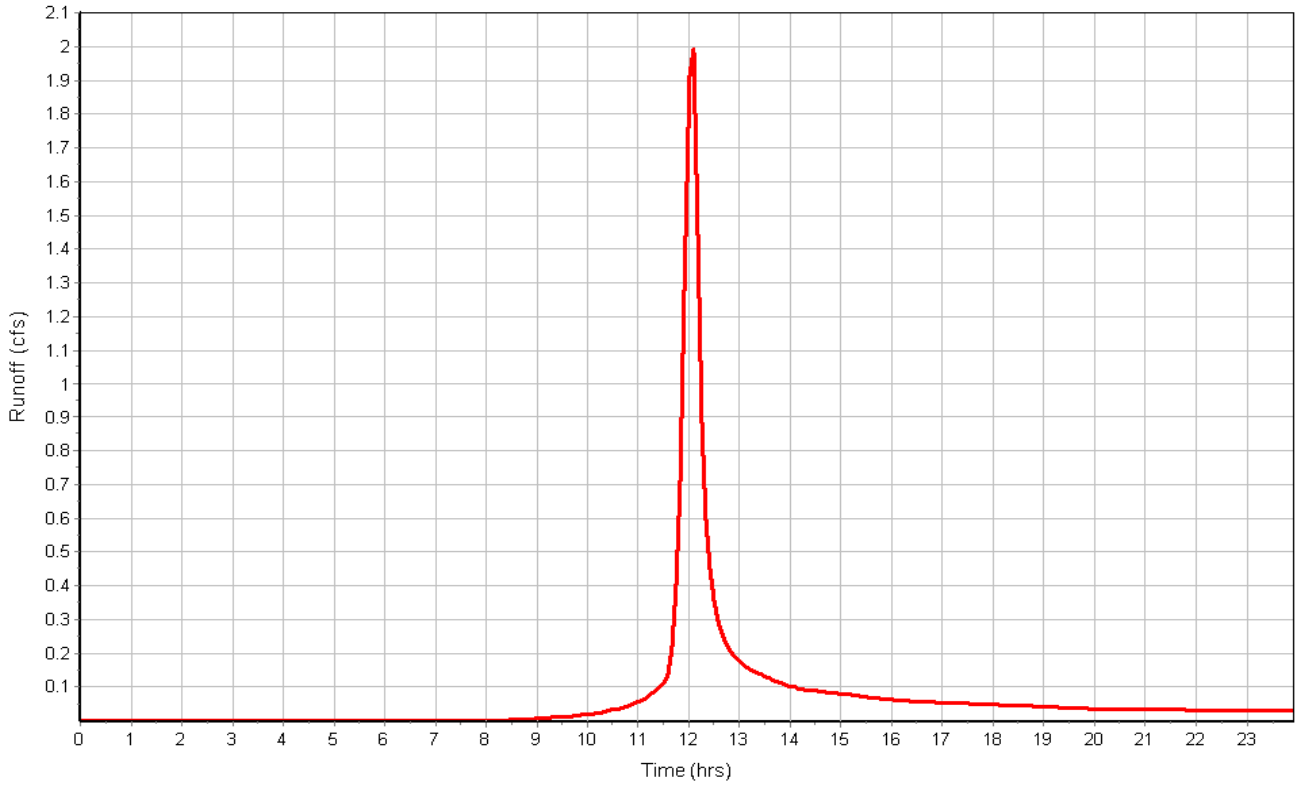
Total Rainfall (in) 3.50
Total Runoff (in) 1.86
Peak Runoff (cfs) 2.05
Weighted Curve Number 83.00
Time of Concentration (days hh:mm:ss) 0 00:15:43

Subbasin : ExSE

Rainfall Intensity Graph



Runoff Hydrograph



Project Description

File Name ..... Existing.SPF

Project Options

Flow Units ..... CFS
Elevation Type ..... Elevation
Hydrology Method ..... SCS TR-55
Time of Concentration (TOC) Method ..... SCS TR-55
Link Routing Method ..... Kinematic Wave
Enable Overflow Ponding at Nodes ..... YES
Skip Steady State Analysis Time Periods ... NO

Analysis Options

Start Analysis On ..... Oct 16, 2018 00:00:00
End Analysis On ..... Oct 17, 2018 00:00:00
Start Reporting On ..... Oct 16, 2018 00:00:00
Antecedent Dry Days ..... 0 days
Runoff (Dry Weather) Time Step ..... 0 01:00:00 days hh:mm:ss
Runoff (Wet Weather) Time Step ..... 0 00:05:00 days hh:mm:ss
Reporting Time Step ..... 0 00:05:00 days hh:mm:ss
Routing Time Step ..... 30 seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	2
Nodes	2
Junctions	0
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	10-Year	Cumulative	inches	Missouri	Jackson	10	5.30	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	ExNW	2.62	74.00	5.30	2.61	6.83	7.58	0 00:19:28
2	ExSE	0.90	83.00	5.30	3.45	3.10	3.76	0 00:15:43

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Out-01	Outfall	0.00					0.00	0.00					
2	Out-03	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : ExNW

Input Data

Area (ac) 2.62
Weighted Curve Number 74.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
> 75% grass cover, Good	2.62	C	74.00
Composite Area & Weighted CN	2.62		74.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.12	0.00	0.00
Computed Flow Time (min) :	13.87	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	380	0.00	0.00
Slope (%) :	2.6	0.00	0.00
Surface Type :	Grass pasture	Unpaved	Unpaved
Velocity (ft/sec) :	1.13	0.00	0.00
Computed Flow Time (min) :	5.60	0.00	0.00

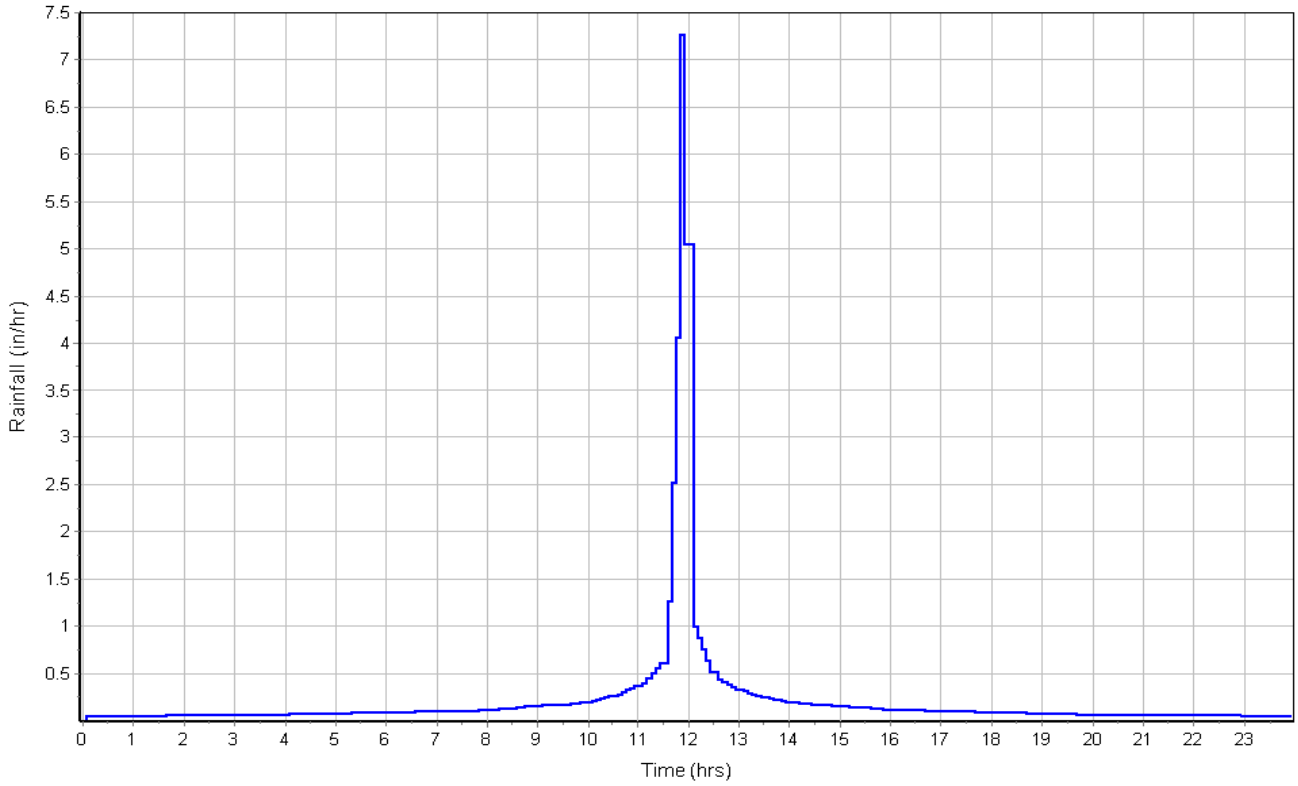
Total TOC (min) 19.47

Subbasin Runoff Results

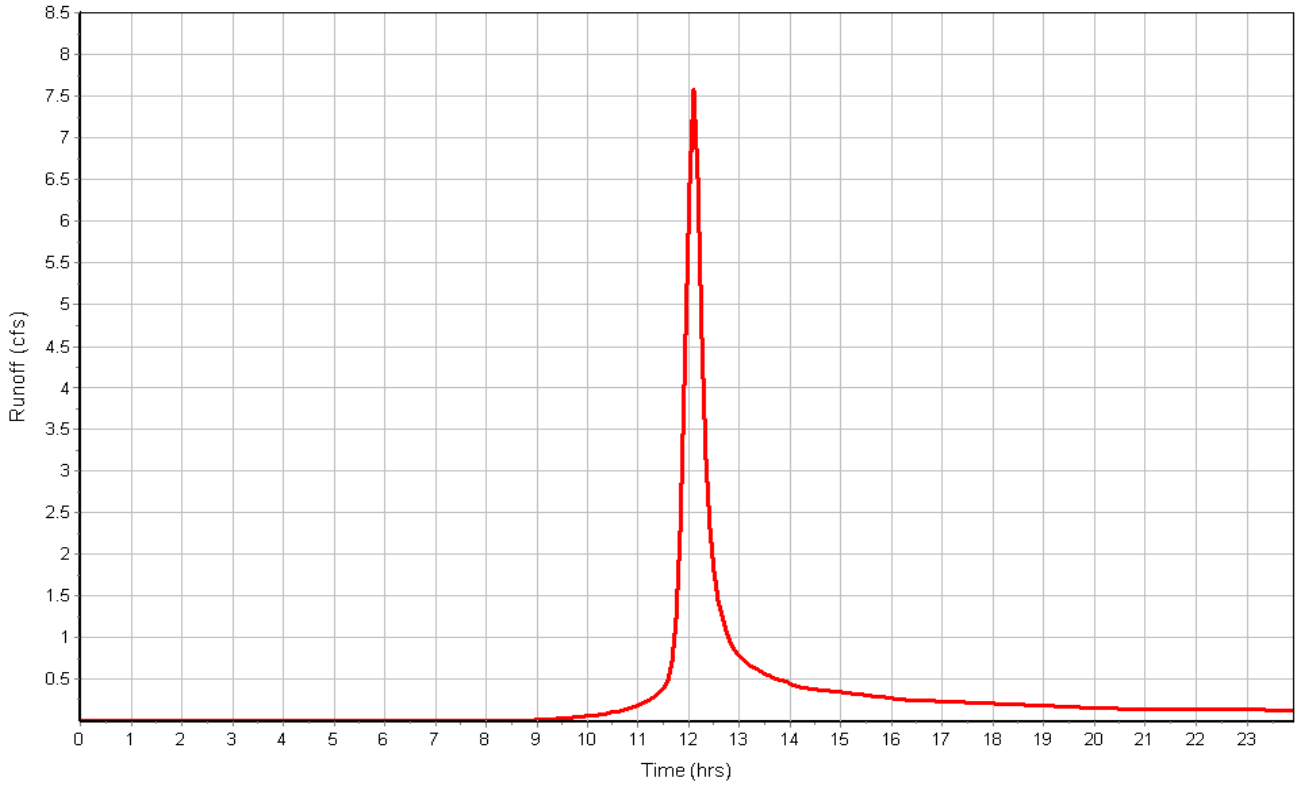
Total Rainfall (in)	5.30
Total Runoff (in)	2.61
Peak Runoff (cfs)	7.58
Weighted Curve Number	74.00
Time of Concentration (days hh:mm:ss)	0 00:19:28

Subbasin : ExNW

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ExSE

Input Data

Area (ac) 0.90
Weighted Curve Number 83.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/4 acre lots, 38% impervious	0.90	C	83.00
Composite Area & Weighted CN	0.90		83.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.12	0.00	0.00
Computed Flow Time (min) :	13.87	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	150	0.00	0.00
Slope (%) :	3.7	0.00	0.00
Surface Type :	Grass pasture	Unpaved	Unpaved
Velocity (ft/sec) :	1.35	0.00	0.00
Computed Flow Time (min) :	1.85	0.00	0.00

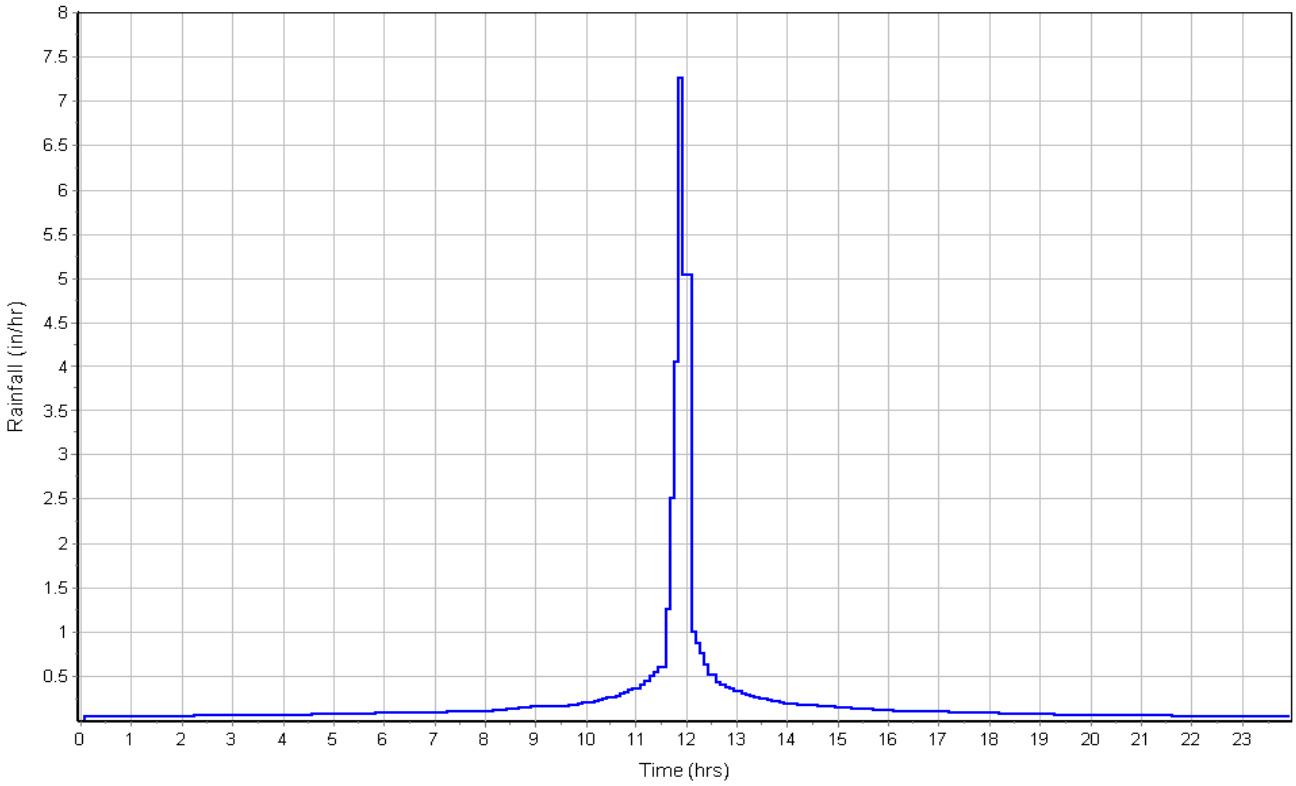
Total TOC (min) 15.72

Subbasin Runoff Results

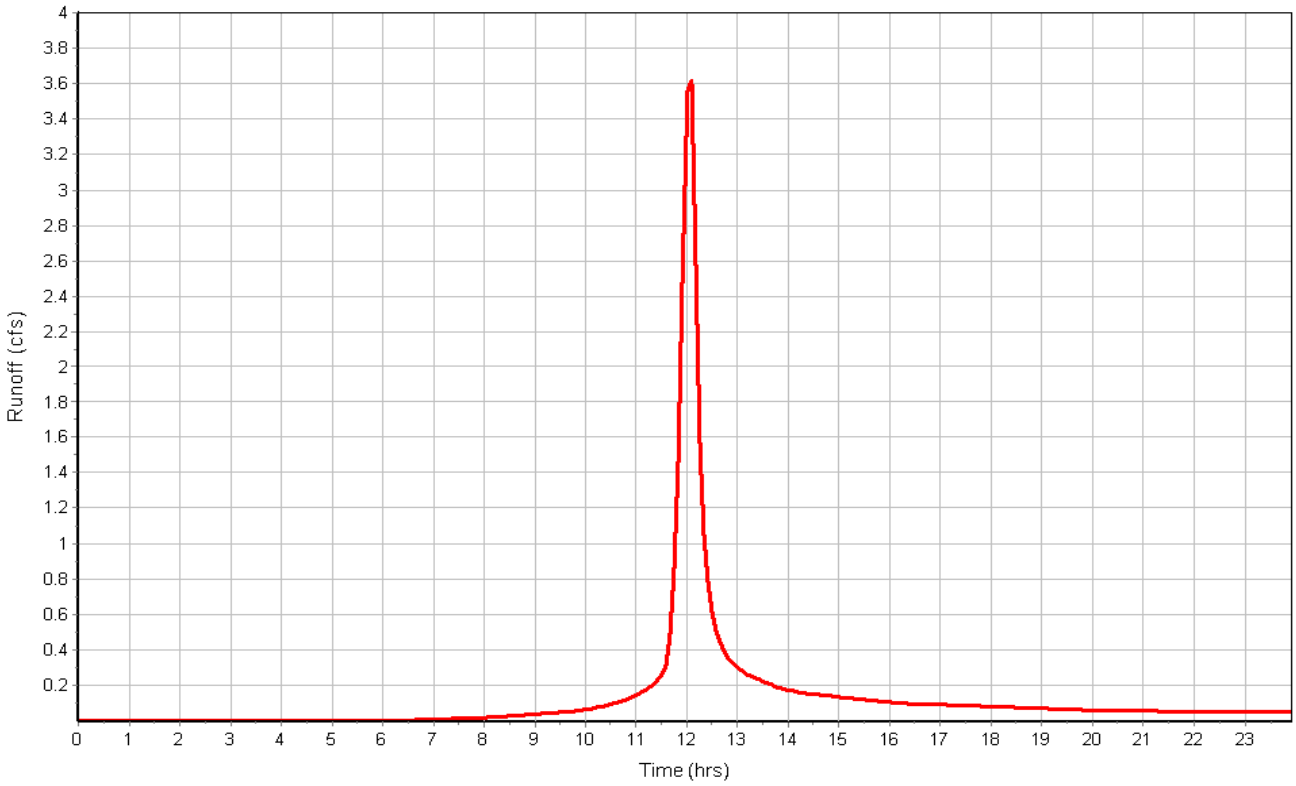
Total Rainfall (in) 5.30
Total Runoff (in) 3.45
Peak Runoff (cfs) 3.76
Weighted Curve Number 83.00
Time of Concentration (days hh:mm:ss) 0 00:15:43

Subbasin : ExSE

Rainfall Intensity Graph



Runoff Hydrograph



Project Description

File Name ..... Existing.SPF

Project Options

Flow Units ..... CFS
Elevation Type ..... Elevation
Hydrology Method ..... SCS TR-55
Time of Concentration (TOC) Method ..... SCS TR-55
Link Routing Method ..... Kinematic Wave
Enable Overflow Ponding at Nodes ..... YES
Skip Steady State Analysis Time Periods ... NO

Analysis Options

Start Analysis On ..... Oct 16, 2018 00:00:00
End Analysis On ..... Oct 17, 2018 00:00:00
Start Reporting On ..... Oct 16, 2018 00:00:00
Antecedent Dry Days ..... 0 days
Runoff (Dry Weather) Time Step ..... 0 01:00:00 days hh:mm:ss
Runoff (Wet Weather) Time Step ..... 0 00:05:00 days hh:mm:ss
Reporting Time Step ..... 0 00:05:00 days hh:mm:ss
Routing Time Step ..... 30 seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	2
Nodes	2
Junctions	0
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	100-Year	Cumulative	inches	Missouri	Jackson	100	7.70	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	ExNW	2.62	74.00	7.70	4.66	12.20	13.56	0 00:19:28
2	ExSE	0.90	83.00	7.70	5.69	5.12	6.09	0 00:15:43

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Out-01	Outfall	0.00					0.00	0.00					
2	Out-03	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : ExNW

Input Data

Area (ac) 2.62
Weighted Curve Number 74.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
> 75% grass cover, Good	2.62	C	74.00
Composite Area & Weighted CN	2.62		74.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.12	0.00	0.00
Computed Flow Time (min) :	13.87	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	380	0.00	0.00
Slope (%) :	2.6	0.00	0.00
Surface Type :	Grass pasture	Unpaved	Unpaved
Velocity (ft/sec) :	1.13	0.00	0.00
Computed Flow Time (min) :	5.60	0.00	0.00

