Hydrology Report

For
Providence Development
McKissick Street, Pleasant Hill, CA

4-Lot Residential Development

Prepared By
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August 8, 2018

Purpose

The purpose of this hydrology report is to compare the current hydrologic properties of the project site with a proposed four residential unit development on two existing lots. The Assessor's Parcel Numbers of the lots are 149-061-026 and 033.

Standards

The local jurisdiction is the City of Pleasant Hill located in Contra Costa County, CA. The hydrology standards used in this report are based from the Contra Costa County Flood Control and Water Conservation District manuals. The unit hydrograph method was generally followed for this relatively small project site.

Per Section 7.c of the City of Pleasant Hill Public Works Standards, this report will analyze a 6-hour, 25-year project storm. All storm data parameters used in the report originated from the county hydrology manual. The Mean Seasonal Precipitation (MSP) for this area was determined to be 18.75". The 6-hour, 25-year storm depth was calculated using the formula and tables found in Appendix A of the County's HEC-HMS Guidance document to yield a project storm depth of 2.30" (Attachment 3).

Project Details

The site is currently undeveloped and is being utilized as an orchard. It is located near the westerly terminus of McKissick Street on the south side of the road. It is located on 1.19 acres. The tributary drainage area includes 2.12 acres with a maximum flow path of 421 feet and an elevation drop of 16 feet from northwest to southeast. The average slope of the terrain is 3.6%. The site drains to Matson Creek which runs west to east just south of the subject property.

The storm water runoff from the proposed development must be equal to or less than the existing runoff. The development will create more impervious area and, as a result, will generate greater runoff from the project site. To mitigate this potential increase in runoff due to development, the runoff will be detained onsite so that the peak runoff flow will be equal to or less than the peak flow in the undeveloped state. The detention storage will consist of an over-sized storm drain pipe that will serve as both a storm water conveyance system and a storage facility.

Methodology

The Contra Costa County Flood Control and Water Conservation District Hydrology Manual was used to guide the analysis of this report. Even though the project area is considerably smaller than recommended for using the unit hydrograph method, it is the best method for determining the pre and post development comparisons.

The full scope of this analysis was achieved using two hydrology modeling programs. Per CCCFCWCD standards, the HEC-HMS model was used to perform analysis of the subject site. However, the HEC-HMS model was intended to analyze large-scale watersheds. As such, it was determined that more precision could be achieved for this small project by using HydroCAD Stormwater Modeling software. HydroCAD performs stormwater routing and also aids in the design of detention pipe structures with controlled outflow devices. It is also efficient in analyzing the effects of tailwater/headwater within a drainage system.

These two hydrology models work in tandem. For instance, the unit hydrograph was generated by HEC-HMS and then imported into HydroCAD for routing purposes. Furthermore, HydroCAD generated Stage-Storage and Stage-Discharge curves (for the detention structure) that were imported into HEC-HMS in order to verify runoff results. Both models were run and results compared. One observation is that the HEC-HMS model tended to produce a lower post-development discharge flow than that yielded by HydroCAD. For this reason, we feel it prudent to include both analyses in this report, since the HydroCAD results tend to be more conservative.

To mitigate the potential for erroneous data entry into the HEC-HMS model, the county's template was used as the starting point for the analysis. Also, the CCCFCWCD HEC-HMS Guidance document was consulted for inputting the particular hydrology parameters that are based on this particular site and project. The input data is shown in Attachment 6 herein.

Stormwater Detention

The storage element utilized is a 24'' diameter reinforced concrete pipe (RCP). Storm runoff is routed through this pipe, but the outlet is restricted so it will detain the runoff in order to reduce the discharge rate to at least the pre-development levels. This pipe is approximately 161 feet in length, with a slope of 0.5%. The downstream invert is at elevation 70.08.

Outlet Control Devices

The primary outlet device is a 7"x7" vertical-faced orifice that is designed to meter the outflow. The orifice is cut into a steel plate, the top of which will serve as a weir and as the secondary outlet during peak flows. This is also the overflow device in case the orifice gets plugged. The top of the weir is designed to be at elevation 71.50'. Per the results, the peak elevation is 71.78', which is approximately 3 inches below the crown of the storage pipe.

Tailwater Conditions

Tailwater conditions were accounted for and dynamically calculated in the HydroCAD model. The assumption is that Hubbard Avenue is flooded. Therefore the tailwater elevation is set at the top of end wall elevation on the east side of the street (downstream), which is 65.7'. The outfall invert is designed at elevation 62.5'. Hence, in a flowing-full condition, the system will encounter significant tailwater. The effects of the given tailwaters on the performance of the drainage system can be seen in the HydroCAD reports located in the Attachment sections at the end of this report.

Plugged Orifice

An analysis was performed using the weir as the sole outlet device. The purpose of this scenario was to determine how the drainage network would function in the event that the primary outlet device was to get blocked or plugged. The system will still perform as intended without backing up and flooding the project. The peak flow is 3.3 cfs over the weir with a peak elevation of 71.93'. Further details can be found in Attachment 13.

Results

All the design parameters and results can be seen in the attachments to this report. See the List of Attachments below to view the desired documents.

A summary of the results for the 6- hour, 25-year storm are listed here:

HEC-HMS Analysis

	Peak Discharge (cfs)	Time of Peak	Volume (cf)
Pre-Development:	3.2	4:30	10,716
Post-Development:			
Without Storage	3.4	4:30	14,505
With Storage	2.4	4:45	14,505

HydroCAD Analysis

	Peak Discharge (cfs)	Time of Peak	Volume (cf)
Post-Development:			
Without Storage	3.4	4:30	14,505
With Storage	3.1	4:32	14,505

Conclusion

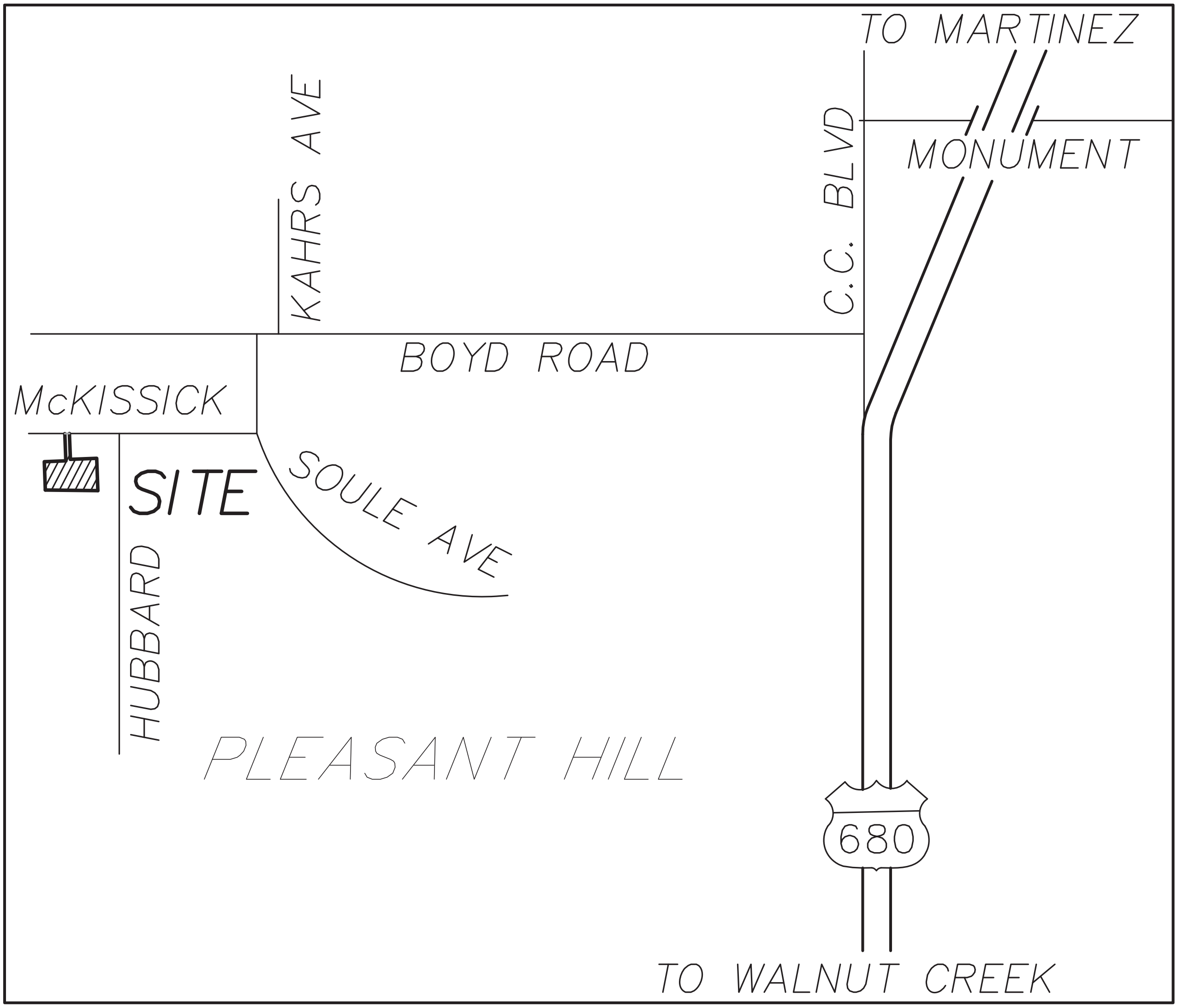
The post-development 6-hour, 25-year peak discharge with storage is 3% less than the pre-development peak discharge. The 24" RCP with 7"x7" orifice is an effective detention facility to meet storm water runoff regulation requirements.

Hydraulic Analysis

A hydraulic analysis of the discharge piping system is included in Attachment 14.

List of Attachments

Attachment 1: Maps



VICINITY MAP
N.T.S.

PRE–DEVELOPMENT DRAINAGE PATTERN

LEGEND

- WATERSHED BOUNDARY
- PROPERTY BOUNDARY
- EXISTING GRAVEL
- EXISTING CONCRETE
- DIRECTION OF DRAINAGE
- EXISTING PAVEMENT
- NEW PAVEMENT

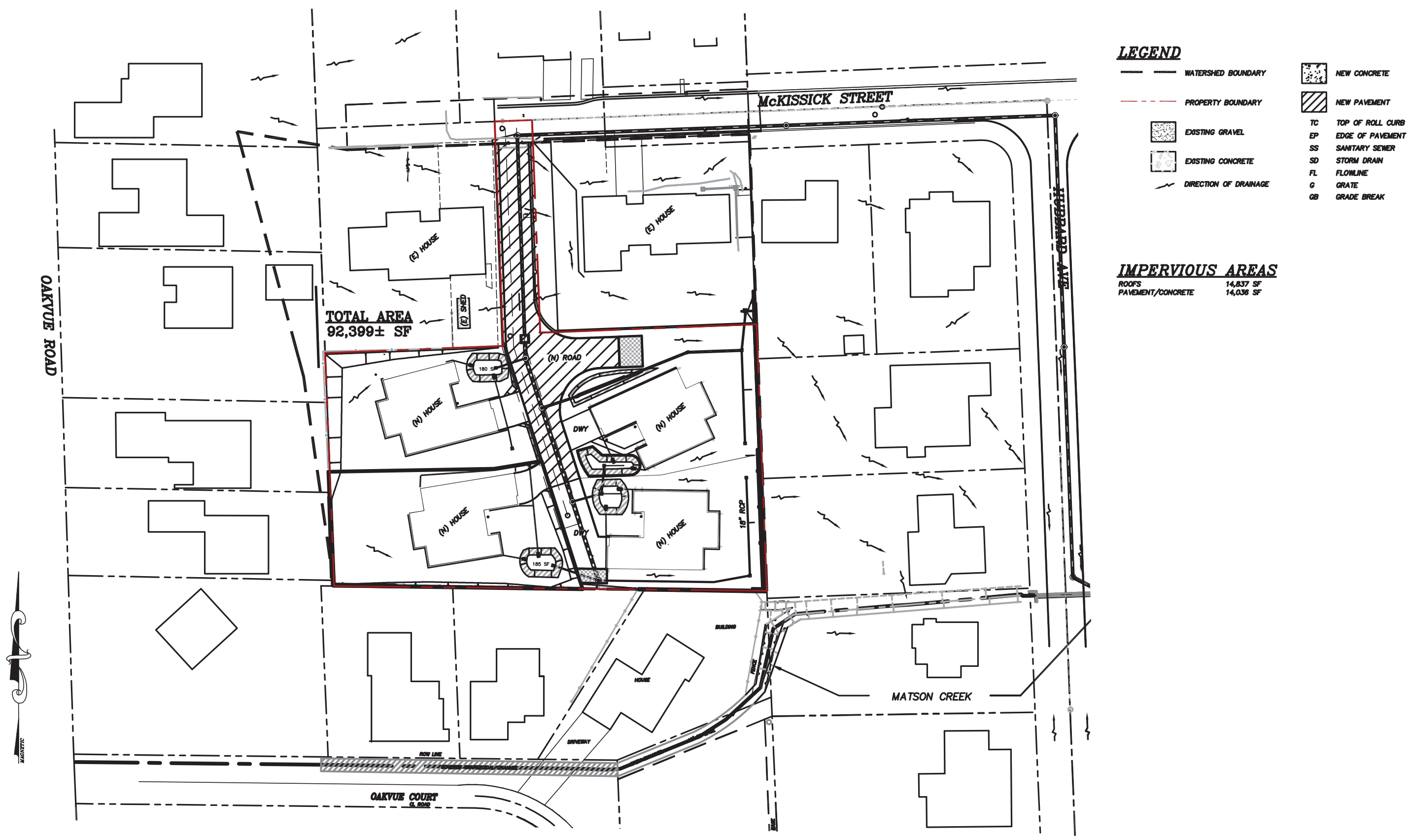
TC	TOP OF ROLL CURB
EP	EDGE OF PAVEMENT
SS	SANITARY SEWER
SD	STORM DRAIN
FL	FLOWLINE
G	GRATE
GB	GRADE BREAK

