LEGACY ENGINEERING

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730 Main Street
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Millis, MA 02054

January 3, 2023

Planning Board
900 Main Street
Town Offices
Millis, MA 02054

Ref: Acorn Place
Stormwater Basin Modifications

Dear Members of the Board:

I am writing on behalf of the applicant to request a modification to the stormwater basin designs at Acorn Place. As has been documented, Basin 1 does not drain down within 72 hours during wet seasons (periods of time with repeated, frequent rainfall events). During these same wet seasons, Basin 2 holds more shallow depths of water for longer than 72 hours. it is well known that the glacial till soils on the site are restrictive[1], which is why there are wetlands on the site in low lying valley areas (areas where stormwater cannot readily runoff). These wetlands exhibit similar patterns to the stormwater basins, holding surface water during wet seasons but being dry during other times of the year.

Due to shallow perched groundwater conditions typically associated with these types of glacial till soils, the design called for unsuitable soils to be removed and the floor of the basin to be filled with clean sand or loamy sand to raise the grade to design elevations. We took samples of the topsoil and underlying fill materials for each basin and had them tested for classification (See Attachment A for results). For Basin 1, a processed gravel material was used as the fill material. Both the loam and processed fill material samples were classified as loamy sand. For Basin 2, Title V septic sand was used as the fill material. Both the loam and processed fill material samples were classified as sand. We therefore conclude that the fill materials imported into the basins are not restricting infiltration.

[1] The NRCS soil survey classifies them as Woodbridge, Class C/D (depending on groundwater depth).

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We note the following provisions from the MassDEP Stormwater Handbook relative to stormwater infiltration basins:

- As Volume 1, Chapter 1, page 6-7 notes, "MassDEP recognized that it may be difficult to infiltrate the required recharge volume on certain sites because of soils conditions. For sites comprised solely of C and D soils…proponents are required to infiltrate the required recharge volume only to the maximum extent practicable." It is noted that the site is comprised of Class C and D soils (woodbridge soils per NRCS).
- The minimum permitted design infiltration rate for an infiltration facility is 0.17 inches per hour. Soils with slower permeability rates are typically not deemed to be suitable for infiltration. This is very close to the design infiltration rate for Basin 1 (design rate of 0.4 inches per hour), which supports a conclusion that the natural soils on the site are simply not suited to the infiltration of large volumes of runoff, which is anecdotally supporting by surficial hydrology conditions during certain times of the year.
- The detail at the top of Volume 2, Chapter 2, page 87 of the Handbook includes the possible provision for an underdrain underneath an infiltration basin "in case of standing water problems."

Given the fact that the site is comprised of C/D soils, during periods of persistent rainfall and perched high groundwater conditions, it is our conclusion that the underlying glacial till is simply unable to accommodate the infiltration of significant volumes of runoff, as the natural till soil matrix is likely already highly saturated by perched groundwater conditions throughout the site during these periods. The performance of Basin 2 supports this conclusion. It is a shallow basin with a holding depth of only 0.3 feet, and it has difficulty draining down within 72 hours during periods of persistent saturation.

While eliminating long periods of standing water with the introduction of a small low-flow outlet at the bottom of each basin is a potential solution, it is our view that the subdrain method noted in the Handbook is likely a better solution. This would allow stormwater residence time in the basin to achieve treatment, will allow some amount of infiltration (as much as the glacial till soils can accommodate, which will vary by season) and will ensure that the basin can drain down within 72 hours. Each of the two basins has a substantial thickness of imported permeable fill soils above the underlying glacial till at the bottom of the basin. It is our recommendation that a subdrain be placed within this permeable fill layer per the enclosed details, which would allow for the slow and gradual release of infiltrated water over a period of days, allowing the basins to draw down in a reasonable time frame.

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As a conservative measure, although water will infiltrate into the underlying permeable fill materials, we have re-run the Hydrocad models with no infiltration accounted for to ensure that there will be no increase in peak rates of runoff. Given the low permeability of the natural glacial till soils, infiltration did not play a significant role in peak rate mitigation. However, due to the specific configuration of the discharge headwalls in the basins, existing outlet configurations in the headwalls would need to be modified to maintain peak rates below pre-development conditions with no infiltration accounted for in the Hydrocad model. See below for further discussion:

DESIGN POINT #1: Flow to Shadowfax Farm

For Basin 1, the elimination of infiltration in the Hydrocad model only resulting in an increased peak rate of runoff in the 100-year storm. Thus, additional low-flow outlets are proposed to change the stage-discharge model to allow all peak rates to be lowered. In order to maintain the Water Quality Volume storage within the basin (4,332 c.f.), three additional 4" diameter cores are proposed to be added to the headwall at elevation 210.80, which results in a raw standing volume of 4,981 c.f. within the basin. These three new outlets will be 0.2 feet lower than the existing low-flow outlet, reducing the depth of standing water in the basin to 0.3 feet. This modification yields the following as indicated in the attached Hydrocad model:

Design Storm (Year)	Peak Runoff Rate (cfs)	
	Existing	Proposed
1	1.80	1.70
2	3.78	3.20
10	9.08	6.83
50	14.74	10.80
100	17.30	15.49

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DESIGN POINT #2: Flow to Southern Abutters

For Basin 2, the elimination of infiltration in the Hydrocad resulting in small peak rate increases in all storm events. Thus, to accommodate the revised stage-storage relationship with no infiltration included, the outlet notch is proposed to be modified per the detail in attachment C. This modification yields the following as indicated in the attached Hydrocad model:

Design Storm (Year)	Peak Runoff Rate (cfs)	
	Existing	Proposed
1	3.20	3.16
2	6.64	6.36
10	15.82	15.32
50	25.64	25.16
100	30.09	29.54

Do not hesitate to contact me should you have any questions or comments.

Yours Truly,

LEGACY ENGINEERING LLC

Digitally signed by Daniel J. Merrikin, P.E.
Date: 2023.01.03 15:54:32 -05'00'

Daniel J. Merrikin, P.E.
President

cc: File

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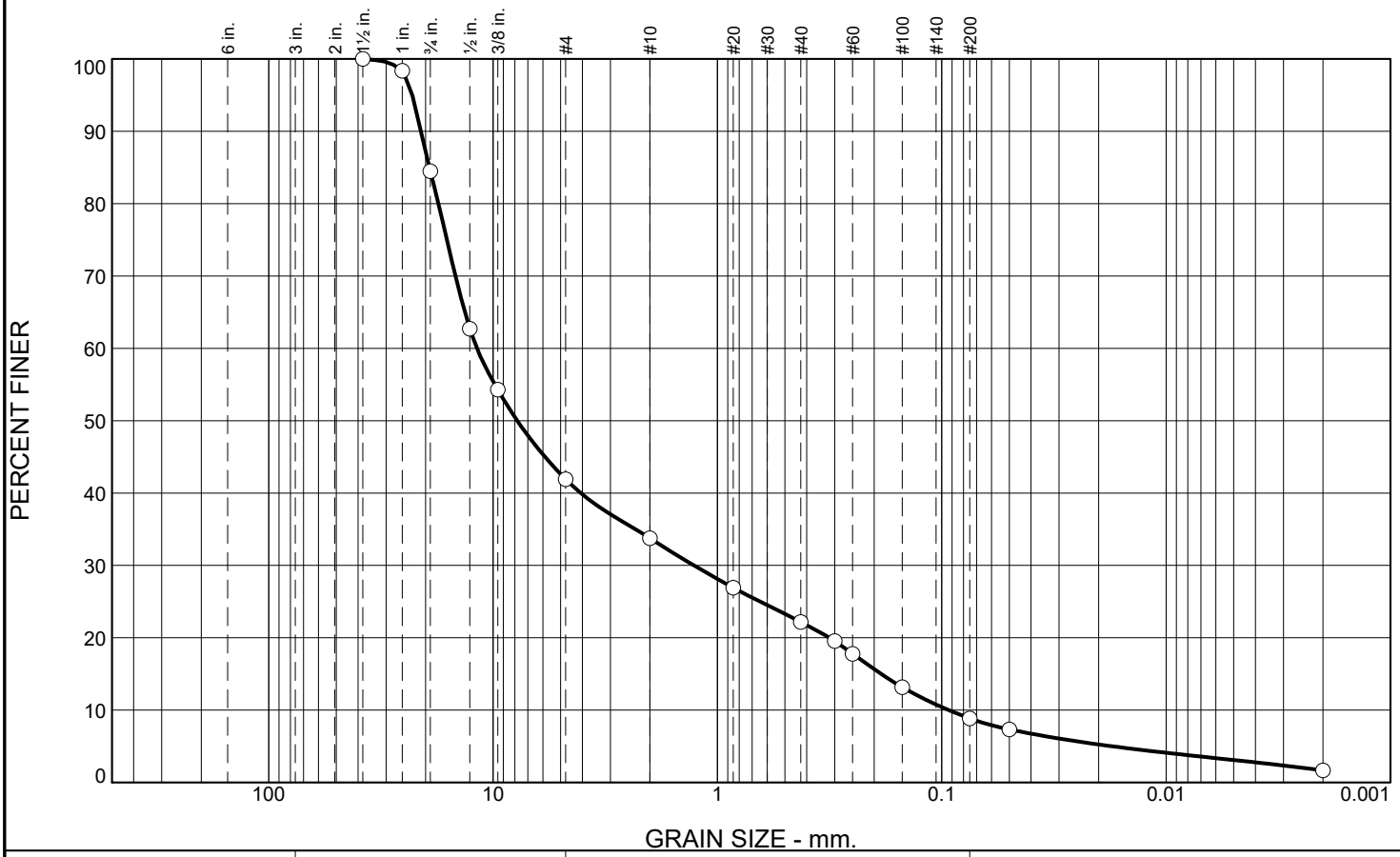
ATTACHMENT A

STORMWATER BASIN SOILS SAMPLING TEST RESULTS

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	15.5	42.6	8.1	11.6	13.3	7.2	1.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	98.3		
.75	84.5		
.5	62.7		
.375	54.3		
#4	41.9		
#10	33.8		
#20	26.9		
#40	22.2		
#50	19.5		
#60	17.8		
#100	13.2		
#200	8.9		
0.05mm	7.3		
0.002mm	1.7		

* (no specification provided)

Material Description

Brown 1.5" max gravel some f/m sand trace silt
USDA Textural Classification = Loamy Sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 19.2385 D_{60}= 11.8080 D_{50}= 7.8065
D_{30}= 1.2719 D_{15}= 0.1863 D_{10}= 0.0930
C_u= 126.95 C_c= 1.47

Classification

USCS= GW-GM AASHTO= A-1-a

Remarks

Sample submitted by client on 06/16/22
No soil specs provided

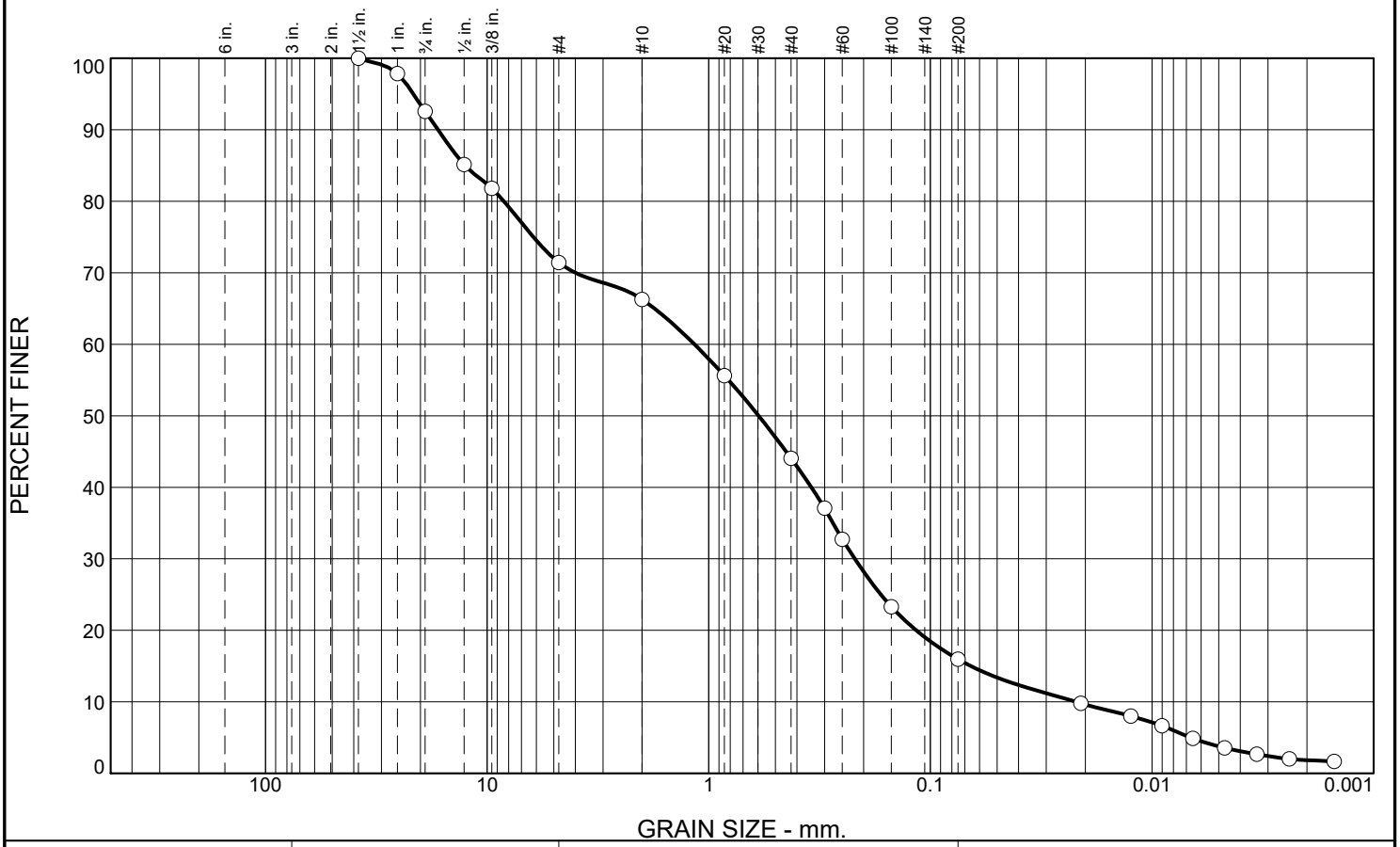
Sample No.: L-31524 **Source of Sample:** Unknown Site **Date:** 6/22/22
Location: Basin Fill #1 **Elev./Depth:** submitted

YANKEE ENGINEERING & TESTING, INC.