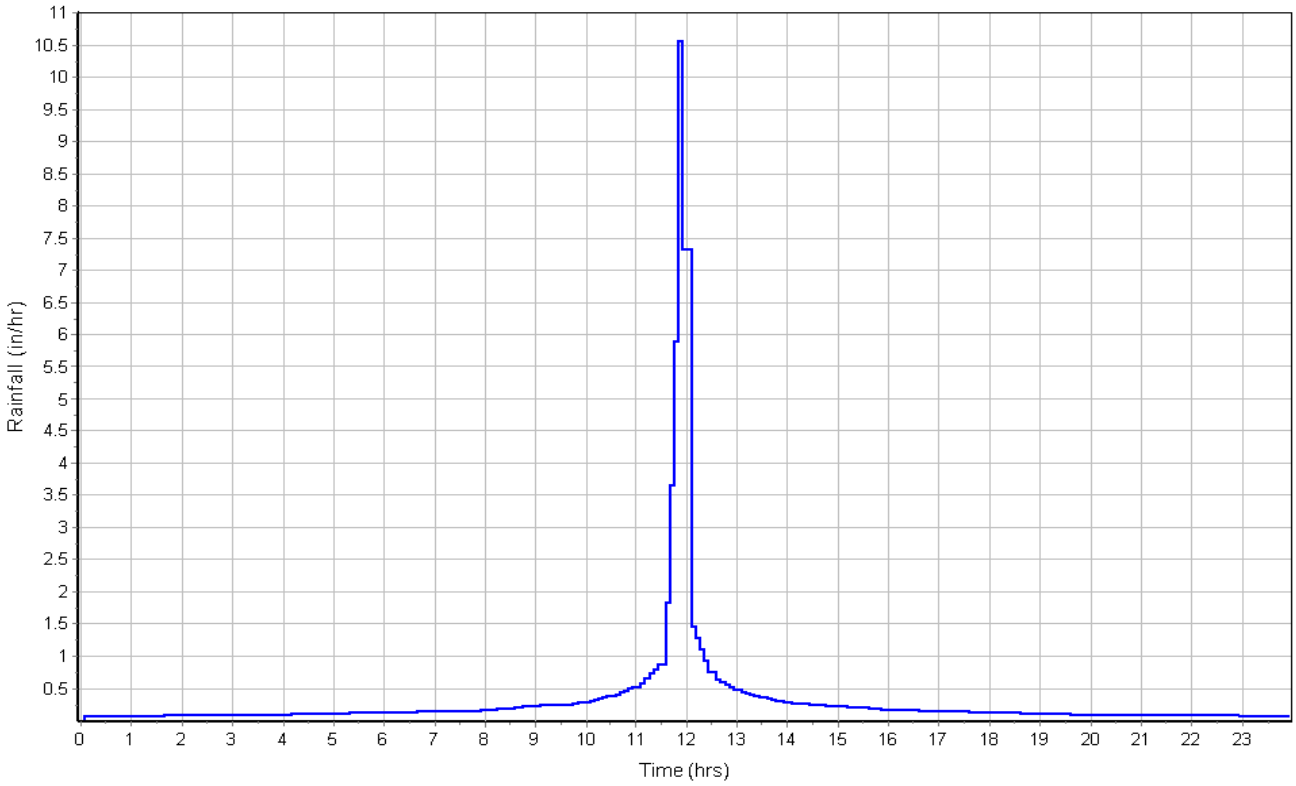
Total TOC (min) 19.47

Subbasin Runoff Results

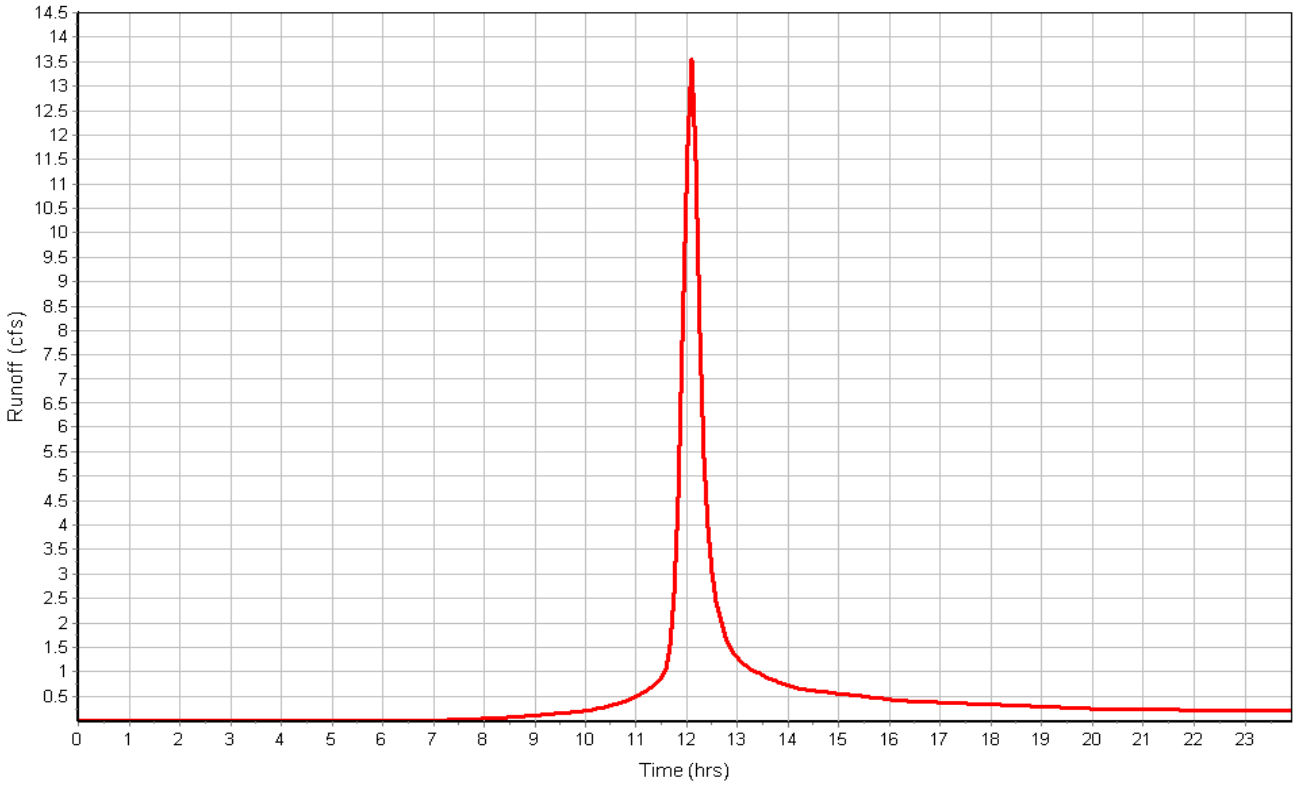
Total Rainfall (in)	7.70
Total Runoff (in)	4.66
Peak Runoff (cfs)	13.56
Weighted Curve Number	74.00
Time of Concentration (days hh:mm:ss)	0 00:19:28

Subbasin : ExNW

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ExSE

Input Data

Area (ac) 0.90
Weighted Curve Number 83.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/4 acre lots, 38% impervious	0.90	C	83.00
Composite Area & Weighted CN	0.90		83.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.12	0.00	0.00
Computed Flow Time (min) :	13.87	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	150	0.00	0.00
Slope (%) :	3.7	0.00	0.00
Surface Type :	Grass pasture	Unpaved	Unpaved
Velocity (ft/sec) :	1.35	0.00	0.00
Computed Flow Time (min) :	1.85	0.00	0.00

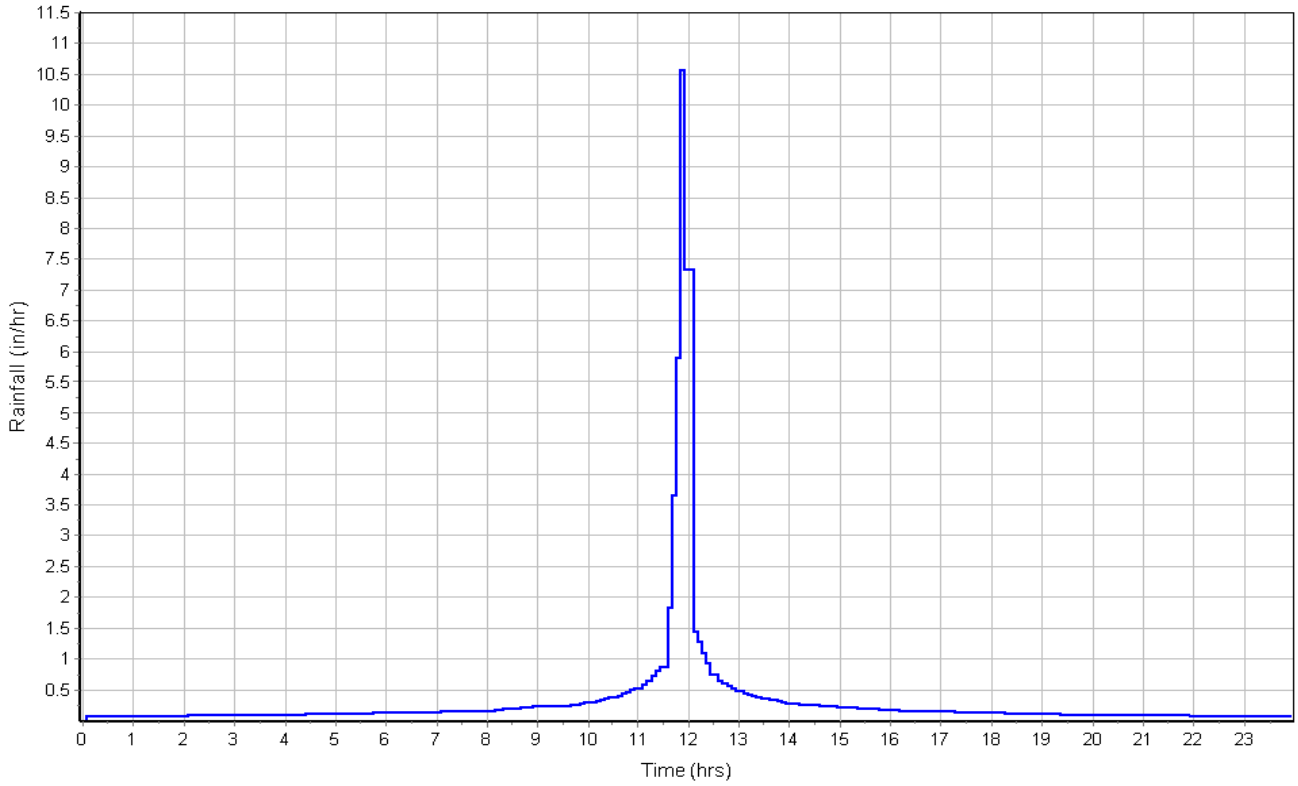
Total TOC (min) 15.72

Subbasin Runoff Results

Total Rainfall (in) 7.70
Total Runoff (in) 5.69
Peak Runoff (cfs) 6.09
Weighted Curve Number 83.00
Time of Concentration (days hh:mm:ss) 0 00:15:43

Subbasin : ExSE

Rainfall Intensity Graph



Runoff Hydrograph

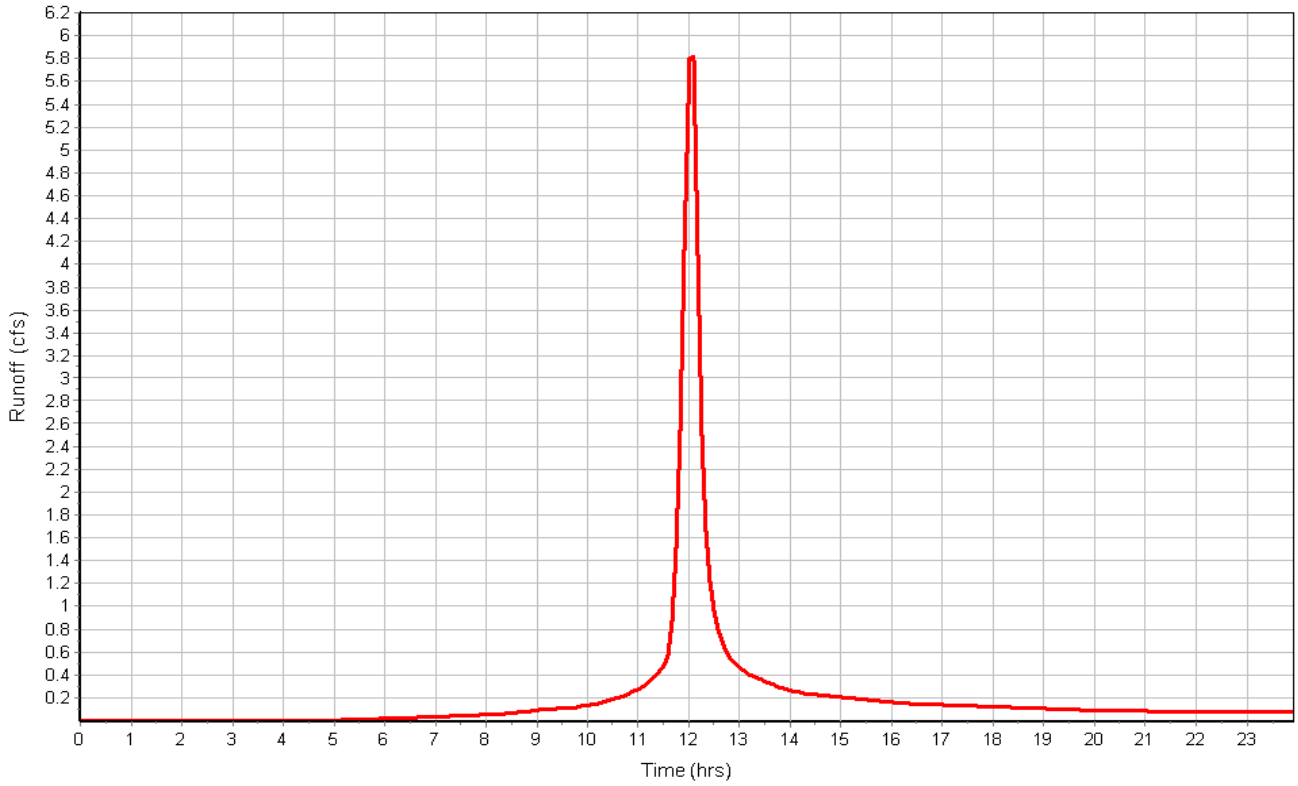
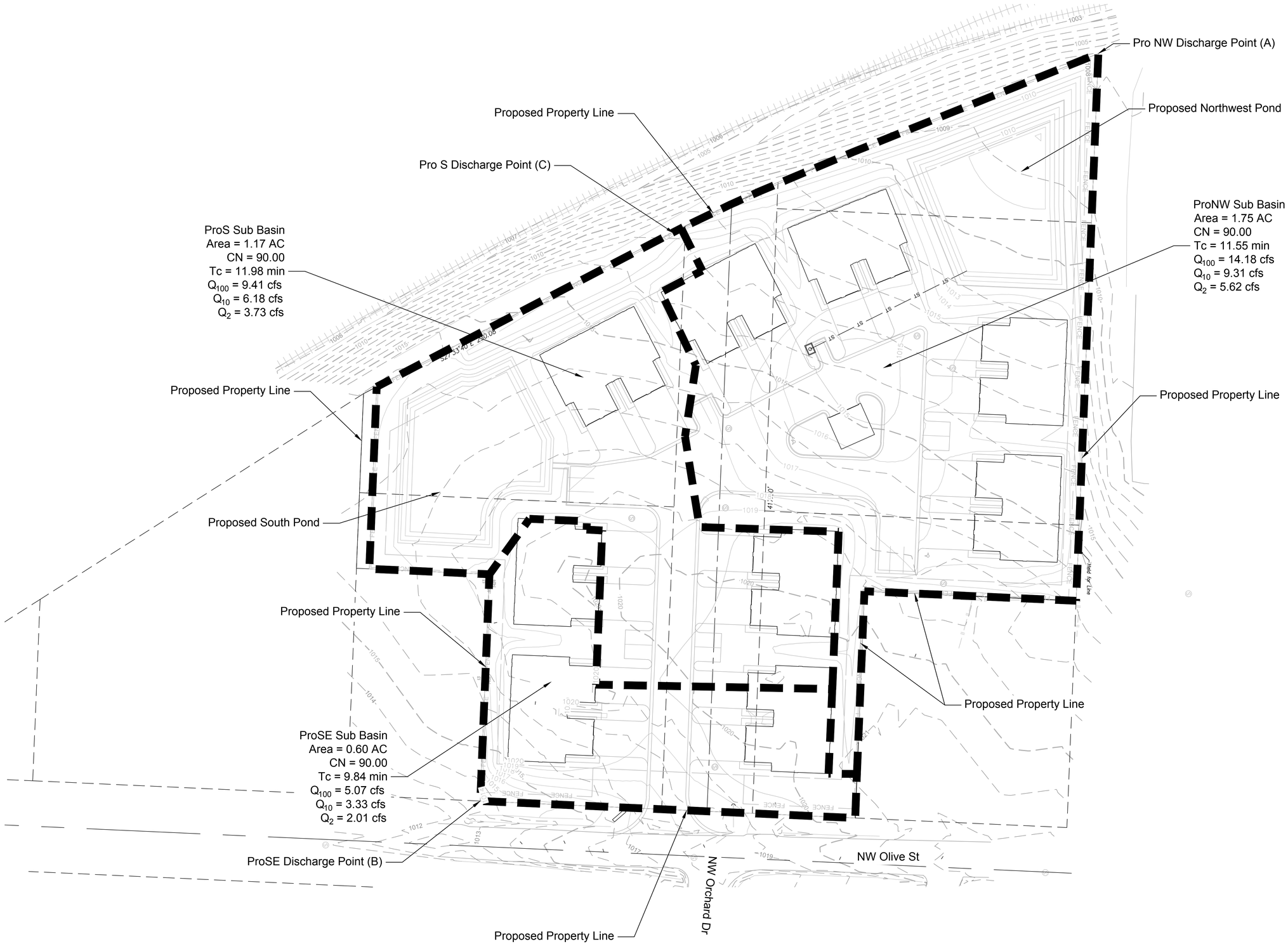


Exhibit F

Proposed Drainage Map



NORTH

1" = 30'

0 15' 30'

Sheet
Exhibit F

Storm Report

18-0251
Lee's Summit, Jackson County, MO

Proposed Drainage Map

NO.	BY	CD	DATE	REVISION
1	JGD	MCS	01/18/19	ORIGINAL SUBMISSION

Renaissance Infrastructure Consulting
1815 McGee Street, Suite 200
Kansas City, Missouri 64108
816.800.0950
www.RIC-CONSULT.COM

MO Certificate of Authority: E-2010033630

Jan 16, 2019 3:21pm
Z:\RIC Design\2018\18-0251 Burton Townhomes Lees Summit\Official\Storm Report\18-0251 - SWR.dwg

Exhibit G

Proposed Conditions Analysis

Project Description

File Name ..... Proposed.SPF

Project Options

Flow Units ..... CFS
Elevation Type ..... Elevation
Hydrology Method ..... SCS TR-55
Time of Concentration (TOC) Method ..... SCS TR-55
Link Routing Method ..... Kinematic Wave
Enable Overflow Ponding at Nodes ..... YES
Skip Steady State Analysis Time Periods ... NO

Analysis Options

Start Analysis On ..... Oct 16, 2018 00:00:00
End Analysis On ..... Oct 17, 2018 00:00:00
Start Reporting On ..... Oct 16, 2018 00:00:00
Antecedent Dry Days ..... 0 days
Runoff (Dry Weather) Time Step ..... 0 01:00:00 days hh:mm:ss
Runoff (Wet Weather) Time Step ..... 0 00:05:00 days hh:mm:ss
Reporting Time Step ..... 0 00:05:00 days hh:mm:ss
Routing Time Step ..... 30 seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	3
Nodes	3
Junctions	0
Outfalls	3
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	2-year	Cumulative	inches	Missouri	Jackson	2	3.50	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	ProNW	1.75	90.00	3.50	2.45	4.28	5.62	0 00:11:33
2	ProS	1.17	90.00	3.50	2.45	2.86	3.73	0 00:11:58
3	ProSE	0.60	90.00	3.50	2.45	1.47	2.01	0 00:09:50

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	NWoutfall	Outfall	0.00					0.00	0.00					
2	SEoutfall	Outfall	0.00					0.00	0.00					
3	Soutfall	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : ProNW

Input Data

Area (ac) 1.75
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	1.75	C	90.00
Composite Area & Weighted CN	1.75		90.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	1.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	10.34	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	175	0.00	0.00
Slope (%) :	2.5	0.00	0.00
Surface Type :	Paved	Paved	Grass pasture
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.91	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.012	0.00	0.00
Flow Length (ft) :	117	0.00	0.00
Channel Slope (%) :	1.0	0.00	0.00
Cross Section Area (ft²) :	1.77	0.00	0.00
Wetted Perimeter (ft) :	4.71	0.00	0.00
Velocity (ft/sec) :	6.47	0.00	0.00
Computed Flow Time (min) :	0.30	0.00	0.00