IMPERVIOUS AREAS

ROOFS	8,217 SF
PAVEMENT/CONCRETE	3,847 SF
GRAVEL	2,630 SF

ATTACHMENT 1.1

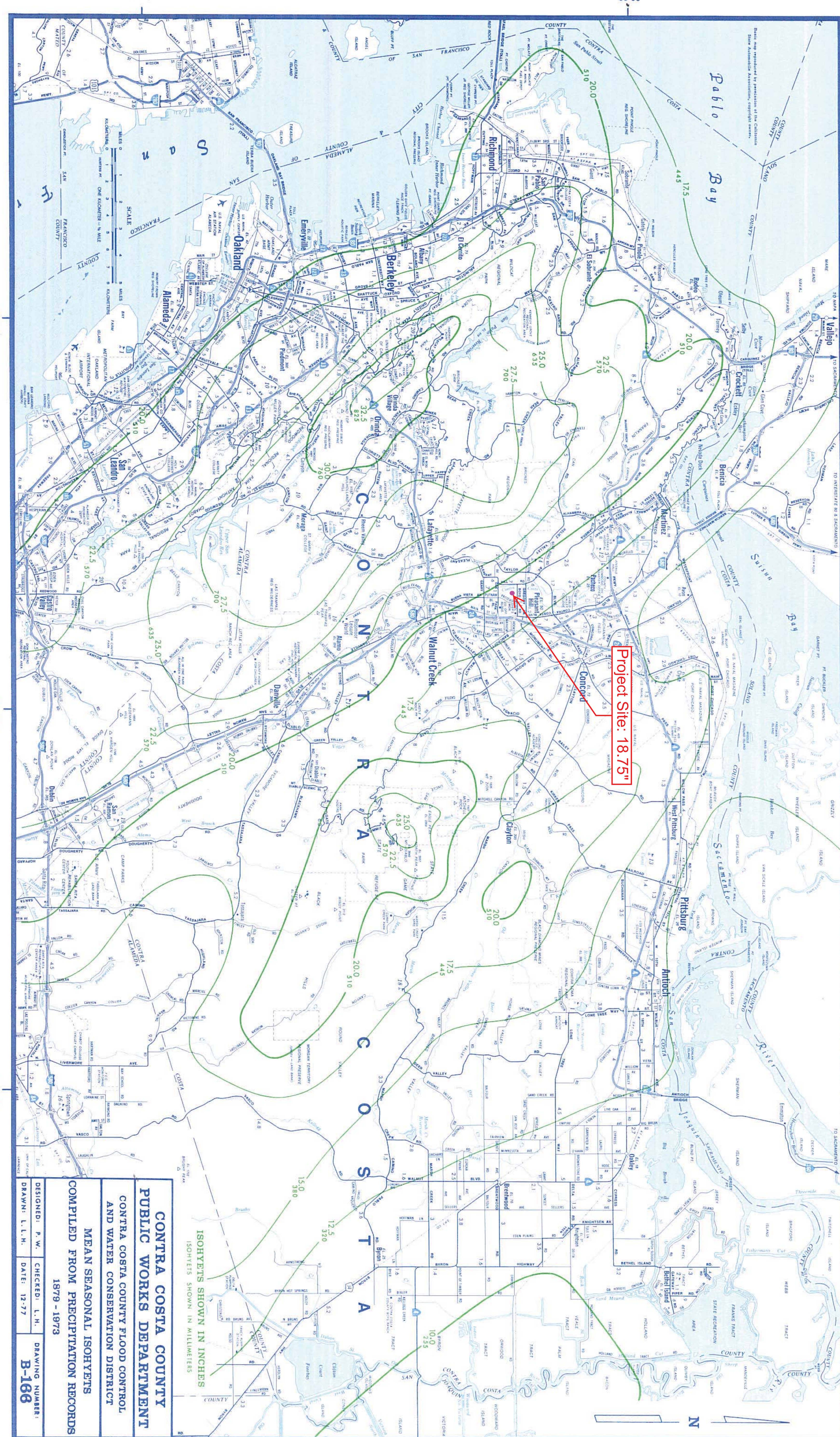
POST-DEVELOPMENT DRAINAGE PATTERN

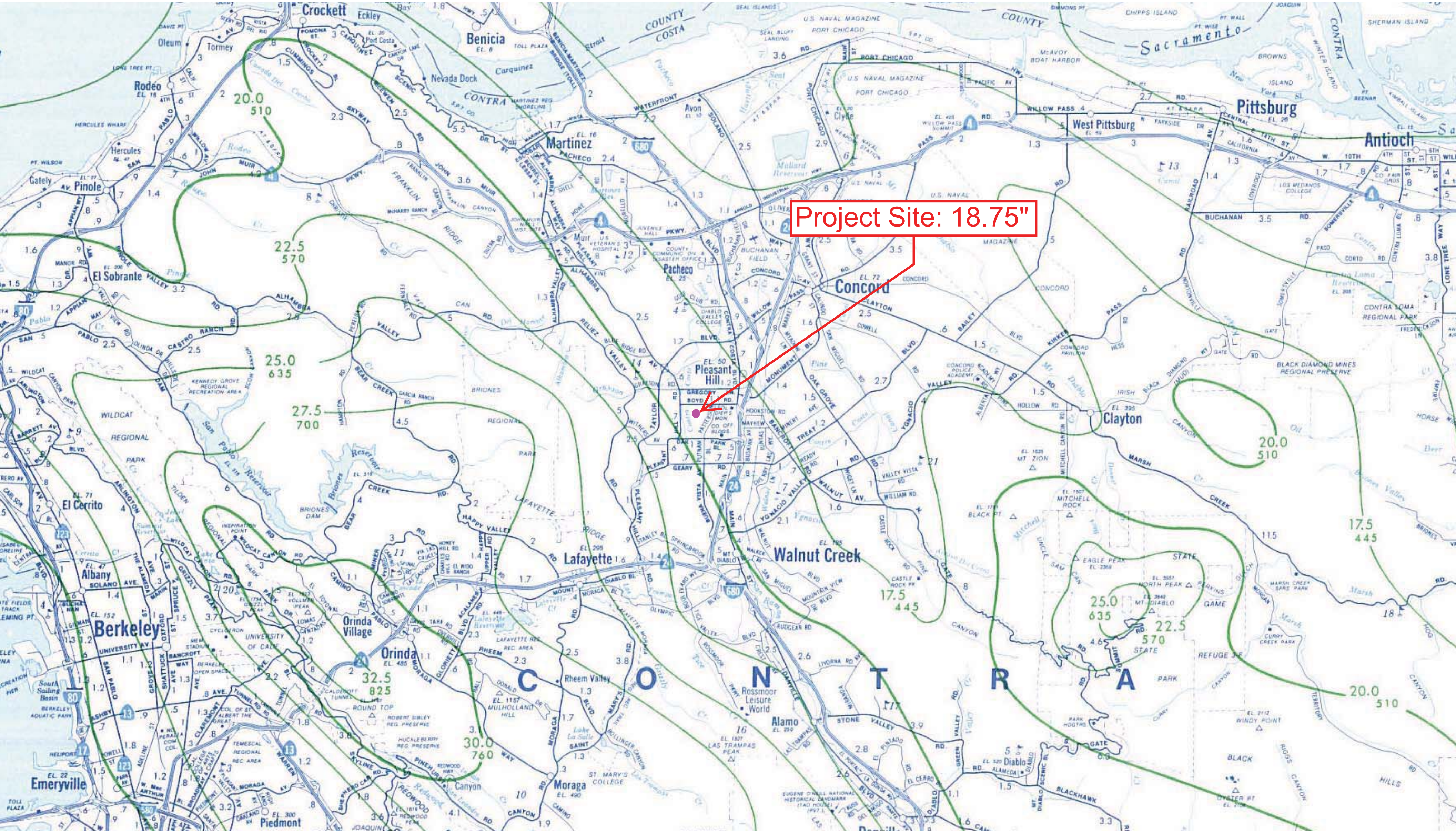


ATTACHMENT 1.2

Attachment 2: County Annual Storm Depth Map

Attachment 2





Project Site: 18.75"
Crockett
Benicia
Martinez
Pittsburg
West Pittsburg
Antioch
Concord
Pleasant Hill
Pacheco
Clayton
Walnut Creek
Lafayette
Orinda
Moraga
Berkeley
Albany
El Cerrito
Emeryville
Piedmont
Pinole
Hercules
Rodeo
El Sobrante
Alamo
Diablo
C O N T R A

Attachment 3: County Project Storm Depth Calculation

Storm Depth Calculation

Simplified Tables: Appendix A, CCCFCWCD HEC-HMS Guidance

D = C1 + MSP X C2

where:

D =	storm rainfall depth	
C1 =	0.584	Table A-1
MSP =	18.75	
C2 =	0.0916	Table A-2

D = 2.30 in

See tables next sheet

Simplified Tables

If we simplify the above equation, we can reduce the number of operations in the equation from six to two and perform the calculations faster.

$$\boldsymbol{D = C1 + MSP \times C2}$$

Where:

D = storm rainfall depth (inches)
MSP = mean seasonal precipitation depth (inches) from the District Isohyet map. (The value of MSP should be within the range of 10 and 35 inches/year.)
C1 = constant based on rainfall duration and frequency from Table A-3

$$= \frac{MR1}{100} - 10 \times \left(\frac{MR2 - MR1}{250}\right)$$

C2 = constant based on rainfall duration and frequency from Table A-4

$$= \frac{MR2 - MR1}{250}$$

Table A-1 C1 Constants for Storm Rainfall Depths - Simplified

C1	3-hour	6-hour	12-hour	24-hour	96-hour
2-year	0.246	0.286	0.330	0.356	0.316
5-Year	0.374	0.432	0.492	0.556	0.628
10-Year	0.434	0.520	0.588	0.636	0.684
25-Year	0.492	0.584	0.680	0.736	0.904
50-Year	0.592	0.674	0.768	0.840	1.052
100-Year	0.620	0.760	0.888	0.968	1.088

Table A-2 C2 Constants for Storm Rainfall Depths - Simplified

C2	3-hour	6-hour	12-hour	24-hour	96-hour
2-year	0.0304	0.0444	0.0640	0.0884	0.1684
5-Year	0.0436	0.0648	0.0928	0.1304	0.2392
10-Year	0.0516	0.0760	0.1112	0.1584	0.2976
25-Year	0.0608	0.0916	0.1320	0.1884	0.3456
50-Year	0.0688	0.1036	0.1512	0.2160	0.3928
100-Year	0.0760	0.1120	0.1632	0.2352	0.4432

Use the number of decimal places shown for C1 and C2 to produce the same results as the more complicated equation using MR1 and MR2.

Attachment 4: County 24-hour, 2-year Computation

Storm Depth Estimation for Frequent Return Intervals for Contra Costa County, California

by

Contra Costa County Flood Control and Water Conservation District

June 21, 2010

We are frequently asked by engineers, architects, landscape architects, and planners to provide the 24-hour storm depth for storms less than the 5-year storms. Our standard Precipitation Duration-Frequency-Depth (DFD) Curves are published in drawing numbers B-158 through B-162. However, these only cover the 5-year through 100-year storm recurrence intervals.

(As of the last editing of this document, the PDFs of these documents can be downloaded from http://www.co.contra-costa.ca.us/index.aspx?nid=2455)

To estimate the storm depth for a storm smaller than the 5-year storm, probability-log paper can be used along with information from the DFD curves. The following is a step by step explanation of how to do this using an example. The example will be a site in San Ramon near the Bollinger Canyon Road intersection with Interstate 680. The desired rainfall amount is the 2-year 24-hour storm depth.

Step 1 - Determine the MSP

The first step is to determine the Mean Seasonal Precipitation (MSP) for your site. Determine this from the Isohyet[1] map found at the link above. The map with the GIS features provides smaller MSP intervals which is handy in some area of the county. Find your site location on this map and interpolate as needed between the isohyets to determine the MSP at your site. The site location for our example is within the circle in Figure 1 and has an estimated MSP of 21.0 inches.

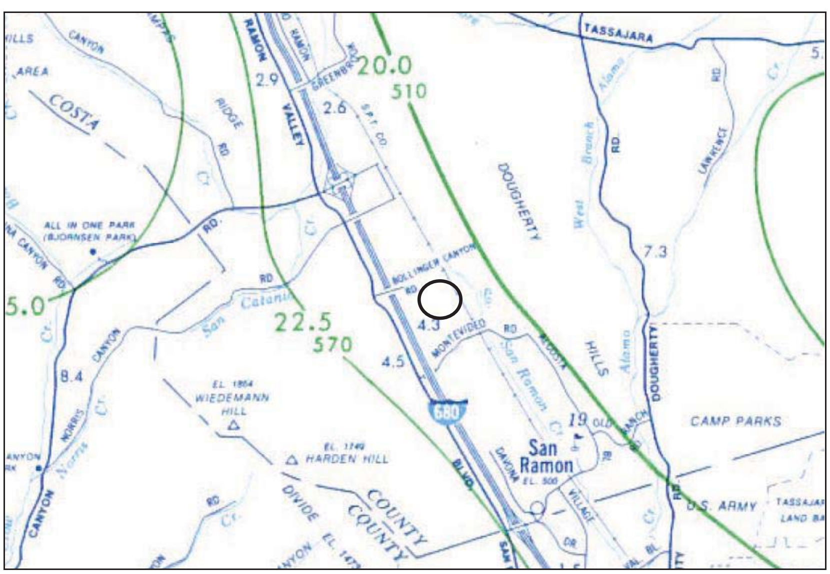


Figure 1 - A portion of the Contra Costa County Mean Seasonal Isohyet Map

[1] In hydrology, **Isohyet** refers to a line on a map that represents the rainfall depth. All points along an isohyet line have the same depth of rainfall. The rainfall amount can be per year, per month, or from a single storm. The FC District's isohyet map is for average (mean) seasonal (annual June-July) rainfall totals.

Step 2 - Determine the Rainfall for Other Recurrence intervals.

The next step is to determine the storm depth for the duration you want the depth for. In our example we want the 24-hour storm depth. We first find the 24-hour storm depth from the DFD curve for the 5-year, 10-year and 25-year storms. These three points should be enough to estimate the 2-year storm depth. You can also find the 50-year and 100-year storm depths if you'd like. The DFD curves can be found via the link above.

In our example, start with the 5-year recurrence interval DFD curves and find 24-hours (1 day) on the horizontal axis. We trace the 24-your grid line up to a point between the 20 inch and 25 inch MSP. Next we interpolate between the MSP lines to find the 21" MSP, and read the depth from the vertical axis. In the example in Figure 2, the precipitation depth for the 5-year, 24-hour storm is 3.4 inches.

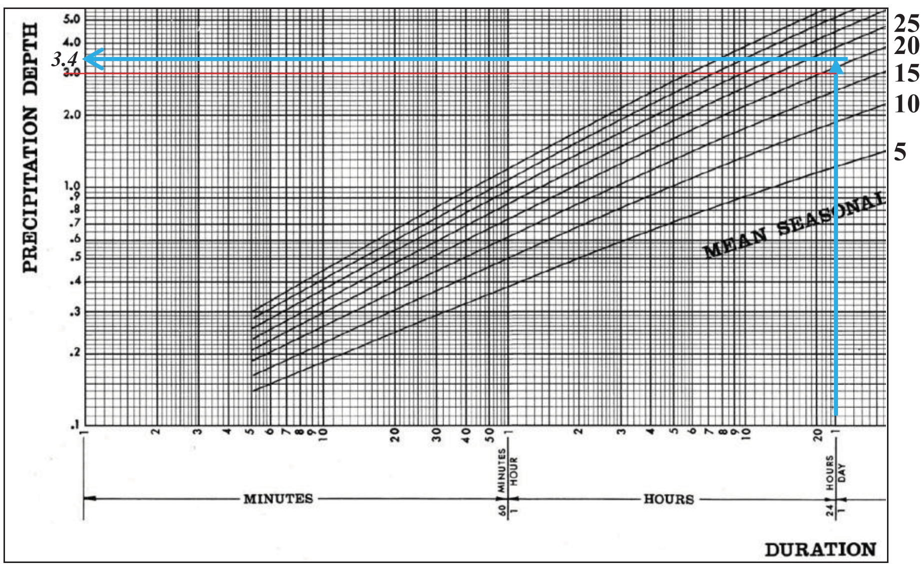


Figure 2 – Determining the 5-year 24-hour Storm depth from the 5-year DFD curves.

In our example, we repeat the process used for the 5-year recurrence interval to find the 10-year and 25-year 24-hour storm depths. For this example:

- 10-year 24-hour storm depth is 4.2 inches
- 25-year 24-hour storm depth is 4.8 inches

Step 3 - Plotting the Data on Probability-Log Paper

The recurrence interval for the depths you determined need to be converted to percent chance. You do this simply by taking their inverts. The 5-year recurrence interval is the 1/5 or 20-percent annual chance storm. The 10-year and 25-year storms are the 1/10 or 10-percent annual chance and 1/25 or 4-percent chance storms. "Percent annual chance" is also known as the "percent annual exceedance probability".

Our example is summarized below in Table 1 below.

Table 1 - Summary of 24-hour Storm Depths

Recurrence interval	Percent Chance Storm	Depth (inches)
5-year	1/5 = 0.20 = 20%	3.4
10-year	1/10 = 0.10 = 10%	4.2
25-year	1/25 = 0.04 = 4%	4.8

A scan of a sheet of probability-log paper is also available on-line. Print a copy of the probability-log sheet. Plot the values in Table 1 on the probability-log paper as shown in the example in Figure 3. Project the best fit straight line through the three points to the 50% vertical grid which represents the 2-year recurrence interval. From this we read the 2-year 24-hour storm depth of approximately 2.3 inches. This is the storm depth we are looking for.

Other Considerations

- It is a good idea to neatly document your calculations on the plot sheet for future reference (see Figure 3 example).

- This method can be used to estimate other durations. You must always use the same duration for each of the points you plot on the graph. For example, you could use this method to estimate the 1.5 year 12-hour storm depth, but you would have to determine the 12-hour storm depth for the 5-, 10-, and 25-year storm recurrence intervals.

- Technically, you cannot estimate the 1-year storm depth. Plotting the 1-year percent chance, which equals 1/1 or 100%, is not technically feasible because chart that only goes to 99.99%. Sometimes we are asked for the 1.5 year (66.67% chance) storm depth or flow as a surrogate for the 1-year event.

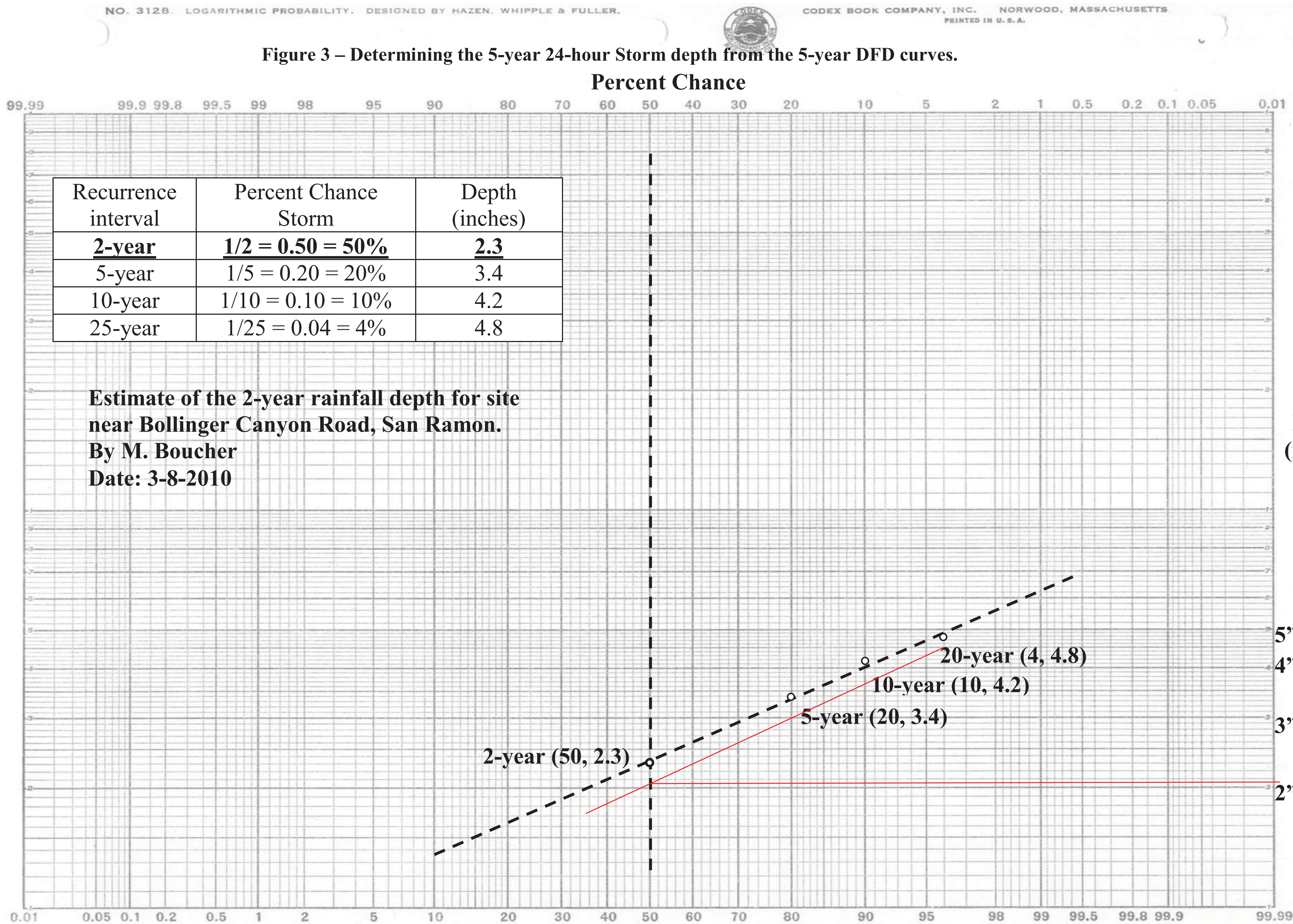
- This graph paper can also be use to project storm peak flows, but should be use with caution in doing that. Flow peaks can be influences by off stream storage (natural flooding or man-made detention basins), backup of flows behind road embankments, and other factors.

Questions regarding this procedure or other hydrology questions can be directed to the Flood Control District Hydrologist via the Contra Costa County Public Works receptionist at 925-313-2000.