Client: Legacy Engineering
Project: Legacy Engineering
Various Projects/Sites
BASIN 1 - IMPORTED FILL
Project No: 2022.44

Tested By: AK **Checked By:** SMM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	7.4	21.2	5.1	22.3	28.0	14.2	1.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	97.8		
.75	92.6		
.5	85.1		
.375	81.8		
#4	71.4		
#10	66.3		
#20	55.6		
#40	44.0		
#50	37.1		
#60	32.7		
#100	23.3		
#200	16.0		

* (no specification provided)

Material Description

Brown 1.5" max silty sand some gravel
USDA Textural Classification = Loamy Sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 12.5906 D_{60}= 1.1609 D_{50}= 0.5955
D_{30}= 0.2193 D_{15}= 0.0656 D_{10}= 0.0220
C_u= 52.78 C_c= 1.88

Classification

USCS= SM AASHTO= A-1-b

Remarks

Sample submitted by client on 06/16/22
No soil specs provided
Silty soils = moisture susceptible

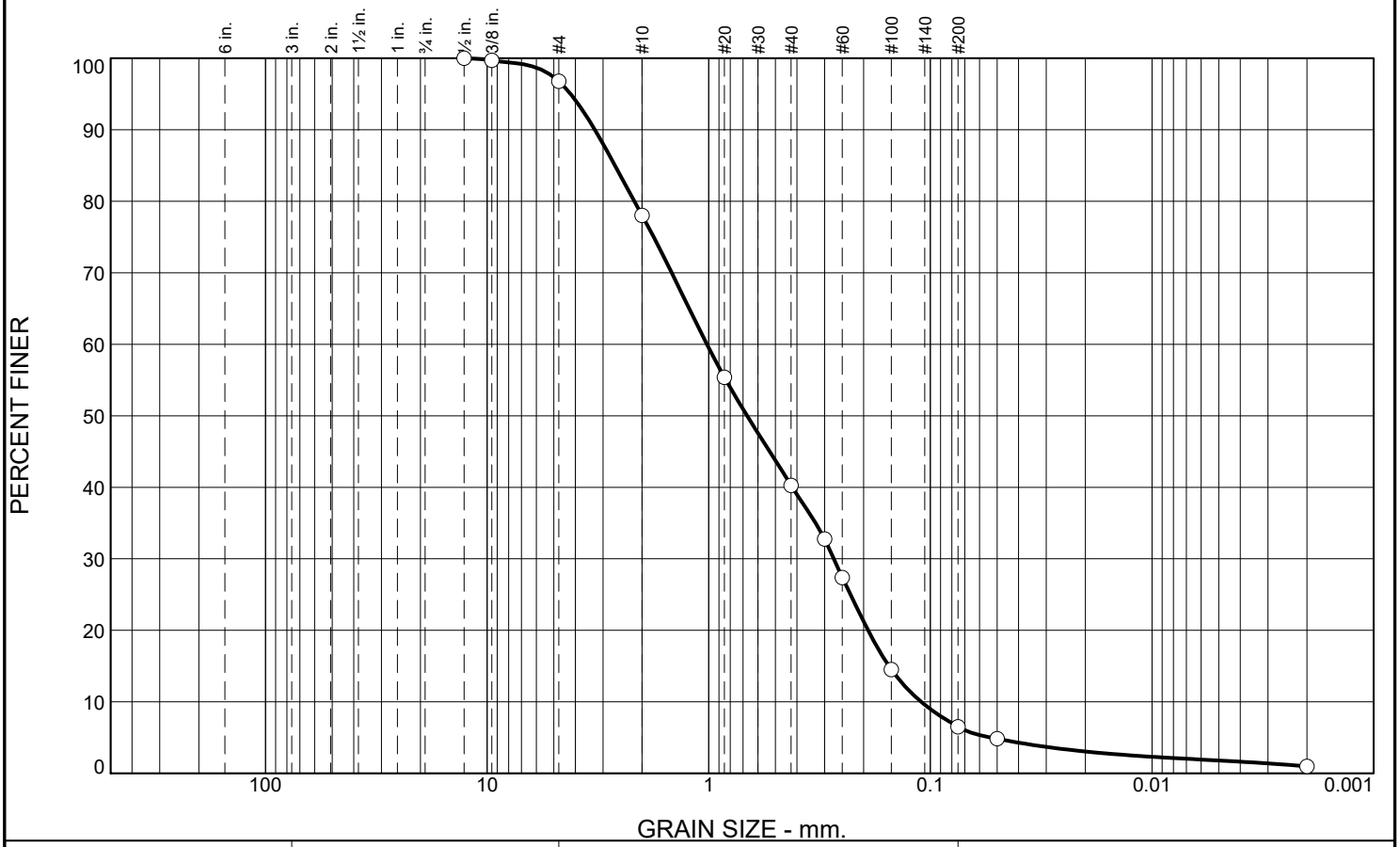
Sample No.: L-31525 **Source of Sample:** Unknown Site **Date:** 6/22/22
Location: Topsoil #1 **Elev./Depth:** submitted

YANKEE ENGINEERING & TESTING, INC.

Client: Legacy Engineering
Project: Legacy Engineering
Various Projects/Sites
BASIN 1 - TOPSOIL
Project No: 2022.44

Tested By: AK / AH **Checked By:** SMM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.2	18.8	37.7	33.8	5.5	1.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5	100.0		
.375	99.7		
#4	96.8		
#10	78.0		
#20	55.4		
#40	40.3		
#50	32.8		
#60	27.4		
#100	14.5		
#200	6.5		
0.05mm	4.8		
0.002mm	1.0		

* (no specification provided)

Material Description

Brown m/f sand trace silt trace gravel
USDA Textural Classification = Sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 2.6487 D_{60}= 1.0190 D_{50}= 0.6714
D_{30}= 0.2728 D_{15}= 0.1540 D_{10}= 0.1101
C_u= 9.26 C_c= 0.66

Classification

USCS= SP-SM AASHTO= A-1-b

Remarks

Sample submitted by client on 06/16/22
No soil specs provided

Sample No.: L-31526 **Source of Sample:** Unknown Site **Date:** 6/22/22
Location: Basin Fill #2 **Elev./Depth:** submitted

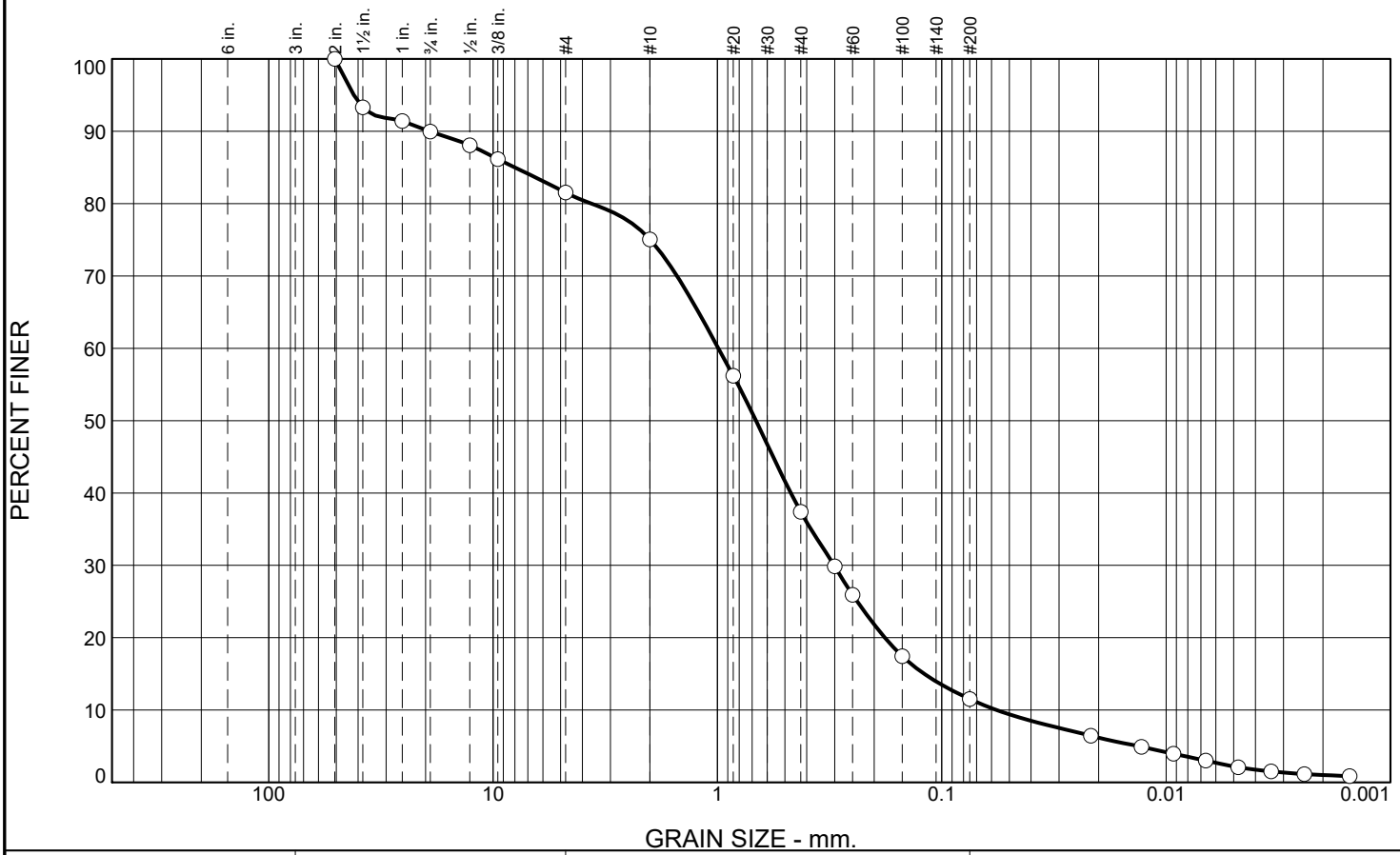
YANKEE ENGINEERING & TESTING, INC.

Client: Legacy Engineering
Project: Legacy Engineering
Various Projects/Sites
Project No: 2022.44

BASIN 2 - IMPORTED FILL

Tested By: AK / AH **Checked By:** SMM

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	10.0	8.5	6.4	37.7	25.9	10.5	1.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2	100.0		
1.5	93.3		
1	91.4		
.75	90.0		
.5	88.1		
.375	86.1		
#4	81.5		
#10	75.1		
#20	56.2		
#40	37.4		
#50	29.9		
#60	25.9		
#100	17.4		
#200	11.5		

* (no specification provided)

Material Description

Brown 1.5" max silty m/f sand little gravel
USDA Textural Classification = Sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 7.9974 D_{60}= 0.9909 D_{50}= 0.6734
D_{30}= 0.3020 D_{15}= 0.1198 D_{10}= 0.0569
C_u= 17.41 C_c= 1.62

Classification

USCS= SW-SM AASHTO= A-1-b

Remarks

Sample submitted by client on 06/16/22
No soil specs provided

Sample No.: L-31527 **Source of Sample:** Unknown Site **Date:** 6/22/22
Location: Topsoil #2 **Elev./Depth:** submitted

YANKEE ENGINEERING & TESTING, INC.

Client: Legacy Engineering
Project: Legacy Engineering
Various Projects/Sites
Project No: 2022.44

BASIN 2 - TOPSOIL

Tested By: AK / AH **Checked By:** SMM

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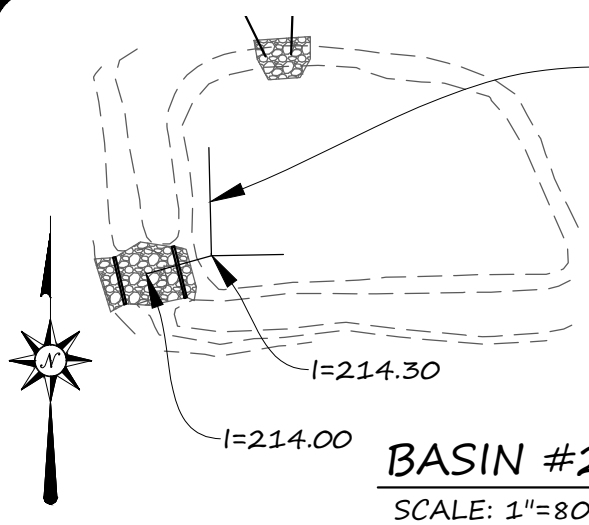
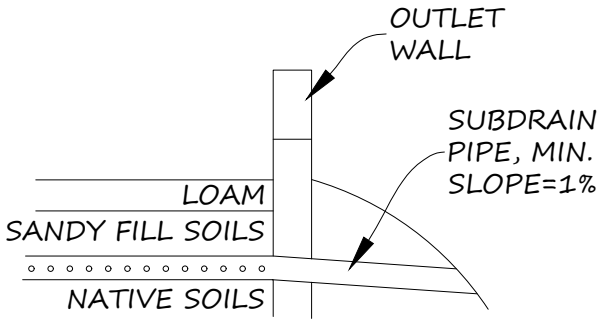
ATTACHMENT B

BASIN SUBDRAIN DETAILS

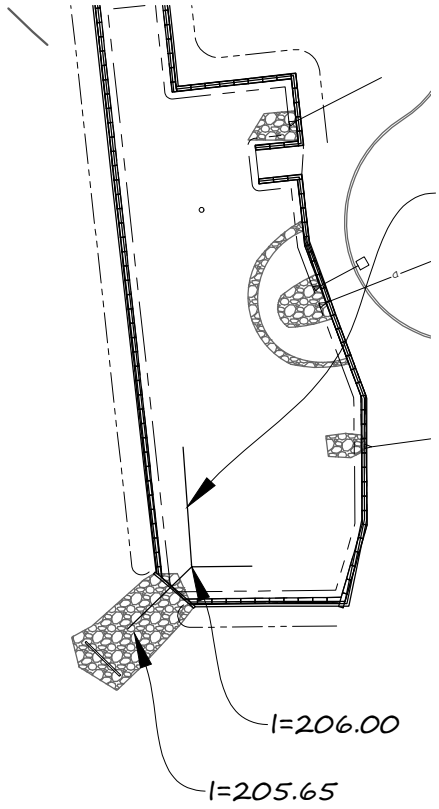


BASIN #2

SCALE: 1"=80'