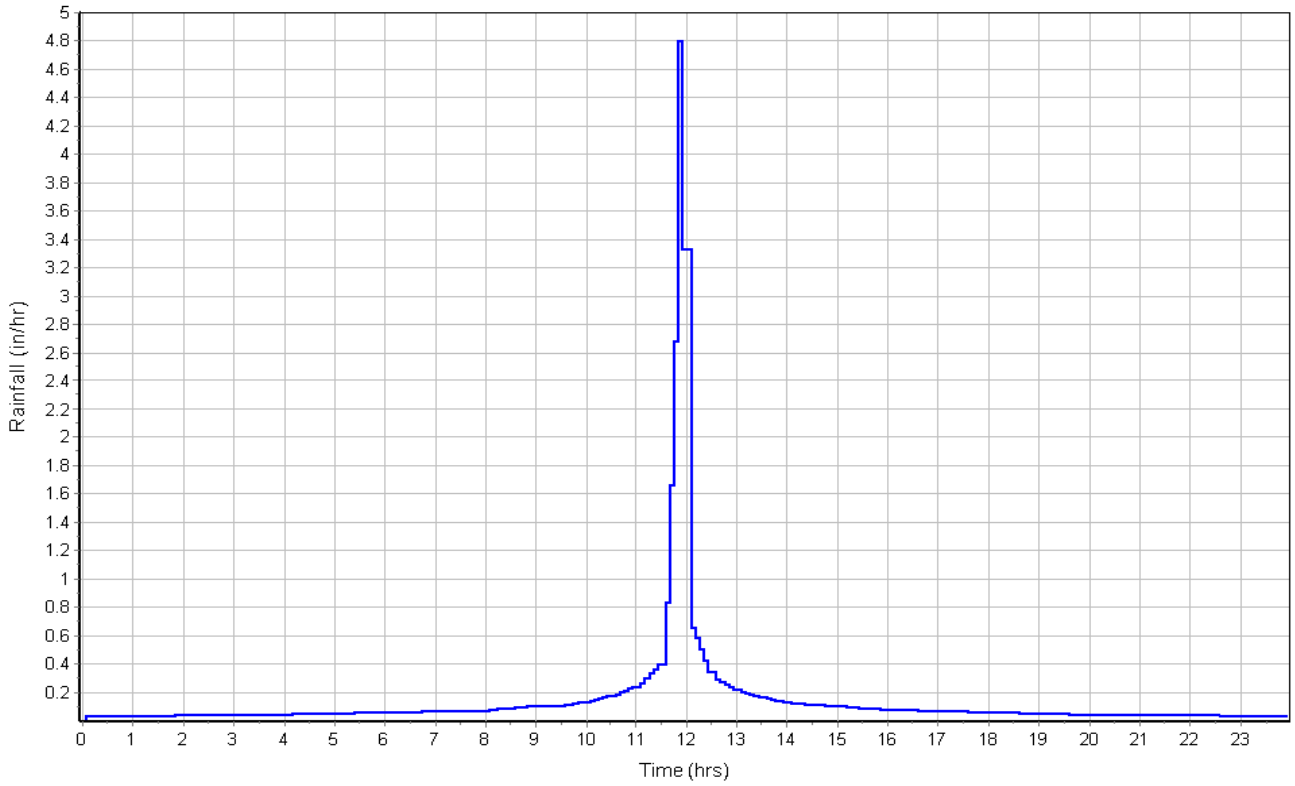
Total TOC (min) 11.55

Subbasin Runoff Results

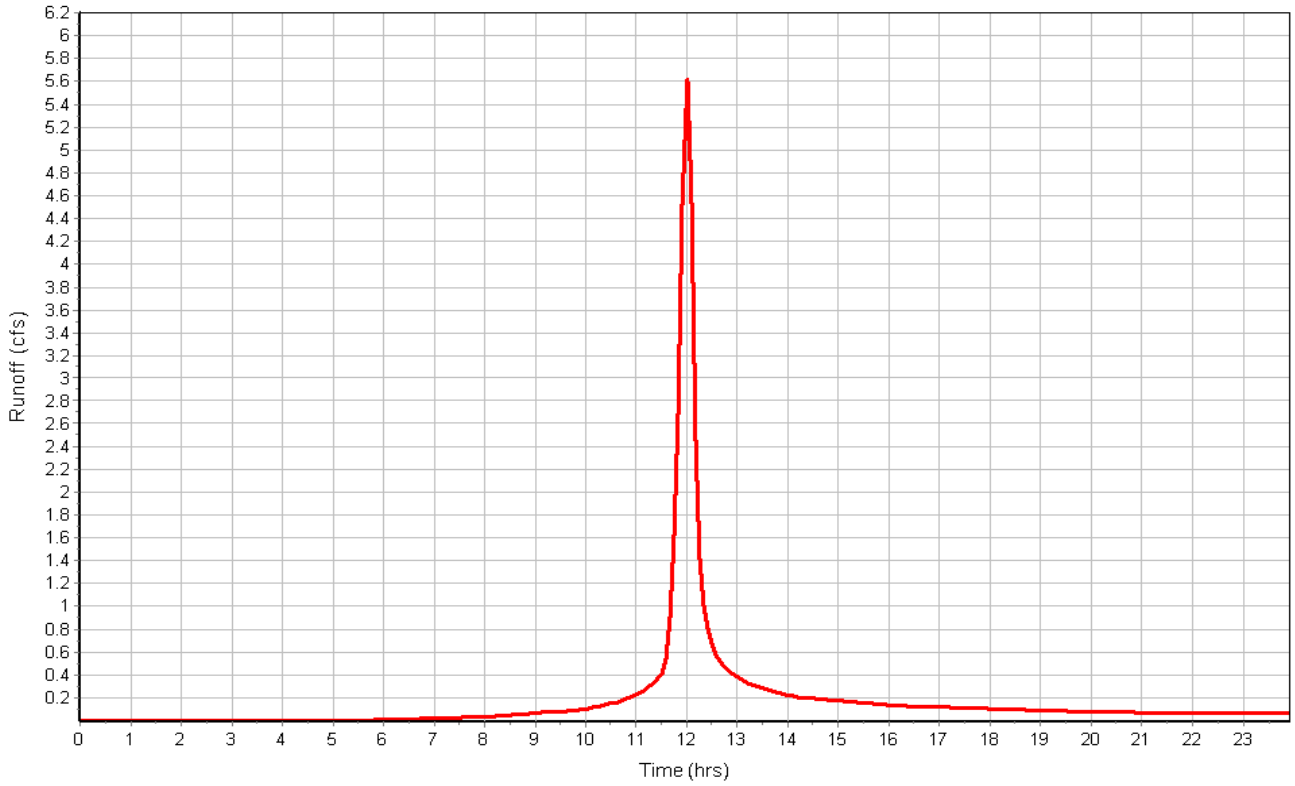
Total Rainfall (in)	3.50
Total Runoff (in)	2.45
Peak Runoff (cfs)	5.62
Weighted Curve Number	90.00
Time of Concentration (days hh:mm:ss)	0 00:11:33

Subbasin : ProNW

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ProS

Input Data

Area (ac) 1.17
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	1.17	C	90.00
Composite Area & Weighted CN	1.17		90.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.3	0.00	0.00
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	1.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	10.34	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	200	0.00	0.00
Slope (%) :	1.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.03	0.00	0.00
Computed Flow Time (min) :	1.64	0.00	0.00

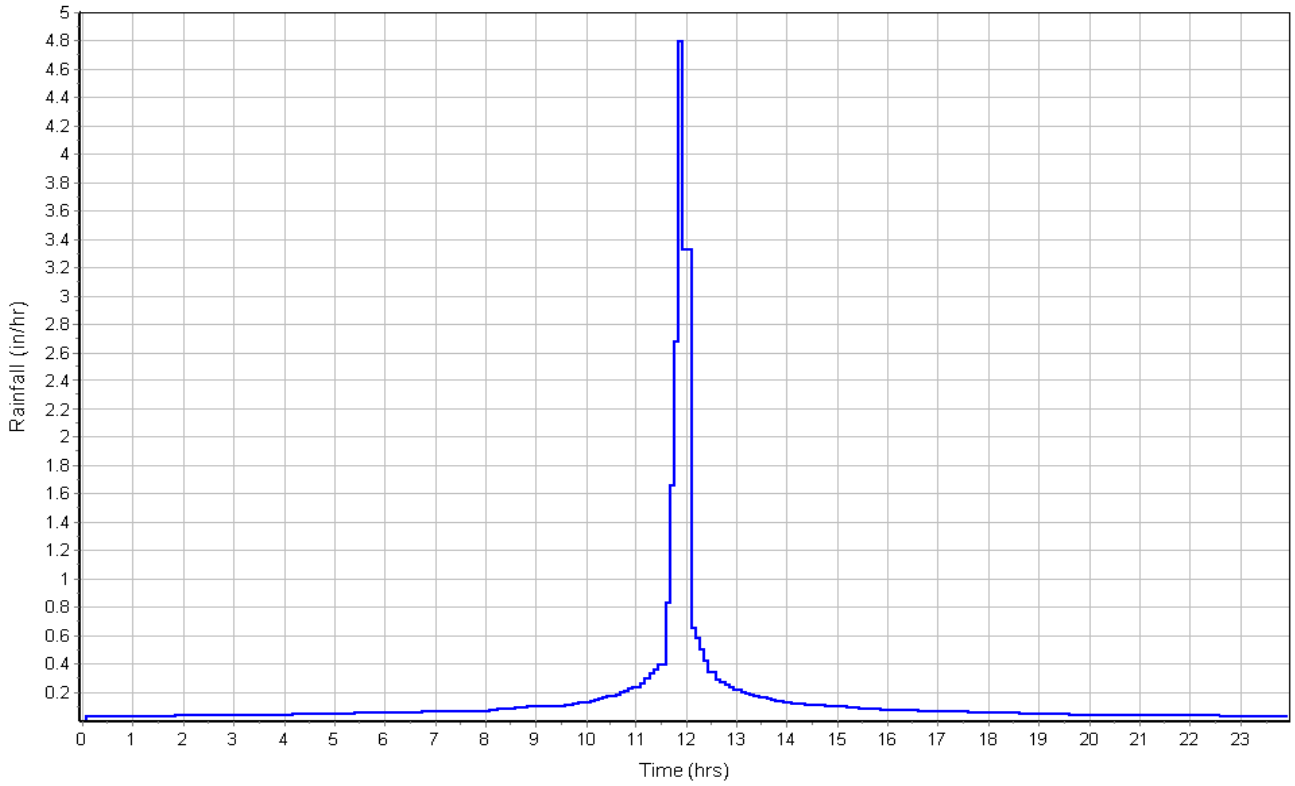
Total TOC (min) 11.98

Subbasin Runoff Results

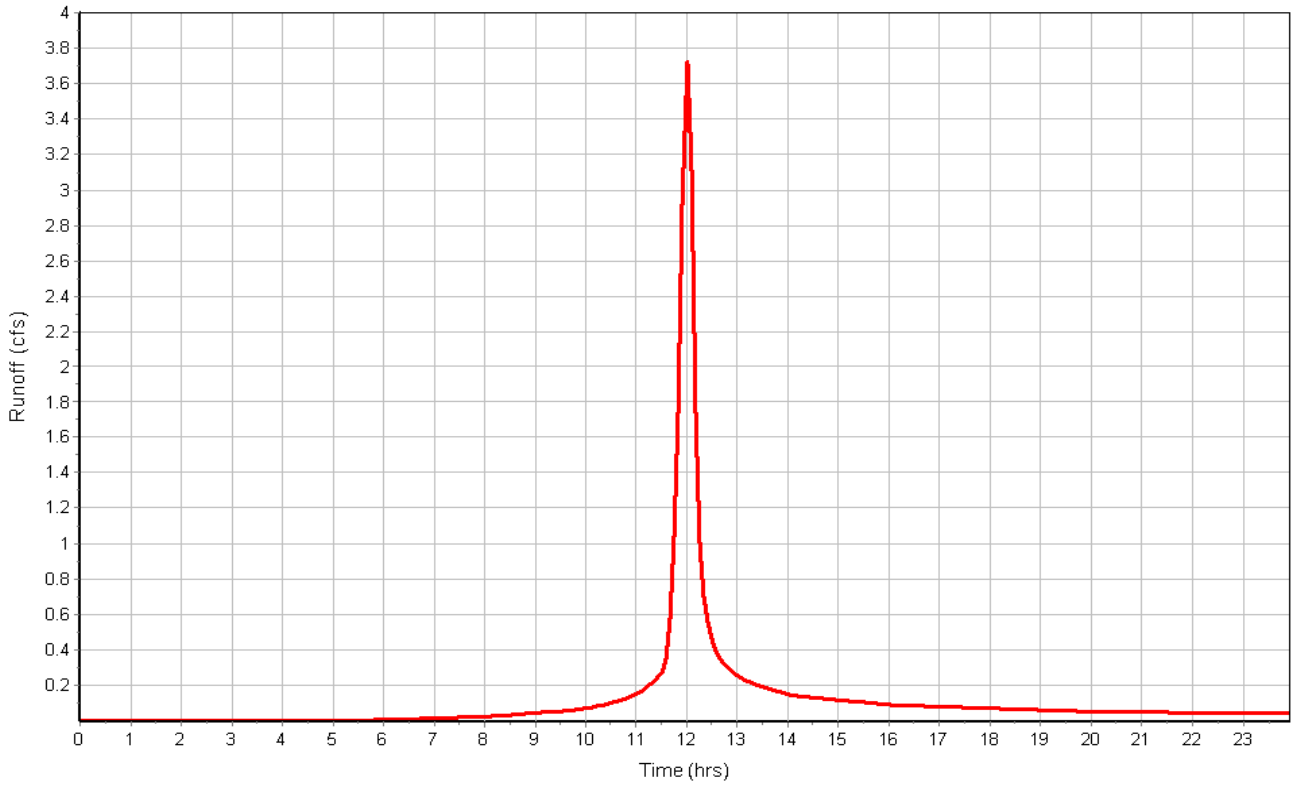
Total Rainfall (in) 3.50
Total Runoff (in) 2.45
Peak Runoff (cfs) 3.73
Weighted Curve Number 90.00
Time of Concentration (days hh:mm:ss) 0 00:11:59

Subbasin : ProS

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ProSE

Input Data

Area (ac) 0.60
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	0.60	C	90.00
Composite Area & Weighted CN	0.60		90.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.30	0.00
Flow Length (ft) :	70	70	0.00
Slope (%) :	1.0	1.0	0.00
2 yr, 24 hr Rainfall (in) :	3.50	3.50	0.00
Velocity (ft/sec) :	0.79	0.07	0.00
Computed Flow Time (min) :	1.47	16.18	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	120	0.00	0.00
Slope (%) :	2	0.00	0.00
Surface Type :	Grass pasture	ass pastu	Unpaved
Velocity (ft/sec) :	0.99	0.00	0.00
Computed Flow Time (min) :	2.02	0.00	0.00

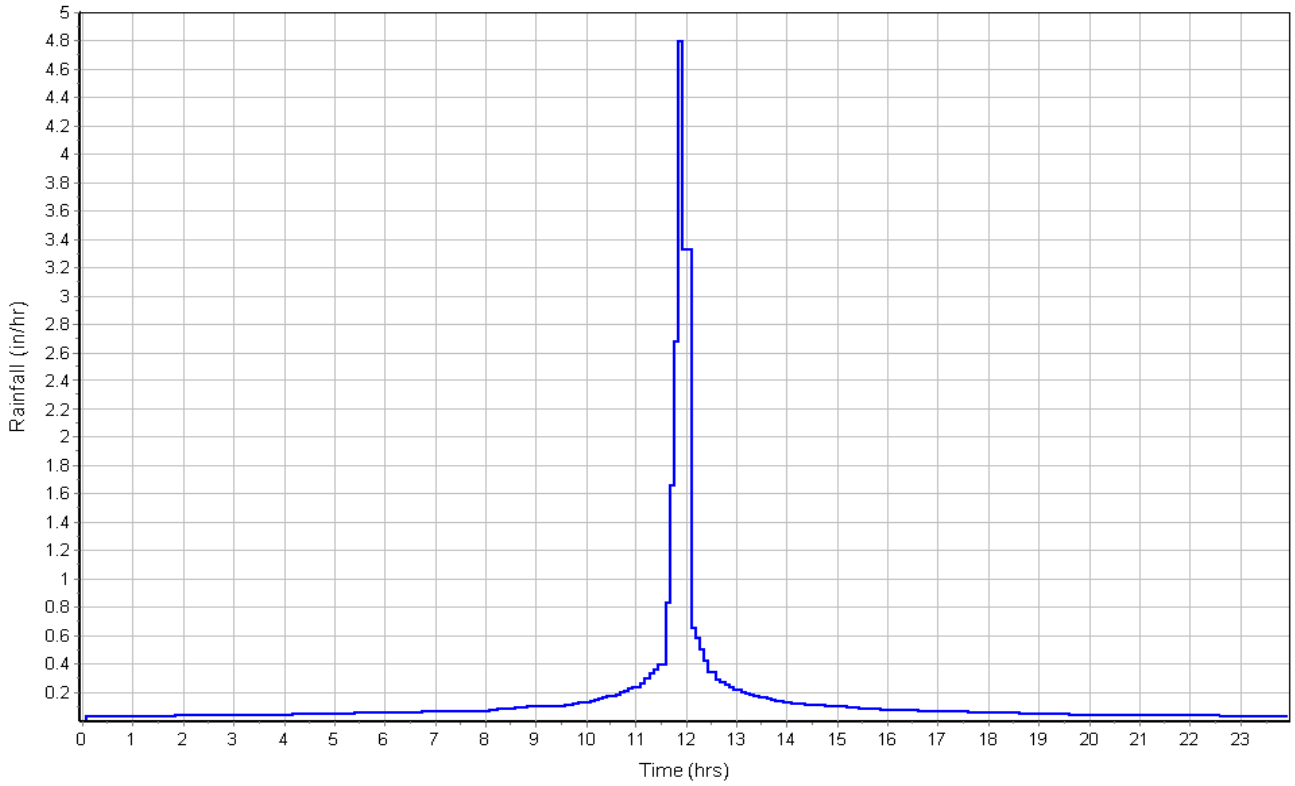
Total TOC (min) 9.84

Subbasin Runoff Results

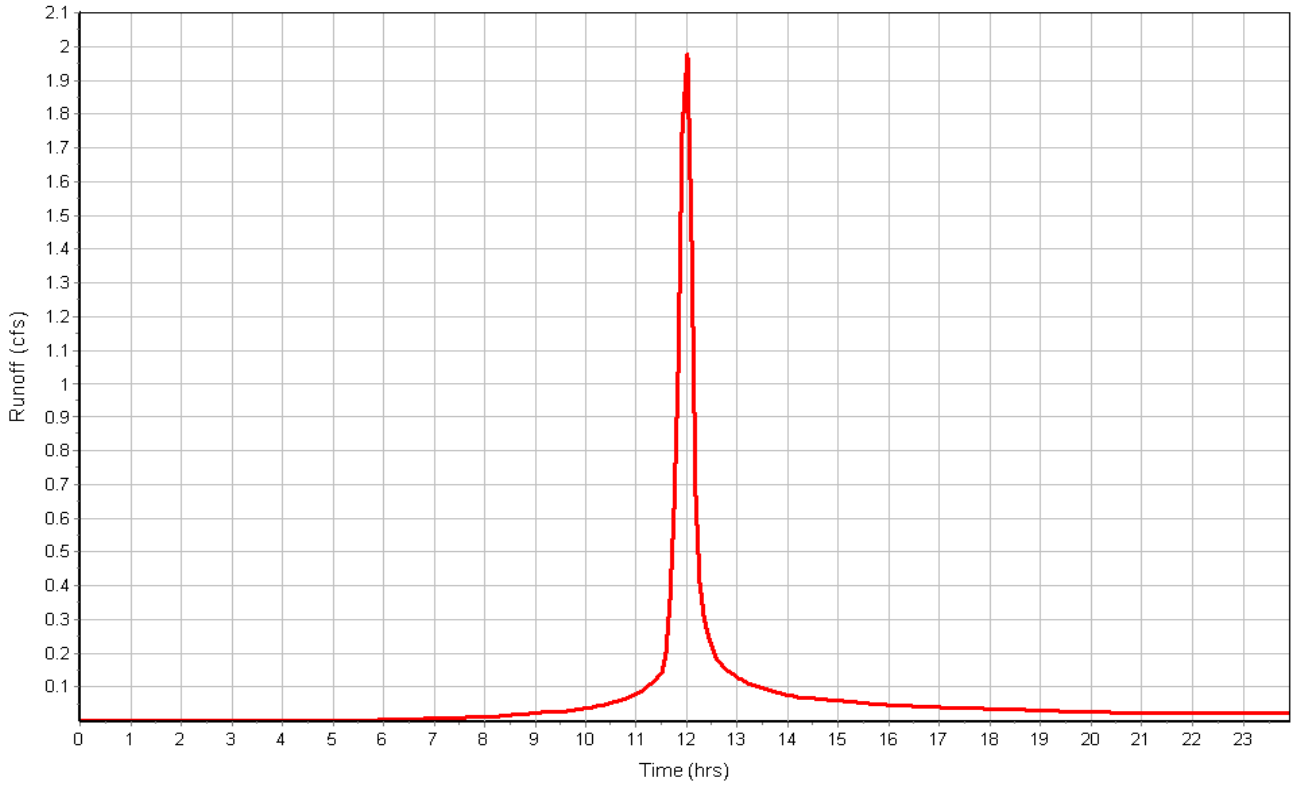
Total Rainfall (in) 3.50
Total Runoff (in) 2.45
Peak Runoff (cfs) 2.01
Weighted Curve Number 90.00
Time of Concentration (days hh:mm:ss) 0 00:09:50