MB:mb
G:\FldCtl\Standards\Hydrology\DRAFT Storm Depth Estimation for Frequent Return Intervals.doc

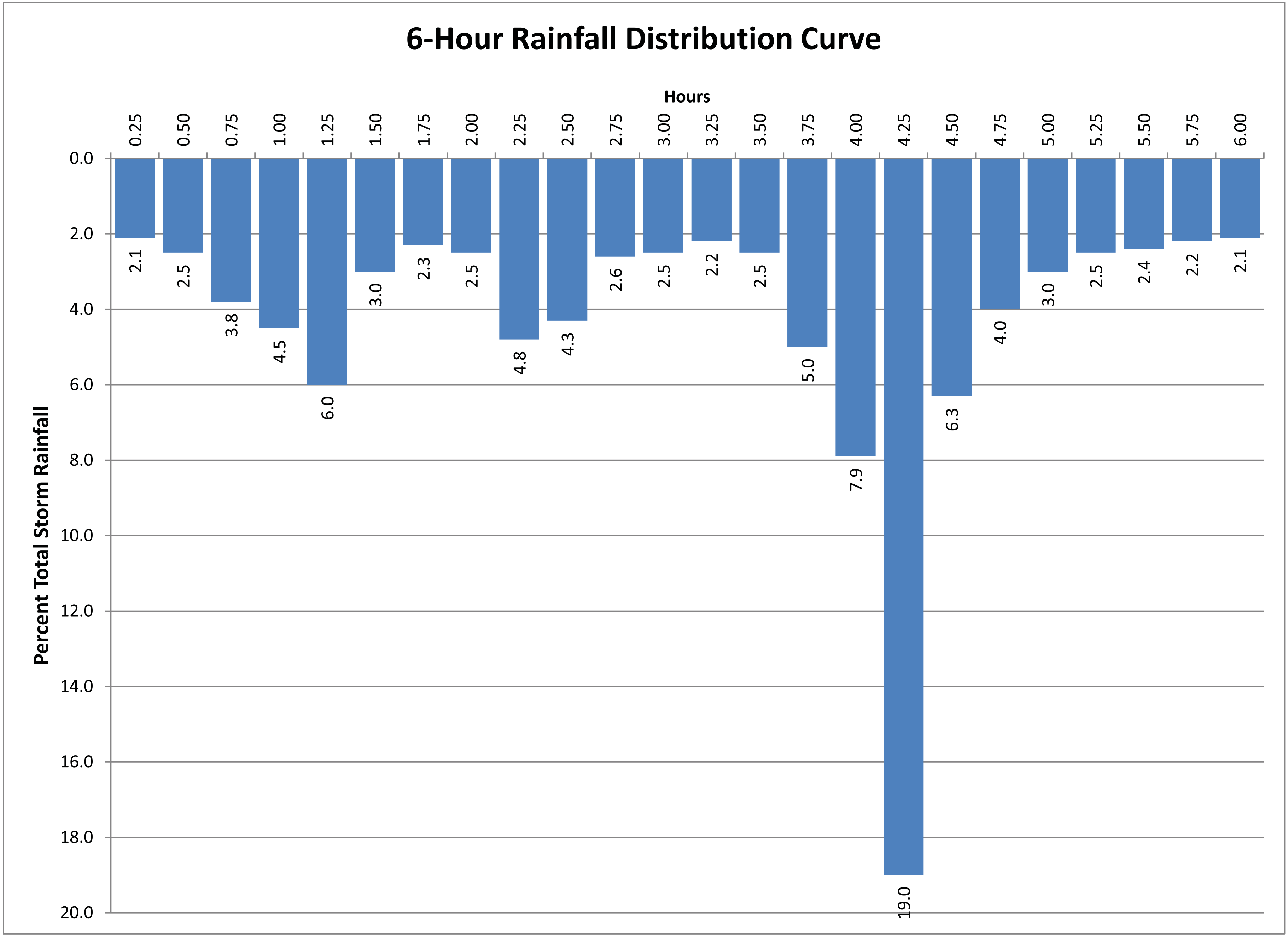
DRAFT

Figure 3 – Determining the 5-year 24-hour Storm depth from the 5-year DFD curves.



Recurrence interval	Percent Chance Storm	Depth (inches)
2-year	**1/2 = 0.50 = 50%**	**2.3**
5-year	1/5 = 0.20 = 20%	3.4
10-year	1/10 = 0.10 = 10%	4.2
25-year	1/25 = 0.04 = 4%	4.8

Attachment 5: County 6-hour Rainfall Distribution


6-Hour Rainfall Distribution Curve
Hours
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
3.75
4.00
4.25
4.50
4.75
5.00
5.25
5.50
5.75
6.00
Percent Total Storm Rainfall
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
2.1
2.5
3.8
4.5
6.0
3.0
2.3
2.5
4.8
4.3
2.6
2.5
2.2
2.5
5.0
7.9
19.0
6.3
4.0
3.0
2.5
2.4
2.2
2.1

Attachment 6: Hydrology Inputs/Calculations

Pre-Development

(E) House #1				
	Roof	3,730		
	Concrete	3,165		
	Other			
				Roofs
(E) House #2				8,217
	Roof	3,952		
	Concrete	682		
	Other			Driveways
				3,847
Misc				
	Roof	535		
	Driveway (gravel)	2,630		
	Natural Ground	77,705		
	Total	92,399	ft^2	
		0.0033	mi^2	
	% Impervious	**16%**		

Inputs for HEC-HMS

T_{lag}	0.07	hr
L =	0.08	mi
Lca =	0.04	mi
S =	190	ft/mi
N =	0.068	(weighted)

Existing Conditions	Area	SF	N	Weighted 'N' Calc:	Infiltration	Weighted Infiltration
Developed	48%	44,352	0.05	0.024	0.095	0.046
Open	52%	48,047	0.085	0.044	0.17	0.088
Total		**92,399**		**0.068**		**0.134**

Post Development

(E) House #1			
	Roof	3,730	
	Concrete	3,165	
	Other		
(E) House #2			
	Roof	3,952	
	Concrete	682	
	Other		Roofs
			21,457
Misc			
	Roof	535	
	Street (asphalt)	6,160	Driveways
			17,210
2 - (N) Houses			
	Roof	6,620	
	Concrete	1,725	
	Other	2,304	
+2 - (N) Houses			
	Roof	6,620	
	Concrete	870	
	Other	2,304	
	Natural Ground	53,732	
		92,399	
	% Impervious	**42%**	

Inputs for HEC-HMS

T_{lag}	0.07	hr
L =	0.08	mi
Lca =	0.04	mi
S =	50	ft/mi
N =	0.052	(Figure 1, CCC Hydro6 Program Requests)(interpolated)

Proposed Conditions

N =	0.052	
Infil =	0.08	in/hr

Attachment 7: Pre-development Report (HEC-HMS)

Project: McKissick Pre-Dev Simulation Run: 025y 06h

Subbasin: McKissick pre-development

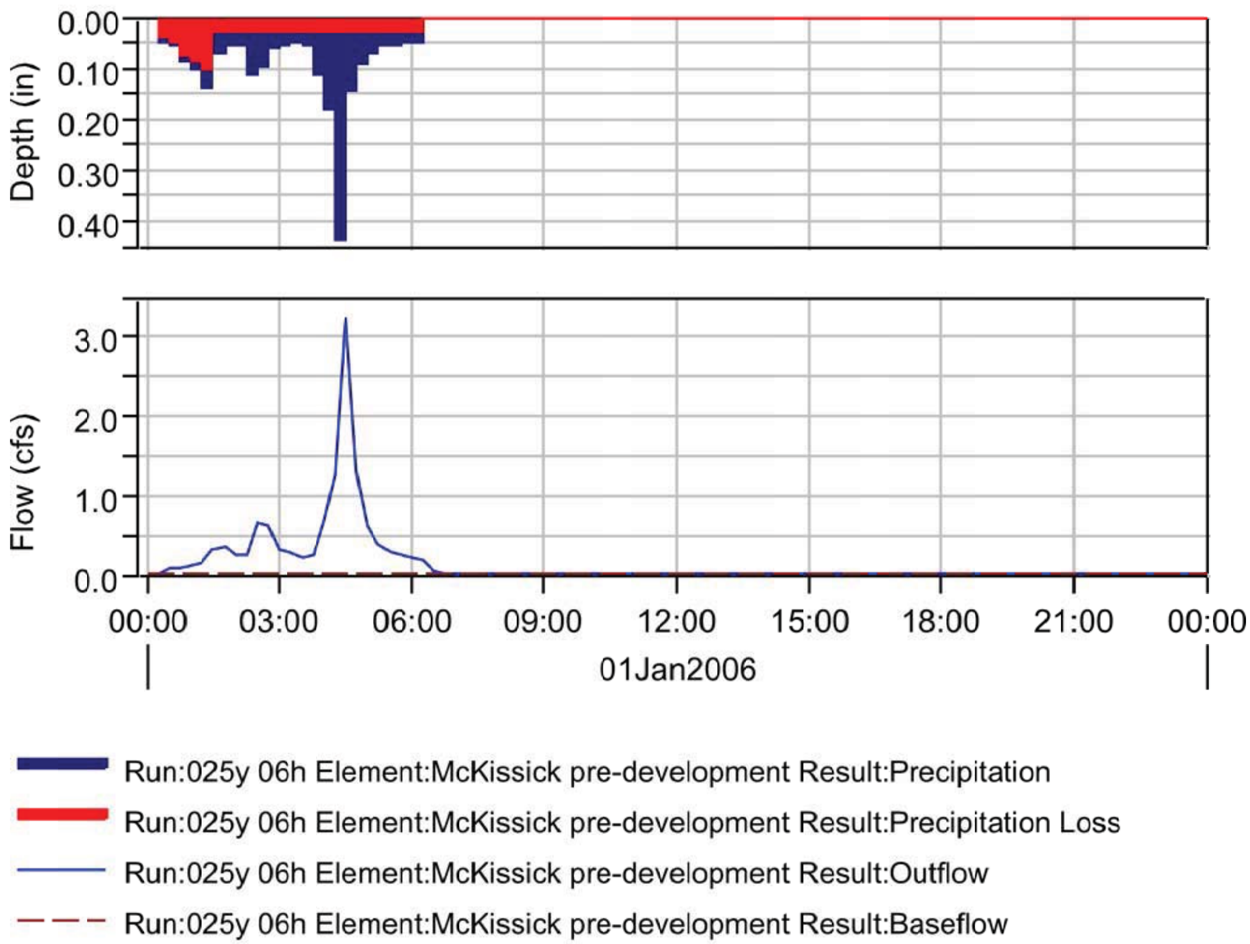
Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2006, 00:00	Meteorologic Model:	025y 06h
Compute Time:	03Apr2018, 14:22:16	Control Specifications:	01-day

Volume Units: IN

Computed Results

Peak Discharge:	3.2 (CFS)	Date/Time of Peak Discharge	01Jan2006, 04:30
Precipitation Volume	2.30 (IN)	Direct Runoff Volume:	1.41 (IN)
Loss Volume:	0.89 (IN)	Baseflow Volume:	0.19 (IN)
Excess Volume:	1.41 (IN)	Discharge Volume:	1.60 (IN)

Subbasin "McKissick pre-development" Results for Run "025y 06h"



Project: McKissick Pre-Dev Simulation Run: 025y 06h
Subbasin: McKissick pre-development

Start of Run: 01Jan2006, 00:00 Basin Model: Basin 1
End of Run: 02Jan2006, 00:00 Meteorologic Model: 025y 06h
Compute Time: 03Apr2018, 14:22:16 Control Specifications:01-day

Date	Time	Precip (IN)	Loss (IN)	Excess (IN)	Direct Flow (CFS)	Baseflow (CFS)	Total Flow (CFS)
01Jan2006	00:00				0.0	0.0	0.0
01Jan2006	00:15	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	00:30	0.05	0.04	0.01	0.1	0.0	0.1
01Jan2006	00:45	0.06	0.05	0.01	0.1	0.0	0.1
01Jan2006	01:00	0.09	0.07	0.01	0.1	0.0	0.1
01Jan2006	01:15	0.10	0.09	0.02	0.1	0.0	0.2
01Jan2006	01:30	0.14	0.10	0.04	0.3	0.0	0.3
01Jan2006	01:45	0.07	0.03	0.04	0.3	0.0	0.4
01Jan2006	02:00	0.05	0.03	0.02	0.2	0.0	0.2
01Jan2006	02:15	0.06	0.03	0.03	0.2	0.0	0.3
01Jan2006	02:30	0.11	0.03	0.08	0.6	0.0	0.7
01Jan2006	02:45	0.10	0.03	0.07	0.6	0.0	0.6
01Jan2006	03:00	0.06	0.03	0.03	0.3	0.0	0.3
01Jan2006	03:15	0.06	0.03	0.03	0.3	0.0	0.3
01Jan2006	03:30	0.05	0.03	0.02	0.2	0.0	0.2
01Jan2006	03:45	0.06	0.03	0.03	0.2	0.0	0.3

Date	Time	Precip (IN)	Loss (IN)	Excess (IN)	Direct Flow (CFS)	Baseflow (CFS)	Total Flow (CFS)
01Jan2006	04:00	0.11	0.03	0.09	0.7	0.0	0.7
01Jan2006	04:15	0.18	0.03	0.15	1.2	0.0	1.3
01Jan2006	04:30	0.44	0.03	0.41	3.2	0.0	3.2
01Jan2006	04:45	0.14	0.03	0.12	1.3	0.0	1.3
01Jan2006	05:00	0.09	0.03	0.06	0.6	0.0	0.6
01Jan2006	05:15	0.07	0.03	0.04	0.4	0.0	0.4
01Jan2006	05:30	0.06	0.03	0.03	0.3	0.0	0.3
01Jan2006	05:45	0.06	0.03	0.03	0.2	0.0	0.3
01Jan2006	06:00	0.05	0.03	0.02	0.2	0.0	0.2
01Jan2006	06:15	0.05	0.03	0.02	0.2	0.0	0.2
01Jan2006	06:30	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	06:45	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	07:00	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	07:15	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	07:30	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	07:45	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	08:00	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	08:15	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	08:30	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	08:45	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	09:00	0.00	0.00	0.00	0.0	0.0	0.0

Attachment 8: Intentionally Deleted

Attachment 9: Post-development Report (HEC-HMS)

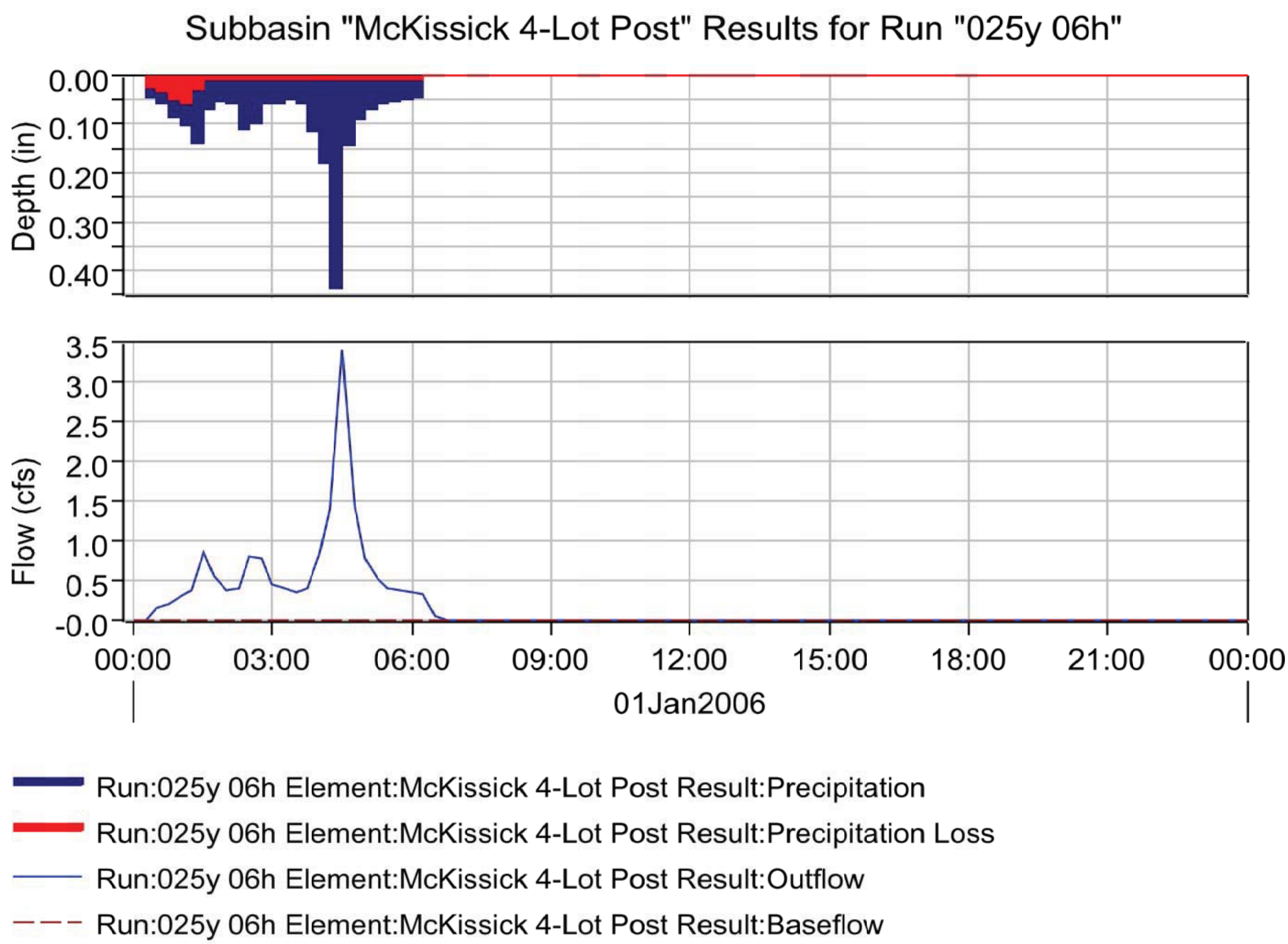
Project: McKissick-Outflow Structures Simulation Run: 025y 06h
Subbasin: McKissick 4-Lot Post

Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2006, 00:00	Meteorologic Model:	025y 06h
Compute Time:	04Apr2018, 08:49:26	Control Specifications:	01-day

Volume Units: IN

Computed Results

Peak Discharge:	3.4 (CFS)	Date/Time of Peak Discharge	01Jan2006, 04:30
Precipitation Volume	2.30 (IN)	Direct Runoff Volume:	1.88 (IN)
Loss Volume:	0.42 (IN)	Baseflow Volume:	0.19 (IN)
Excess Volume:	1.88 (IN)	Discharge Volume:	2.06 (IN)