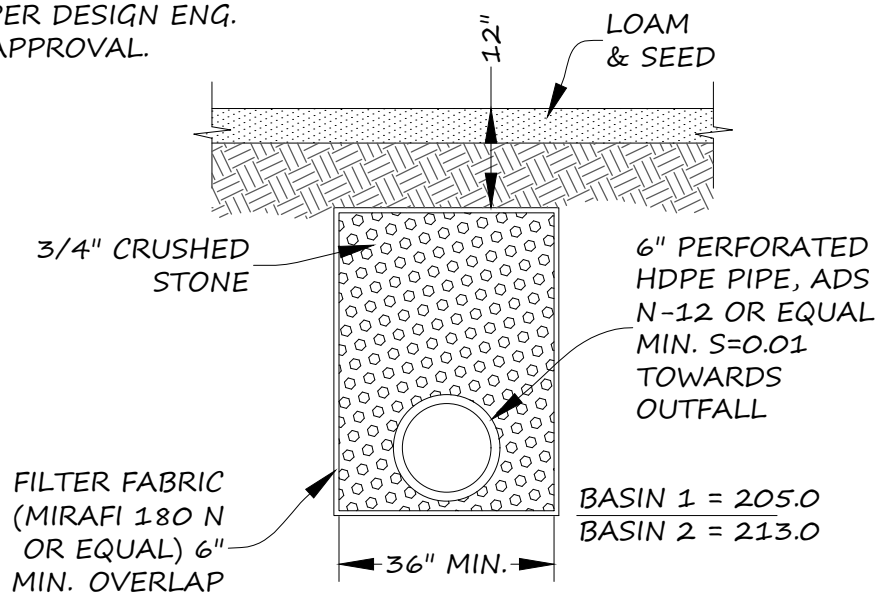


CROSS SECTION VIEW



BASIN #1

SCALE: 1"=80'



END SECTION VIEW

BASIN SUBDRAIN DETAIL

NOT TO SCALE

730 MAIN STREET
SUITE 2C
MILLIS, MA 02054
508-376-8883(o)

SHEET 1 OF 1

LEGACY ENGINEERING

ACORN PLACE
SUBDRAIN DETAILS
PLAN OF LAND
IN
MILLIS, MA

PLAN DATE: 2022-01-03

PLAN SCALE: 1"=80'

0' 80' 160'

REVISION	DATE

LEGACY ENGINEERING

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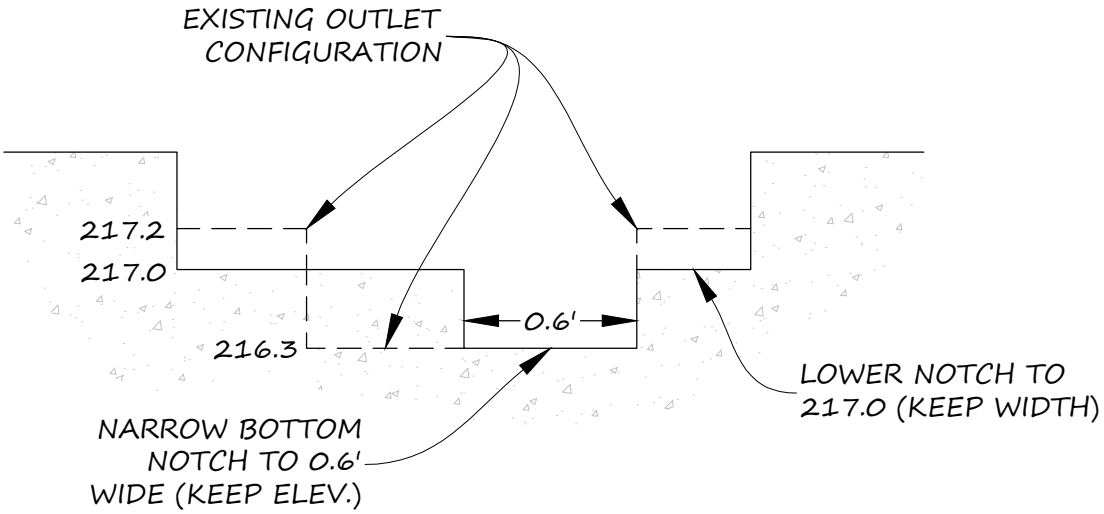
Suite 2C
Millis, MA 02054

ATTACHMENT C

BASIN HEADWALL MODIFICATION DETAILS

BASIN #1 OUTLET DETAIL

NOT TO SCALE



BASIN #2 OUTLET DETAIL

NOT TO SCALE

730 MAIN STREET
SUITE 2C
MILLIS, MA 02054
508-376-8883(o)

SHEET 1 OF 1

LEGACY ENGINEERING

ACORN PLACE
HEADWALL DETAIL
PLAN OF LAND
IN
MILLIS, MA

PLAN DATE: 2022-01-03

PLAN SCALE: 1"=80'

0' 80' 160'

REVISION	DATE

LEGACY ENGINEERING

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ATTACHMENT D

HYDROCAD RESULTS – NO BASIN INFILTRATION

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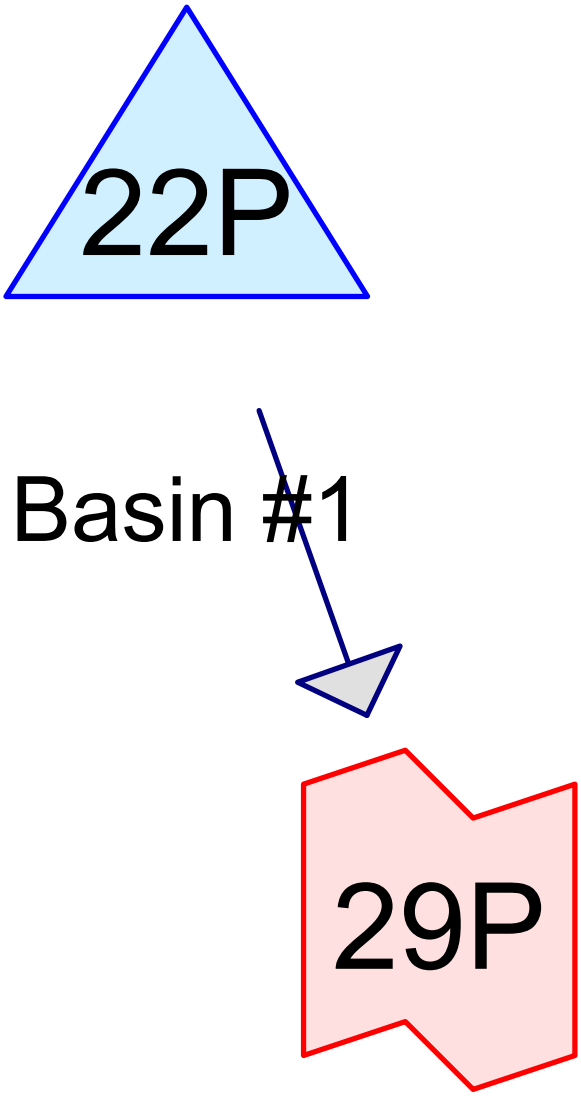
DESIGN POINT #1 – BASIN 1



Design Point #1: Flow to Shadowfax Farm

Subcat Reach Pond Link

Routing Diagram for 2023-01-03 Basin Reconfiguration
Prepared by Legacy Engineering LLC, Printed 1/3/2023

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 22P: Basin #1 Peak Elev=211.27' Storage=13,436 cf Inflow=6.17 cfs 0.536 af
Outflow=0.71 cfs 0.398 af

Link 29P: Design Point #1: Flow to Shadowfax Farm Inflow=1.70 cfs 0.541 af
Primary=1.70 cfs 0.541 af

Summary for Pond 22P: Basin #1

Inflow Area = 3.658 ac, 77.31% Impervious, Inflow Depth = 1.76" for 1-YR event
Inflow = 6.17 cfs @ 12.12 hrs, Volume= 0.536 af
Outflow = 0.71 cfs @ 12.99 hrs, Volume= 0.398 af, Atten= 88%, Lag= 52.3 min
Primary = 0.71 cfs @ 12.99 hrs, Volume= 0.398 af
Routed to Link 29P : Design Point #1: Flow to Shadowfax Farm

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 211.27' @ 12.99 hrs Surf.Area= 18,041 sf Storage= 13,436 cf

Plug-Flow detention time= 307.0 min calculated for 0.398 af (74% of inflow)
Center-of-Mass det. time= 218.9 min (1,017.8 - 799.0)

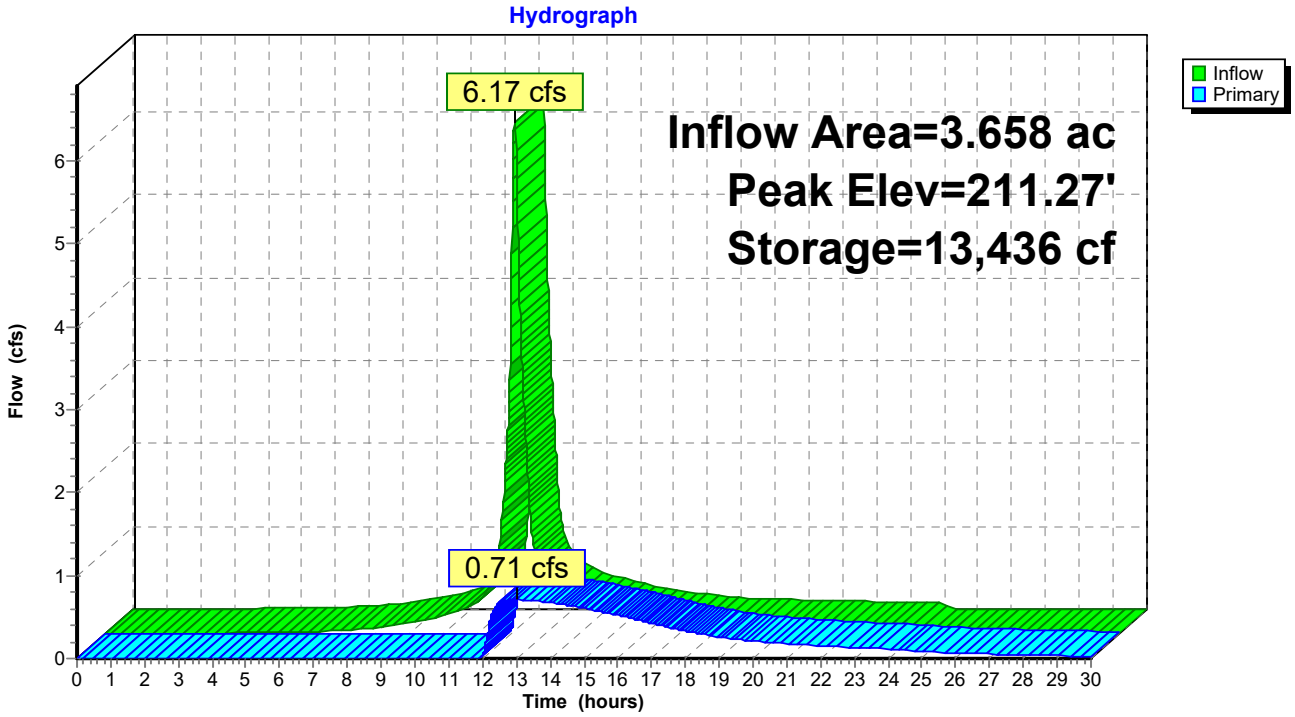
Volume	Invert	Avail.Storage	Storage Description
#1	210.50'	53,991 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
210.50	16,003	665.0	0	0	16,003
211.00	18,041	690.0	8,506	8,506	18,720
213.00	18,041	690.0	36,082	44,588	20,100
213.50	19,580	704.0	9,403	53,991	21,692

Device	Routing	Invert	Outlet Devices
#1	Primary	212.32'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 212.32 213.00 Width (feet) 15.00 15.00
#2	Primary	211.00'	**1.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	210.80'	**4.0" Vert. Orifice/Grate X 3.00** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.71 cfs @ 12.99 hrs HW=211.27' (Free Discharge)
- **1=Custom Weir/Orifice** (Controls 0.00 cfs)
- **2=Orifice/Grate** (Orifice Controls 0.01 cfs @ 2.32 fps)
- **3=Orifice/Grate** (Orifice Controls 0.70 cfs @ 2.67 fps)

Pond 22P: Basin #1

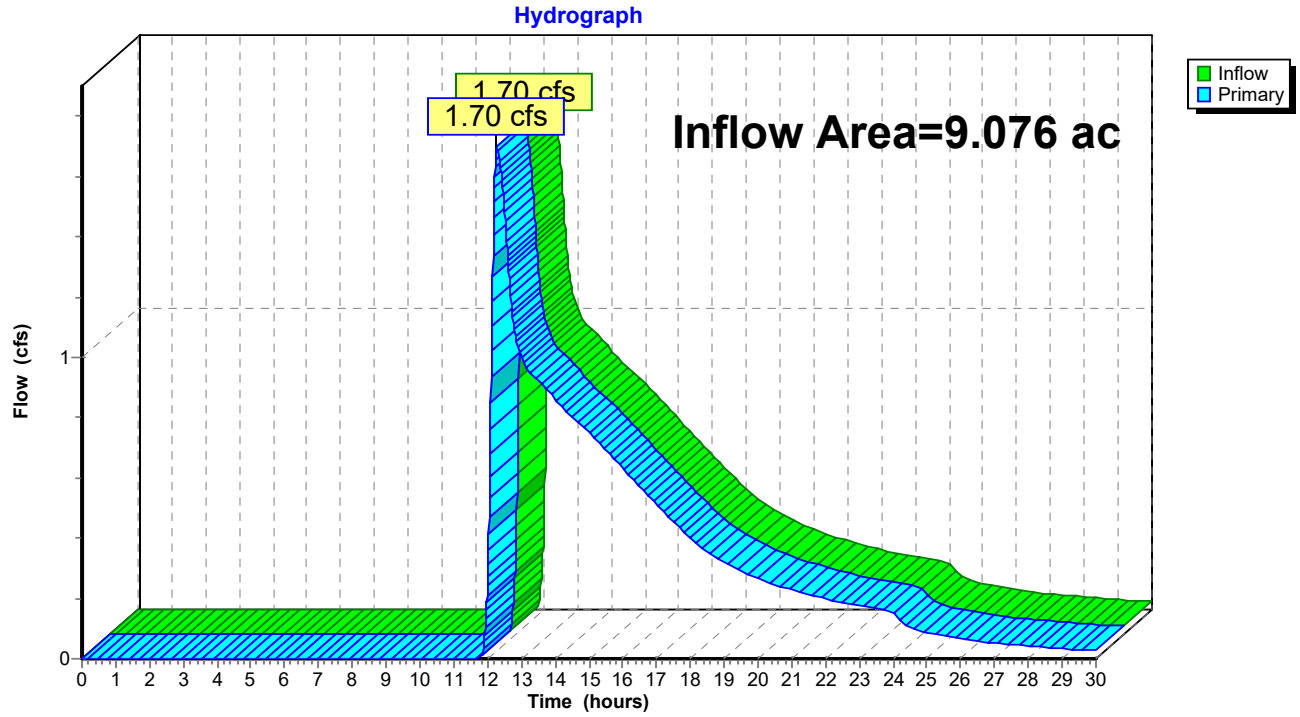


Summary for Link 29P: Design Point #1: Flow to Shadowfax Farm

Inflow Area = 9.076 ac, 41.50% Impervious, Inflow Depth > 0.71" for 1-YR event
Inflow = 1.70 cfs @ 12.27 hrs, Volume= 0.541 af
Primary = 1.70 cfs @ 12.27 hrs, Volume= 0.541 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 29P: Design Point #1: Flow to Shadowfax Farm



Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 22P: Basin #1 Peak Elev=211.55' Storage=18,448 cf Inflow=8.40 cfs 0.736 af
Outflow=0.98 cfs 0.596 af

Link 29P: Design Point #1: Flow to Shadowfax Farm Inflow=3.20 cfs 0.851 af
Primary=3.20 cfs 0.851 af

Summary for Pond 22P: Basin #1

Inflow Area = 3.658 ac, 77.31% Impervious, Inflow Depth = 2.42" for 2-YR event
Inflow = 8.40 cfs @ 12.12 hrs, Volume= 0.736 af
Outflow = 0.98 cfs @ 12.96 hrs, Volume= 0.596 af, Atten= 88%, Lag= 50.1 min
Primary = 0.98 cfs @ 12.96 hrs, Volume= 0.596 af
Routed to Link 29P : Design Point #1: Flow to Shadowfax Farm

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 211.55' @ 12.96 hrs Surf.Area= 18,041 sf Storage= 18,448 cf

Plug-Flow detention time= 297.4 min calculated for 0.596 af (81% of inflow)
Center-of-Mass det. time= 223.2 min (1,014.8 - 791.6)

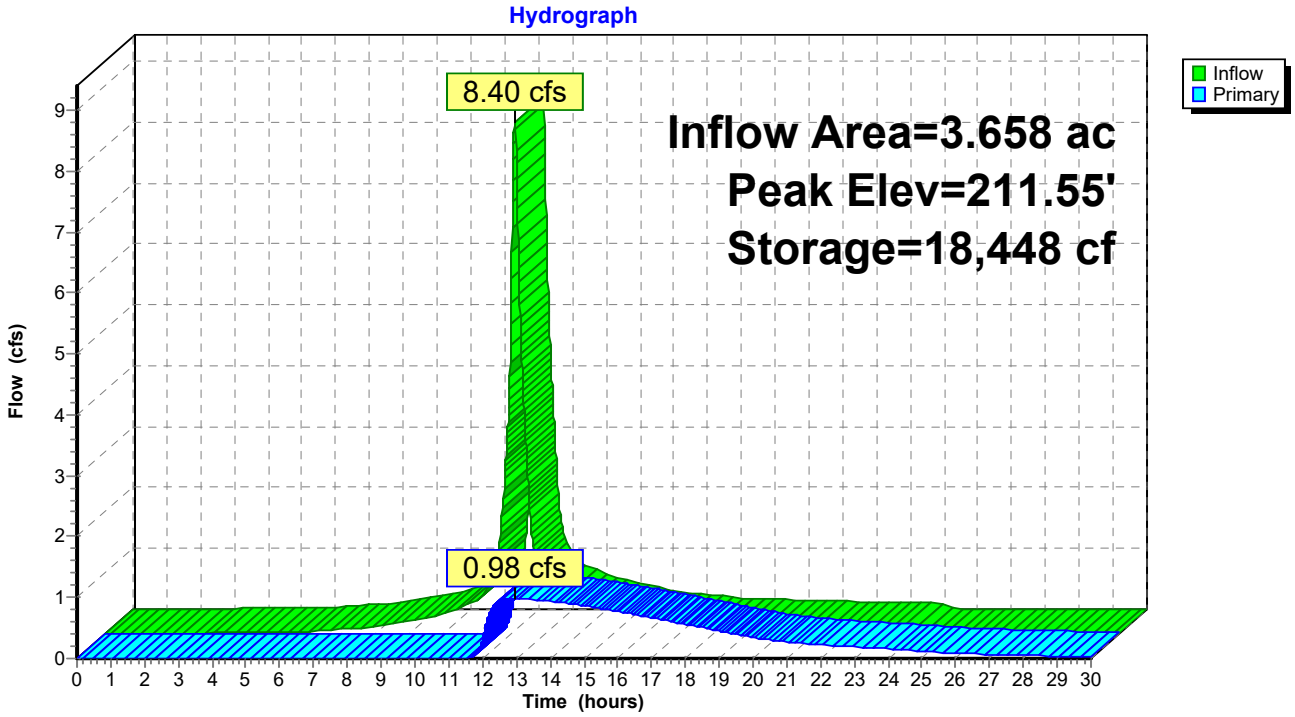
Volume	Invert	Avail.Storage	Storage Description
#1	210.50'	53,991 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
210.50	16,003	665.0	0	0	16,003
211.00	18,041	690.0	8,506	8,506	18,720
213.00	18,041	690.0	36,082	44,588	20,100
213.50	19,580	704.0	9,403	53,991	21,692

Device	Routing	Invert	Outlet Devices
#1	Primary	212.32'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 212.32 213.00 Width (feet) 15.00 15.00
#2	Primary	211.00'	**1.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	210.80'	**4.0" Vert. Orifice/Grate X 3.00** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.98 cfs @ 12.96 hrs HW=211.55' (Free Discharge)
- **1=Custom Weir/Orifice** (Controls 0.00 cfs)
- **2=Orifice/Grate** (Orifice Controls 0.02 cfs @ 3.44 fps)
- **3=Orifice/Grate** (Orifice Controls 0.96 cfs @ 3.68 fps)

Pond 22P: Basin #1

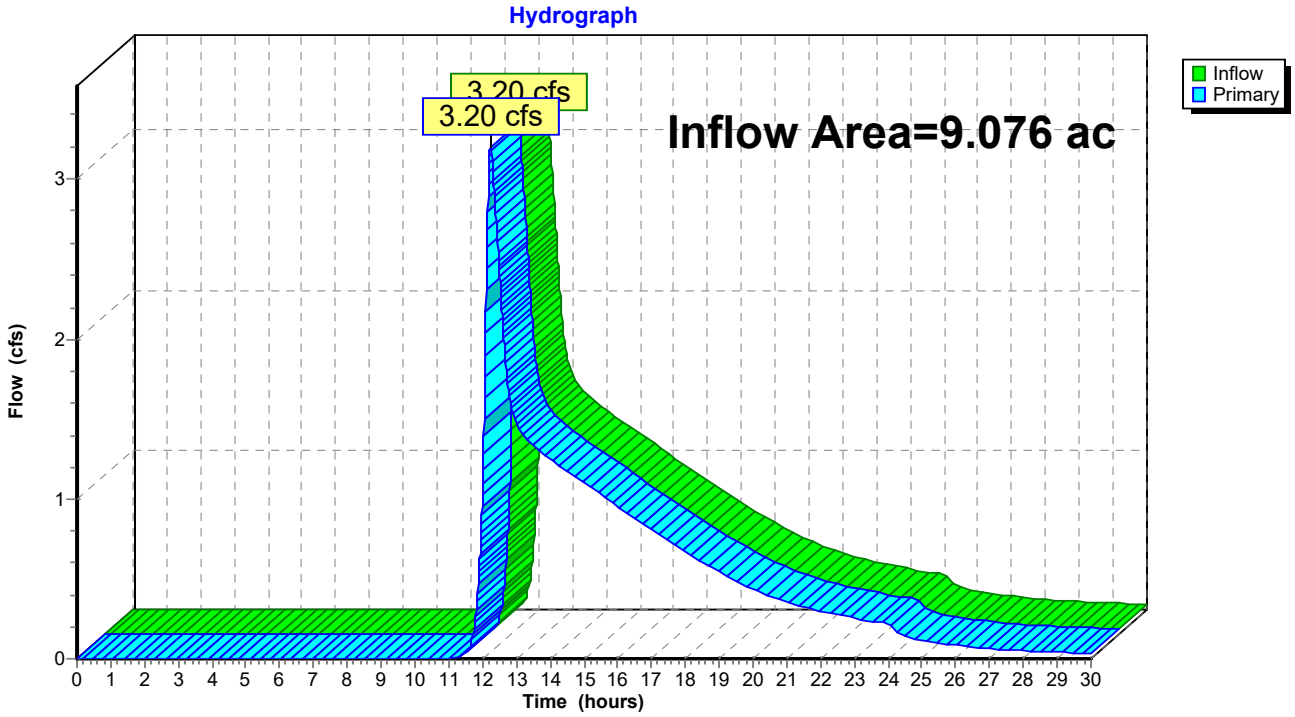


Summary for Link 29P: Design Point #1: Flow to Shadowfax Farm

Inflow Area = 9.076 ac, 41.50% Impervious, Inflow Depth > 1.13" for 2-YR event
Inflow = 3.20 cfs @ 12.23 hrs, Volume= 0.851 af
Primary = 3.20 cfs @ 12.23 hrs, Volume= 0.851 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 29P: Design Point #1: Flow to Shadowfax Farm



Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 22P: Basin #1 Peak Elev=212.16' Storage=29,472 cf Inflow=13.20 cfs 1.176 af
Outflow=1.41 cfs 1.030 af

Link 29P: Design Point #1: Flow to Shadowfax Farm Inflow=6.83 cfs 1.582 af
Primary=6.83 cfs 1.582 af

Summary for Pond 22P: Basin #1

Inflow Area = 3.658 ac, 77.31% Impervious, Inflow Depth = 3.86" for 10-YR event
Inflow = 13.20 cfs @ 12.12 hrs, Volume= 1.176 af
Outflow = 1.41 cfs @ 13.02 hrs, Volume= 1.030 af, Atten= 89%, Lag= 53.8 min
Primary = 1.41 cfs @ 13.02 hrs, Volume= 1.030 af
Routed to Link 29P : Design Point #1: Flow to Shadowfax Farm

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 212.16' @ 13.02 hrs Surf.Area= 18,041 sf Storage= 29,472 cf

Plug-Flow detention time= 307.7 min calculated for 1.030 af (88% of inflow)
Center-of-Mass det. time= 250.9 min (1,031.8 - 780.9)

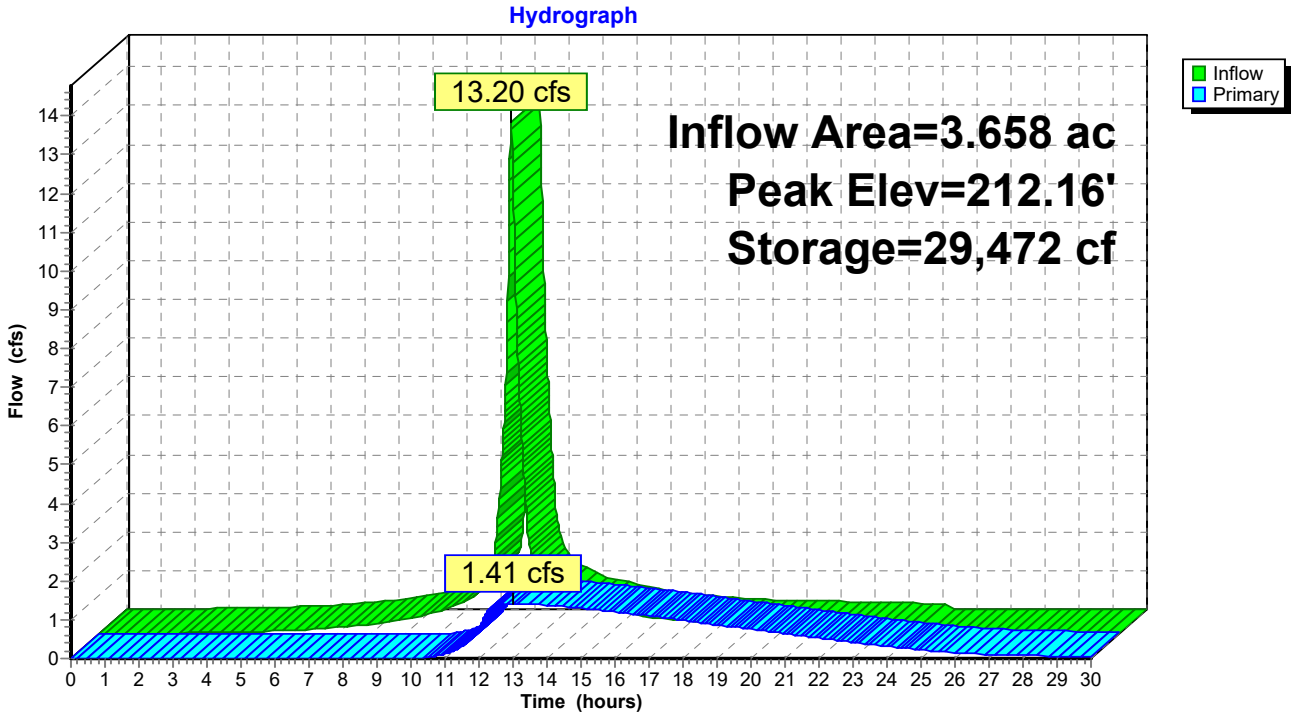
Volume	Invert	Avail.Storage	Storage Description
#1	210.50'	53,991 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
210.50	16,003	665.0	0	0	16,003
211.00	18,041	690.0	8,506	8,506	18,720
213.00	18,041	690.0	36,082	44,588	20,100
213.50	19,580	704.0	9,403	53,991	21,692

Device	Routing	Invert	Outlet Devices
#1	Primary	212.32'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 212.32 213.00 Width (feet) 15.00 15.00
#2	Primary	211.00'	**1.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	210.80'	**4.0" Vert. Orifice/Grate X 3.00** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=1.41 cfs @ 13.02 hrs HW=212.16' (Free Discharge)
- **1=Custom Weir/Orifice** (Controls 0.00 cfs)
- **2=Orifice/Grate** (Orifice Controls 0.03 cfs @ 5.10 fps)
- **3=Orifice/Grate** (Orifice Controls 1.38 cfs @ 5.26 fps)