Subbasin : ProSE

Rainfall Intensity Graph



Runoff Hydrograph



Project Description

File Name	Proposed.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Oct 16, 2018	00:00:00
End Analysis On	Oct 17, 2018	00:00:00
Start Reporting On	Oct 16, 2018	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	3
Nodes	3
Junctions	0
Outfalls	3
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	10-year	Cumulative	inches	Missouri	Jackson	10	5.30	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	ProNW	1.75	90.00	5.30	4.17	7.29	9.31	0 00:11:33
2	ProS	1.17	90.00	5.30	4.17	4.87	6.18	0 00:11:58
3	ProSE	0.60	90.00	5.30	4.17	2.50	3.33	0 00:09:50

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	NWoutfall	Outfall	0.00					0.00	0.00					
2	SEoutfall	Outfall	0.00					0.00	0.00					
3	Soutfall	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : ProNW

Input Data

Area (ac) 1.75
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	1.75	C	90.00
Composite Area & Weighted CN	1.75		90.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	1.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	10.34	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	175	0.00	0.00
Slope (%) :	2.5	0.00	0.00
Surface Type :	Paved	Paved	Grass pasture
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.91	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.012	0.00	0.00
Flow Length (ft) :	117	0.00	0.00
Channel Slope (%) :	1.0	0.00	0.00
Cross Section Area (ft²) :	1.77	0.00	0.00
Wetted Perimeter (ft) :	4.71	0.00	0.00
Velocity (ft/sec) :	6.47	0.00	0.00
Computed Flow Time (min) :	0.30	0.00	0.00

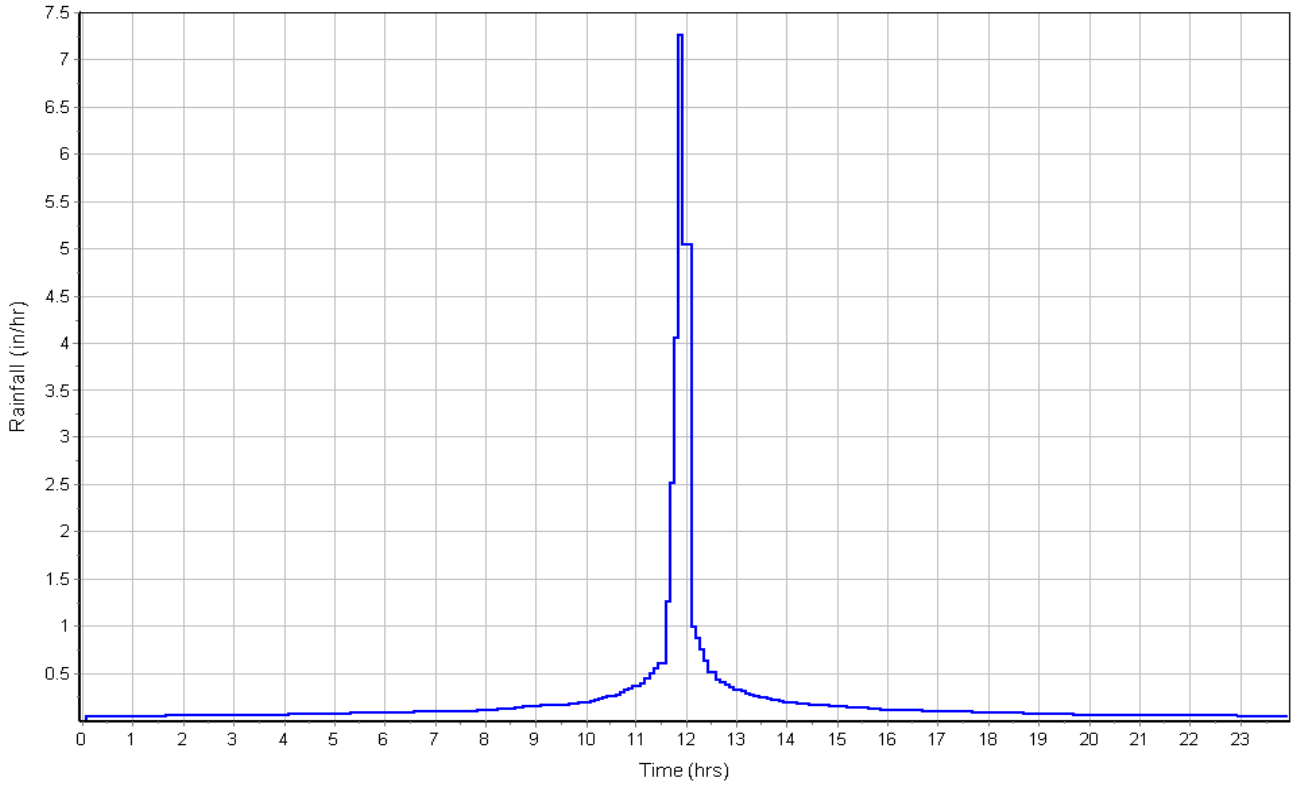
Total TOC (min) 11.55

Subbasin Runoff Results

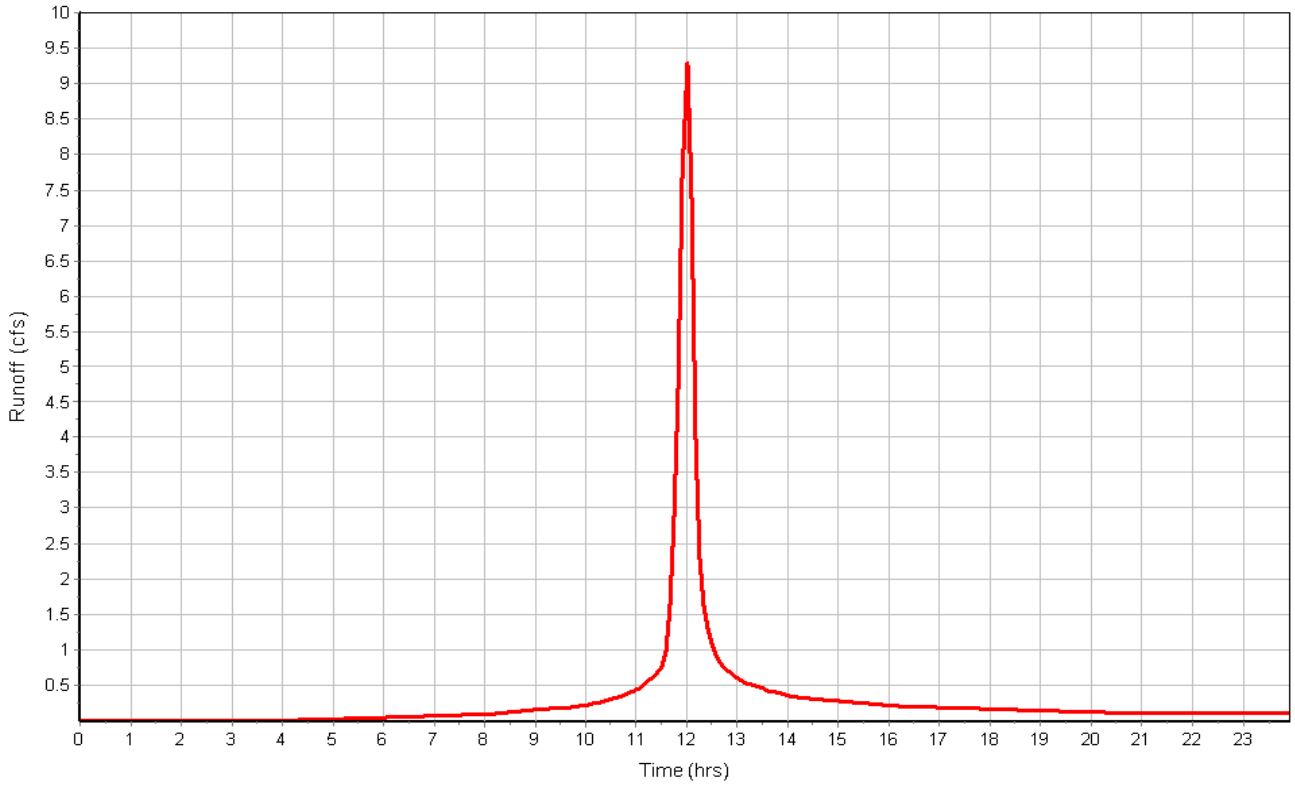
Total Rainfall (in)	5.30
Total Runoff (in)	4.17
Peak Runoff (cfs)	9.31
Weighted Curve Number	90.00
Time of Concentration (days hh:mm:ss)	0 00:11:33

Subbasin : ProNW

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ProS

Input Data

Area (ac) 1.17
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	1.17	C	90.00
Composite Area & Weighted CN	1.17		90.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.3	0.00	0.00
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	1.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	10.34	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	200	0.00	0.00
Slope (%) :	1.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.03	0.00	0.00
Computed Flow Time (min) :	1.64	0.00	0.00

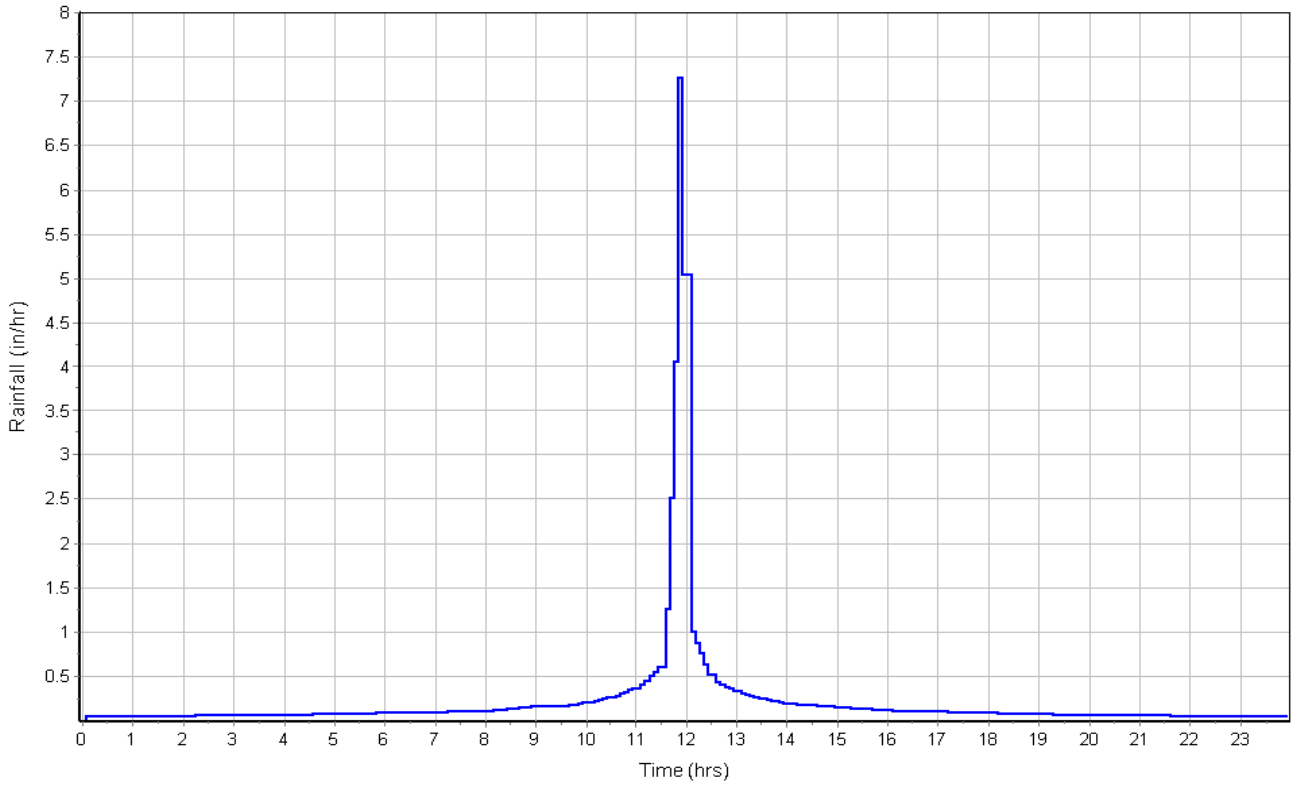
Total TOC (min) 11.98

Subbasin Runoff Results

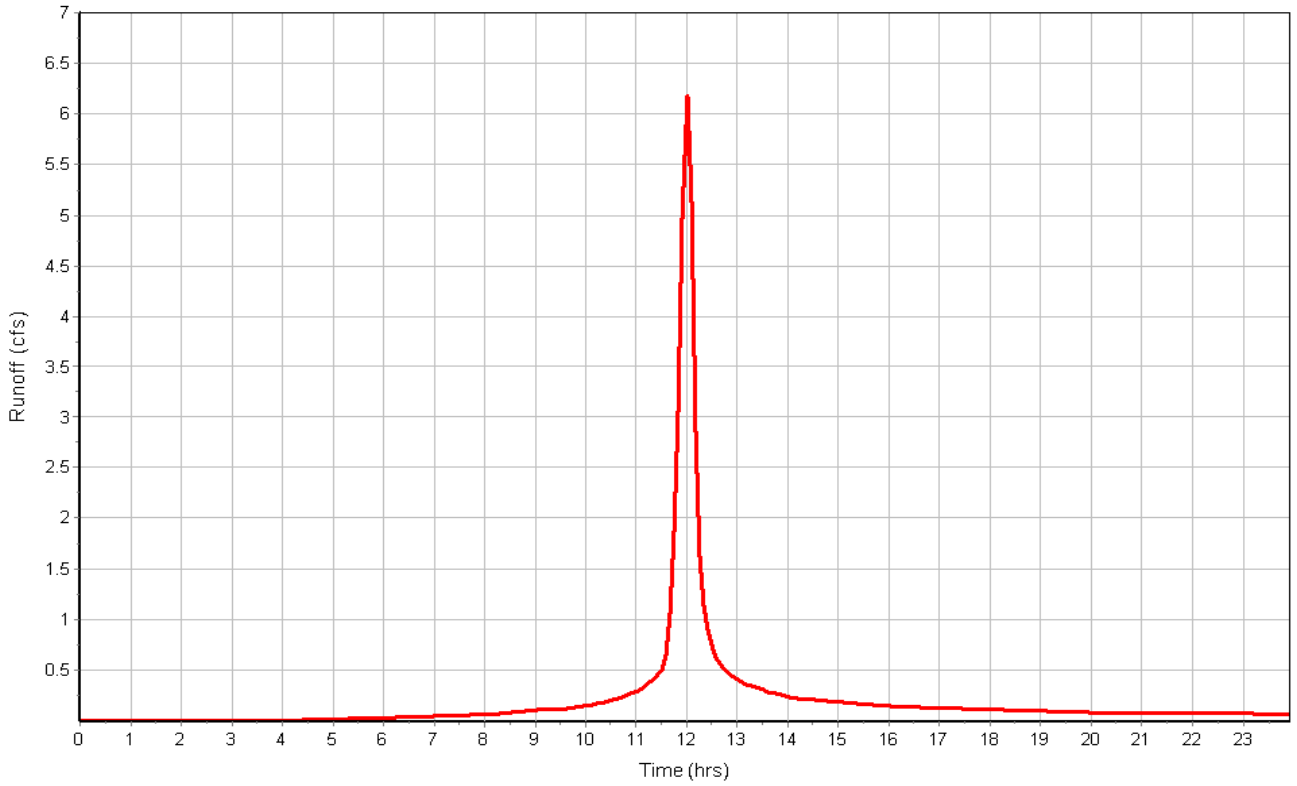
Total Rainfall (in) 5.30
Total Runoff (in) 4.17
Peak Runoff (cfs) 6.18
Weighted Curve Number 90.00
Time of Concentration (days hh:mm:ss) 0 00:11:59

Subbasin : ProS

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ProSE

Input Data

Area (ac) 0.60
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	0.60	C	90.00
Composite Area & Weighted CN	0.60		90.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.30	0.00
Flow Length (ft) :	70	70	0.00
Slope (%) :	1.0	1.0	0.00
2 yr, 24 hr Rainfall (in) :	3.50	3.50	0.00
Velocity (ft/sec) :	0.79	0.07	0.00
Computed Flow Time (min) :	1.47	16.18	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	120	0.00	0.00
Slope (%) :	2	0.00	0.00
Surface Type :	Grass pasture	ass pastu	Unpaved
Velocity (ft/sec) :	0.99	0.00	0.00
Computed Flow Time (min) :	2.02	0.00	0.00

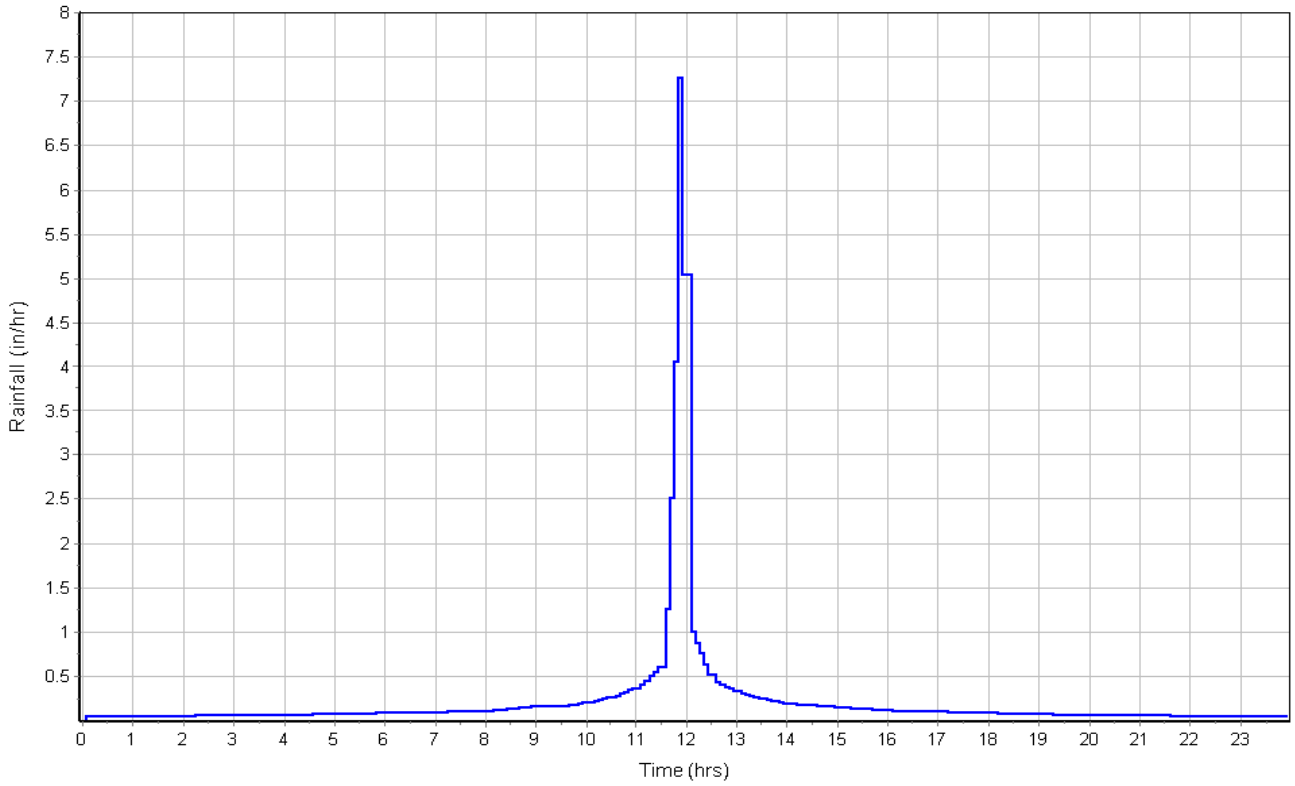
Total TOC (min) 9.84

Subbasin Runoff Results

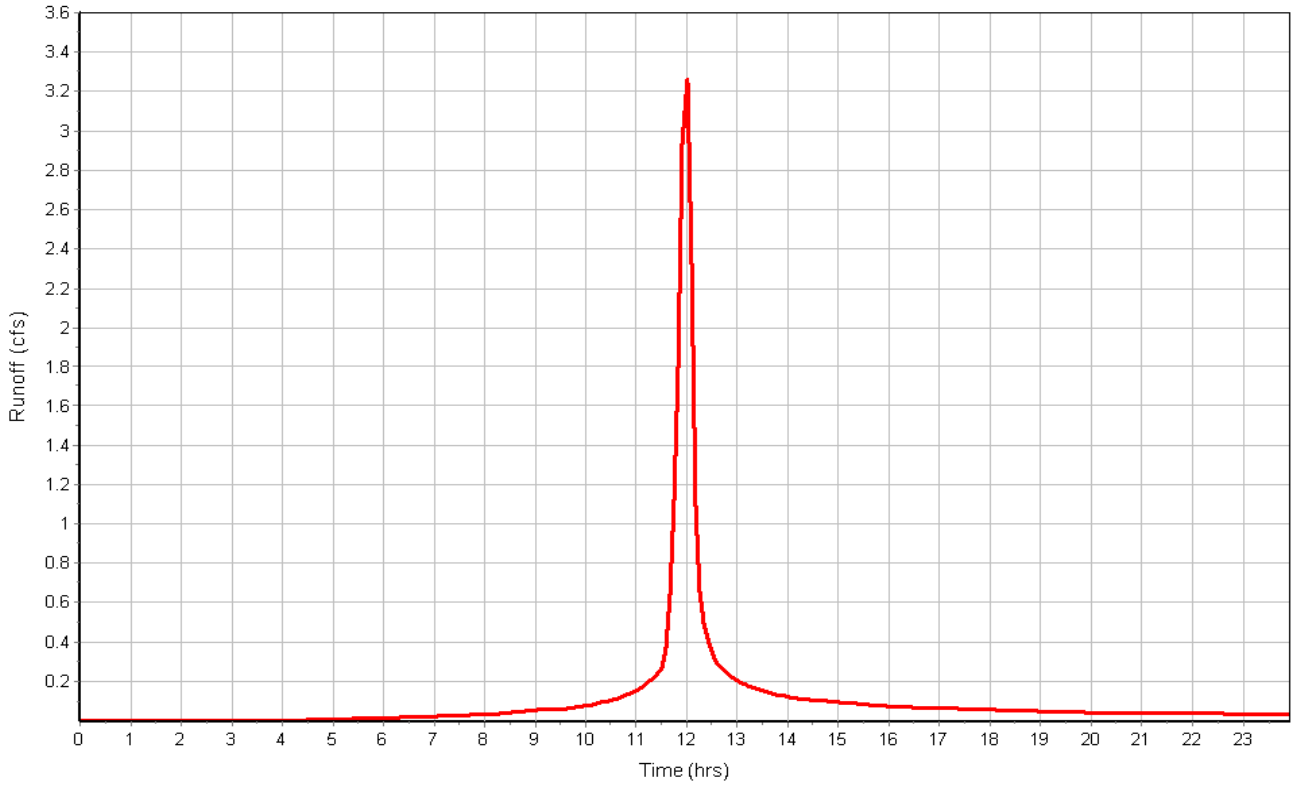
Total Rainfall (in) 5.30
Total Runoff (in) 4.17
Peak Runoff (cfs) 3.33
Weighted Curve Number 90.00
Time of Concentration (days hh:mm:ss) 0 00:09:50