Subbasin "McKissick 4-Lot Post" Results for Run "025y 06h"
Depth (in)
0.00
0.10
0.20
0.30
0.40
Flow (cfs)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2006
Run:025y 06h Element:McKissick 4-Lot Post Result:Precipitation
Run:025y 06h Element:McKissick 4-Lot Post Result:Precipitation Loss
Run:025y 06h Element:McKissick 4-Lot Post Result:Outflow
Run:025y 06h Element:McKissick 4-Lot Post Result:Baseflow

Project: McKissick-Outflow Structures Simulation Run: 025y 06h
Subbasin: McKissick 4-Lot Post

Start of Run: 01Jan2006, 00:00 Basin Model: Basin 1
End of Run: 02Jan2006, 00:00 Meteorologic Model: 025y 06h
Compute Time: 04Apr2018, 08:49:26 Control Specifications: 01-day

Date	Time	Precip (IN)	Loss (IN)	Excess (IN)	Direct Flow (CFS)	Baseflow (CFS)	Total Flow (CFS)
01Jan2006	00:00				0.0	0.0	0.0
01Jan2006	00:15	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	00:30	0.05	0.03	0.02	0.2	0.0	0.2
01Jan2006	00:45	0.06	0.03	0.02	0.2	0.0	0.2
01Jan2006	01:00	0.09	0.05	0.04	0.3	0.0	0.3
01Jan2006	01:15	0.10	0.06	0.04	0.4	0.0	0.4
01Jan2006	01:30	0.14	0.03	0.11	0.8	0.0	0.9
01Jan2006	01:45	0.07	0.01	0.06	0.5	0.0	0.6
01Jan2006	02:00	0.05	0.01	0.04	0.4	0.0	0.4
01Jan2006	02:15	0.06	0.01	0.05	0.4	0.0	0.4
01Jan2006	02:30	0.11	0.01	0.10	0.8	0.0	0.8
01Jan2006	02:45	0.10	0.01	0.09	0.8	0.0	0.8
01Jan2006	03:00	0.06	0.01	0.05	0.5	0.0	0.5
01Jan2006	03:15	0.06	0.01	0.05	0.4	0.0	0.4
01Jan2006	03:30	0.05	0.01	0.04	0.3	0.0	0.4
01Jan2006	03:45	0.06	0.01	0.05	0.4	0.0	0.4

Date	Time	Precip (IN)	Loss (IN)	Excess (IN)	Direct Flow (CFS)	Baseflow (CFS)	Total Flow (CFS)
01Jan2006	04:00	0.11	0.01	0.10	0.8	0.0	0.8
01Jan2006	04:15	0.18	0.01	0.17	1.4	0.0	1.4
01Jan2006	04:30	0.44	0.01	0.43	3.4	0.0	3.4
01Jan2006	04:45	0.14	0.01	0.13	1.4	0.0	1.5
01Jan2006	05:00	0.09	0.01	0.08	0.8	0.0	0.8
01Jan2006	05:15	0.07	0.01	0.06	0.5	0.0	0.5
01Jan2006	05:30	0.06	0.01	0.05	0.4	0.0	0.4
01Jan2006	05:45	0.06	0.01	0.04	0.4	0.0	0.4
01Jan2006	06:00	0.05	0.01	0.04	0.3	0.0	0.4
01Jan2006	06:15	0.05	0.01	0.04	0.3	0.0	0.3
01Jan2006	06:30	0.00	0.00	0.00	0.0	0.0	0.1
01Jan2006	06:45	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	07:00	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	07:15	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	07:30	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	07:45	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	08:00	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	08:15	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	08:30	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	08:45	0.00	0.00	0.00	0.0	0.0	0.0
01Jan2006	09:00	0.00	0.00	0.00	0.0	0.0	0.0

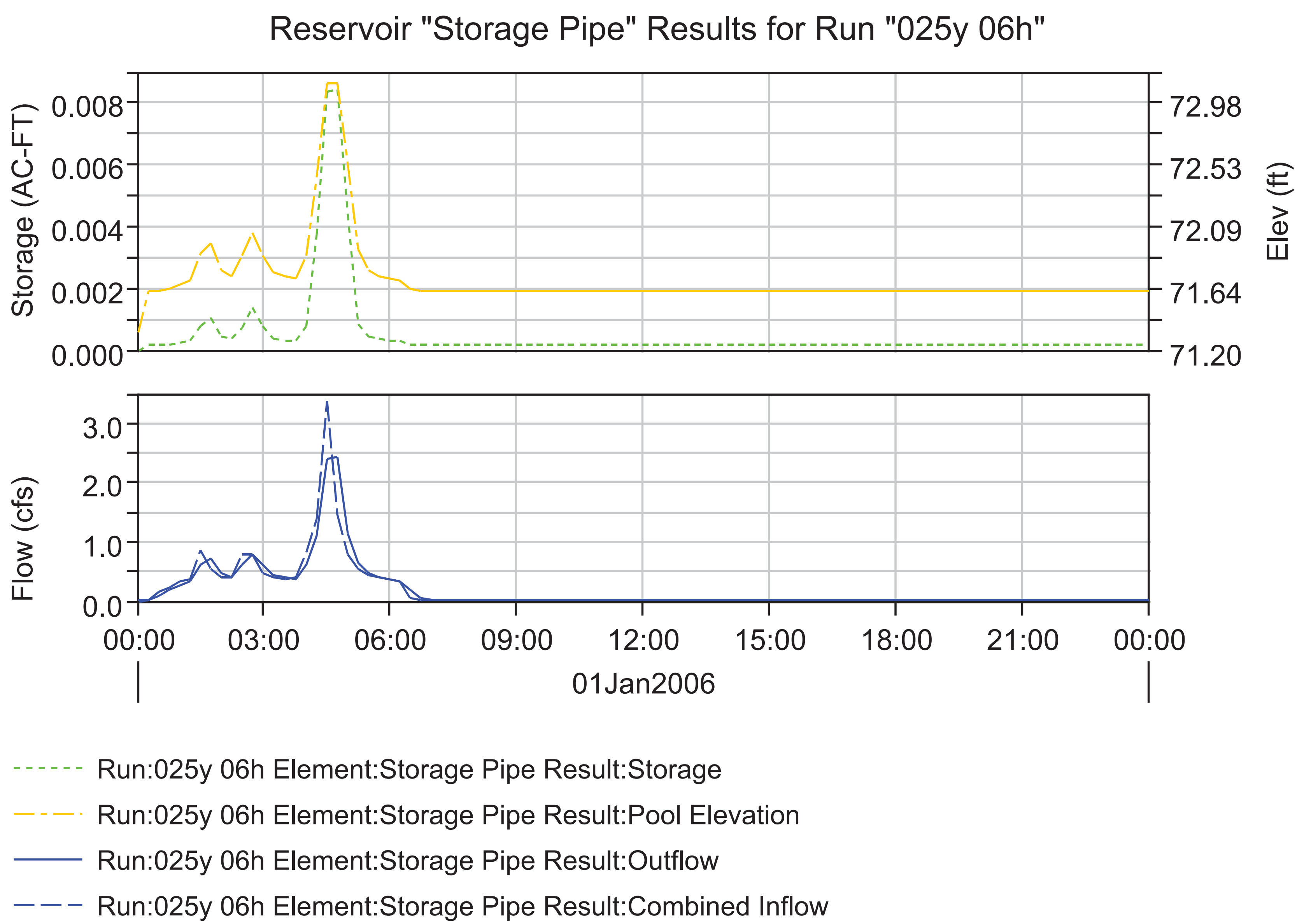
Project: McKissick-Outflow Structures Simulation Run: 025y 06h
Reservoir: Storage Pipe

Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2006, 00:00	Meteorologic Model:	025y 06h
Compute Time:	04Apr2018, 08:49:26	Control Specifications:	01-day

Volume Units: IN

Computed Results

Peak Inflow:	3.4 (CFS)	Date/Time of Peak Inflow:	01Jan2006, 04:30
Peak Discharge:	2.4 (CFS)	Date/Time of Peak Discharge	01Jan2006, 04:45
Inflow Volume:	2.06 (IN)	Peak Storage:	0.0 (AC-FT)
Discharge Volume	2.07 (IN)	Peak Elevation:	73.1 (FT)


Reservoir "Storage Pipe" Results for Run "025y 06h"
Storage (AC-FT)
0.008
0.006
0.004
0.002
0.000
Elev (ft)
72.98
72.53
72.09
71.64
71.20
Flow (cfs)
3.0
2.0
1.0
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
01Jan2006
Run:025y 06h Element:Storage Pipe Result:Storage
Run:025y 06h Element:Storage Pipe Result:Pool Elevation
Run:025y 06h Element:Storage Pipe Result:Outflow
Run:025y 06h Element:Storage Pipe Result:Combined Inflow

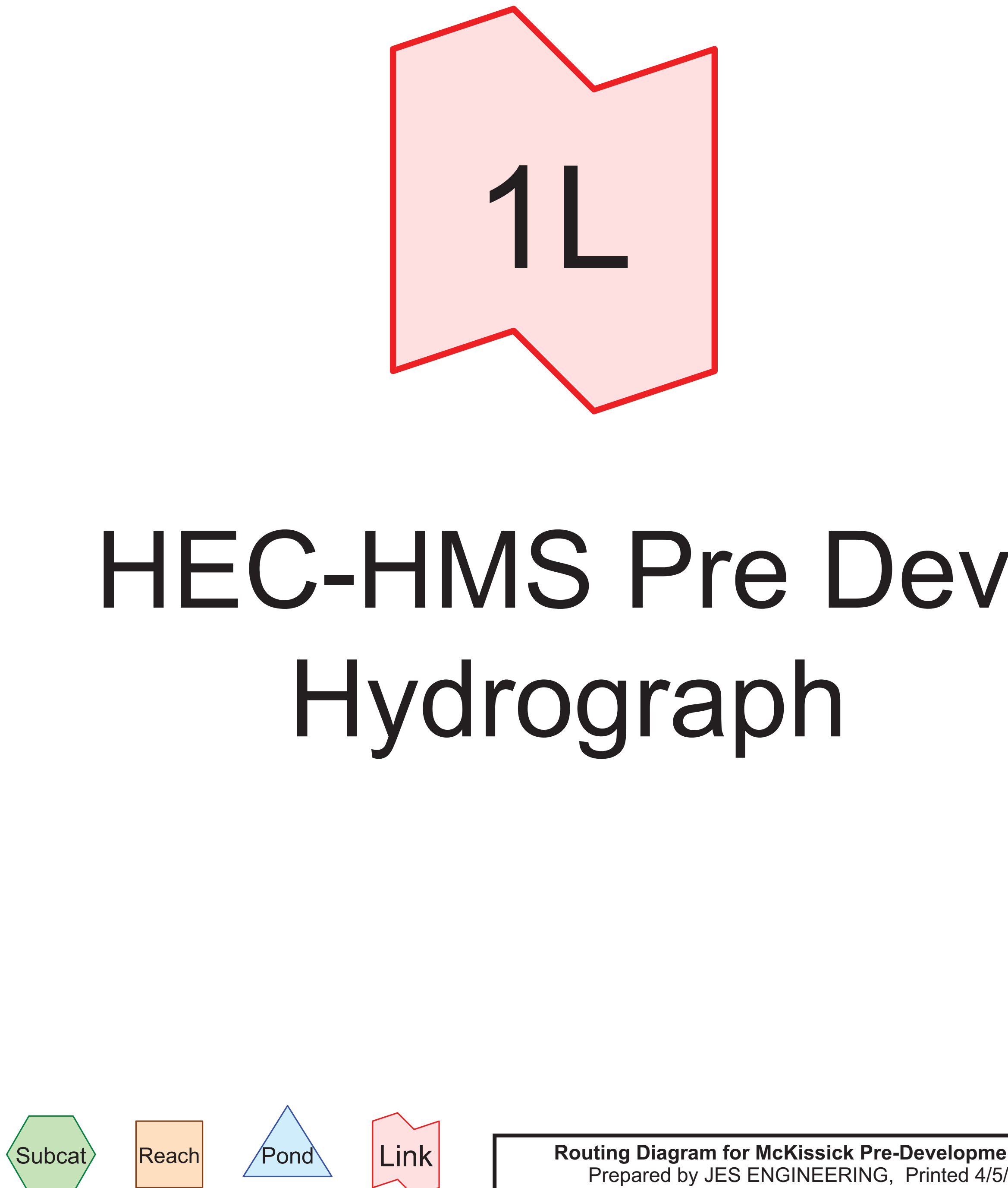
Project: McKissick-Outflow Structures Simulation Run: 025y 06h
Reservoir: Storage Pipe

Start of Run: 01Jan2006, 00:00 Basin Model: Basin 1
End of Run: 02Jan2006, 00:00 Meteorologic Model: 025y 06h
Compute Time: 04Apr2018, 08:49:26 Control Specifications:01-day

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
01Jan2006	00:00	0.0	0.0	71.3	0.0
01Jan2006	00:15	0.0	0.0	71.6	0.0
01Jan2006	00:30	0.2	0.0	71.6	0.1
01Jan2006	00:45	0.2	0.0	71.6	0.2
01Jan2006	01:00	0.3	0.0	71.7	0.3
01Jan2006	01:15	0.4	0.0	71.7	0.3
01Jan2006	01:30	0.9	0.0	71.9	0.6
01Jan2006	01:45	0.6	0.0	72.0	0.7
01Jan2006	02:00	0.4	0.0	71.8	0.5
01Jan2006	02:15	0.4	0.0	71.7	0.4
01Jan2006	02:30	0.8	0.0	71.9	0.6
01Jan2006	02:45	0.8	0.0	72.0	0.8
01Jan2006	03:00	0.5	0.0	71.9	0.6
01Jan2006	03:15	0.4	0.0	71.8	0.4
01Jan2006	03:30	0.4	0.0	71.7	0.4
01Jan2006	03:45	0.4	0.0	71.7	0.4

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
01Jan2006	04:00	0.8	0.0	71.9	0.6
01Jan2006	04:15	1.4	0.0	72.4	1.1
01Jan2006	04:30	3.4	0.0	73.1	2.4
01Jan2006	04:45	1.5	0.0	73.1	2.4
01Jan2006	05:00	0.8	0.0	72.5	1.2
01Jan2006	05:15	0.5	0.0	71.9	0.7
01Jan2006	05:30	0.4	0.0	71.8	0.5
01Jan2006	05:45	0.4	0.0	71.7	0.4
01Jan2006	06:00	0.4	0.0	71.7	0.4
01Jan2006	06:15	0.3	0.0	71.7	0.3
01Jan2006	06:30	0.1	0.0	71.6	0.2
01Jan2006	06:45	0.0	0.0	71.6	0.0
01Jan2006	07:00	0.0	0.0	71.6	0.0
01Jan2006	07:15	0.0	0.0	71.6	0.0
01Jan2006	07:30	0.0	0.0	71.6	0.0
01Jan2006	07:45	0.0	0.0	71.6	0.0
01Jan2006	08:00	0.0	0.0	71.6	0.0
01Jan2006	08:15	0.0	0.0	71.6	0.0
01Jan2006	08:30	0.0	0.0	71.6	0.0
01Jan2006	08:45	0.0	0.0	71.6	0.0
01Jan2006	09:00	0.0	0.0	71.6	0.0

Attachment 10: Pre-development Hydrograph (HydroCAD)



Routing Diagram for McKissick Pre-Development 6h-25yr
Prepared by JES ENGINEERING, Printed 4/5/2018
HydroCAD® 10.00-21 s/n 06131 © 2018 HydroCAD Software Solutions LLC

Time span=0.00-7.00 hrs, dt=0.25 hrs, 29 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Link 1L: HEC-HMS Pre Dev Flow Imported from HEC-HMS hydrograph_Pre Dev.csv Inflow=3.20 cfs 0.246 af
Primary=3.20 cfs 0.246 af

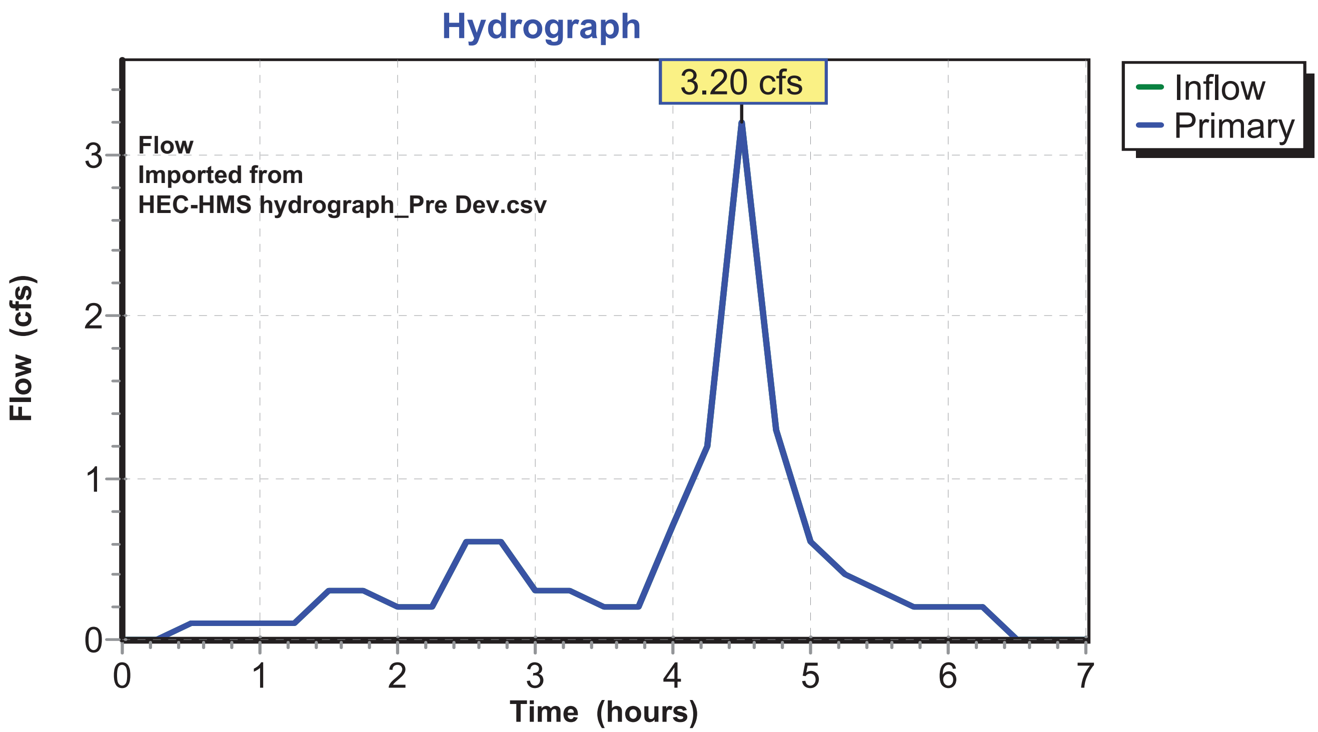
Summary for Link 1L: HEC-HMS Pre Dev Hydrograph