Pond 22P: Basin #1

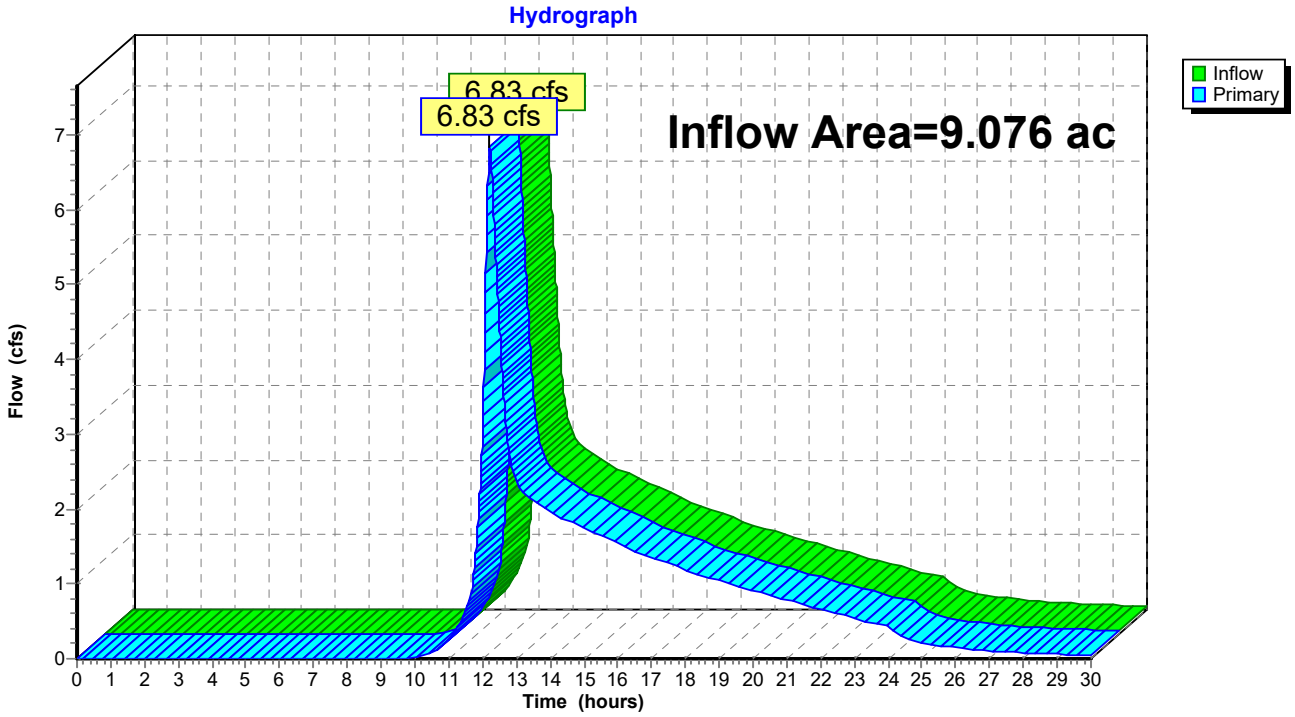


Summary for Link 29P: Design Point #1: Flow to Shadowfax Farm

Inflow Area = 9.076 ac, 41.50% Impervious, Inflow Depth > 2.09" for 10-YR event
Inflow = 6.83 cfs @ 12.21 hrs, Volume= 1.582 af
Primary = 6.83 cfs @ 12.21 hrs, Volume= 1.582 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 29P: Design Point #1: Flow to Shadowfax Farm



Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 22P: Basin #1 Peak Elev=212.50' Storage=35,609 cf Inflow=17.65 cfs 1.594 af
Outflow=5.42 cfs 1.443 af

Link 29P: Design Point #1: Flow to Shadowfax Farm Inflow=10.80 cfs 2.345 af
Primary=10.80 cfs 2.345 af

Summary for Pond 22P: Basin #1

Inflow Area = 3.658 ac, 77.31% Impervious, Inflow Depth = 5.23" for 50-YR event
Inflow = 17.65 cfs @ 12.12 hrs, Volume= 1.594 af
Outflow = 5.42 cfs @ 12.50 hrs, Volume= 1.443 af, Atten= 69%, Lag= 22.9 min
Primary = 5.42 cfs @ 12.50 hrs, Volume= 1.443 af
Routed to Link 29P : Design Point #1: Flow to Shadowfax Farm

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 212.50' @ 12.50 hrs Surf.Area= 18,041 sf Storage= 35,609 cf

Plug-Flow detention time= 279.1 min calculated for 1.443 af (91% of inflow)
Center-of-Mass det. time= 232.0 min (1,006.2 - 774.2)

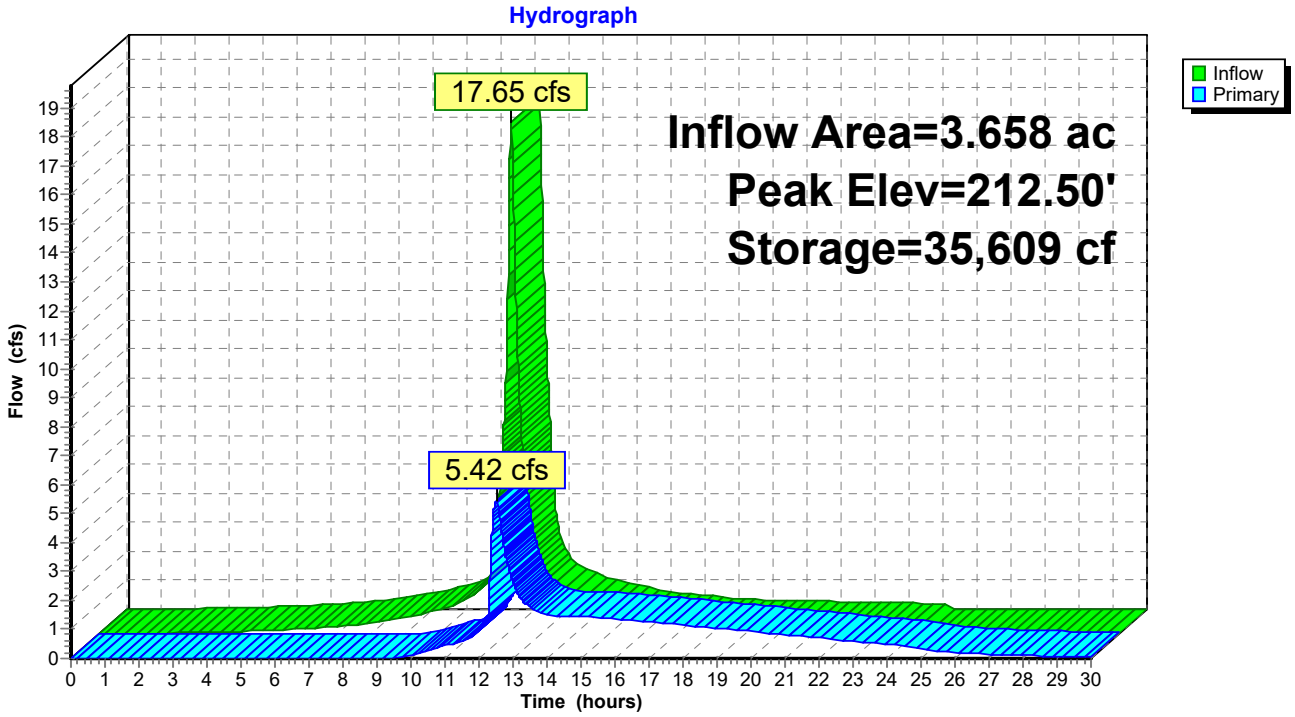
Volume	Invert	Avail.Storage	Storage Description
#1	210.50'	53,991 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
210.50	16,003	665.0	0	0	16,003
211.00	18,041	690.0	8,506	8,506	18,720
213.00	18,041	690.0	36,082	44,588	20,100
213.50	19,580	704.0	9,403	53,991	21,692

Device	Routing	Invert	Outlet Devices
#1	Primary	212.32'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 212.32 213.00 Width (feet) 15.00 15.00
#2	Primary	211.00'	**1.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	210.80'	**4.0" Vert. Orifice/Grate X 3.00** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=5.42 cfs @ 12.50 hrs HW=212.50' (Free Discharge)
- **1=Custom Weir/Orifice** (Weir Controls 3.82 cfs @ 1.40 fps)
- **2=Orifice/Grate** (Orifice Controls 0.03 cfs @ 5.82 fps)
- **3=Orifice/Grate** (Orifice Controls 1.56 cfs @ 5.97 fps)

Pond 22P: Basin #1

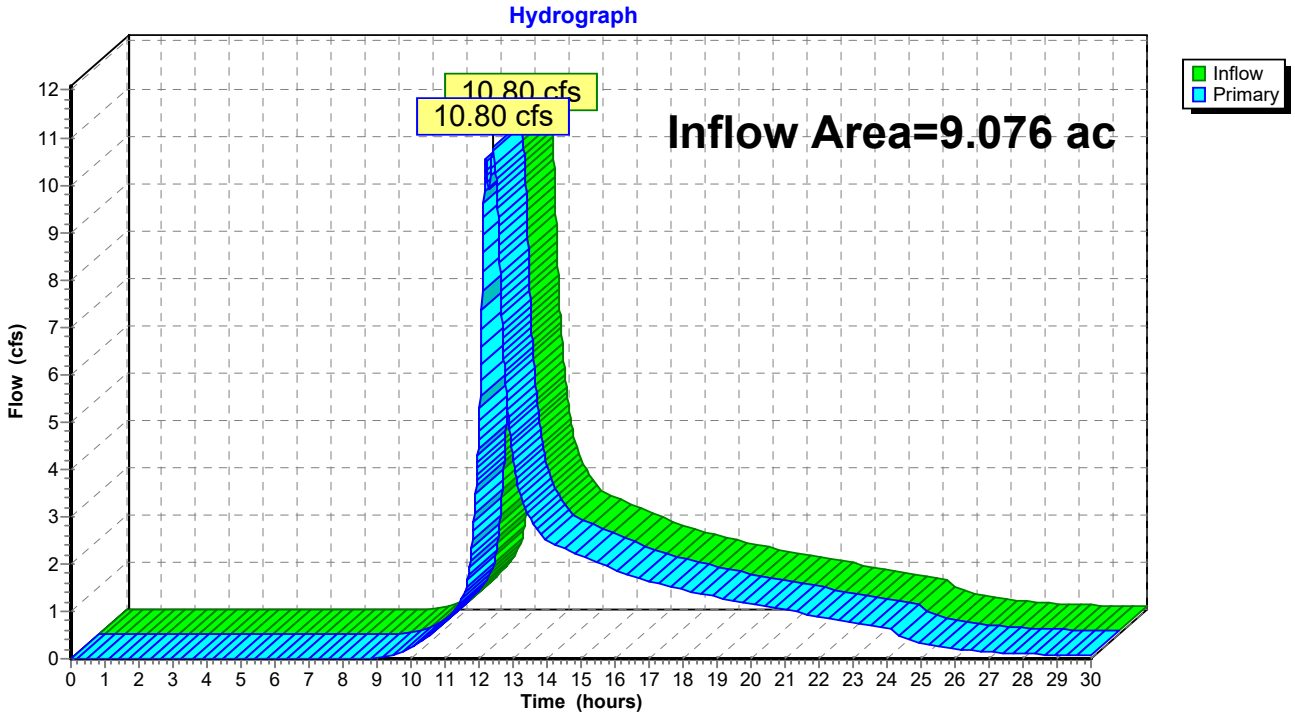


Summary for Link 29P: Design Point #1: Flow to Shadowfax Farm

Inflow Area = 9.076 ac, 41.50% Impervious, Inflow Depth > 3.10" for 50-YR event
Inflow = 10.80 cfs @ 12.42 hrs, Volume= 2.345 af
Primary = 10.80 cfs @ 12.42 hrs, Volume= 2.345 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 29P: Design Point #1: Flow to Shadowfax Farm



Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 22P: Basin #1 Peak Elev=212.57' Storage=36,885 cf Inflow=19.55 cfs 1.774 af
Outflow=7.89 cfs 1.622 af

Link 29P: Design Point #1: Flow to Shadowfax Farm Inflow=15.49 cfs 2.700 af
Primary=15.49 cfs 2.700 af

Summary for Pond 22P: Basin #1

Inflow Area = 3.658 ac, 77.31% Impervious, Inflow Depth = 5.82" for 100-YR event
Inflow = 19.55 cfs @ 12.12 hrs, Volume= 1.774 af
Outflow = 7.89 cfs @ 12.42 hrs, Volume= 1.622 af, Atten= 60%, Lag= 17.9 min
Primary = 7.89 cfs @ 12.42 hrs, Volume= 1.622 af
Routed to Link 29P : Design Point #1: Flow to Shadowfax Farm

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 212.57' @ 12.42 hrs Surf.Area= 18,041 sf Storage= 36,885 cf

Plug-Flow detention time= 262.1 min calculated for 1.621 af (91% of inflow)
Center-of-Mass det. time= 218.3 min (990.1 - 771.9)

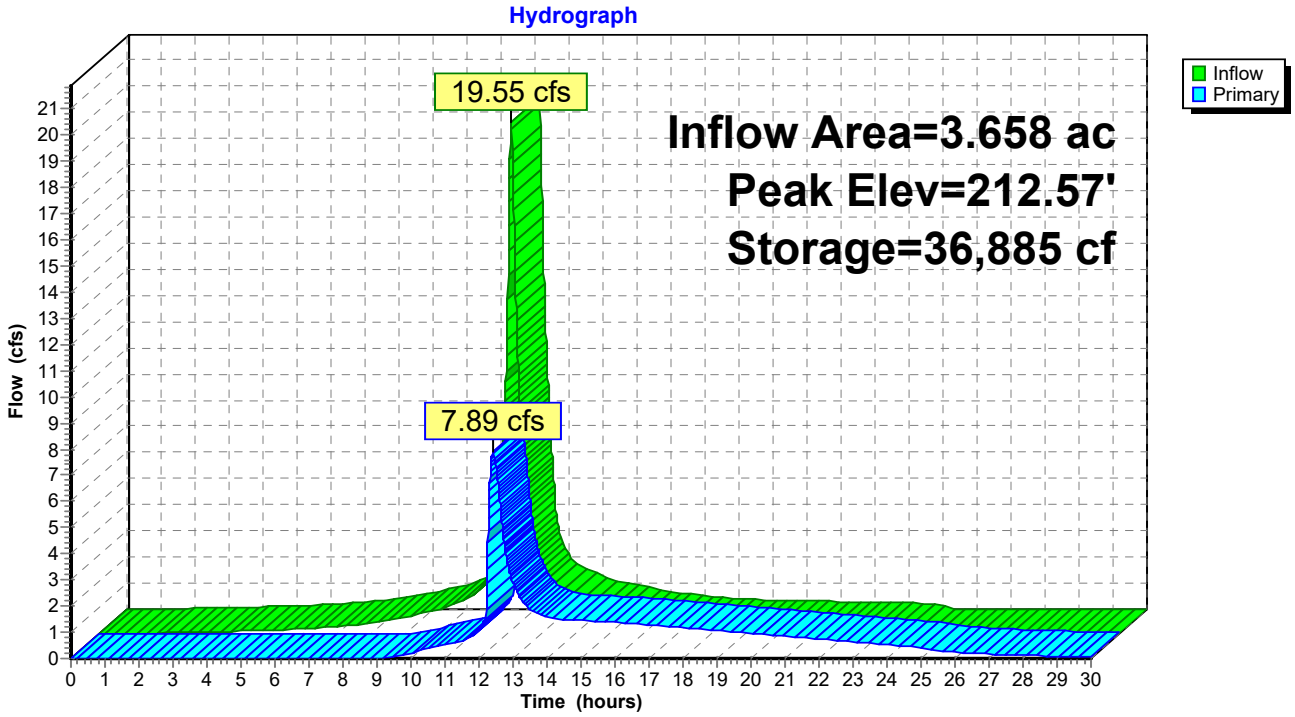
Volume	Invert	Avail.Storage	Storage Description
#1	210.50'	53,991 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
210.50	16,003	665.0	0	0	16,003
211.00	18,041	690.0	8,506	8,506	18,720
213.00	18,041	690.0	36,082	44,588	20,100
213.50	19,580	704.0	9,403	53,991	21,692