Subbasin : ProSE

Rainfall Intensity Graph



Runoff Hydrograph



Project Description

File Name ..... Proposed.SPF

Project Options

Flow Units ..... CFS
Elevation Type ..... Elevation
Hydrology Method ..... SCS TR-55
Time of Concentration (TOC) Method ..... SCS TR-55
Link Routing Method ..... Kinematic Wave
Enable Overflow Ponding at Nodes ..... YES
Skip Steady State Analysis Time Periods ... NO

Analysis Options

Start Analysis On	Oct 16, 2018	00:00:00
End Analysis On	Oct 17, 2018	00:00:00
Start Reporting On	Oct 16, 2018	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins.....	3
Nodes.....	3
Junctions	0
Outfalls	3
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links.....	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	100-year	Cumulative	inches	Missouri	Jackson	100	7.70	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	ProNW	1.75	90.00	7.70	6.51	11.39	14.18	0 00:11:33
2	ProS	1.17	90.00	7.70	6.51	7.62	9.41	0 00:11:58
3	ProSE	0.60	90.00	7.70	6.51	3.91	5.07	0 00:09:50

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	NWoutfall	Outfall	0.00					0.00	0.00					
2	SEoutfall	Outfall	0.00					0.00	0.00					
3	Soutfall	Outfall	0.00					0.00	0.00					

Subbasin Hydrology

Subbasin : ProNW

Input Data

Area (ac) 1.75
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	1.75	C	90.00
Composite Area & Weighted CN	1.75		90.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.30	0.00	0.00
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	1.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	10.34	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	175	0.00	0.00
Slope (%) :	2.5	0.00	0.00
Surface Type :	Paved	Paved	Grass pasture
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.91	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.012	0.00	0.00
Flow Length (ft) :	117	0.00	0.00
Channel Slope (%) :	1.0	0.00	0.00
Cross Section Area (ft²) :	1.77	0.00	0.00
Wetted Perimeter (ft) :	4.71	0.00	0.00
Velocity (ft/sec) :	6.47	0.00	0.00
Computed Flow Time (min) :	0.30	0.00	0.00

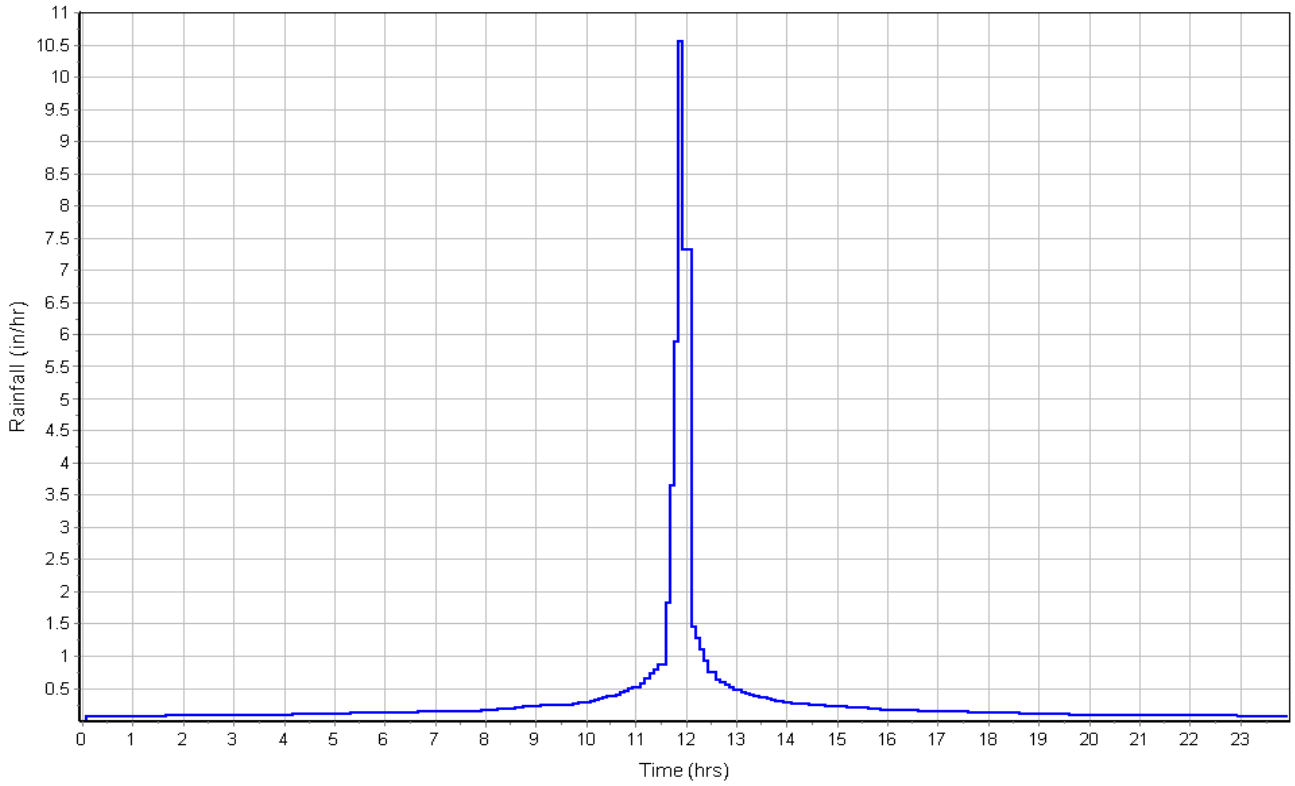
Total TOC (min) 11.55

Subbasin Runoff Results

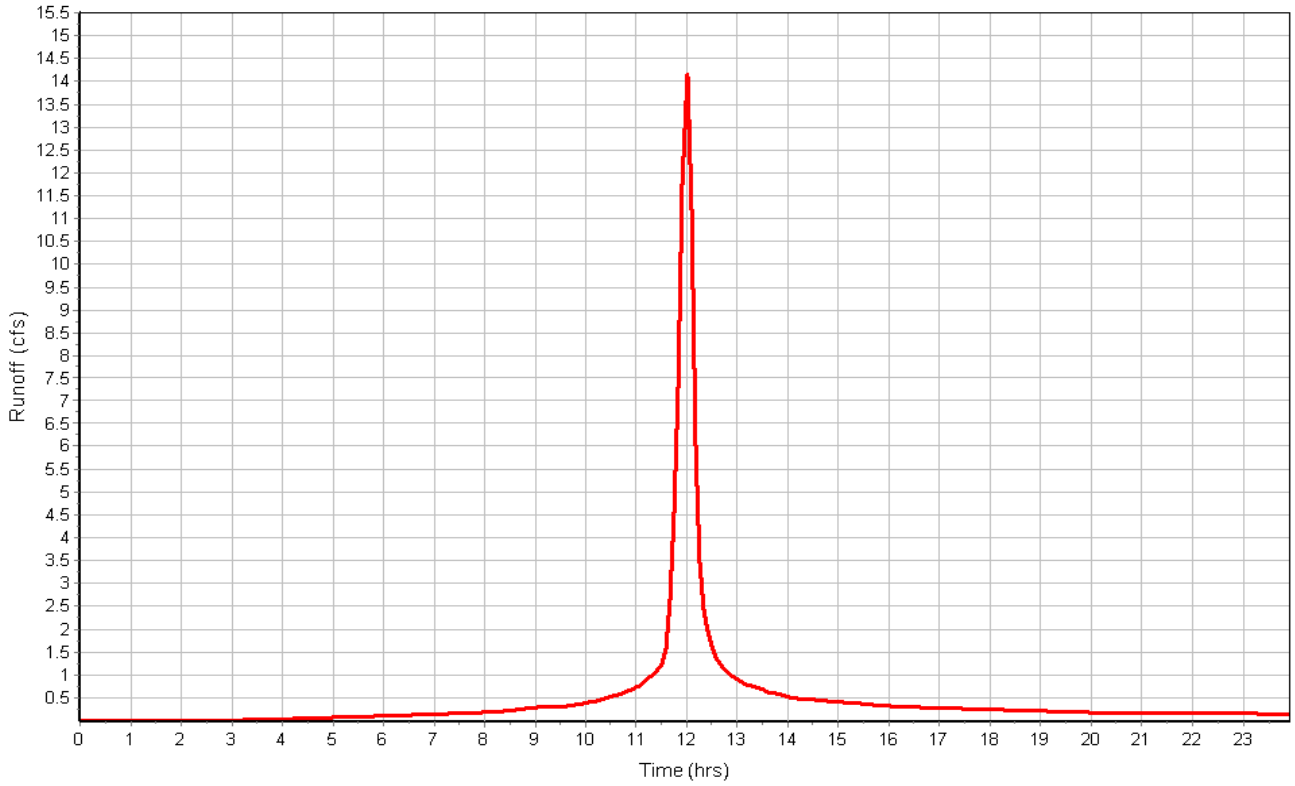
Total Rainfall (in)	7.70
Total Runoff (in)	6.51
Peak Runoff (cfs)	14.18
Weighted Curve Number	90.00
Time of Concentration (days hh:mm:ss)	0 00:11:33

Subbasin : ProNW

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ProS

Input Data

Area (ac) 1.17
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	1.17	C	90.00
Composite Area & Weighted CN	1.17		90.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.3	0.00	0.00
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	1.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.50	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	10.34	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	200	0.00	0.00
Slope (%) :	1.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.03	0.00	0.00
Computed Flow Time (min) :	1.64	0.00	0.00

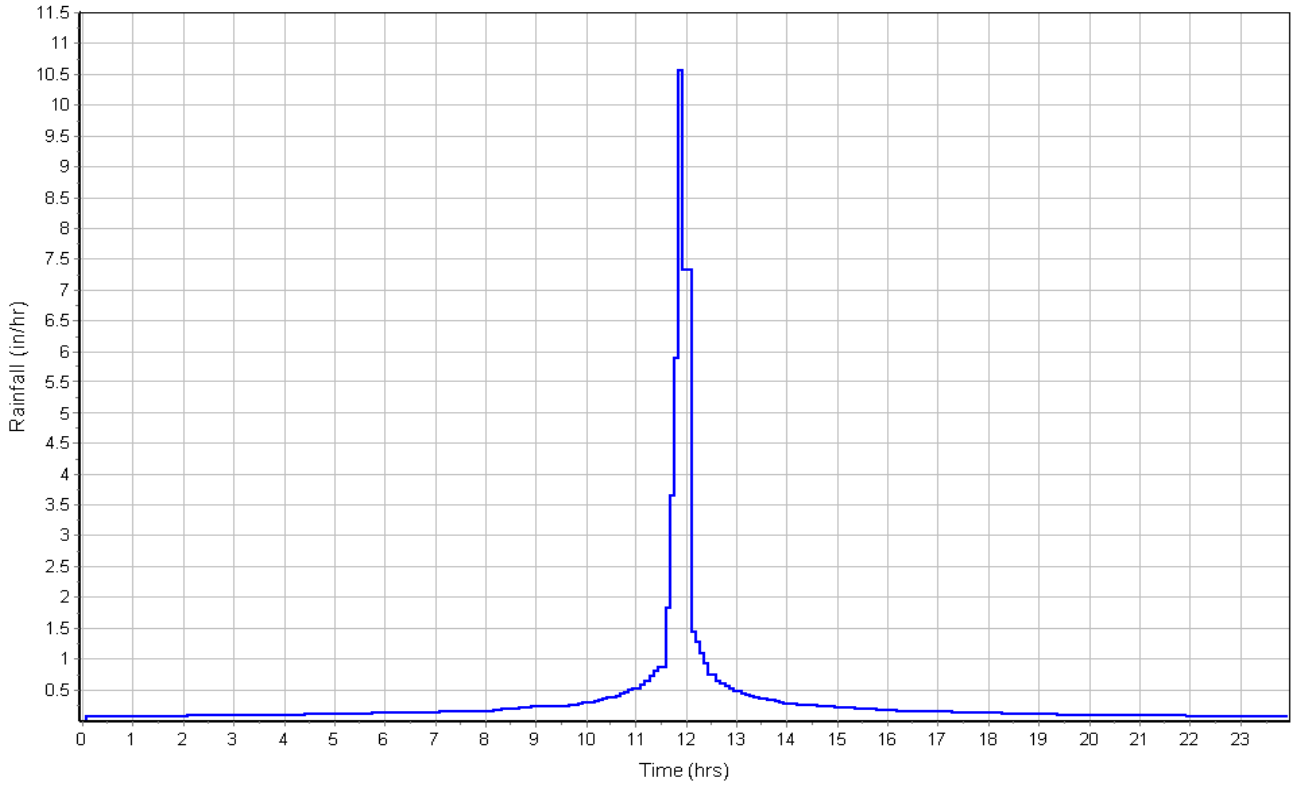
Total TOC (min) 11.98

Subbasin Runoff Results

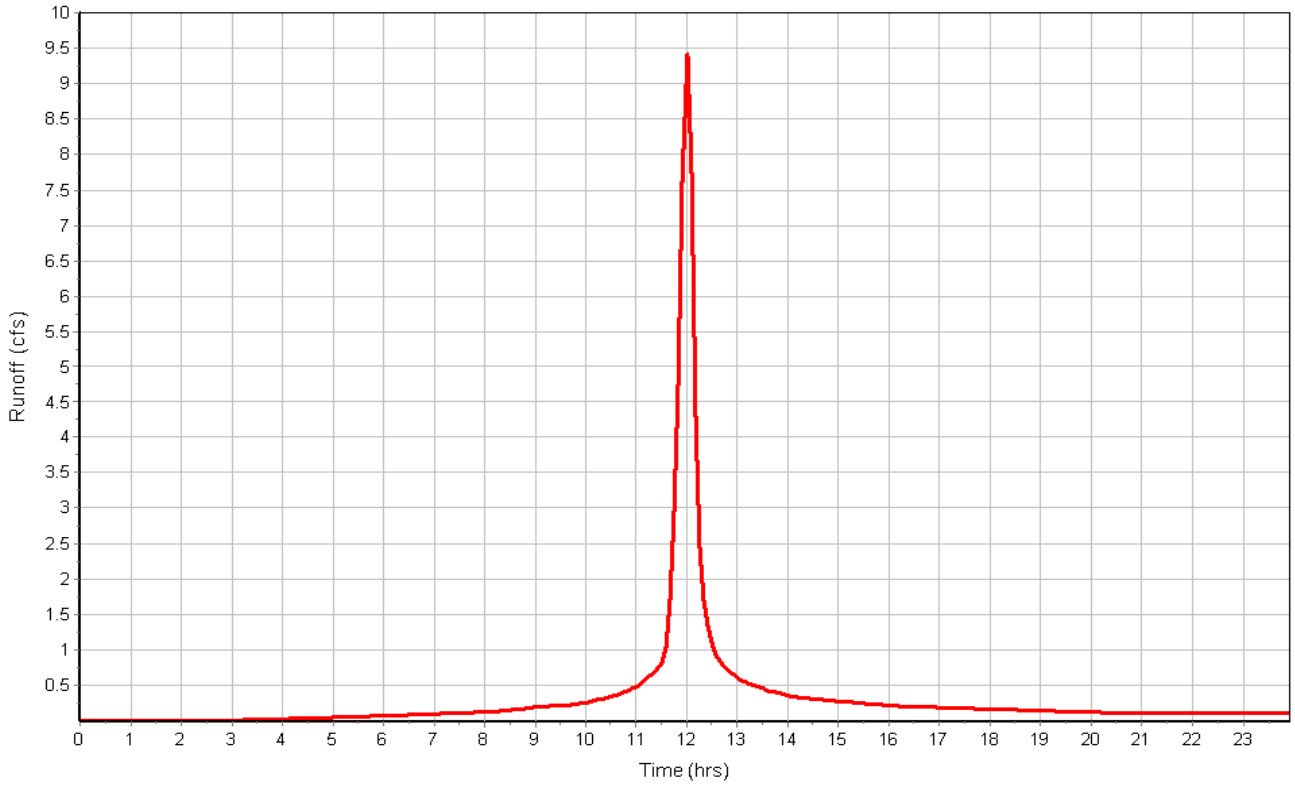
Total Rainfall (in) 7.70
Total Runoff (in) 6.51
Peak Runoff (cfs) 9.41
Weighted Curve Number 90.00
Time of Concentration (days hh:mm:ss) 0 00:11:59

Subbasin : ProS

Rainfall Intensity Graph



Runoff Hydrograph



Subbasin : ProSE

Input Data

Area (ac) 0.60
Weighted Curve Number 90.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
1/8 acre lots, 65% impervious	0.60	C	90.00
Composite Area & Weighted CN	0.60		90.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.30	0.00
Flow Length (ft) :	70	70	0.00
Slope (%) :	1.0	1.0	0.00
2 yr, 24 hr Rainfall (in) :	3.50	3.50	0.00
Velocity (ft/sec) :	0.79	0.07	0.00
Computed Flow Time (min) :	1.47	16.18	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	120	0.00	0.00
Slope (%) :	2	0.00	0.00
Surface Type :	Grass pasture	ass pastu	Unpaved
Velocity (ft/sec) :	0.99	0.00	0.00
Computed Flow Time (min) :	2.02	0.00	0.00

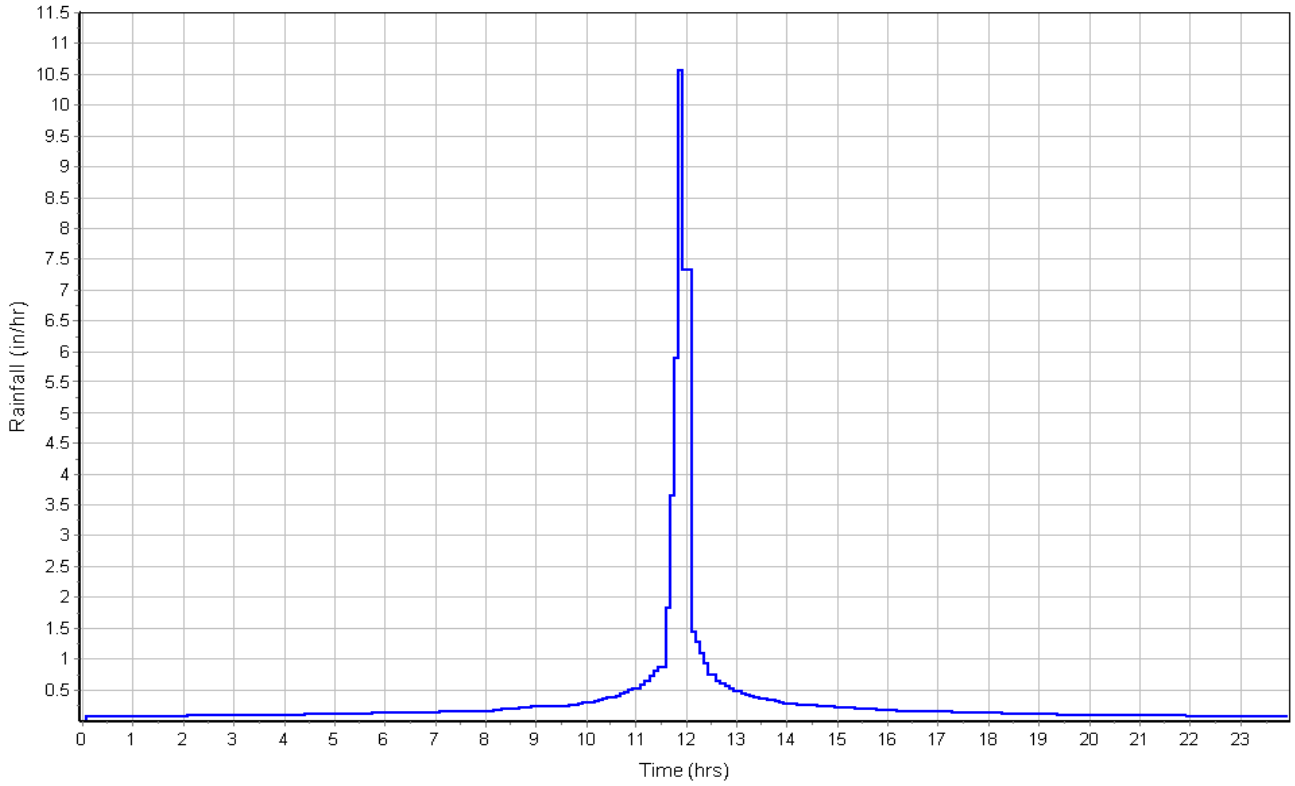
Total TOC (min) 9.84

Subbasin Runoff Results

Total Rainfall (in) 7.70
Total Runoff (in) 6.51
Peak Runoff (cfs) 5.07
Weighted Curve Number 90.00
Time of Concentration (days hh:mm:ss) 0 00:09:50