Inflow	=	3.20 cfs @	4.50 hrs, Volume=	0.246 af
Primary	=	3.20 cfs @	4.50 hrs, Volume=	0.246 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-7.00 hrs, dt= 0.25 hrs

Flow Imported from HEC-HMS hydrograph_Pre Dev.csv

Link 1L: HEC-HMS Pre Dev Hydrograph

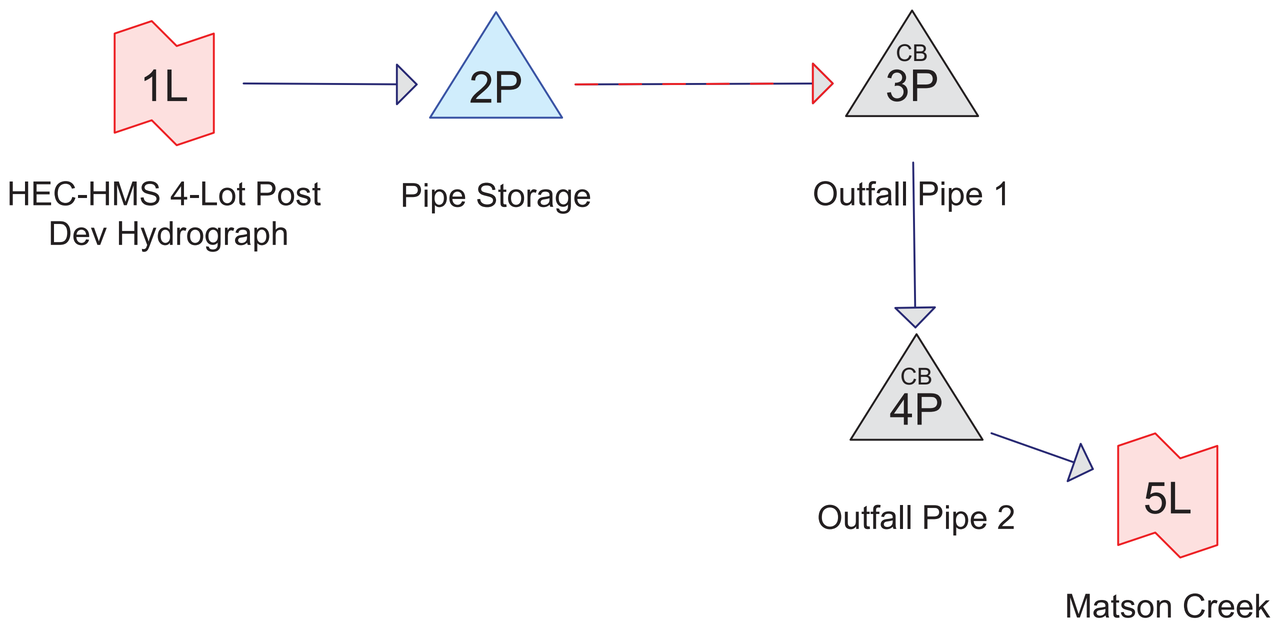


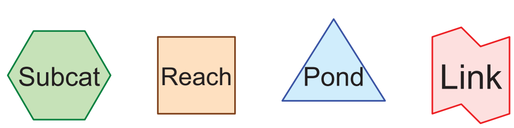
Hydrograph for Link 1L: HEC-HMS Pre Dev Hydrograph

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
0.25	0.00	0.00	0.00
0.50	0.10	0.00	0.10
0.75	0.10	0.00	0.10
1.00	0.10	0.00	0.10
1.25	0.10	0.00	0.10
1.50	0.30	0.00	0.30
1.75	0.30	0.00	0.30
2.00	0.20	0.00	0.20
2.25	0.20	0.00	0.20
2.50	0.60	0.00	0.60
2.75	0.60	0.00	0.60
3.00	0.30	0.00	0.30
3.25	0.30	0.00	0.30
3.50	0.20	0.00	0.20
3.75	0.20	0.00	0.20
4.00	0.70	0.00	0.70
4.25	1.20	0.00	1.20
4.50	**3.20**	0.00	**3.20**
4.75	1.30	0.00	1.30
5.00	0.60	0.00	0.60
5.25	0.40	0.00	0.40
5.50	0.30	0.00	0.30
5.75	0.20	0.00	0.20
6.00	0.20	0.00	0.20
6.25	0.20	0.00	0.20
6.50	0.00	0.00	0.00
6.75	0.00	0.00	0.00
7.00	0.00	0.00	0.00

Attachment 11: Intentionally Deleted

Attachment 12: Post-development Report (HydroCAD)





Routing Diagram for McKissick 4LOT Post-Development 6hr-25 yr_REVISED
Prepared by JES ENGINEERING, Printed 8/8/2018
HydroCAD® 10.00-21 s/n 06131 © 2018 HydroCAD Software Solutions LLC

Time span=0.00-9.00 hrs, dt=0.25 hrs, 37 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Link 1L: HEC-HMS 4-Lot Flow Imported from HEC-HMS hydrograph_4-Lot Post.csv Inflow=3.40 cfs 0.333 af
Primary=3.40 cfs 0.333 af

Pond 2P: Pipe Storage Peak Elev=71.78' Storage=344 cf Inflow=3.40 cfs 0.333 af
Primary=1.76 cfs 0.296 af Secondary=1.36 cfs 0.036 af Outflow=3.12 cfs 0.333 af

Pond 3P: Outfall Pipe 1 Peak Elev=70.91' Inflow=3.12 cfs 0.333 af
18.0" Round Culvert n=0.010 L=742.0' S=0.0100 '/' Outflow=3.12 cfs 0.333 af

Pond 4P: Outfall Pipe 2 Peak Elev=65.83' Inflow=3.12 cfs 0.333 af
18.0" Round Culvert n=0.010 L=17.0' S=0.0100 '/' Outflow=3.12 cfs 0.333 af

Link 5L: Matson Creek Inflow=3.12 cfs 0.333 af
Primary=3.12 cfs 0.333 af

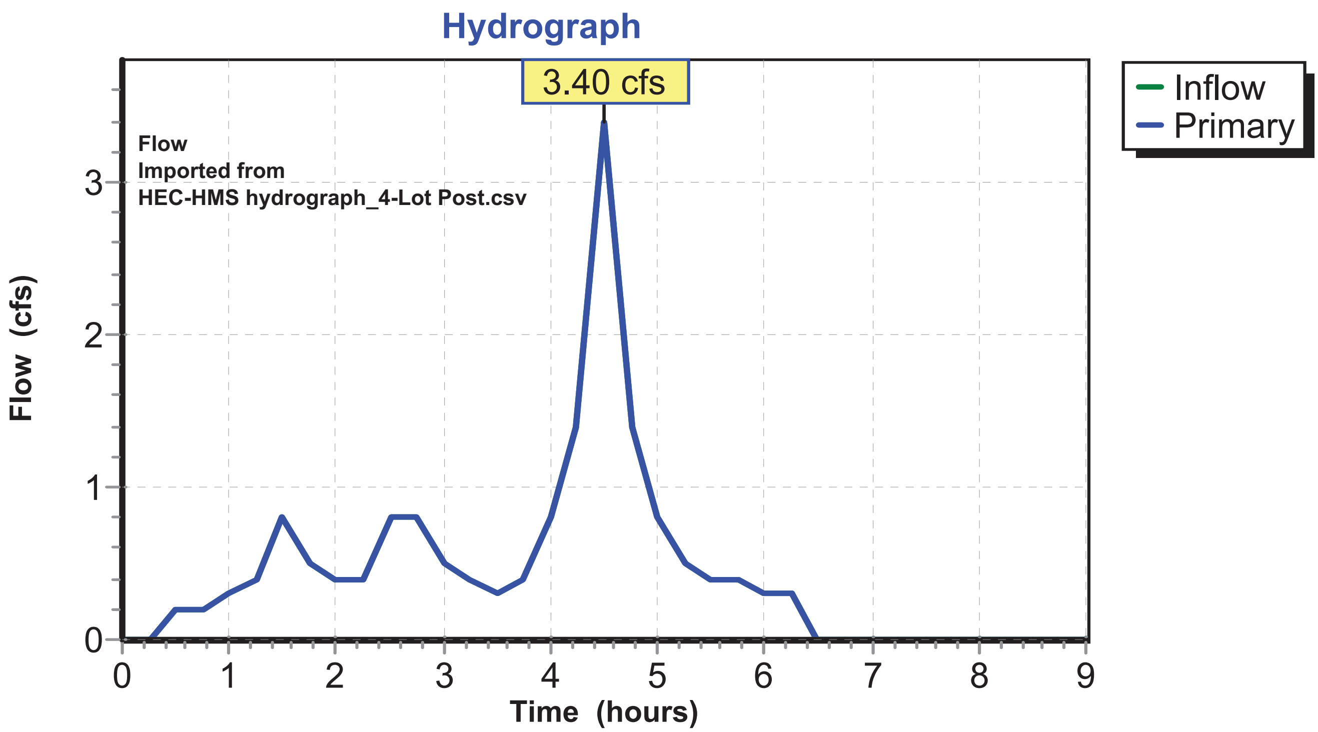
Summary for Link 1L: HEC-HMS 4-Lot Post Dev Hydrograph

Inflow	=	3.40 cfs @	4.50 hrs,	Volume=	0.333 af
Primary	=	3.40 cfs @	4.50 hrs,	Volume=	0.333 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs

Flow Imported from HEC-HMS hydrograph_4-Lot Post.csv

Link 1L: HEC-HMS 4-Lot Post Dev Hydrograph



Hydrograph for Link 1L: HEC-HMS 4-Lot Post Dev Hydrograph

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
0.25	0.00	0.00	0.00
0.50	0.20	0.00	0.20
0.75	0.20	0.00	0.20
1.00	0.30	0.00	0.30
1.25	0.40	0.00	0.40
1.50	0.80	0.00	0.80
1.75	0.50	0.00	0.50
2.00	0.40	0.00	0.40
2.25	0.40	0.00	0.40
2.50	0.80	0.00	0.80
2.75	0.80	0.00	0.80
3.00	0.50	0.00	0.50
3.25	0.40	0.00	0.40
3.50	0.30	0.00	0.30
3.75	0.40	0.00	0.40
4.00	0.80	0.00	0.80
4.25	1.40	0.00	1.40
4.50	**3.40**	0.00	**3.40**
4.75	1.40	0.00	1.40
5.00	0.80	0.00	0.80
5.25	0.50	0.00	0.50
5.50	0.40	0.00	0.40
5.75	0.40	0.00	0.40
6.00	0.30	0.00	0.30
6.25	0.30	0.00	0.30
6.50	0.00	0.00	0.00
6.75	0.00	0.00	0.00
7.00	0.00	0.00	0.00
7.25	0.00	0.00	0.00
7.50	0.00	0.00	0.00
7.75	0.00	0.00	0.00
8.00	0.00	0.00	0.00
8.25	0.00	0.00	0.00
8.50	0.00	0.00	0.00
8.75	0.00	0.00	0.00
9.00	0.00	0.00	0.00

Summary for Pond 2P: Pipe Storage

Inflow	=	3.40 cfs @	4.50 hrs,	Volume=	0.333 af
Outflow	=	3.12 cfs @	4.52 hrs,	Volume=	0.333 af, Atten= 8%, Lag= 1.3 min
Primary	=	1.76 cfs @	4.52 hrs,	Volume=	0.296 af
Secondary	=	1.36 cfs @	4.52 hrs,	Volume=	0.036 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs
Peak Elev= 71.78' @ 4.58 hrs Surf.Area= 297 sf Storage= 344 cf
Flood Elev= 81.60' Surf.Area= 0 sf Storage= 506 cf

Plug-Flow detention time= 1.3 min calculated for 0.324 af (97% of inflow)
Center-of-Mass det. time= 1.4 min (226.0 - 224.6)

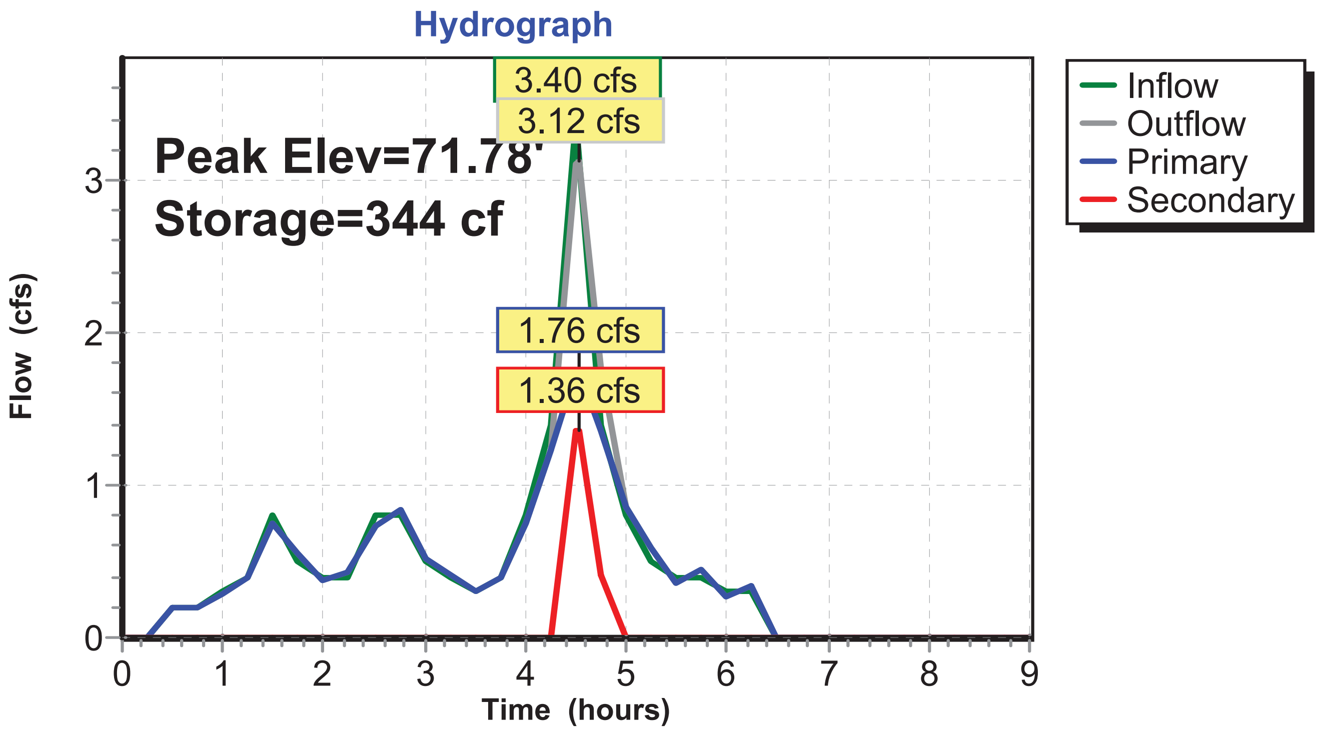
Volume	Invert	Avail.Storage	Storage Description
#1	70.08'	506 cf	**24.0" Round RCP_Round 24"** L= 161.0' S= 0.0050 '/'

Device	Routing	Invert	Outlet Devices
#1	Primary	70.08'	**7.0" W x 7.0" H Vert. Orifice/Grate** C= 0.600
#2	Secondary	71.50'	**3.7' long x 0.50' rise Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=1.49 cfs @ 4.52 hrs HW=71.73' TW=70.89' (Dynamic Tailwater)
└─**1=Orifice/Grate** (Orifice Controls 1.49 cfs @ 4.39 fps)

Secondary OutFlow Max=1.26 cfs @ 4.52 hrs HW=71.72' TW=70.89' (Dynamic Tailwater)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 1.26 cfs @ 1.54 fps)

Pond 2P: Pipe Storage



Hydrograph for Pond 2P: Pipe Storage

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	0.00	0	70.08	0.00	0.00	0.00
0.25	0.00	0	70.08	0.00	0.00	0.00
0.50	0.20	3	70.30	0.19	0.19	0.00
0.75	0.20	6	70.35	0.20	0.20	0.00
1.00	0.30	9	70.41	0.29	0.29	0.00
1.25	0.40	15	70.48	0.40	0.40	0.00
1.50	0.80	37	70.67	0.75	0.75	0.00
1.75	0.50	31	70.63	0.56	0.56	0.00
2.00	0.40	18	70.52	0.37	0.37	0.00
2.25	0.40	18	70.51	0.43	0.43	0.00
2.50	0.80	36	70.66	0.73	0.73	0.00
2.75	0.80	53	70.76	0.83	0.83	0.00
3.00	0.50	31	70.62	0.52	0.52	0.00
3.25	0.40	19	70.53	0.41	0.41	0.00
3.50	0.30	13	70.46	0.30	0.30	0.00
3.75	0.40	15	70.48	0.39	0.39	0.00
4.00	0.80	37	70.67	0.76	0.76	0.00
4.25	1.40	129	71.07	1.24	1.24	0.00
4.50	**3.40**	**331**	**71.73**	**3.11**	**1.76**	**1.36**
4.75	1.40	291	71.61	1.78	1.37	0.41
5.00	0.80	98	70.96	0.85	0.85	0.00
5.25	0.50	35	70.65	0.59	0.59	0.00
5.50	0.40	18	70.51	0.35	0.35	0.00
5.75	0.40	18	70.52	0.45	0.45	0.00
6.00	0.30	12	70.45	0.27	0.27	0.00
6.25	0.30	12	70.44	0.33	0.33	0.00
6.50	0.00	0	70.08	0.00	0.00	0.00
6.75	0.00	0	70.08	0.00	0.00	0.00
7.00	0.00	0	70.08	0.00	0.00	0.00
7.25	0.00	0	70.08	0.00	0.00	0.00
7.50	0.00	0	70.08	0.00	0.00	0.00
7.75	0.00	0	70.08	0.00	0.00	0.00
8.00	0.00	0	70.08	0.00	0.00	0.00
8.25	0.00	0	70.08	0.00	0.00	0.00
8.50	0.00	0	70.08	0.00	0.00	0.00
8.75	0.00	0	70.08	0.00	0.00	0.00
9.00	0.00	0	70.08	0.00	0.00	0.00