Device	Routing	Invert	Outlet Devices
#1	Primary	212.32'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 212.32 213.00 Width (feet) 15.00 15.00
#2	Primary	211.00'	**1.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	210.80'	**4.0" Vert. Orifice/Grate X 3.00** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=7.88 cfs @ 12.42 hrs HW=212.57' (Free Discharge)
- **1=Custom Weir/Orifice** (Weir Controls 6.25 cfs @ 1.65 fps)
- **2=Orifice/Grate** (Orifice Controls 0.03 cfs @ 5.96 fps)
- **3=Orifice/Grate** (Orifice Controls 1.60 cfs @ 6.10 fps)

Pond 22P: Basin #1

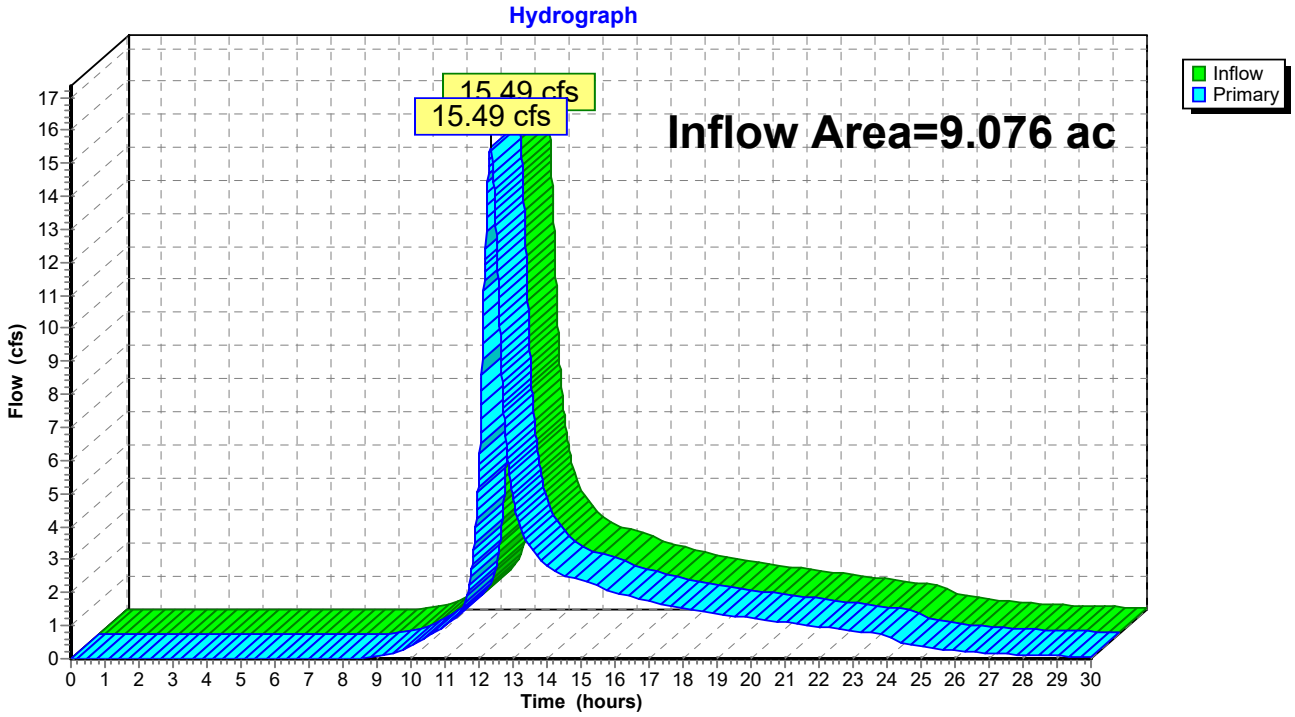


Summary for Link 29P: Design Point #1: Flow to Shadowfax Farm

Inflow Area = 9.076 ac, 41.50% Impervious, Inflow Depth > 3.57" for 100-YR event
Inflow = 15.49 cfs @ 12.34 hrs, Volume= 2.700 af
Primary = 15.49 cfs @ 12.34 hrs, Volume= 2.700 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 29P: Design Point #1: Flow to Shadowfax Farm



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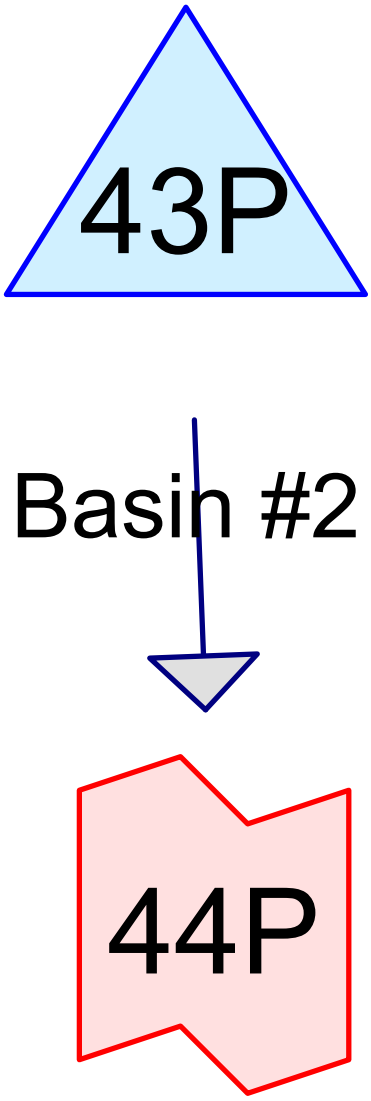
DESIGN POINT #2 – BASIN 2



Design Point #2: Flow to Southern Abutters

Subcat Reach Pond Link

Routing Diagram for 2023-01-03 Basin Reconfiguration
Prepared by Legacy Engineering LLC, Printed 1/3/2023

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 43P: Basin #2 Peak Elev=216.69' Storage=8,859 cf Inflow=3.40 cfs 0.356 af
Outflow=0.47 cfs 0.255 af

Link 44P: Design Point #2: Flow to Southern Abutters Inflow=3.16 cfs 0.683 af
Primary=3.16 cfs 0.683 af

Summary for Pond 43P: Basin #2

Inflow Area = 2.747 ac, 65.33% Impervious, Inflow Depth = 1.56" for 1-YR event
Inflow = 3.40 cfs @ 12.16 hrs, Volume= 0.356 af
Outflow = 0.47 cfs @ 13.06 hrs, Volume= 0.255 af, Atten= 86%, Lag= 54.3 min
Primary = 0.47 cfs @ 13.06 hrs, Volume= 0.255 af
Routed to Link 44P : Design Point #2: Flow to Southern Abutters

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 216.69' @ 13.06 hrs Surf.Area= 13,557 sf Storage= 8,859 cf

Plug-Flow detention time= 326.1 min calculated for 0.255 af (72% of inflow)
Center-of-Mass det. time= 231.6 min (1,038.3 - 806.7)

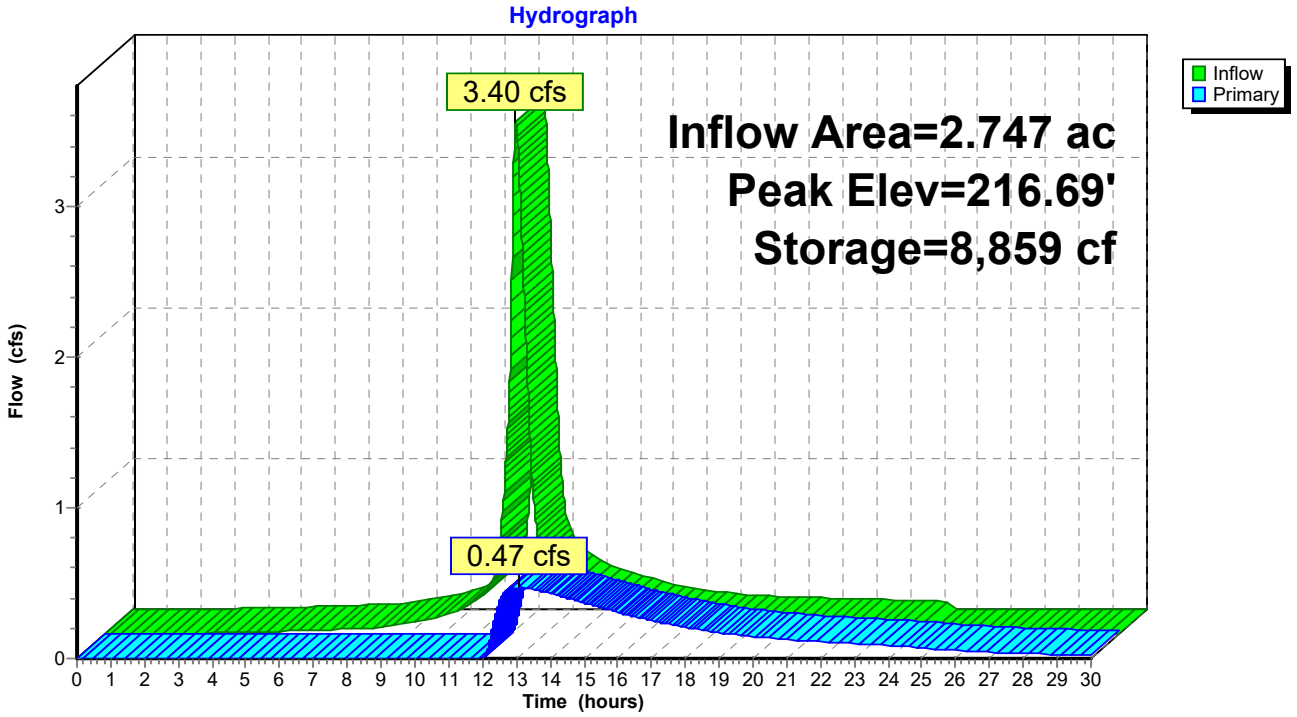
Volume	Invert	Avail.Storage	Storage Description
#1	216.00'	36,749 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
216.00	12,268	457.0	0	0	12,268
218.50	17,274	522.0	36,749	36,749	17,478

Device	Routing	Invert	Outlet Devices
#1	Primary	216.30'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 216.30 217.00 217.00 218.00 Width (feet) 0.60 0.60 2.00 2.00

Primary OutFlow Max=0.47 cfs @ 13.06 hrs HW=216.69' (Free Discharge)
↑**1=Custom Weir/Orifice** (Weir Controls 0.47 cfs @ 2.04 fps)

Pond 43P: Basin #2

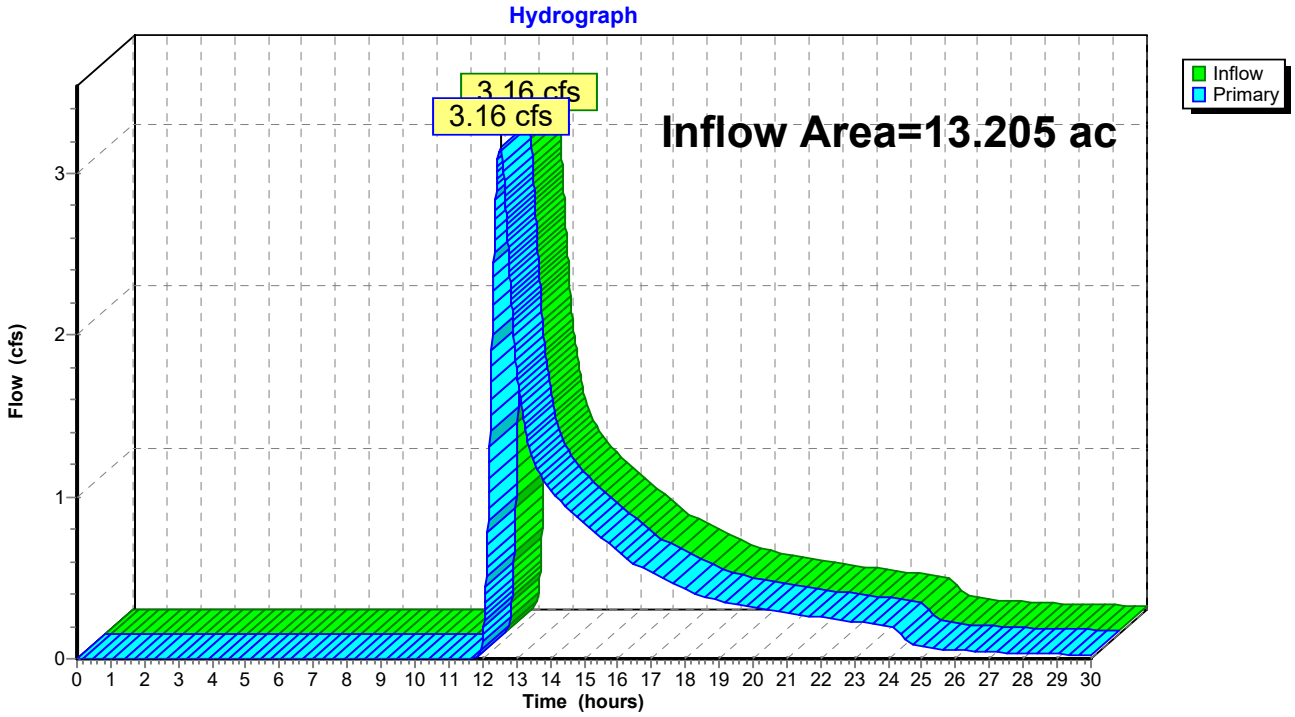


Summary for Link 44P: Design Point #2: Flow to Southern Abutters

Inflow Area = 13.205 ac, 13.59% Impervious, Inflow Depth > 0.62" for 1-YR event
Inflow = 3.16 cfs @ 12.53 hrs, Volume= 0.683 af
Primary = 3.16 cfs @ 12.53 hrs, Volume= 0.683 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 44P: Design Point #2: Flow to Southern Abutters



Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 43P: Basin #2 Peak Elev=216.90' Storage=11,859 cf Inflow=4.74 cfs 0.499 af
Outflow=0.92 cfs 0.395 af

Link 44P: Design Point #2: Flow to Southern Abutters Inflow=6.36 cfs 1.161 af
Primary=6.36 cfs 1.161 af

Summary for Pond 43P: Basin #2

Inflow Area = 2.747 ac, 65.33% Impervious, Inflow Depth = 2.18" for 2-YR event
Inflow = 4.74 cfs @ 12.16 hrs, Volume= 0.499 af
Outflow = 0.92 cfs @ 12.80 hrs, Volume= 0.395 af, Atten= 81%, Lag= 38.4 min
Primary = 0.92 cfs @ 12.80 hrs, Volume= 0.395 af
Routed to Link 44P : Design Point #2: Flow to Southern Abutters

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 216.90' @ 12.80 hrs Surf.Area= 13,980 sf Storage= 11,859 cf

Plug-Flow detention time= 280.3 min calculated for 0.395 af (79% of inflow)
Center-of-Mass det. time= 201.5 min (1,001.8 - 800.3)

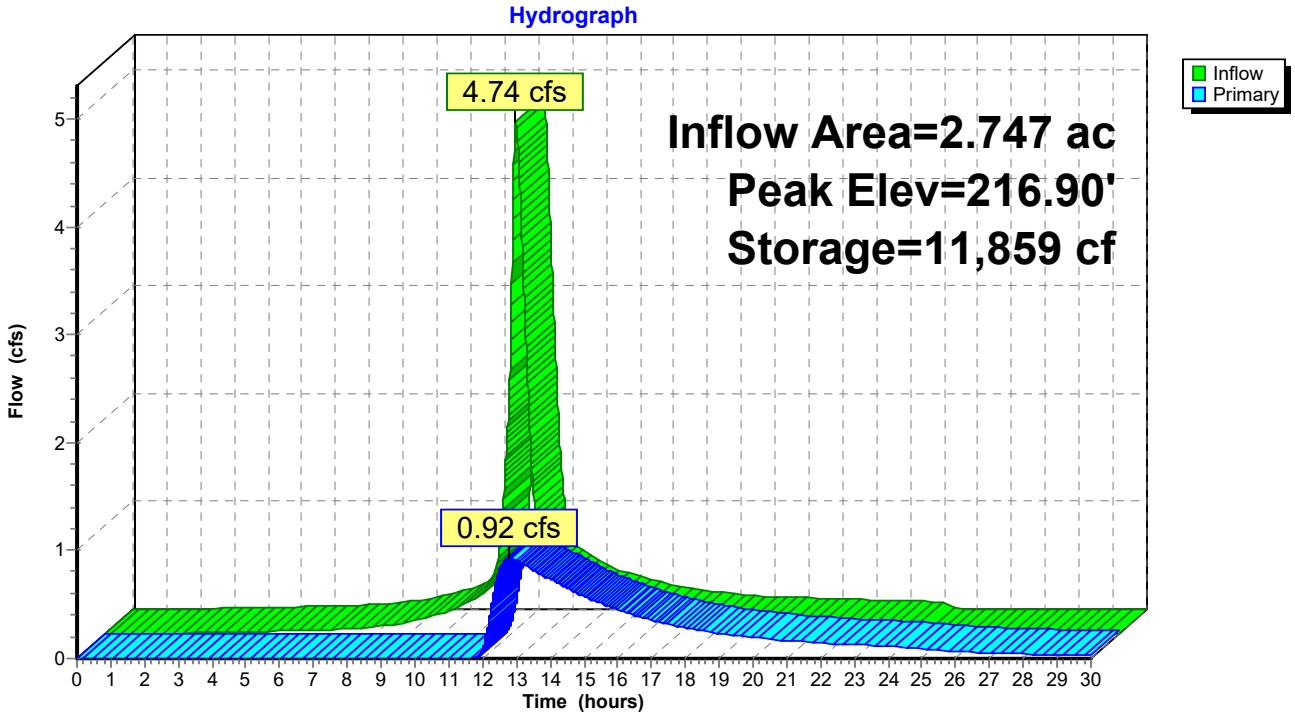
Volume	Invert	Avail.Storage	Storage Description
#1	216.00'	36,749 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
216.00	12,268	457.0	0	0	12,268
218.50	17,274	522.0	36,749	36,749	17,478

Device	Routing	Invert	Outlet Devices
#1	Primary	216.30'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 216.30 217.00 217.00 218.00 Width (feet) 0.60 0.60 2.00 2.00

Primary OutFlow Max=0.92 cfs @ 12.80 hrs HW=216.90' (Free Discharge)
↑**1=Custom Weir/Orifice** (Weir Controls 0.92 cfs @ 2.55 fps)

Pond 43P: Basin #2

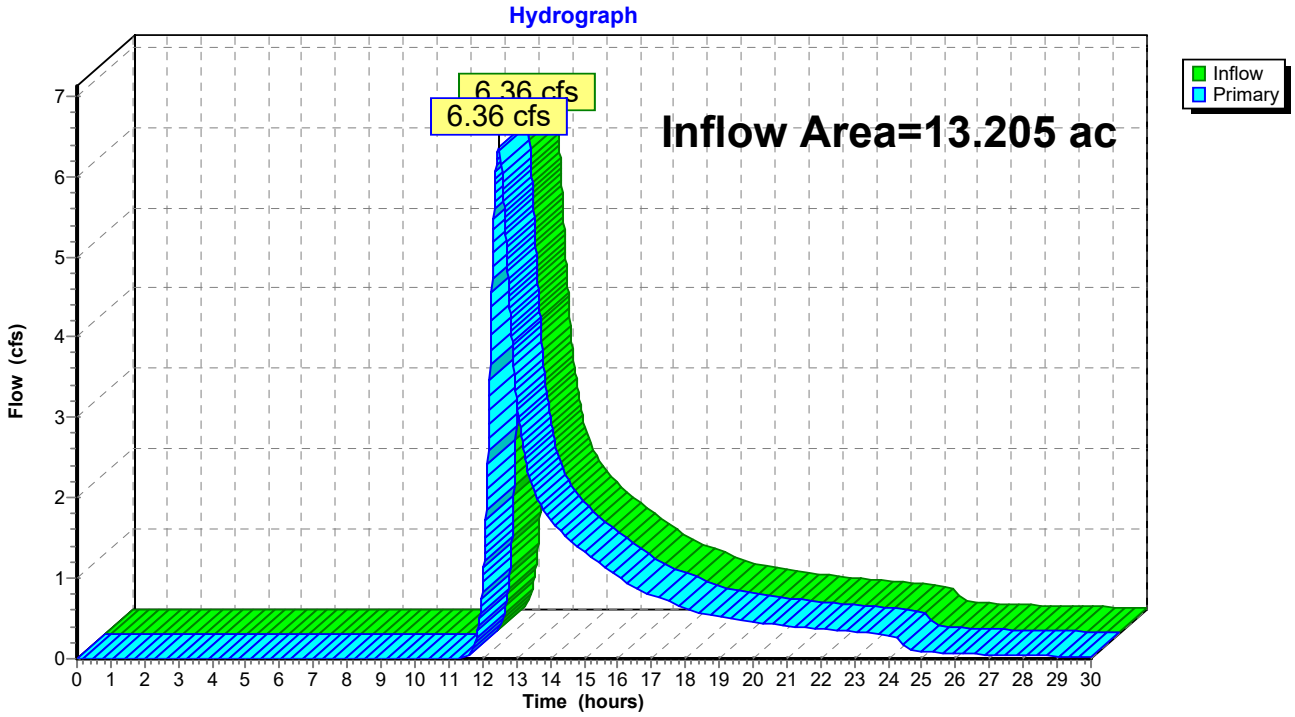


Summary for Link 44P: Design Point #2: Flow to Southern Abutters

Inflow Area = 13.205 ac, 13.59% Impervious, Inflow Depth > 1.05" for 2-YR event
Inflow = 6.36 cfs @ 12.47 hrs, Volume= 1.161 af
Primary = 6.36 cfs @ 12.47 hrs, Volume= 1.161 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 44P: Design Point #2: Flow to Southern Abutters



Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 43P: Basin #2 Peak Elev=217.29' Storage=17,430 cf Inflow=7.63 cfs 0.818 af
Outflow=2.67 cfs 0.712 af

Link 44P: Design Point #2: Flow to Southern Abutters Inflow=15.32 cfs 2.361 af
Primary=15.32 cfs 2.361 af

Summary for Pond 43P: Basin #2

Inflow Area = 2.747 ac, 65.33% Impervious, Inflow Depth = 3.57" for 10-YR event
Inflow = 7.63 cfs @ 12.16 hrs, Volume= 0.818 af
Outflow = 2.67 cfs @ 12.61 hrs, Volume= 0.712 af, Atten= 65%, Lag= 27.1 min
Primary = 2.67 cfs @ 12.61 hrs, Volume= 0.712 af
Routed to Link 44P : Design Point #2: Flow to Southern Abutters

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 217.29' @ 12.61 hrs Surf.Area= 14,749 sf Storage= 17,430 cf

Plug-Flow detention time= 221.6 min calculated for 0.712 af (87% of inflow)
Center-of-Mass det. time= 163.1 min (953.6 - 790.4)

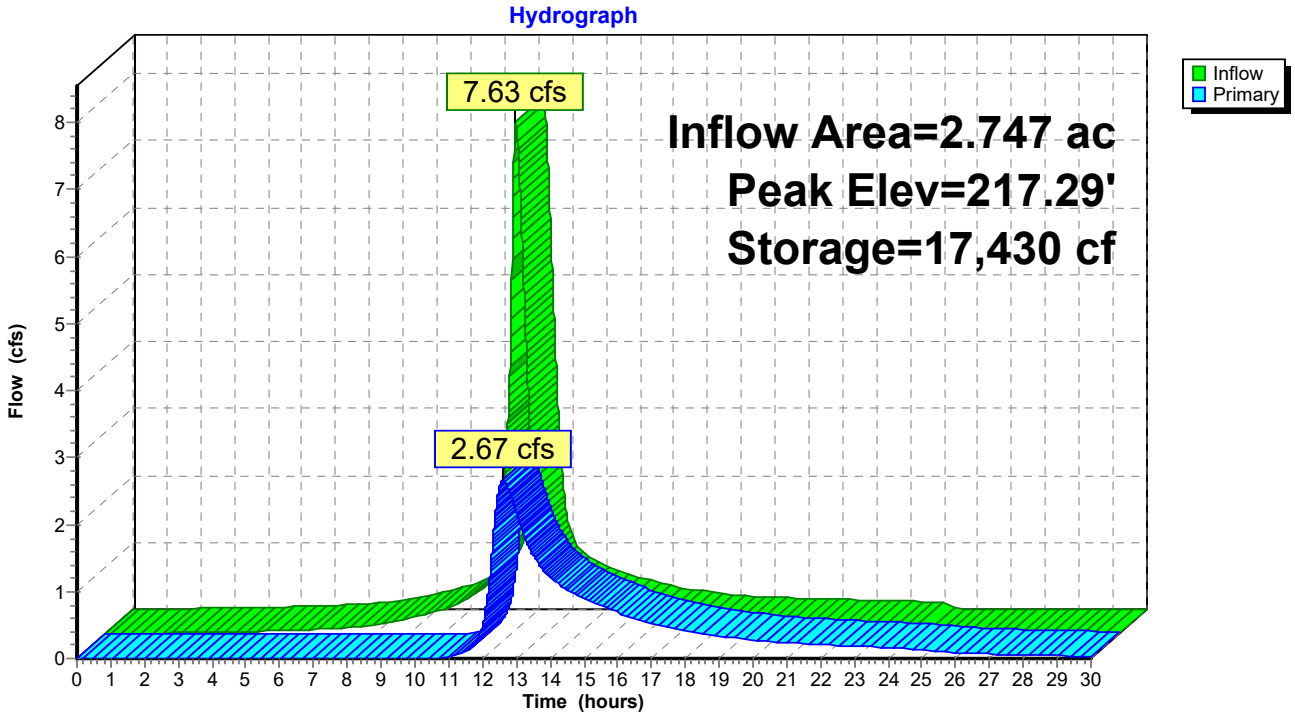
Volume	Invert	Avail.Storage	Storage Description
#1	216.00'	36,749 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
216.00	12,268	457.0	0	0	12,268
218.50	17,274	522.0	36,749	36,749	17,478

Device	Routing	Invert	Outlet Devices
#1	Primary	216.30'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 216.30 217.00 217.00 218.00 Width (feet) 0.60 0.60 2.00 2.00

Primary OutFlow Max=2.67 cfs @ 12.61 hrs HW=217.29' (Free Discharge)
↑**1=Custom Weir/Orifice** (Weir Controls 2.67 cfs @ 2.65 fps)

Pond 43P: Basin #2

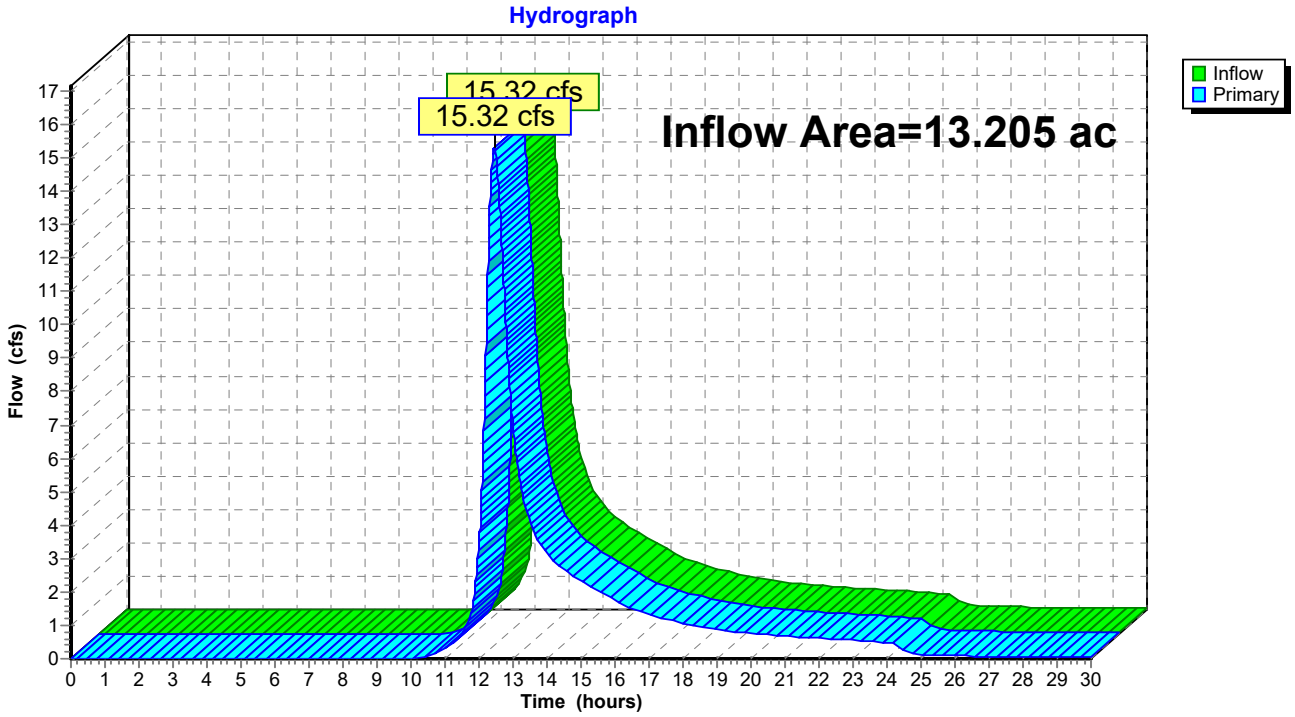


Summary for Link 44P: Design Point #2: Flow to Southern Abutters

Inflow Area = 13.205 ac, 13.59% Impervious, Inflow Depth > 2.15" for 10-YR event
Inflow = 15.32 cfs @ 12.46 hrs, Volume= 2.361 af
Primary = 15.32 cfs @ 12.46 hrs, Volume= 2.361 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 44P: Design Point #2: Flow to Southern Abutters



Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 43P: Basin #2 Peak Elev=217.56' Storage=21,440 cf Inflow=10.27 cfs 1.124 af
Outflow=4.69 cfs 1.017 af

Link 44P: Design Point #2: Flow to Southern Abutters Inflow=25.16 cfs 3.613 af
Primary=25.16 cfs 3.613 af

Summary for Pond 43P: Basin #2

Inflow Area = 2.747 ac, 65.33% Impervious, Inflow Depth = 4.91" for 50-YR event
Inflow = 10.27 cfs @ 12.16 hrs, Volume= 1.124 af
Outflow = 4.69 cfs @ 12.54 hrs, Volume= 1.017 af, Atten= 54%, Lag= 22.9 min
Primary = 4.69 cfs @ 12.54 hrs, Volume= 1.017 af
Routed to Link 44P : Design Point #2: Flow to Southern Abutters

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 217.56' @ 12.54 hrs Surf.Area= 15,290 sf Storage= 21,440 cf

Plug-Flow detention time= 188.2 min calculated for 1.017 af (90% of inflow)
Center-of-Mass det. time= 140.6 min (924.6 - 784.0)

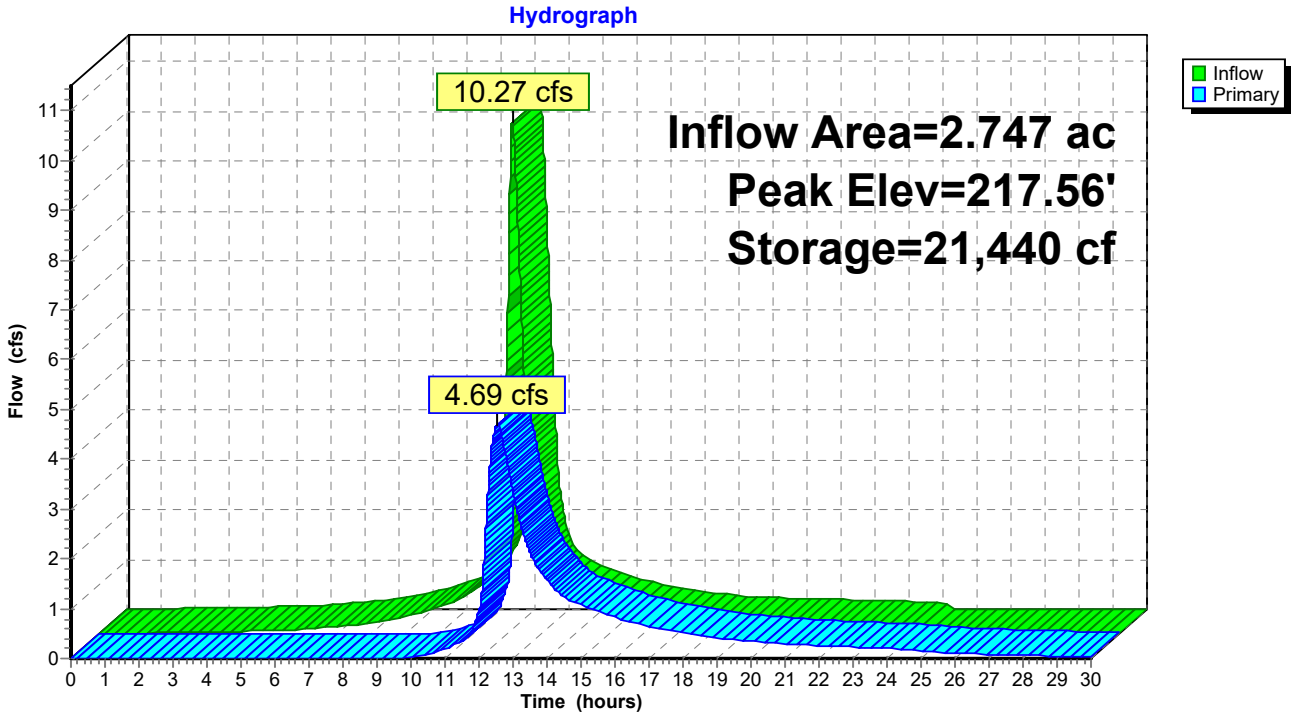
Volume	Invert	Avail.Storage	Storage Description
#1	216.00'	36,749 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
216.00	12,268	457.0	0	0	12,268
218.50	17,274	522.0	36,749	36,749	17,478

Device	Routing	Invert	Outlet Devices
#1	Primary	216.30'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 216.30 217.00 217.00 218.00 Width (feet) 0.60 0.60 2.00 2.00

Primary OutFlow Max=4.69 cfs @ 12.54 hrs HW=217.56' (Free Discharge)
↑**1=Custom Weir/Orifice** (Weir Controls 4.69 cfs @ 3.05 fps)

Pond 43P: Basin #2

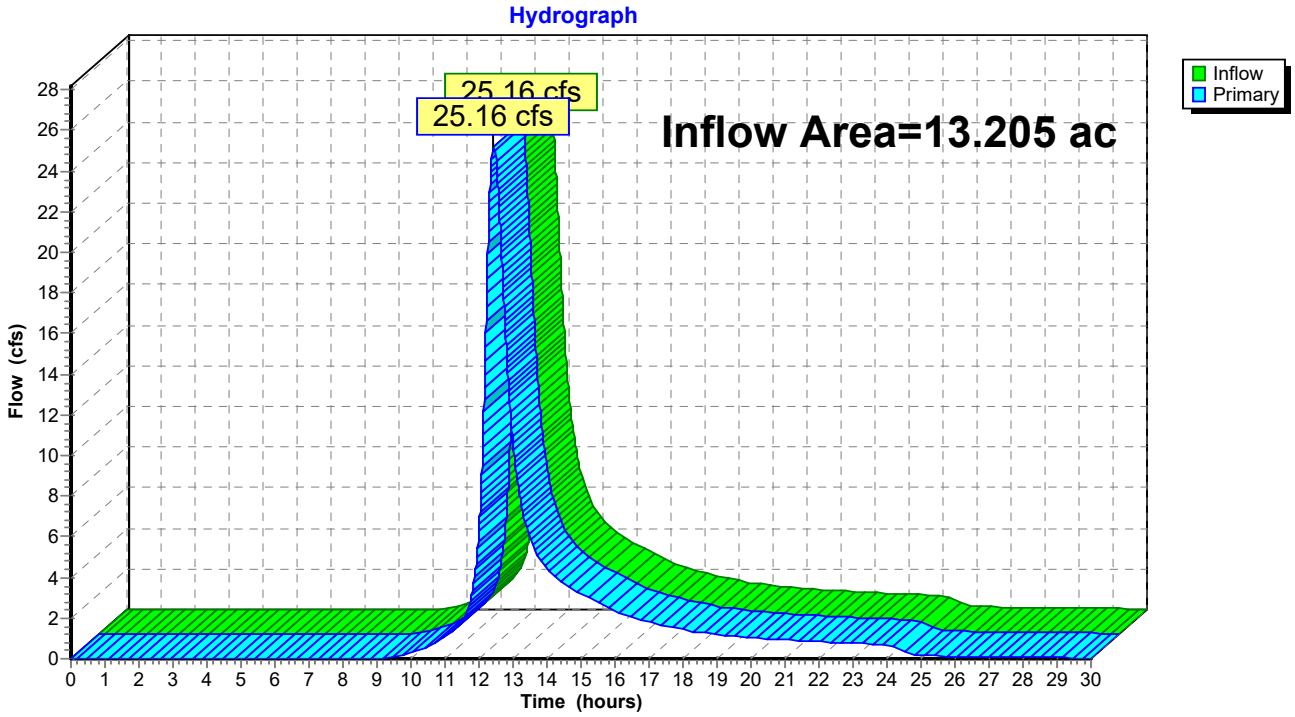


Summary for Link 44P: Design Point #2: Flow to Southern Abutters

Inflow Area = 13.205 ac, 13.59% Impervious, Inflow Depth > 3.28" for 50-YR event
Inflow = 25.16 cfs @ 12.43 hrs, Volume= 3.613 af
Primary = 25.16 cfs @ 12.43 hrs, Volume= 3.613 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 44P: Design Point #2: Flow to Southern Abutters



Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Pond 43P: Basin #2 Peak Elev=217.66' Storage=22,977 cf Inflow=11.36 cfs 1.257 af
Outflow=5.57 cfs 1.149 af

Link 44P: Design Point #2: Flow to Southern Abutters Inflow=29.54 cfs 4.175 af
Primary=29.54 cfs 4.175 af

Summary for Pond 43P: Basin #2

Inflow Area = 2.747 ac, 65.33% Impervious, Inflow Depth = 5.49" for 100-YR event
Inflow = 11.36 cfs @ 12.16 hrs, Volume= 1.257 af
Outflow = 5.57 cfs @ 12.52 hrs, Volume= 1.149 af, Atten= 51%, Lag= 21.9 min
Primary = 5.57 cfs @ 12.52 hrs, Volume= 1.149 af
Routed to Link 44P : Design Point #2: Flow to Southern Abutters

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 217.66' @ 12.52 hrs Surf.Area= 15,495 sf Storage= 22,977 cf

Plug-Flow detention time= 177.8 min calculated for 1.149 af (91% of inflow)
Center-of-Mass det. time= 133.7 min (915.5 - 781.8)

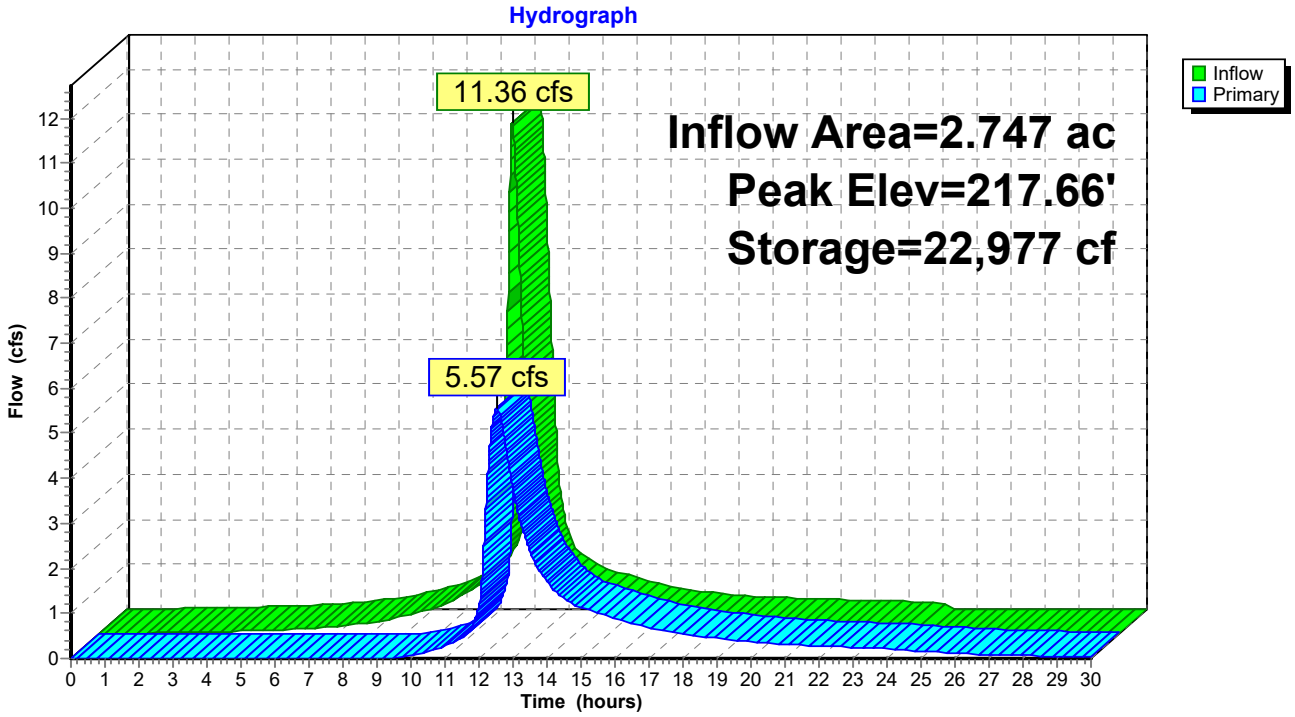
Volume	Invert	Avail.Storage	Storage Description
#1	216.00'	36,749 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
216.00	12,268	457.0	0	0	12,268
218.50	17,274	522.0	36,749	36,749	17,478

Device	Routing	Invert	Outlet Devices
#1	Primary	216.30'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 216.30 217.00 217.00 218.00 Width (feet) 0.60 0.60 2.00 2.00

Primary OutFlow Max=5.57 cfs @ 12.52 hrs HW=217.66' (Free Discharge)
↑**1=Custom Weir/Orifice** (Weir Controls 5.57 cfs @ 3.20 fps)

Pond 43P: Basin #2



Summary for Link 44P: Design Point #2: Flow to Southern Abutters

Inflow Area = 13.205 ac, 13.59% Impervious, Inflow Depth > 3.79" for 100-YR event
Inflow = 29.54 cfs @ 12.43 hrs, Volume= 4.175 af
Primary = 29.54 cfs @ 12.43 hrs, Volume= 4.175 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Link 44P: Design Point #2: Flow to Southern Abutters