Subbasin : ProSE

Rainfall Intensity Graph



Runoff Hydrograph

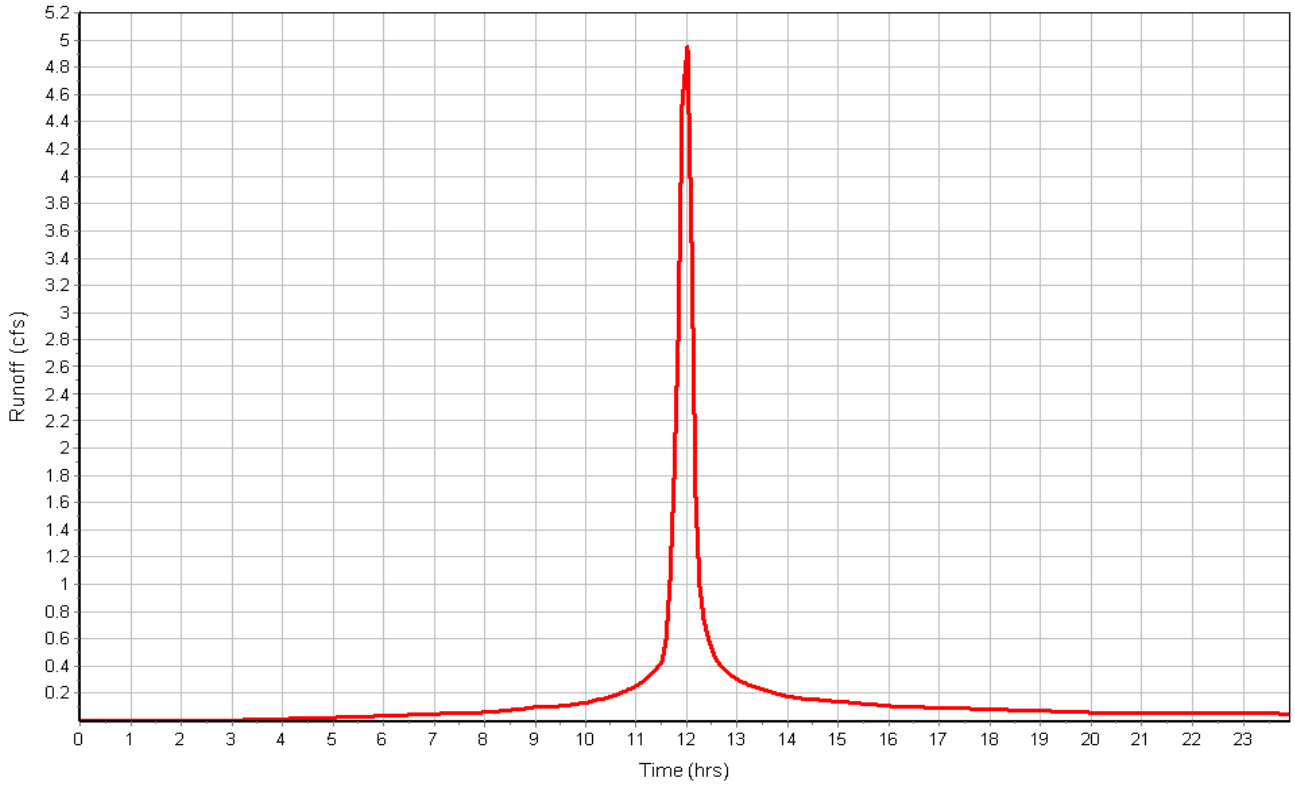


Exhibit H

Proposed Detention Stage-Storage Curves

Storage Nodes

Storage Node : NWpond

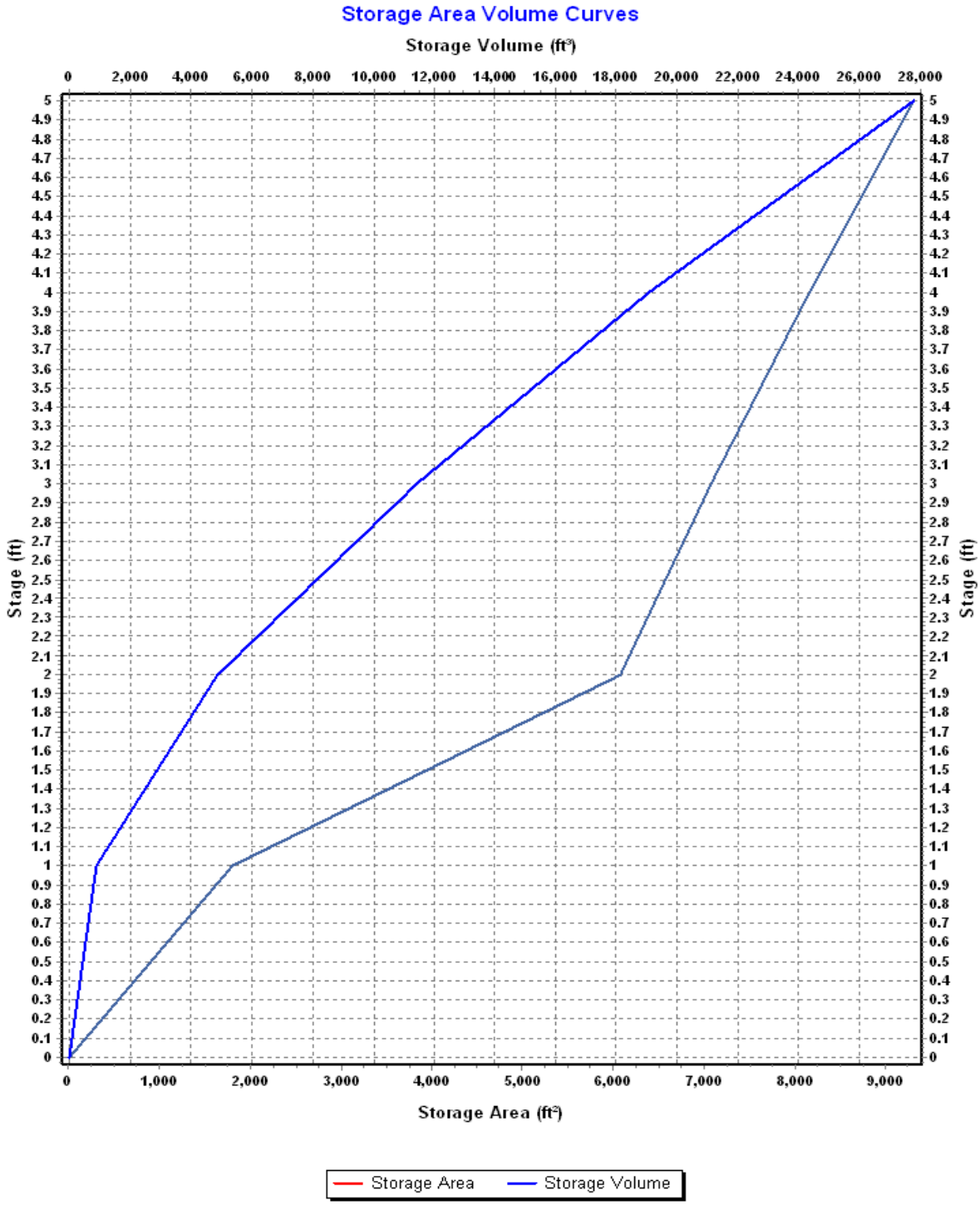
Input Data

Invert Elevation (ft)	1007.00
Max (Rim) Elevation (ft)	1012.10
Max (Rim) Offset (ft)	5.10
Initial Water Elevation (ft)	1007.00
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : NWpond

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	10	0.000
1	1810	910.00
2	6080	4855.00
3	7080	11435.00
4	8155	19052.50
5	9310	27785.00


Storage Area Volume Curves
Storage Volume (ft³)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
Stage (ft)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
Stage (ft)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : NWpond (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	NWweir	Trapezoidal	No	1011.00	4.00	100.00	1.10	3.33

Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	NW-12in	Side	CIRCULAR	No	12.00			1009.02	0.61
2	NW-WQoutlet	Side	CIRCULAR	No	4.00			1007.00	0.61

Output Summary Results

Peak Inflow (cfs)	5.61
Peak Lateral Inflow (cfs)	5.61
Peak Outflow (cfs)	0.87
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1009.23
Max HGL Depth Attained (ft)	2.23
Average HGL Elevation Attained (ft)	1007.51
Average HGL Depth Attained (ft)	0.51
Time of Max HGL Occurrence (days hh:mm)	0 12:29
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Spond

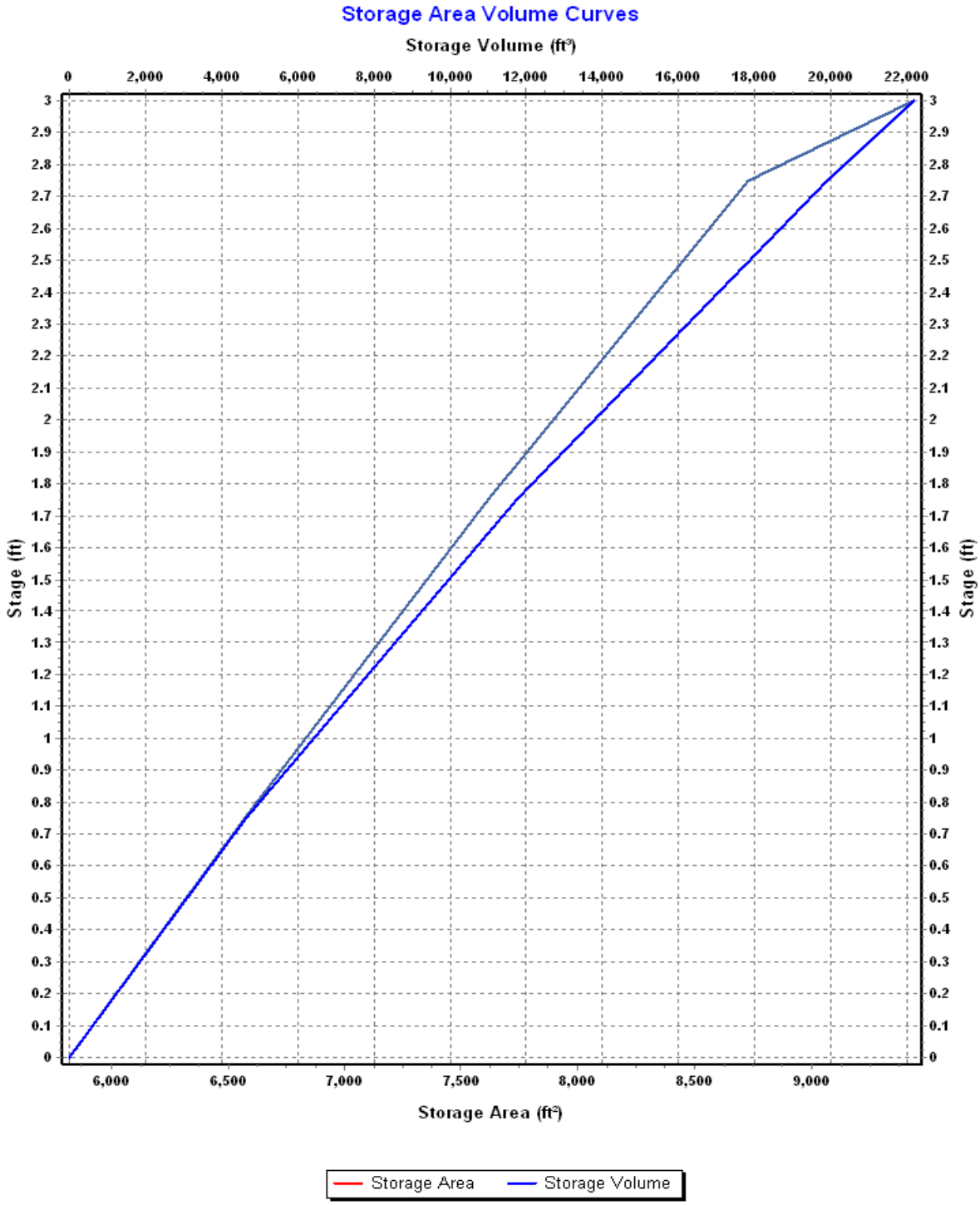
Input Data

Invert Elevation (ft)	1014.25
Max (Rim) Elevation (ft)	1017.60
Max (Rim) Offset (ft)	3.35
Initial Water Elevation (ft)	1014.25
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Spond

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	5820	0.000
0.75	6570	4646.25
1.75	7613	11737.75
2.75	8730	19909.25
3.0	9440	22180.50


Storage Area Volume Curves
Storage Volume (ft³)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
Stage (ft)
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6,000
6,500
7,000
7,500
8,000
8,500
9,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Spond (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	Swier	Trapezoidal	No	1016.50	2.25	75.00	1.10	3.33

Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	S-12in	Side	CIRCULAR	No	12.00			1014.95	0.61
2	S-WQoutlet	Side	CIRCULAR	No	4.00			1014.25	0.61

Output Summary Results

Peak Inflow (cfs)	3.72
Peak Lateral Inflow (cfs)	3.72
Peak Outflow (cfs)	0.52
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1015.10
Max HGL Depth Attained (ft)	0.85
Average HGL Elevation Attained (ft)	1014.48
Average HGL Depth Attained (ft)	0.23
Time of Max HGL Occurrence (days hh:mm)	0 12:32
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Nodes

Storage Node : NWpond

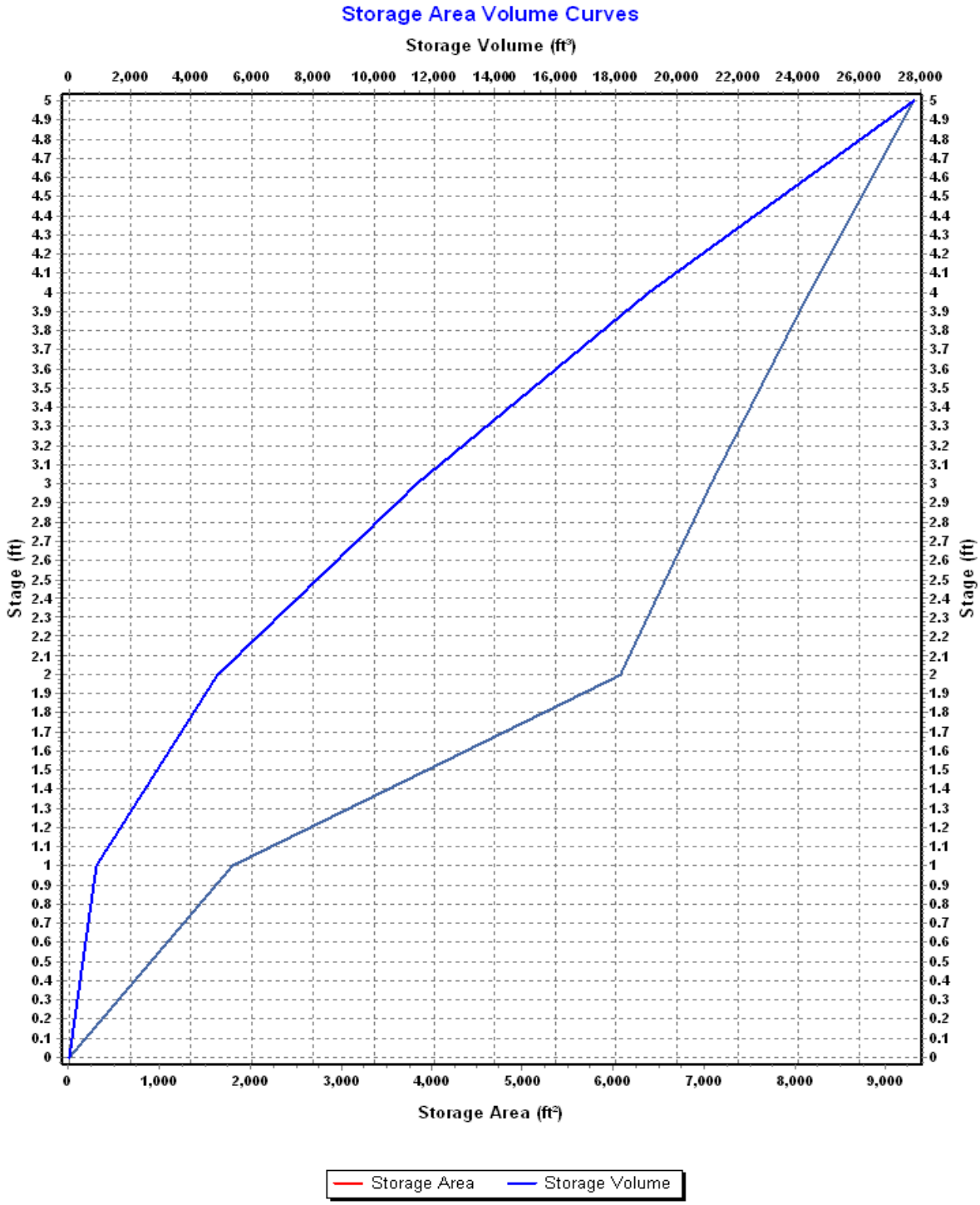
Input Data

Invert Elevation (ft)	1007.00
Max (Rim) Elevation (ft)	1012.10
Max (Rim) Offset (ft)	5.10
Initial Water Elevation (ft)	1007.00
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : NWpond

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	10	0.000
1	1810	910.00
2	6080	4855.00
3	7080	11435.00
4	8155	19052.50
5	9310	27785.00


Storage Area Volume Curves
Storage Volume (ft³)
0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000 18,000 20,000 22,000 24,000 26,000 28,000
Stage (ft)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 5
0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : NWpond (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	NWweir	Trapezoidal	No	1011.00	4.00	100.00	1.10	3.33

Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	NW-12in	Side	CIRCULAR	No	12.00			1009.02	0.61
2	NW-WQoutlet	Side	CIRCULAR	No	4.00			1007.00	0.61

Output Summary Results

Peak Inflow (cfs)	9.30
Peak Lateral Inflow (cfs)	9.30
Peak Outflow (cfs)	2.59
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1009.80
Max HGL Depth Attained (ft)	2.8
Average HGL Elevation Attained (ft)	1007.70
Average HGL Depth Attained (ft)	0.7
Time of Max HGL Occurrence (days hh:mm)	0 12:19
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Spond

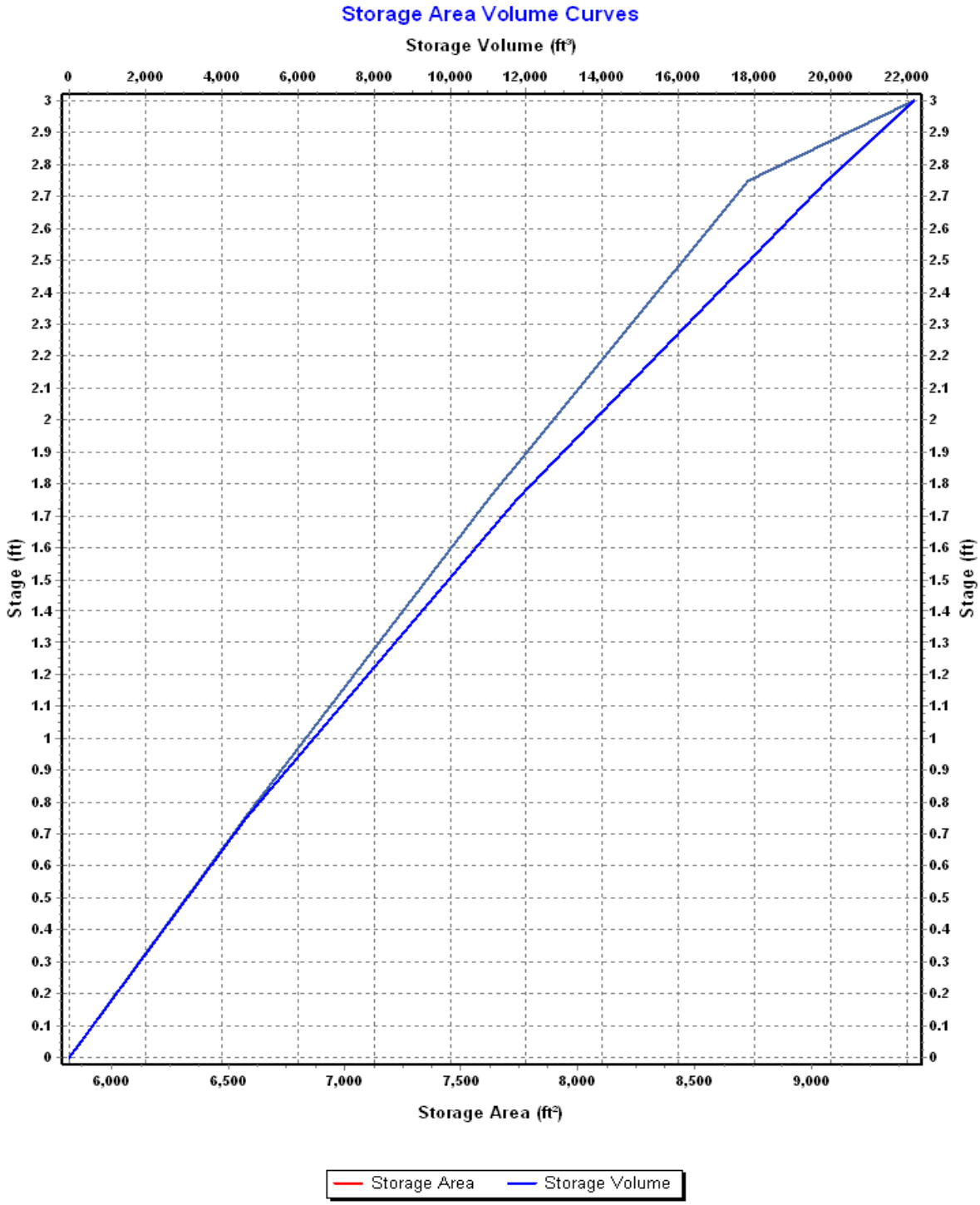
Input Data

Invert Elevation (ft)	1014.25
Max (Rim) Elevation (ft)	1017.60
Max (Rim) Offset (ft)	3.35
Initial Water Elevation (ft)	1014.25
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Spond