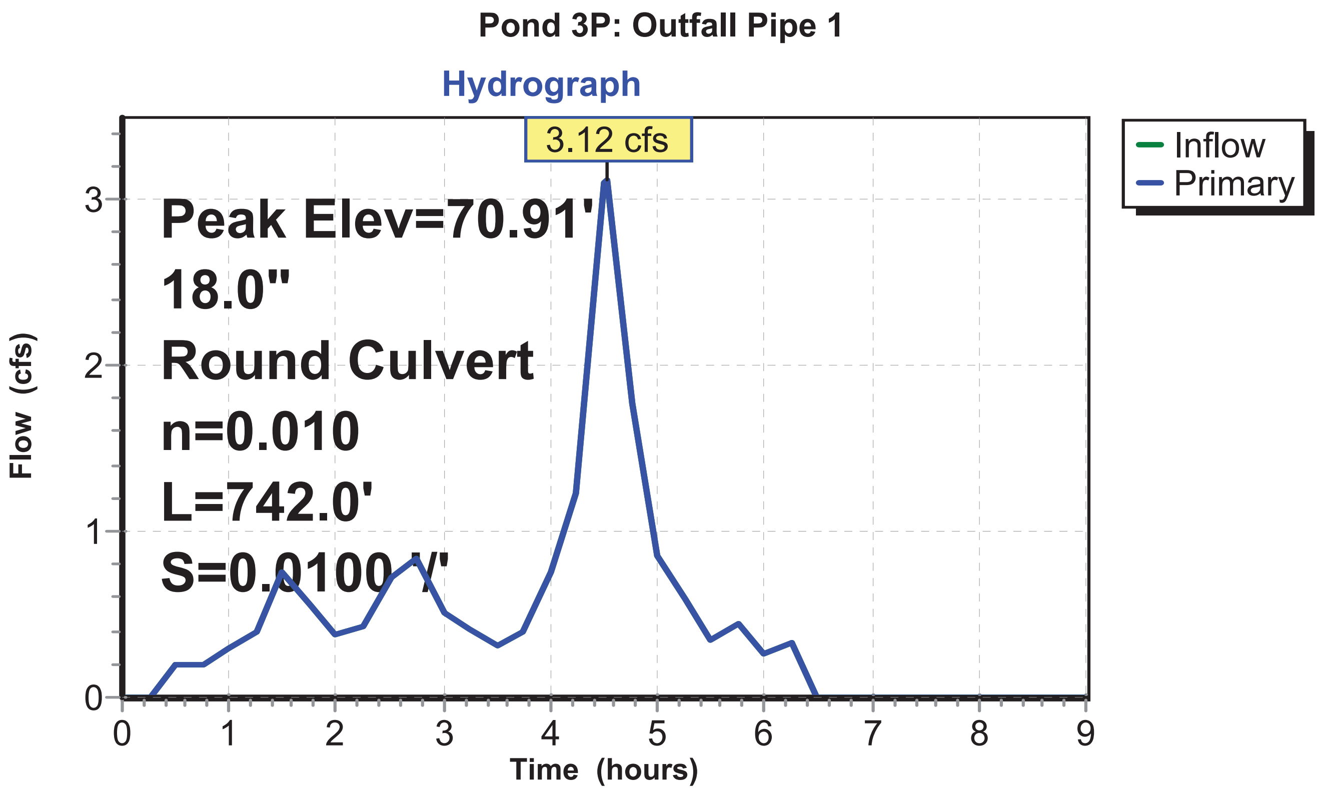
Summary for Pond 3P: Outfall Pipe 1

Inflow	=	3.12 cfs @	4.52 hrs, Volume=	0.333 af
Outflow	=	3.12 cfs @	4.52 hrs, Volume=	0.333 af, Atten= 0%, Lag= 0.0 min
Primary	=	3.12 cfs @	4.52 hrs, Volume=	0.333 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs
Peak Elev= 70.91' @ 4.52 hrs
Flood Elev= 77.50'

Device	Routing	Invert	Outlet Devices
#1	Primary	70.08'	**18.0" Round RCP_Round 18"** L= 742.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 70.08' / 62.67' S= 0.0100 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.77 sf

Primary OutFlow Max=2.99 cfs @ 4.52 hrs HW=70.89' TW=65.83' (Dynamic Tailwater)
1=RCP_Round 18" (Inlet Controls 2.99 cfs @ 3.07 fps)



Hydrograph for Pond 3P: Outfall Pipe 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	70.08	0.00
0.25	0.00	70.08	0.00
0.50	0.19	70.27	0.19
0.75	0.20	70.27	0.20
1.00	0.29	70.31	0.29
1.25	0.40	70.35	0.40
1.50	0.75	70.46	0.75
1.75	0.56	70.41	0.56
2.00	0.37	70.35	0.37
2.25	0.43	70.37	0.43
2.50	0.73	70.46	0.73
2.75	0.83	70.48	0.83
3.00	0.52	70.39	0.52
3.25	0.41	70.36	0.41
3.50	0.30	70.32	0.30
3.75	0.39	70.35	0.39
4.00	0.76	70.47	0.76
4.25	1.24	70.58	1.24
4.50	**3.11**	**70.91**	**3.11**
4.75	1.78	70.69	1.78
5.00	0.85	70.49	0.85
5.25	0.59	70.42	0.59
5.50	0.35	70.34	0.35
5.75	0.45	70.37	0.45
6.00	0.27	70.30	0.27
6.25	0.33	70.33	0.33
6.50	0.00	70.08	0.00
6.75	0.00	70.08	0.00
7.00	0.00	70.08	0.00
7.25	0.00	70.08	0.00
7.50	0.00	70.08	0.00
7.75	0.00	70.08	0.00
8.00	0.00	70.08	0.00
8.25	0.00	70.08	0.00
8.50	0.00	70.08	0.00
8.75	0.00	70.08	0.00
9.00	0.00	70.08	0.00

Summary for Pond 4P: Outfall Pipe 2

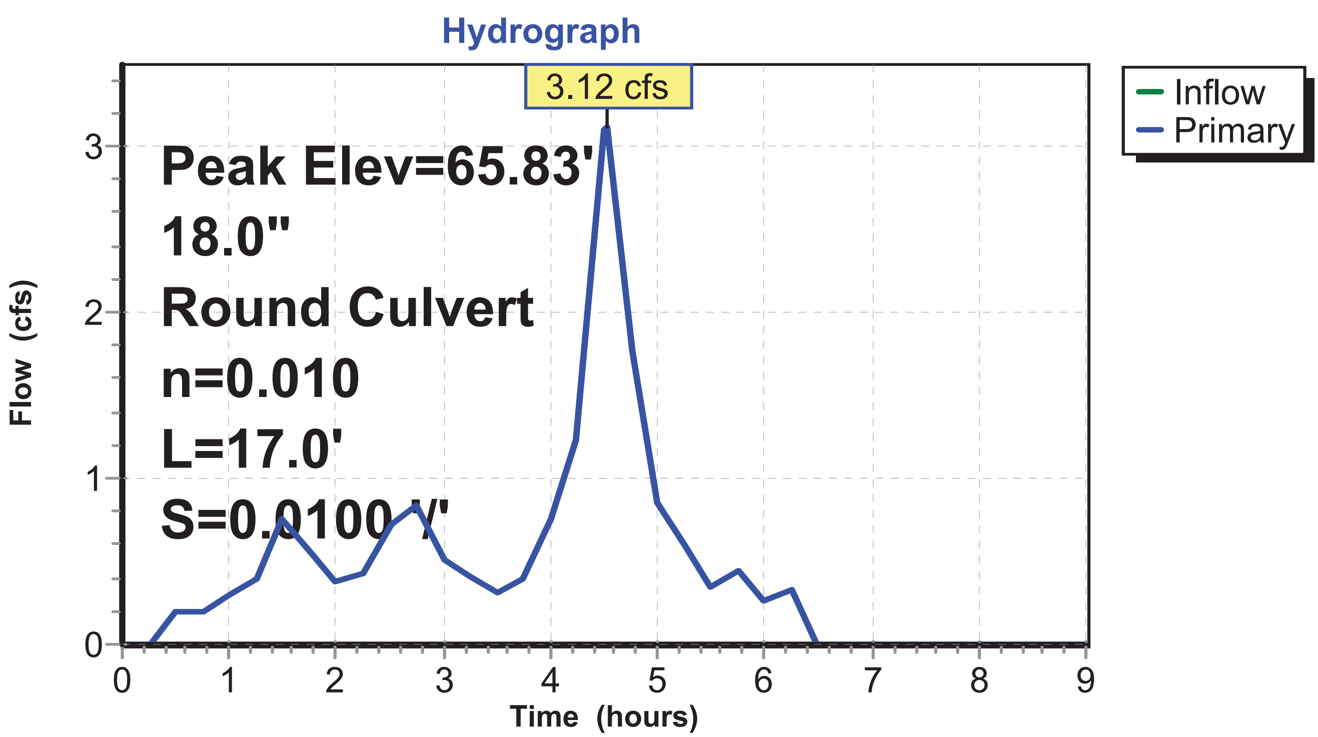
Inflow	=	3.12 cfs @	4.52 hrs, Volume=	0.333 af
Outflow	=	3.12 cfs @	4.52 hrs, Volume=	0.333 af, Atten= 0%, Lag= 0.0 min
Primary	=	3.12 cfs @	4.52 hrs, Volume=	0.333 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs
Peak Elev= 65.83' @ 4.51 hrs
Flood Elev= 69.10'

Device	Routing	Invert	Outlet Devices
#1	Primary	62.67'	**18.0" Round RCP_Round 18"** L= 17.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 62.67' / 62.50' S= 0.0100 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.77 sf

Primary OutFlow Max=3.02 cfs @ 4.52 hrs HW=65.83' TW=65.70' (Dynamic Tailwater)
└**1=RCP_Round 18"** (Inlet Controls 3.02 cfs @ 1.71 fps)

Pond 4P: Outfall Pipe 2



Hydrograph for Pond 4P: Outfall Pipe 2

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	62.67	0.00
0.25	0.00	62.73	0.00
0.50	0.19	65.70	0.19
0.75	0.20	65.70	0.20
1.00	0.29	65.70	0.29
1.25	0.40	65.70	0.40
1.50	0.75	65.71	0.75
1.75	0.56	65.70	0.56
2.00	0.37	65.70	0.37
2.25	0.43	65.70	0.43
2.50	0.73	65.71	0.73
2.75	0.83	65.71	0.83
3.00	0.52	65.70	0.52
3.25	0.41	65.70	0.41
3.50	0.30	65.70	0.30
3.75	0.39	65.70	0.39
4.00	0.76	65.71	0.76
4.25	1.24	65.72	1.24
4.50	**3.11**	**65.83**	**3.11**
4.75	1.78	65.74	1.78
5.00	0.85	65.71	0.85
5.25	0.59	65.70	0.59
5.50	0.35	65.70	0.35
5.75	0.45	65.70	0.45
6.00	0.27	65.70	0.27
6.25	0.33	65.70	0.33
6.50	0.00	65.69	0.00
6.75	0.00	65.69	0.00
7.00	0.00	65.69	0.00
7.25	0.00	65.69	0.00
7.50	0.00	65.69	0.00
7.75	0.00	65.69	0.00
8.00	0.00	65.69	0.00
8.25	0.00	65.69	0.00
8.50	0.00	65.69	0.00
8.75	0.00	65.69	0.00
9.00	0.00	65.69	0.00

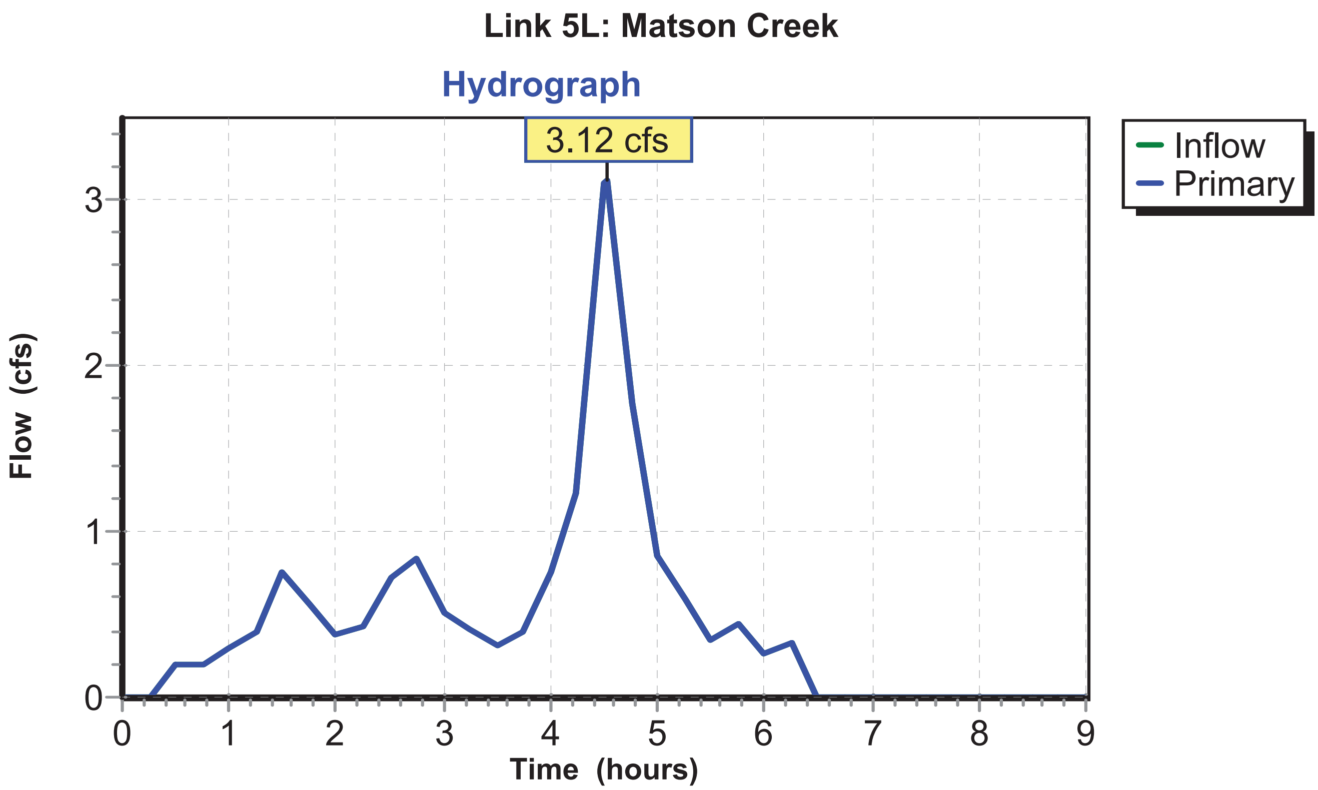
Summary for Link 5L: Matson Creek

[80] Warning: Exceeded Pond 4P by 3.03' @ 0.00 hrs (12.85 cfs 0.687 af)

Inflow	=	3.12 cfs @	4.52 hrs, Volume=	0.333 af
Primary	=	3.12 cfs @	4.52 hrs, Volume=	0.333 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs

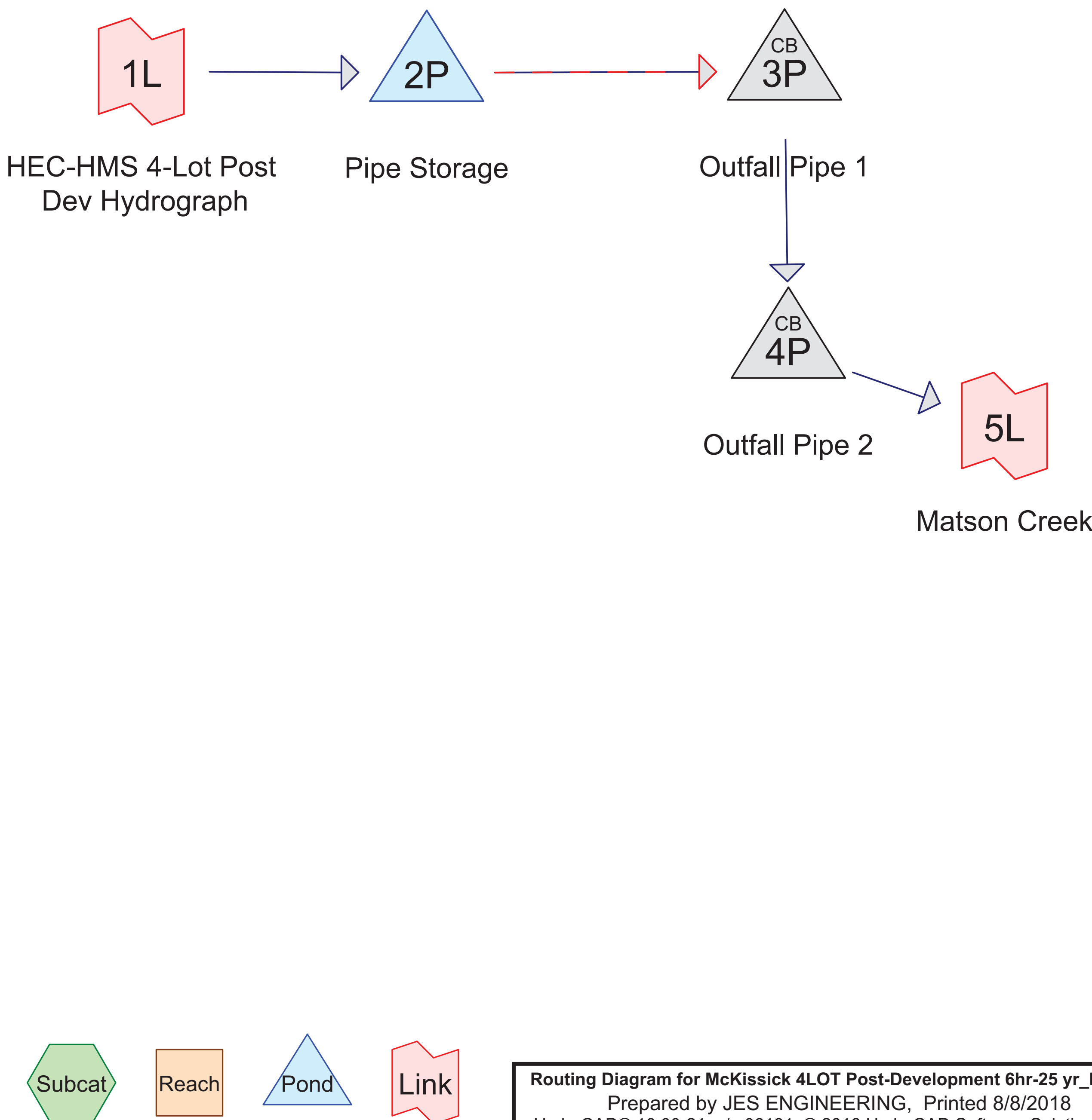
Fixed water surface Elevation= 65.70'