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	5820	0.000
0.75	6570	4646.25
1.75	7613	11737.75
2.75	8730	19909.25
3.0	9440	22180.50


Storage Area Volume Curves
Storage Volume (ft³)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
Stage (ft)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
6,000
6,500
7,000
7,500
8,000
8,500
9,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Spond (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	Swier	Trapezoidal	No	1016.50	2.25	75.00	1.10	3.33

Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	S-12in	Side	CIRCULAR	No	12.00			1014.95	0.61
2	S-WQoutlet	Side	CIRCULAR	No	4.00			1014.25	0.61

Output Summary Results

Peak Inflow (cfs)	6.18
Peak Lateral Inflow (cfs)	6.18
Peak Outflow (cfs)	1.65
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1015.53
Max HGL Depth Attained (ft)	1.28
Average HGL Elevation Attained (ft)	1014.56
Average HGL Depth Attained (ft)	0.31
Time of Max HGL Occurrence (days hh:mm)	0 12:20
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Nodes

Storage Node : NWpond

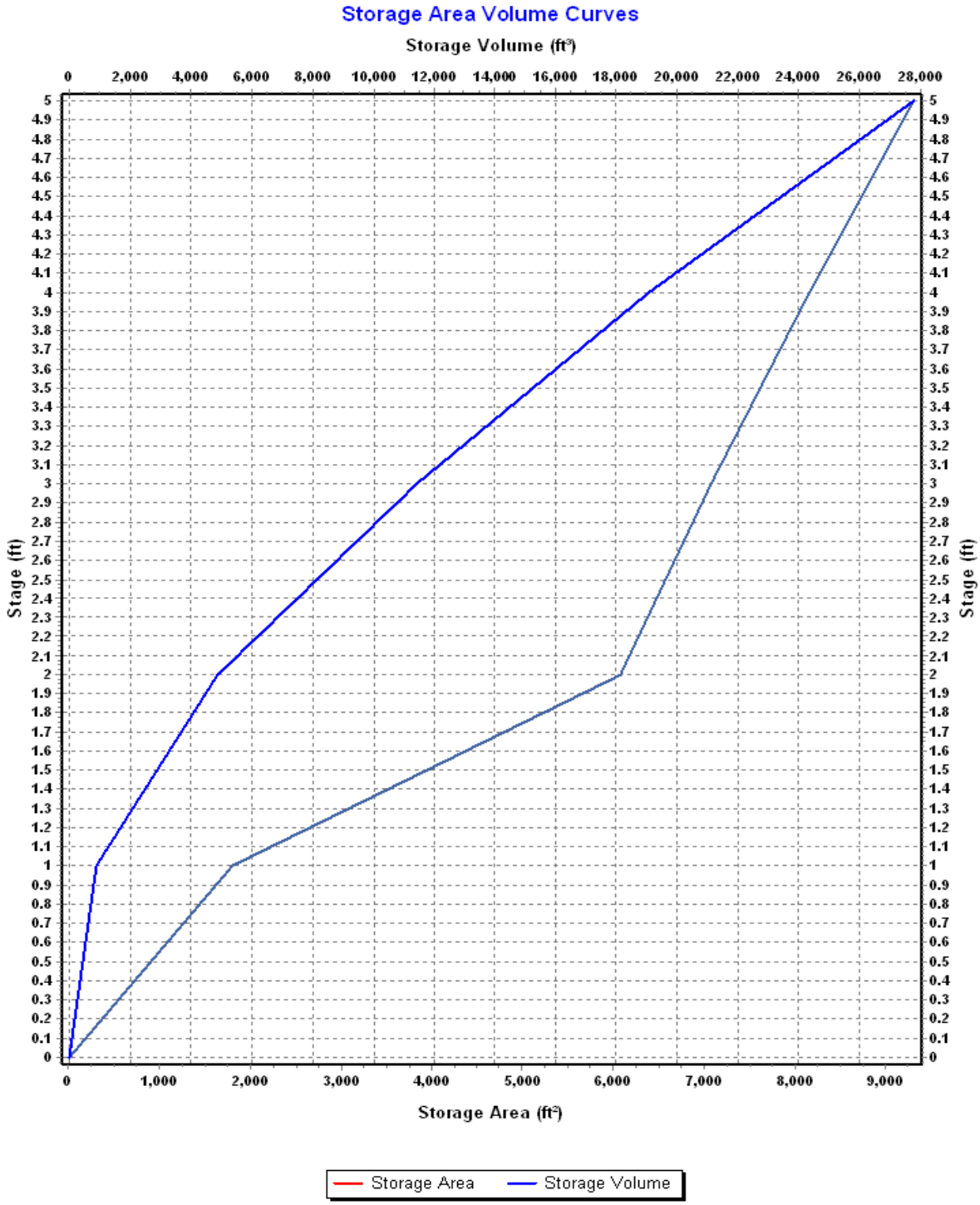
Input Data

Invert Elevation (ft)	1007.00
Max (Rim) Elevation (ft)	1012.10
Max (Rim) Offset (ft)	5.10
Initial Water Elevation (ft)	1007.00
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : NWpond

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	10	0.000
1	1810	910.00
2	6080	4855.00
3	7080	11435.00
4	8155	19052.50
5	9310	27785.00


Storage Area Volume Curves
Storage Volume (ft³)
0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000 18,000 20,000 22,000 24,000 26,000 28,000
Stage (ft)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 5
0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : NWpond (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	NWweir	Trapezoidal	No	1011.00	4.00	100.00	1.10	3.33

Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	NW-12in	Side	CIRCULAR	No	12.00			1009.02	0.61
2	NW-WQoutlet	Side	CIRCULAR	No	4.00			1007.00	0.61

Output Summary Results

Peak Inflow (cfs)	14.15
Peak Lateral Inflow (cfs)	14.15
Peak Outflow (cfs)	4.62
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1010.50
Max HGL Depth Attained (ft)	3.5
Average HGL Elevation Attained (ft)	1007.92
Average HGL Depth Attained (ft)	0.92
Time of Max HGL Occurrence (days hh:mm)	0 12:18
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Spond

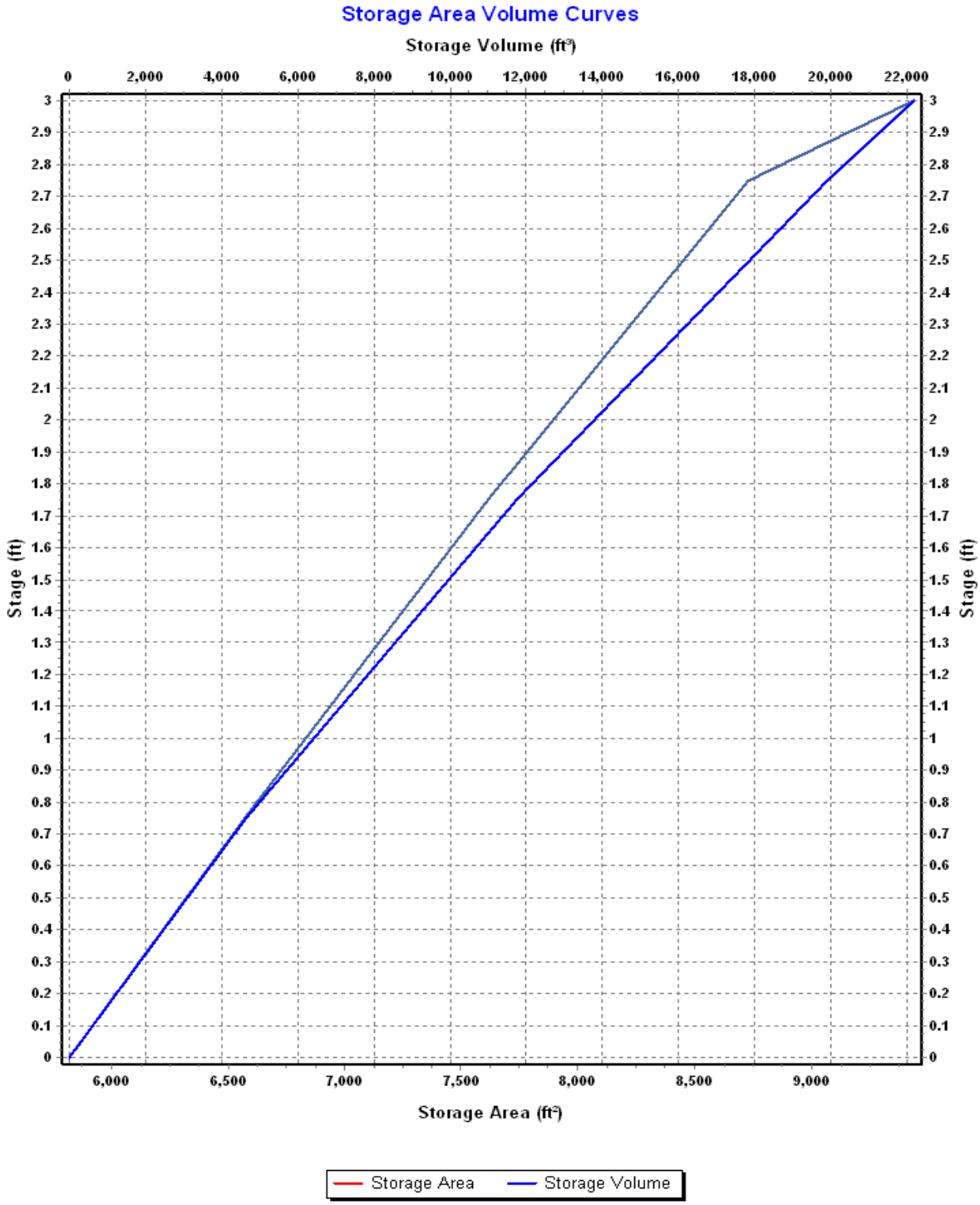
Input Data

Invert Elevation (ft)	1014.25
Max (Rim) Elevation (ft)	1017.60
Max (Rim) Offset (ft)	3.35
Initial Water Elevation (ft)	1014.25
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Spond

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	5820	0.000
0.75	6570	4646.25
1.75	7613	11737.75
2.75	8730	19909.25
3.0	9440	22180.50


Storage Area Volume Curves
Storage Volume (ft³)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
Stage (ft)
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6,000
6,500
7,000
7,500
8,000
8,500
9,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Spond (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	Swier	Trapezoidal	No	1016.50	2.25	75.00	1.10	3.33

Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	S-12in	Side	CIRCULAR	No	12.00			1014.95	0.61
2	S-WQoutlet	Side	CIRCULAR	No	4.00			1014.25	0.61

Output Summary Results

Peak Inflow (cfs)	9.41
Peak Lateral Inflow (cfs)	9.41
Peak Outflow (cfs)	3.40
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1016.00
Max HGL Depth Attained (ft)	1.75
Average HGL Elevation Attained (ft)	1014.65
Average HGL Depth Attained (ft)	0.4
Time of Max HGL Occurrence (days hh:mm)	0 12:18
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Nodes

Storage Node : NWpond

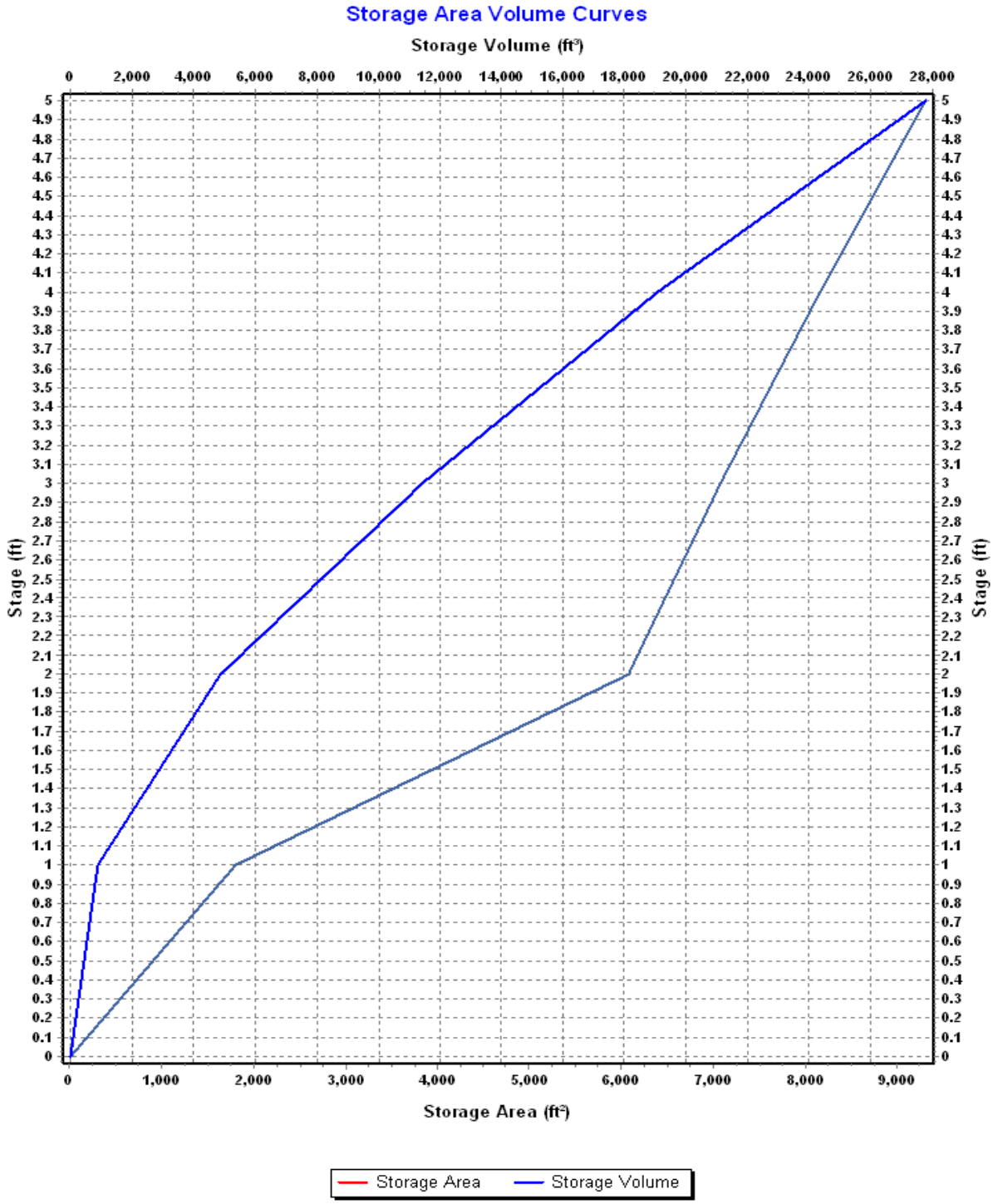
Input Data

Invert Elevation (ft)	1007.00
Max (Rim) Elevation (ft)	1012.10
Max (Rim) Offset (ft)	5.10
Initial Water Elevation (ft)	1007.00
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : NWpond

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	10	0.000
1	1810	910.00
2	6080	4855.00
3	7080	11435.00
4	8155	19052.50
5	9310	27785.00


Storage Area Volume Curves
Storage Volume (ft³)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
Stage (ft)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : NWpond (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	NWweir	Trapezoidal	No	1011.00	4.00	103.00	1.10	3.33

Output Summary Results

Peak Inflow (cfs)	14.10
Peak Lateral Inflow (cfs)	14.10
Peak Outflow (cfs)	11.59
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1011.10
Max HGL Depth Attained (ft)	4.1
Average HGL Elevation Attained (ft)	1009.45
Average HGL Depth Attained (ft)	2.45
Time of Max HGL Occurrence (days hh:mm)	0 12:10
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : Spond

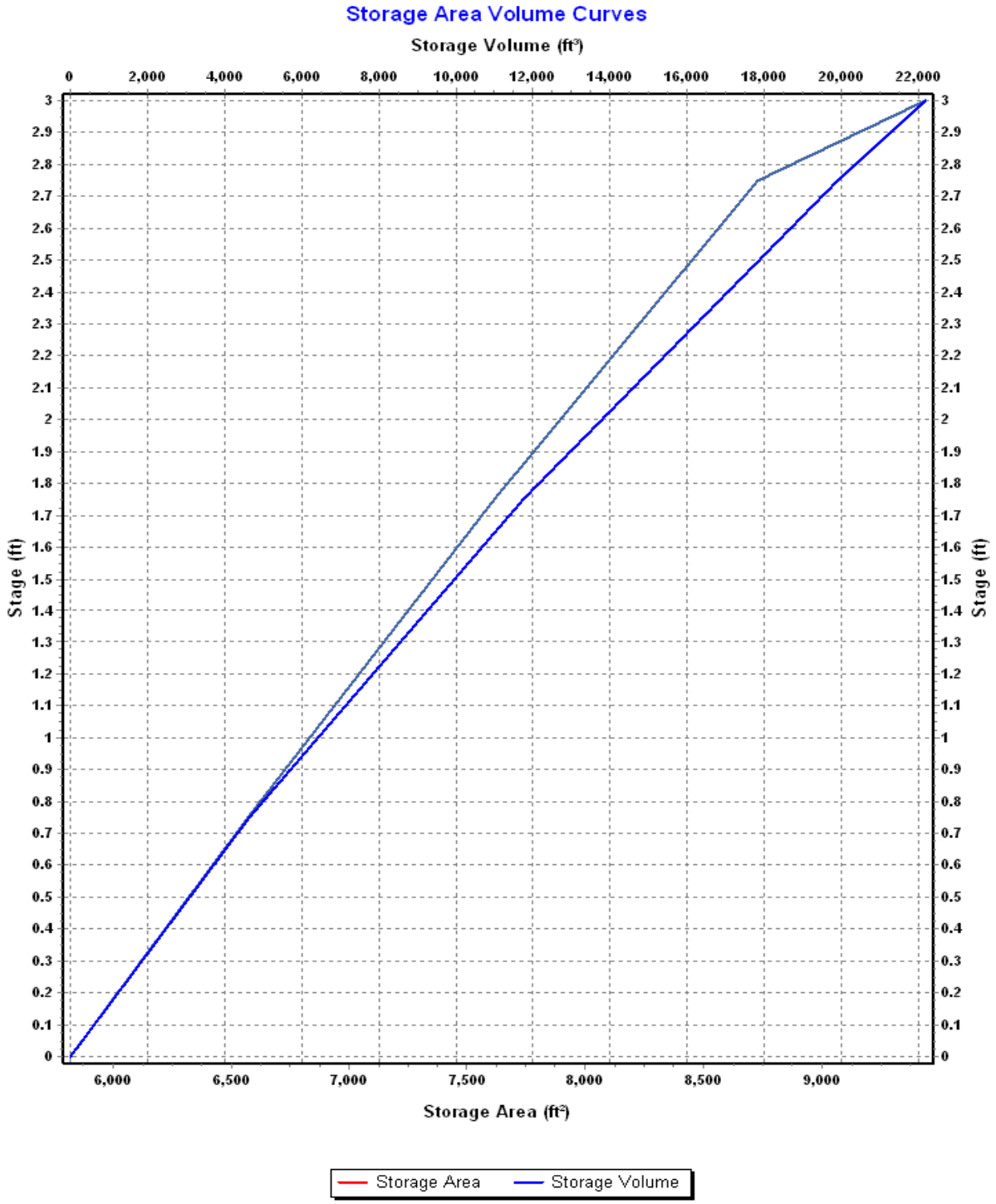
Input Data

Invert Elevation (ft)	1014.25
Max (Rim) Elevation (ft)	1017.60
Max (Rim) Offset (ft)	3.35
Initial Water Elevation (ft)	1014.25
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	0.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : Spond

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	5820	0.000
0.75	6570	4646.25
1.75	7613	11737.75
2.75	8730	19909.25
3.0	9440	22180.50


Storage Area Volume Curves
Storage Volume (ft³)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
Stage (ft)
Stage (ft)
6,000
6,500
7,000
7,500
8,000
8,500
9,000
Storage Area (ft²)
Storage Area
Storage Volume

Storage Node : Spond (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	Swier	Trapezoidal	No	1016.50	2.25	75.00	1.10	3.33

Output Summary Results

Peak Inflow (cfs)	9.41
Peak Lateral Inflow (cfs)	9.41
Peak Outflow (cfs)	3.52
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1016.56
Max HGL Depth Attained (ft)	2.31
Average HGL Elevation Attained (ft)	1015.46
Average HGL Depth Attained (ft)	1.21
Time of Max HGL Occurrence (days hh:mm)	0 12:17
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Exhibit I

MARC BMP Worksheets

WORKSHEET 1A: REQUIRED LEVEL OF SERVICE - DEVELOPED SITE

Project:	18-0251 Burton Townhomes	By:	JGD	Date:	1/18/2019
Location:	Lee's Summit, MO	Checked:	MES	Date:	1/18/2019

1. Required Treatment Area

A. Total Area Disturbed by Redevelopment Activity (ac.)

Disturbed Area Description	Acres
Existing Single Family Residential Lots	3.52
"1A" Total:	3.52

B. Existing Impervious Area Inside Disturbed Area (ac.)

Existing Impervious Area Description	Acres
Driveways	0.13
House and Garage	0.05
"1B" Total:	0.18

C. Required Treatment Area (ac.)

"1A" Total Less "1B" Total **"1C"** 3.34

2. Percent Impervious in Postdevelopedment Conditions and Level of Service (LS)

A. Total Postdevelopment Impervious Area Inside Disturbed Area (ac.)

Postdevelopment Impervious Area Description	Acres
Parking/Roof/Impervious Area	1.70
"2A" Total:	1.70

B. Existing Impervious Area Inside Disturbed Area (ac.)

"1B" Total 0.18

C. Net Increase in Impervious Area (ac.)

"2A" Total Less "1B" Total **"2C"** 1.52

D. Percent Impervious

Net Increase in Impervious Area/Required Treatment Area

"2C"/"1C" x 100 **"2C"** 46 (Round to Integer)

E. Level of Service

Use Percent Impervious to Enter Table 4. **LS =** 5.5

3. Minimum Required Total Value Rating of BMP Package

Total Value Rating = LS x Required Treatment Are

LS x "1C" **VR =** 18.37

WORKSHEET 2: DEVELOP MITIGATION PACKAGE(S) THAT MEET THE REQUIRED LS

Project:	18-0251 Burton Townhomes	By:	JGD	Date:	1/18/2019
Location	Lee's Summit, MO	Checked:	MES	Date:	1/18/2019

Sheet __ of __

1. Required LS (New Development, Wksht 1) or Total VR (Redevelopment, Wksht 1A) 18.37

Note: Various BMPs may alter CN of proposed development, and LS; recalculate bith if applicable.

2. Proposed BMP Option Package No. **1**

Cover/BMP Description	Treatment Area	VR from Table 4.4 or 4.6[1]	Product of VR x Area
Extended Dry Detention	1.75	4	7
EDD to Vegatative Swale	1.17	7	8.19
Native Vegation	0.6	9.25	5.55
			0
			0
Total[2]:	3.52	**Total:**	20.74
		***Weighted VR:**	= total product/total area

[1] VR calculated for final BMP only in Treatment Train

[2] Total treatment area cannot exceed 100 percent of the actual site area

* Blank in Redevelopment

Meets required LS (Yes/No)? **Yes** (If No, or if additional options are being tested, proceed below)

3. Proposed BMP Option Package No. **2**

Cover/BMP Description	Treatment Area	VR from Table 4.4 or 4.6[1]	Product of VR x Area
Total[2]:		**Total:**	
		***Weighted VR:**	= total product/total area

[1] VR calculated for final BMP only in Treatment Train

[2] Total treatment area cannot exceed 100 percent of the actual site area

* Blank in Redevelopment

Meets required LS (Yes/No)? (If No, or if additional options are being tested, move to next sheet)

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed NW Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

I. Water Quality Volume

	Rational C =	0.65
Step 1) Tributary area to EDDC, A_T (ac)	A_T (ac) =	1.75
Step 2) Calculate WQv using methodology in Section 6	WQv (ac-ft) =	0.13
Step 3) Add 20 percent to account for silt and sediment deposition in the basin	V_{design} (ac-ft) =	0.16

IIa. Pretreatment

Step 1) Set water quality outlet type — Outlet type = 2

Type 1 = single orifice
Type 2 = perforated riser or plate
Type 3 = v-notch weir

Step 3) Proceed to Part IIb, IIc or IId based on water qulity outlet type selected

IIb. Water Quality Outlet, Single Orifice

Step 1) Depth of water quality volume and outlet, Z_{WQ} (ft) — Z_{WQ} (ft) = 1.65

Step 2) Average head of water quality volume over invert of orifice, H_{WQ} (ft) — H_{WQ} (ft) = 0.83

$H_{WQ} = 0.5 * Z_{WQ}$

Step 3) Average water quality outfall rate, Q_{WQ} (cfs) — C_{WQ} (cfs) = 0.04

$Q_{WQ} = (WQ_V * 43{,}560)/(40 * 3{,}600)$

Step 4) Set Value of orifice discharge coefficient, C_0 — C_0 = 0.66

C_0 = 0.66 when thickness of riser/weir plate it ≤ orifice diameter
C_0 = 0.80 when thickness of riser/weir plate it ≥ orifice diameter

Step 5) Water quality outlet orifice diameter (minimum of 4 inches), D_0 (in) — D_0 (in) = 1.24

$D_0 = 12 * 2 * (Q_{WQ} / (C_0 * \pi * (2*g*H)^{0.5}))^{0.5}$

Step 6) To size outlet orifice for EDDB with an irregular stage-volume relationship, use the Single Orifice Worksheet

IIc. Water Quality Outlet, Perforated Riser

Step 1) Depth at outlet above lowest perforateion, Z_{WQ} (ft) — Z_{WQ} (ft) = 1.65

Step 2) Recommended maximum outlet area per row, A_0 (in^2) — A_0 (in^2) = 0.4

$A_0 = (WQ_V)/(0.013*Z_{WQ}^2+0.22*Z_{WQ}-0.10)$

Step 3) Circular perforation diameter per row assuming a single column, D_1 (in) — D_1 (in) = 0.75

Step 4) Number of columns, n_c — n_c = 2.00

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed NW Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

Step 5) Design circular perforation diameter (should be between 1 and 2 inches), D_{perf} (in)	D_{perf} (in) =	1.51
Step 6) Horizontal perforation column spacing when $n_c > 1$, center to center, S_c If $D_{perf} \geq 1.0$ inche, $S_c = 4$		
Step 7) Number of rows (4" vertical spacing between perforations, center to center), n_r	n_r =	5

IId. Other Pretreatment Devices

Step 1) Depth of water quality volume permanent pool, Z_{WQ} (ft)	Z_{WQ} (ft) =	1.65
Step 2) Average head of water quality pool volume over invert of v-notch, H_{WQ} (ft) $H_{WQ} = 0.5 * Z_{WQ}$	H_{WQ} (ft) =	0.83
Step 3) Average water quality pool outfall rate, Q_{WQ} (cfs) $Q_{WQ} = (WQ_V * 43{,}560)/(40 * 3{,}600)$	Q_{WQ} (cfs) =	0.04
Step 4) V-notch weir coefficient, C_V	C_V =	2.50
Step 5) V-notch weir angle, θ (deg) $\theta = 2*(180/\pi)*\arctan(Q_{WQ}/(C_v*H_{WQ}^{5/2}))$ V-notch angle should be at least 20 degrees. Set to 20 degrees if calculated angle is smaller.	θ (deg) =	20.0
Step 6) Top width of V-notch weir, W_v (ft) $W_v = 2*Z_{WQ}*\text{Tan}(\theta/2)$	W_v (ft) =	0.55
Step 7) To calculate v-notch angle for EDDB with an irregular stage-volume relationship, use the V-notch Weir worksheet		

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed NW Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

III. Flood Control

Reference APWA Specifications Section 5608

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed NW Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

IV. Trash Rock

Step 1) Total outlet area, A_0 (in^2)	A_{0t} (in^2) =	2.2
Step 2) Depth of gravel blanket, Z_{gravel} (in)		
$A_t = A_{0t}*77*e^{-0.124*D}$ for single orifice outlet	A_t (in^2) =	154
$A_t = (A_{0t}/2)*77*e^{-0.124*D}$ for orifice plate outlet	A_t (in^2) =	77
$A_t = 4*A_{0t}$ for v-notch weir outlet	A_t (in^2) =	9

V. Basin Shape

Step 1) Length to width ratio should be at least 3:1 (L:W) wherever practicable	(L:W) =	4:1
Step 2) Low flow channel side lining	Concrete:	
	Soil/Riprap:	
	No low flow channel:	X
Step 3) Top stage floor drainage slope (toward low flow channel), S_{ts} (%)	S_{ts} (%) =	2%
Top stage depth, D_{ts} (ft)	Dts (ft) =	5
Step 4) Bottom stage volume, V_{bs} (ac-ft)	V_{bs} (% of WQ_V)	10%
1.25 to 3ft deeper than top stage. Bottom stage shall store 10-25% of WQ_v.	V_{bs} (ac-ft)	0.50

VI. Forebay (Optional)

Step 1) Volume should be greater than 10% of WQ_v	Min Vol_{FB} (ac-ft) =	0.02
Step 2) Forebay depth, Z_{FB} (ft)	Z_{FB} (ft) =	1.0
Step 3) Forebay surface area, A_{FB} (ac)	Min A_{FB} (ac) =	0.02
	Min A_{FB} (ft) =	693.69
Step 4) Paved/hardbottom and sides?	Y/N?	N

VI. Basin Side Slopes

Base side slopes should be at least 4:1 (H:V)	Side Slope (H:V) =	4:1

VII. Dam Embankment side slopes

Dam embankment side slopes should be at least 3:1 (H:V)	Dam Embankment (H:V) =	4:1

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed NW Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

IX. Vegetation

Check the method of vegetation planted in the EDDB or describe "other"	Native Grass:	X
	Irrigated Turf Grass:	
	Other:	

X. Inlet Protection

Indicate method of inlet protection/energy dissipation at EDDB inlet	Rip Rap Rock

XI. Access

Indicate that access has been provided for maintenance vehicals	Yes

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed S Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

I. Water Quality Volume

	Rational C =	0.65
Step 1) Tributary area to EDDC, A_T (ac)	A_T (ac) =	1.17
Step 2) Calculate WQv using methodology in Section 6	WQv (ac-ft) =	0.09
Step 3) Add 20 percent to account for silt and sediment deposition in the basin	V_{design} (ac-ft) =	0.11

IIa. Pretreatment

Step 1) Set water quality outlet type — Outlet type = 2

Type 1 = single orifice
Type 2 = perforated riser or plate
Type 3 = v-notch weir

Step 3) Proceed to Part IIb, IIc or IId based on water qulity outlet type selected

IIb. Water Quality Outlet, Single Orifice

Step 1) Depth of water quality volume and outlet, Z_{WQ} (ft) — Z_{WQ} (ft) = 0.65

Step 2) Average head of water quality volume over invert of orifice, H_{WQ} (ft) — H_{WQ} (ft) = 0.33

$H_{WQ} = 0.5 * Z_{WQ}$

Step 3) Average water quality outfall rate, Q_{WQ} (cfs) — C_{WQ} (cfs) = 0.03

$Q_{WQ} = (WQ_V * 43{,}560)/(40 * 3{,}600)$

Step 4) Set Value of orifice discharge coefficient, C_0 — C_0 = 0.66

C_0 = 0.66 when thickness of riser/weir plate it ≤ orifice diameter
C_0 = 0.80 when thickness of riser/weir plate it ≥ orifice diameter

Step 5) Water quality outlet orifice diameter (minimum of 4 inches), D_0 (in) — D_0 (in) = 1.28

$D_0 = 12 * 2 * (Q_{WQ} / (C_0 * \pi * (2*g*H)^{0.5}))^{0.5}$

Step 6) To size outlet orifice for EDDB with an irregular stage-volume relationship, use the Single Orifice Worksheet

IIc. Water Quality Outlet, Perforated Riser

Step 1) Depth at outlet above lowest perforateion, Z_{WQ} (ft) — Z_{WQ} (ft) = 1.65

Step 2) Recommended maximum outlet area per row, A_0 (in^2) — A_0 (in^2) = 0.3

$A_0 = (WQ_V)/(0.013*Z_{WQ}^2+0.22*Z_{WQ}-0.10)$

Step 3) Circular perforation diameter per row assuming a single column, D_1 (in) — D_1 (in) = 0.62

Step 4) Number of columns, n_c — n_c = 2.00

Step 5) Design circular perforation diameter (should be between 1 and 2 inches), D_{perf} (in) — D_{perf} (in) = 1.23

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed S Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

Step 6) Horizontal perforation column spacing when $n_c > 1$, center to center, S_c
If $D_{perf} \geq 1.0$ inche, $S_c = 4$

Step 7) Number of rows (4" vertical spacing between perforations, center to center), n_r — n_r = 5

IIId. Other Pretreatment Devices

Step 1) Depth of water quality volume permanent pool, Z_{WQ} (ft) — Z_{WQ} (ft) = 0.65

Step 2) Average head of water quality pool volume over invert of v-notch, H_{WQ} (ft) — H_{WQ} (ft) = 0.33
$H_{WQ} = 0.5 * Z_{WQ}$

Step 3) Average water quality pool outfall rate, Q_{WQ} (cfs) — Q_{WQ} (cfs) = 0.03
$Q_{WQ} = (WQ_V * 43{,}560)/(40 * 3{,}600)$

Step 4) V-notch weir coefficient, C_V — C_V = 2.50
$C_v = 0.59\text{-}0.57$

Step 5) V-notch weir angle, θ (deg) — θ (deg) = 20.2
$\theta = 2*(180/\pi)*\arctan(Q_{WQ}/(C_v*H_{WQ}^{5/2}))$
V-notch angle should be at least 20 degrees. Set to 20 degrees if calculated angle is smaller.

Step 6) Top width of V-notch weir, W_v (ft) — W_v (ft) = 0.22
$W_v = 2*Z_{WQ}*\text{Tan}(\theta/2)$

Step 7) To calculate v-notch angle for EDDB with an irregular stage-volume relationship, use the V-notch Weir worksheet

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed S Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

III. Flood Control

Reference APWA Specifications Section 5608

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Main Worksheet

Designer: JGD
Checked By: MES
Company: RIC
Date: 1/4/2019
Project: 18-0251 - Burton Townhomes
Location: Proposed S Basin, Lee's Summit, MO
Reference: APWA/MARC BMP Manual, 8.10 EDDB, pg 8-107 thru 8-128

IV. Trash Rock

Step 1) Total outlet area, A_0 (in^2)	A_{0t} (in^2) =	1.5
Step 2) Depth of gravel blanket, Z_{gravel} (in)		
$A_t = A_{0t}*77*e^{-0.124*D}$ for single orifice outlet	A_t (in^2) =	105
$A_t = (A_{0t}/2)*77*e^{-0.124*D}$ for orifice plate outlet	A_t (in^2) =	53
$A_t = 4*A_{0t}$ for v-notch weir outlet	A_t (in^2) =	6

V. Basin Shape

Step 1) Length to width ratio should be at least 3:1 (L:W) wherever practicable	(L:W) =	4:1
Step 2) Low flow channel side lining	Concrete:	
	Soil/Riprap:	
	No low flow channel:	X
Step 3) Top stage floor drainage slope (toward low flow channel), S_{ts} (%)	S_{ts} (%) =	2%
Top stage depth, D_{ts} (ft)	Dts (ft) =	5
Step 4) Bottom stage volume, V_{bs} (ac-ft)	V_{bs} (% of WQ_V)	10%
1.25 to 3ft deeper than top stage. Bottom stage shall store 10-25% of WQ_v.	V_{bs} (ac-ft)	0.50

VI. Forebay (Optional)

Step 1) Volume should be greater than 10% of WQ_v	Min Vol_{FB} (ac-ft) =	0.01
Step 2) Forebay depth, Z_{FB} (ft)	Z_{FB} (ft) =	1.0
Step 3) Forebay surface area, A_{FB} (ac)	Min A_{FB} (ac) =	0.01
	Min A_{FB} (ft) =	463.78
Step 4) Paved/hardbottom and sides?	Y/N?	N

VI. Basin Side Slopes

Base side slopes should be at least 4:1 (H:V)	Side Slope (H:V) =	4:1

VII. Dam Embankment side slopes

Dam embankment side slopes should be at least 3:1 (H:V)	Dam Embankment (H:V) =	4:1

Design Procedure Form: Extended Dry Detention Basin (EDDB)
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IX. Vegetation

Check the method of vegetation planted in the EDDB or describe "other"	Native Grass:	X
	Irrigated Turf Grass:	
	Other:	

X. Inlet Protection

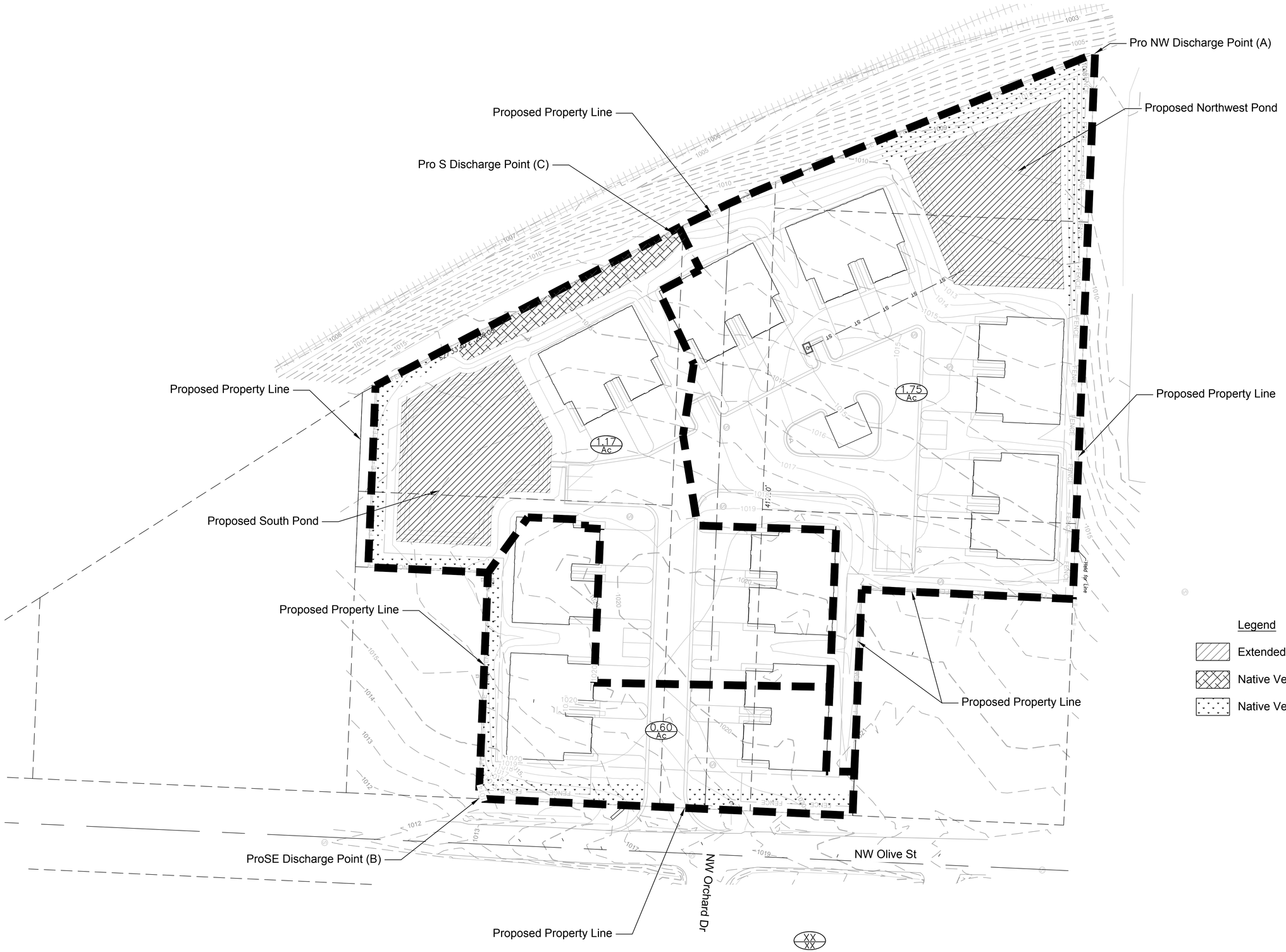
Indicate method of inlet protection/energy dissipation at EDDB inlet	Rip Rap Rock

XI. Access

Indicate that access has been provided for maintenance vehicals	Yes

Exhibit J

Proposed BMP Location Plan



Sheet
Exhibit J

Storm Report
18-0251
Lee's Summit, Jackson County, MO

Proposed BMP Location Plan

NO.	BY	DATE	REVISION
1	JGD	01/18/19	ORIGINAL SUBMISSION

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MO Certificate of Authority: E-2010033630

Jan 17, 2019 4:58pm
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