Hydrograph for Link 5L: Matson Creek

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**65.70**	0.00
0.25	0.00	65.70	0.00
0.50	0.19	65.70	0.19
0.75	0.20	65.70	0.20
1.00	0.29	65.70	0.29
1.25	0.40	65.70	0.40
1.50	0.75	65.70	0.75
1.75	0.56	65.70	0.56
2.00	0.37	65.70	0.37
2.25	0.43	65.70	0.43
2.50	0.73	65.70	0.73
2.75	0.83	65.70	0.83
3.00	0.52	65.70	0.52
3.25	0.41	65.70	0.41
3.50	0.30	65.70	0.30
3.75	0.39	65.70	0.39
4.00	0.76	65.70	0.76
4.25	1.24	65.70	1.24
4.50	**3.11**	65.70	**3.11**
4.75	1.78	65.70	1.78
5.00	0.85	65.70	0.85
5.25	0.59	65.70	0.59
5.50	0.35	65.70	0.35
5.75	0.45	65.70	0.45
6.00	0.27	65.70	0.27
6.25	0.33	65.70	0.33
6.50	0.00	65.70	0.00
6.75	0.00	65.70	0.00
7.00	0.00	65.70	0.00
7.25	0.00	65.70	0.00
7.50	0.00	65.70	0.00
7.75	0.00	65.70	0.00
8.00	0.00	65.70	0.00
8.25	0.00	65.70	0.00
8.50	0.00	65.70	0.00
8.75	0.00	65.70	0.00
9.00	0.00	65.70	0.00

Attachment 13: Post-development Report – Plugged Orifice Analysis



Routing Diagram for McKissick 4LOT Post-Development 6hr-25 yr_REVISED
Prepared by JES ENGINEERING, Printed 8/8/2018

Time span=0.00-9.00 hrs, dt=0.25 hrs, 37 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Link 1L: HEC-HMS 4-Lot Flow Imported from HEC-HMS hydrograph_4-Lot Post.csv Inflow=3.40 cfs 0.333 af
Primary=3.40 cfs 0.333 af

Pond 2P: Pipe Storage Peak Elev=71.93' Storage=387 cf Inflow=3.40 cfs 0.333 af
Primary=0.00 cfs 0.000 af Secondary=3.31 cfs 0.327 af Outflow=3.31 cfs 0.327 af

Pond 3P: Outfall Pipe 1 Peak Elev=70.94' Inflow=3.31 cfs 0.327 af
18.0" Round Culvert n=0.010 L=742.0' S=0.0100 '/' Outflow=3.31 cfs 0.327 af

Pond 4P: Outfall Pipe 2 Peak Elev=65.85' Inflow=3.31 cfs 0.327 af
18.0" Round Culvert n=0.010 L=17.0' S=0.0100 '/' Outflow=3.31 cfs 0.327 af

Link 5L: Matson Creek Inflow=3.31 cfs 0.327 af
Primary=3.31 cfs 0.327 af

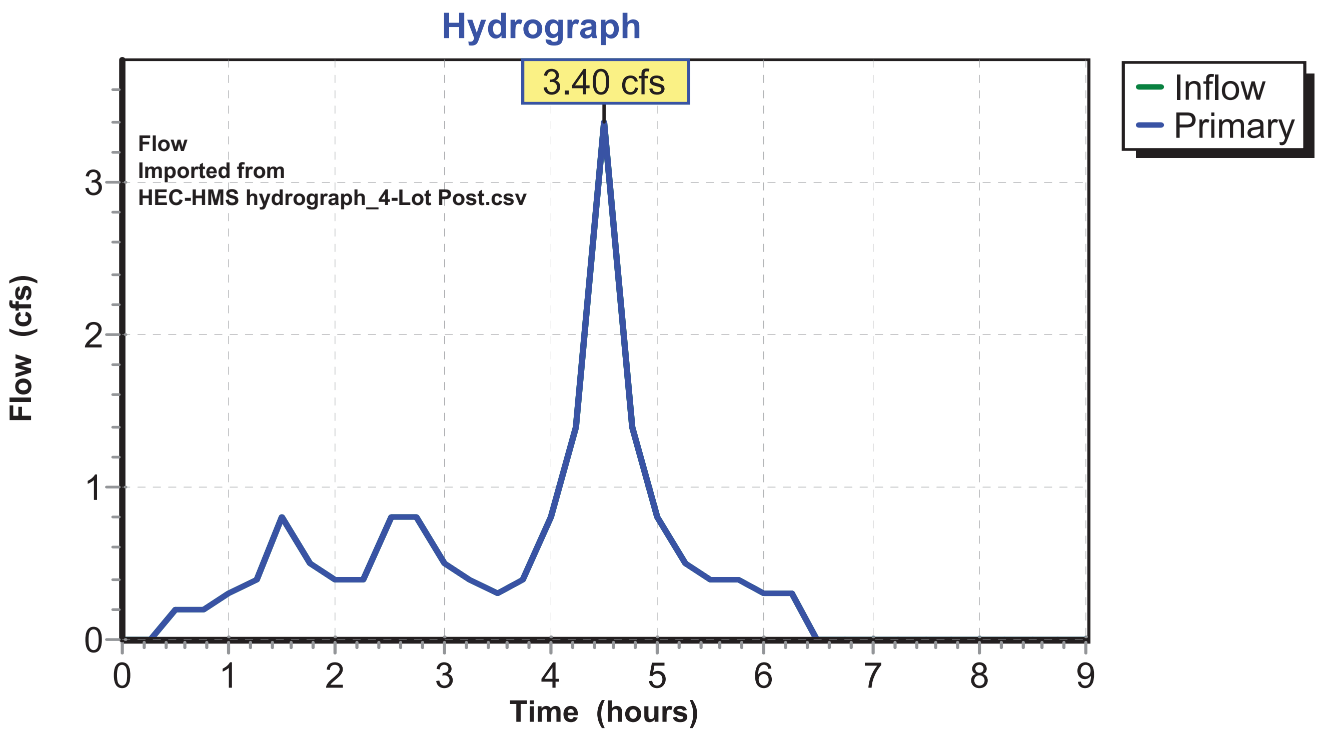
Summary for Link 1L: HEC-HMS 4-Lot Post Dev Hydrograph

Inflow	=	3.40 cfs @	4.50 hrs,	Volume=	0.333 af
Primary	=	3.40 cfs @	4.50 hrs,	Volume=	0.333 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs

Flow Imported from HEC-HMS hydrograph_4-Lot Post.csv

Link 1L: HEC-HMS 4-Lot Post Dev Hydrograph



Hydrograph for Link 1L: HEC-HMS 4-Lot Post Dev Hydrograph

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**0.00**	0.00
0.25	0.00	0.00	0.00
0.50	0.20	0.00	0.20
0.75	0.20	0.00	0.20
1.00	0.30	0.00	0.30
1.25	0.40	0.00	0.40
1.50	0.80	0.00	0.80
1.75	0.50	0.00	0.50
2.00	0.40	0.00	0.40
2.25	0.40	0.00	0.40
2.50	0.80	0.00	0.80
2.75	0.80	0.00	0.80
3.00	0.50	0.00	0.50
3.25	0.40	0.00	0.40
3.50	0.30	0.00	0.30
3.75	0.40	0.00	0.40
4.00	0.80	0.00	0.80
4.25	1.40	0.00	1.40
4.50	**3.40**	0.00	**3.40**
4.75	1.40	0.00	1.40
5.00	0.80	0.00	0.80
5.25	0.50	0.00	0.50
5.50	0.40	0.00	0.40
5.75	0.40	0.00	0.40
6.00	0.30	0.00	0.30
6.25	0.30	0.00	0.30
6.50	0.00	0.00	0.00
6.75	0.00	0.00	0.00
7.00	0.00	0.00	0.00
7.25	0.00	0.00	0.00
7.50	0.00	0.00	0.00
7.75	0.00	0.00	0.00
8.00	0.00	0.00	0.00
8.25	0.00	0.00	0.00
8.50	0.00	0.00	0.00
8.75	0.00	0.00	0.00
9.00	0.00	0.00	0.00

Summary for Pond 2P: Pipe Storage

[87] Warning: Oscillations may require smaller dt or Finer Routing (severity=1)

Inflow	=	3.40 cfs @	4.50 hrs,	Volume=	0.333 af
Outflow	=	3.31 cfs @	4.51 hrs,	Volume=	0.327 af, Atten= 3%, Lag= 0.5 min
Primary	=	0.00 cfs @	0.00 hrs,	Volume=	0.000 af
Secondary	=	3.31 cfs @	4.51 hrs,	Volume=	0.327 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs
Peak Elev= 71.93' @ 4.51 hrs   Surf.Area= 275 sf   Storage= 387 cf
Flood Elev= 81.60'   Surf.Area= 0 sf   Storage= 506 cf

Plug-Flow detention time= 7.1 min calculated for 0.327 af (98% of inflow)
Center-of-Mass det. time= 4.6 min (229.2 - 224.6)

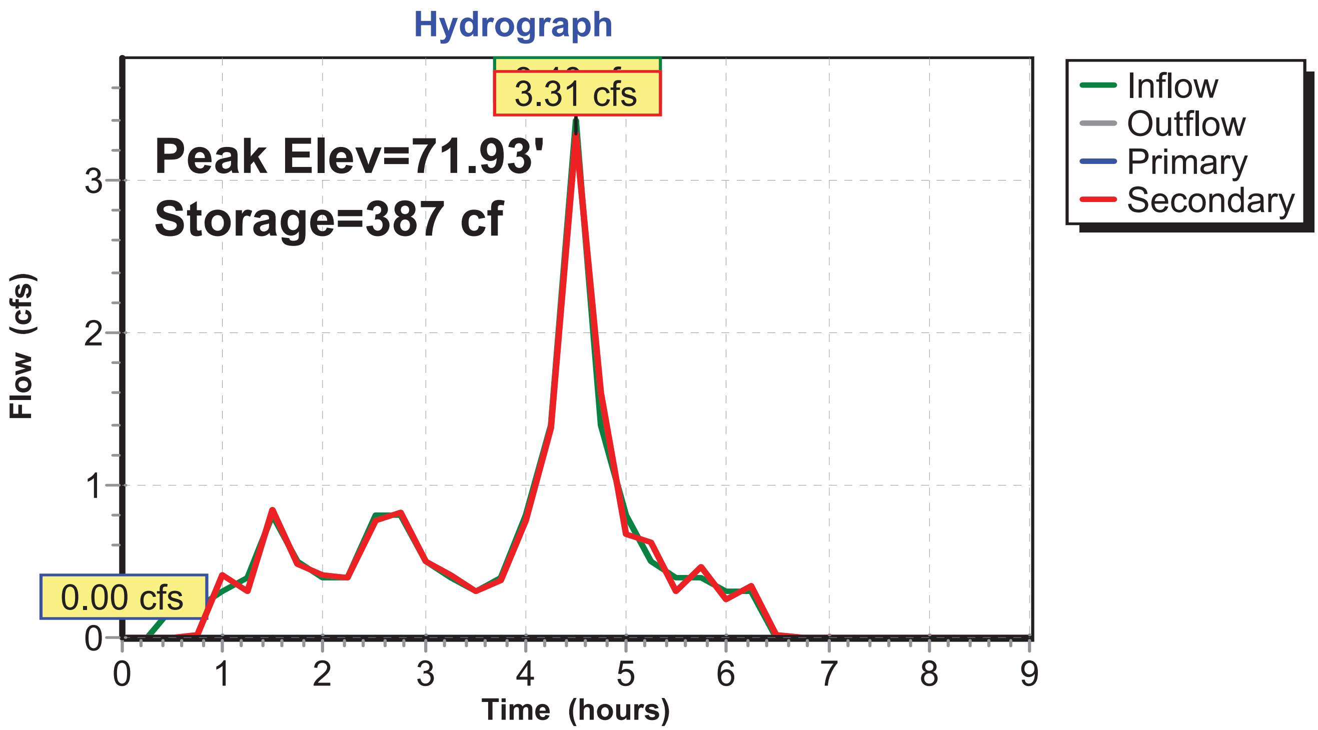
Volume	Invert	Avail.Storage	Storage Description
#1	70.08'	506 cf	**24.0" Round RCP_Round 24"** L= 161.0' S= 0.0050 '/'

Device	Routing	Invert	Outlet Devices
#1	Primary	70.08'	**7.0" W x 7.0" H Vert. Orifice/Grate X 0.00** C= 0.600
#2	Secondary	71.50'	**3.7' long x 0.50' rise Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=70.08' TW=70.08' (Dynamic Tailwater)
└─**1=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=3.24 cfs @ 4.51 hrs HW=71.92' TW=70.93' (Dynamic Tailwater)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 3.24 cfs @ 2.13 fps)

Pond 2P: Pipe Storage



Hydrograph for Pond 2P: Pipe Storage

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)
0.00	0.00	0	70.08	0.00	**0.00**	0.00
0.25	0.00	0	70.08	0.00	0.00	0.00
0.50	0.20	90	70.93	0.00	0.00	0.00
0.75	0.20	262	71.51	0.02	0.00	0.02
1.00	0.30	292	71.61	0.42	0.00	0.42
1.25	0.40	285	71.58	0.30	0.00	0.30
1.50	0.80	311	71.67	0.84	0.00	0.84
1.75	0.50	295	71.62	0.49	0.00	0.49
2.00	0.40	292	71.61	0.42	0.00	0.42
2.25	0.40	290	71.60	0.39	0.00	0.39
2.50	0.80	308	71.66	0.77	0.00	0.77
2.75	0.80	310	71.67	0.82	0.00	0.82
3.00	0.50	296	71.62	0.51	0.00	0.51
3.25	0.40	291	71.60	0.40	0.00	0.40
3.50	0.30	286	71.59	0.31	0.00	0.31
3.75	0.40	290	71.60	0.38	0.00	0.38
4.00	0.80	308	71.66	0.78	0.00	0.78
4.25	1.40	331	71.74	1.37	0.00	1.37
4.50	**3.40**	**387**	**71.93**	**3.30**	0.00	**3.30**
4.75	1.40	339	71.76	1.60	0.00	1.60
5.00	0.80	304	71.65	0.68	0.00	0.68
5.25	0.50	302	71.64	0.63	0.00	0.63
5.50	0.40	285	71.59	0.31	0.00	0.31
5.75	0.40	294	71.62	0.47	0.00	0.47
6.00	0.30	282	71.58	0.25	0.00	0.25
6.25	0.30	287	71.59	0.33	0.00	0.33
6.50	0.00	263	71.51	0.02	0.00	0.02
6.75	0.00	254	71.49	0.00	0.00	0.00
7.00	0.00	254	71.49	0.00	0.00	0.00
7.25	0.00	254	71.49	0.00	0.00	0.00
7.50	0.00	254	71.49	0.00	0.00	0.00
7.75	0.00	254	71.49	0.00	0.00	0.00
8.00	0.00	254	71.49	0.00	0.00	0.00
8.25	0.00	254	71.49	0.00	0.00	0.00
8.50	0.00	254	71.49	0.00	0.00	0.00
8.75	0.00	254	71.49	0.00	0.00	0.00
9.00	0.00	254	71.49	0.00	0.00	0.00

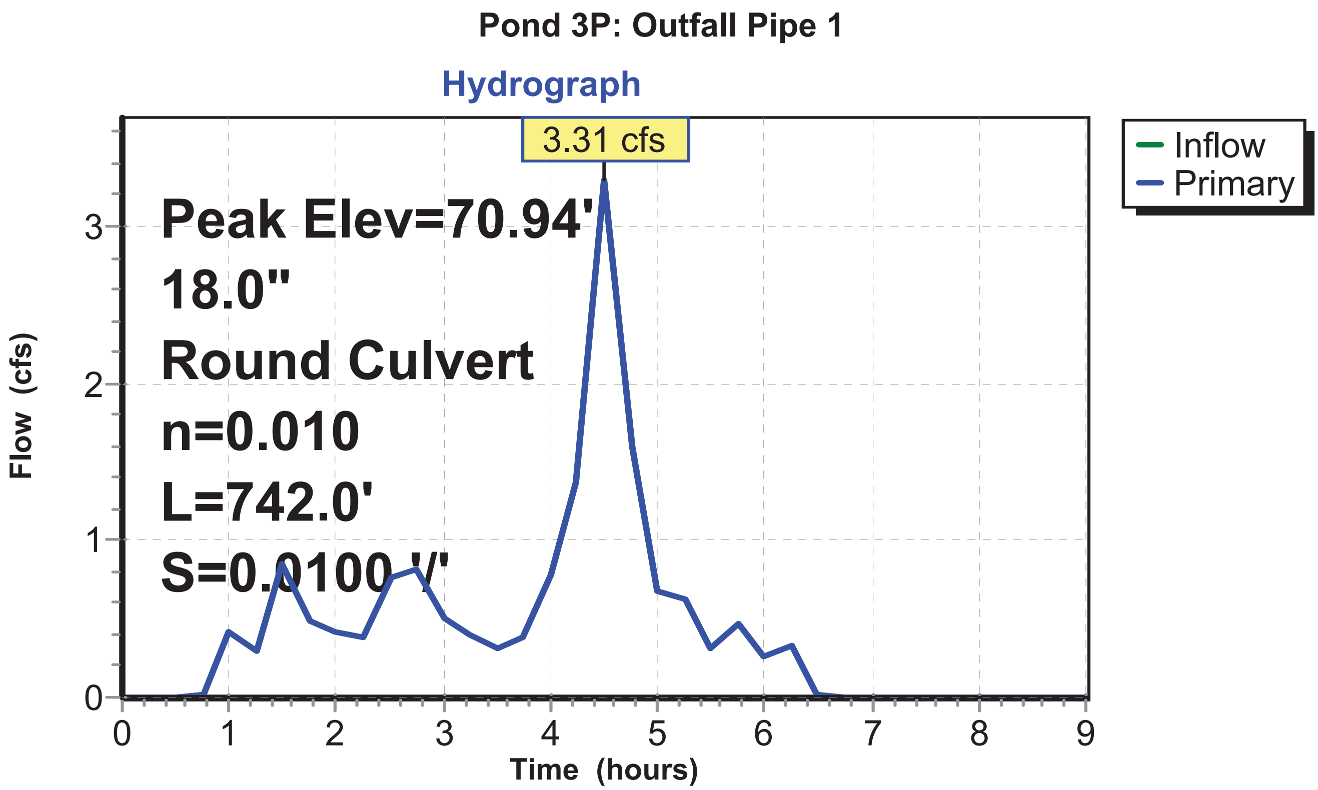
Summary for Pond 3P: Outfall Pipe 1

Inflow	=	3.31 cfs @	4.51 hrs, Volume=	0.327 af
Outflow	=	3.31 cfs @	4.51 hrs, Volume=	0.327 af, Atten= 0%, Lag= 0.0 min
Primary	=	3.31 cfs @	4.51 hrs, Volume=	0.327 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs
Peak Elev= 70.94' @ 4.51 hrs
Flood Elev= 77.50'

Device	Routing	Invert	Outlet Devices
#1	Primary	70.08'	**18.0" Round RCP_Round 18"** L= 742.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 70.08' / 62.67' S= 0.0100 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.77 sf

Primary OutFlow Max=3.24 cfs @ 4.51 hrs HW=70.93' TW=65.85' (Dynamic Tailwater)
↑—**1=RCP_Round 18"** (Inlet Controls 3.24 cfs @ 3.14 fps)



Hydrograph for Pond 3P: Outfall Pipe 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	70.08	0.00
0.25	0.00	70.08	0.00
0.50	0.00	70.08	0.00
0.75	0.02	70.14	0.02
1.00	0.42	70.36	0.42
1.25	0.30	70.32	0.30
1.50	0.84	70.49	0.84
1.75	0.49	70.39	0.49
2.00	0.42	70.36	0.42
2.25	0.39	70.35	0.39
2.50	0.77	70.47	0.77
2.75	0.82	70.48	0.82
3.00	0.51	70.39	0.51
3.25	0.40	70.36	0.40
3.50	0.31	70.32	0.31
3.75	0.38	70.35	0.38
4.00	0.78	70.47	0.78
4.25	1.37	70.61	1.37
4.50	**3.30**	**70.94**	**3.30**
4.75	1.60	70.65	1.60
5.00	0.68	70.44	0.68
5.25	0.63	70.43	0.63
5.50	0.31	70.32	0.31
5.75	0.47	70.38	0.47
6.00	0.25	70.30	0.25
6.25	0.33	70.33	0.33
6.50	0.02	70.14	0.02
6.75	0.00	70.08	0.00
7.00	0.00	70.08	0.00
7.25	0.00	70.08	0.00
7.50	0.00	70.08	0.00
7.75	0.00	70.08	0.00
8.00	0.00	70.08	0.00
8.25	0.00	70.08	0.00
8.50	0.00	70.08	0.00
8.75	0.00	70.08	0.00
9.00	0.00	70.08	0.00

Summary for Pond 4P: Outfall Pipe 2

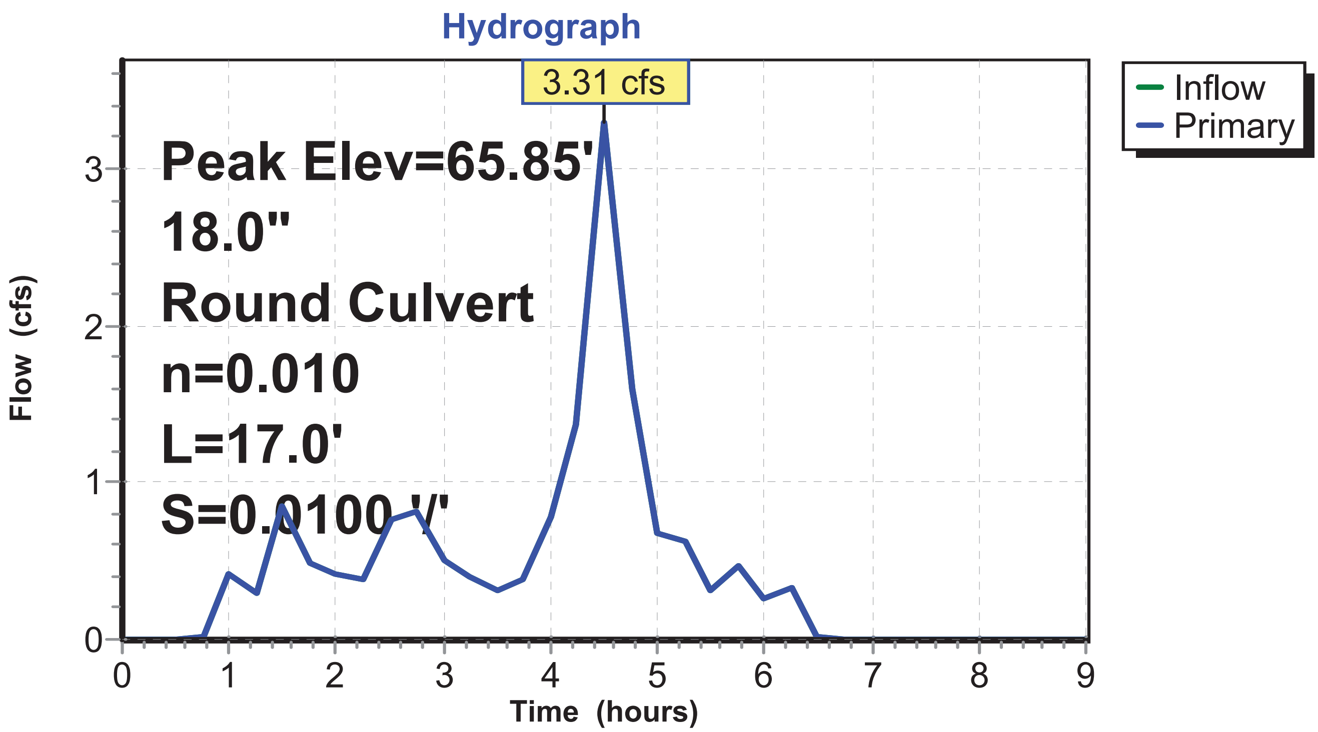
Inflow	=	3.31 cfs @	4.51 hrs,	Volume=	0.327 af
Outflow	=	3.31 cfs @	4.51 hrs,	Volume=	0.327 af, Atten= 0%, Lag= 0.0 min
Primary	=	3.31 cfs @	4.51 hrs,	Volume=	0.327 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs
Peak Elev= 65.85' @ 4.50 hrs
Flood Elev= 69.10'

Device	Routing	Invert	Outlet Devices
#1	Primary	62.67'	**18.0" Round RCP_Round 18"** L= 17.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 62.67' / 62.50' S= 0.0100 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.77 sf

Primary OutFlow Max=3.26 cfs @ 4.51 hrs HW=65.85' TW=65.70' (Dynamic Tailwater)
└**1=RCP_Round 18"** (Inlet Controls 3.26 cfs @ 1.85 fps)

Pond 4P: Outfall Pipe 2



Hydrograph for Pond 4P: Outfall Pipe 2

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	62.67	0.00
0.25	0.00	62.73	0.00
0.50	0.00	62.80	0.00
0.75	0.02	65.70	0.02
1.00	0.42	65.70	0.42
1.25	0.30	65.70	0.30
1.50	0.84	65.71	0.84
1.75	0.49	65.70	0.49
2.00	0.42	65.70	0.42
2.25	0.39	65.70	0.39
2.50	0.77	65.71	0.77
2.75	0.82	65.71	0.82
3.00	0.51	65.70	0.51
3.25	0.40	65.70	0.40
3.50	0.31	65.70	0.31
3.75	0.38	65.70	0.38
4.00	0.78	65.71	0.78
4.25	1.37	65.73	1.37
4.50	**3.30**	**65.85**	**3.30**
4.75	1.60	65.74	1.60
5.00	0.68	65.71	0.68
5.25	0.63	65.71	0.63
5.50	0.31	65.70	0.31
5.75	0.47	65.70	0.47
6.00	0.25	65.70	0.25
6.25	0.33	65.70	0.33
6.50	0.02	65.70	0.02
6.75	0.00	62.67	0.00
7.00	0.00	62.73	0.00
7.25	0.00	62.80	0.00
7.50	0.00	62.86	0.00
7.75	0.00	62.93	0.00
8.00	0.00	62.99	0.00
8.25	0.00	63.06	0.00
8.50	0.00	63.12	0.00
8.75	0.00	63.18	0.00
9.00	0.00	63.25	0.00

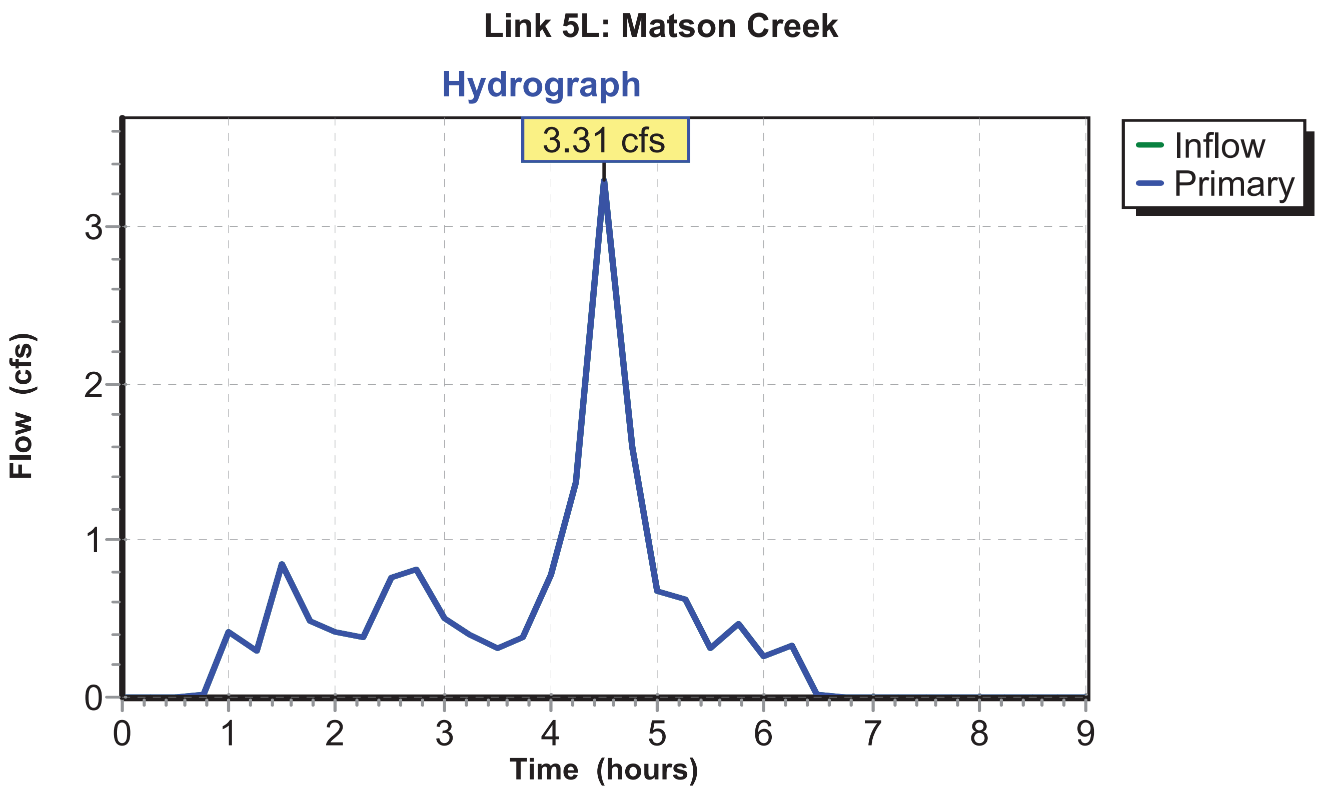
Summary for Link 5L: Matson Creek

[80] Warning: Exceeded Pond 4P by 3.03' @ 0.00 hrs (12.85 cfs 3.185 af)

Inflow	=	3.31 cfs @	4.51 hrs, Volume=	0.327 af	
Primary	=	3.31 cfs @	4.51 hrs, Volume=	0.327 af,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-9.00 hrs, dt= 0.25 hrs

Fixed water surface Elevation= 65.70'

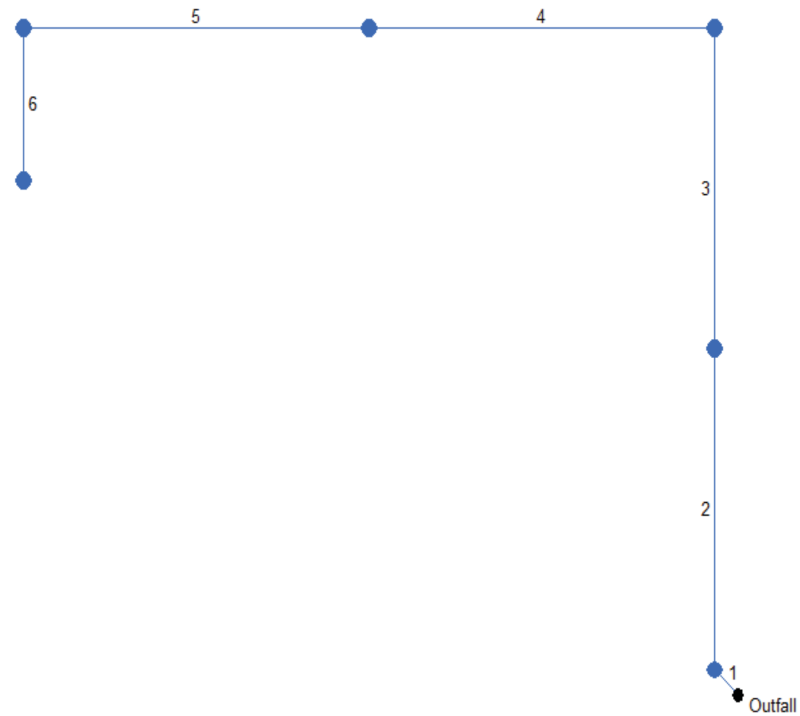


Hydrograph for Link 5L: Matson Creek

Time (hours)	Inflow (cfs)	Elevation (feet)	Primary (cfs)
0.00	0.00	**65.70**	0.00
0.25	0.00	65.70	0.00
0.50	0.00	65.70	0.00
0.75	0.02	65.70	0.02
1.00	0.42	65.70	0.42
1.25	0.30	65.70	0.30
1.50	0.84	65.70	0.84
1.75	0.49	65.70	0.49
2.00	0.42	65.70	0.42
2.25	0.39	65.70	0.39
2.50	0.77	65.70	0.77
2.75	0.82	65.70	0.82
3.00	0.51	65.70	0.51
3.25	0.40	65.70	0.40
3.50	0.31	65.70	0.31
3.75	0.38	65.70	0.38
4.00	0.78	65.70	0.78
4.25	1.37	65.70	1.37
4.50	**3.30**	65.70	**3.30**
4.75	1.60	65.70	1.60
5.00	0.68	65.70	0.68
5.25	0.63	65.70	0.63
5.50	0.31	65.70	0.31
5.75	0.47	65.70	0.47
6.00	0.25	65.70	0.25
6.25	0.33	65.70	0.33
6.50	0.02	65.70	0.02
6.75	0.00	65.70	0.00
7.00	0.00	65.70	0.00
7.25	0.00	65.70	0.00
7.50	0.00	65.70	0.00
7.75	0.00	65.70	0.00
8.00	0.00	65.70	0.00
8.25	0.00	65.70	0.00
8.50	0.00	65.70	0.00
8.75	0.00	65.70	0.00
9.00	0.00	65.70	0.00

Attachment 14: Hydraulic Analysis

Hydraflow Plan View



McKissick 2018	No. Lines: 6	08-08-2018

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
6	18	3.12	69.35	70.35	1.00	1.25	2.49	0.10	70.45	n/a	73.0	70.08	70.75 j	0.67**	0.77	4.05	0.26	71.01i	n/a	n/a	n/a	1.00	n/a
5	18	3.12	67.55	68.55	1.00	1.25	2.49	0.10	68.65	n/a	180	69.35	70.02 j	0.67**	0.77	4.05	0.26	70.28i	n/a	n/a	n/a	1.00	n/a
4	18	3.12	65.75	66.75	1.00	1.25	2.49	0.10	66.85	n/a	180	67.55	68.22 j	0.67**	0.77	4.05	0.26	68.48i	n/a	n/a	n/a	0.15	n/a
3	18	3.12	64.21	65.89	1.50	1.77	1.77	0.05	65.94	n/a	154	65.75	66.42 j	0.67**	0.77	4.05	0.26	66.68i	n/a	n/a	n/a	1.00	n/a
2	18	3.12	62.67	65.75	1.50	1.77	1.77	0.05	65.80	0.088	154	64.21	65.89	1.50	1.77	1.77	0.05	65.94	0.088	0.088	0.136	0.15	0.01
1	18	3.12	62.50	65.70	1.50	1.77	1.77	0.05	65.75	0.088	17.0	62.67	65.72	1.50	1.77	1.77	0.05	65.76	0.088	0.088	0.015	0.75	0.04

McKissick 2018 | Number of lines: 6 | Run Date: 08-08-2018

Notes: ; ** Critical depth.; j-Line contains hyd. jump.