de Bruin

de Bruin Engineering P.C.

Civil Engineering & Construction Management

Report Title:	**Draft Study Report – Rev03**
Report Date:	**December 21, 2021**
Project Title:	Nannahagan Lake Flood Mitigation
Client:	Village of Pleasantville 80 Wheeler Avenue Pleasantville, NY 10570
de Bruin Project No.:	6330

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Report **PG.**

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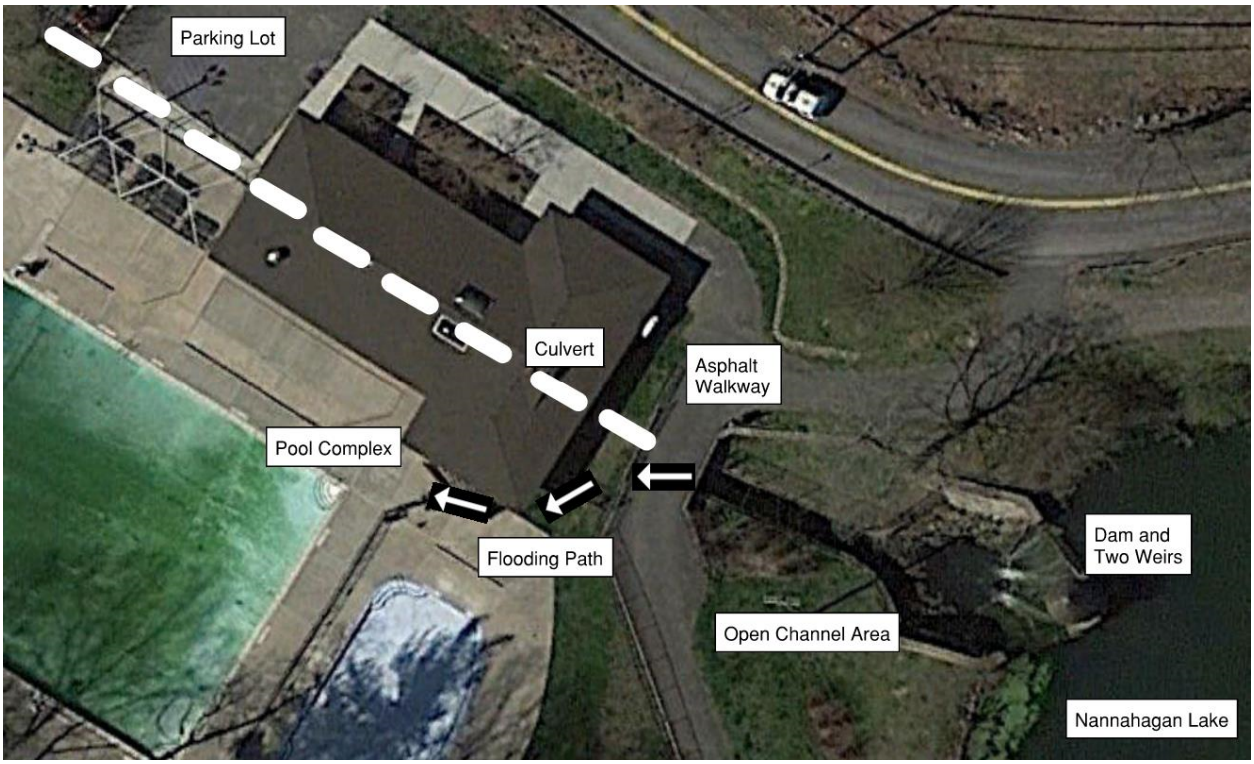
Project Background and Objectives

The Nannahagan Park Pool is located adjacent to Nannahagan Lake and Nanny Hagen Brook. In severe storm events the area has flooded, resulting in damage to the pool's piping, filtration, treatment and electrical systems.

The purpose of this study is to analyze the flow of storm water through the lake and brook system during major rainfall events and to propose improvements that will reduce the probability of flooding the pool area.

As shown in the drawing below the pool complex is adjacent to Nannahagan Lake. The lake is a manmade water body that was created by building a dam on Nanny Hagen Brook. Water flowing over the dam discharges over two weirs into an open channel area between the lake and the walkway adjacent to the pool building. In addition to the weirs, there are two by-pass pipes that take water from the lake and discharge it to the channel during storm events. At the walkway the channel flows into a 7' wide by 6' high box culvert that runs under the pool building and the parking lot before emptying into Nanny Hagen Brook. Nanny Hagen Brook flows on through the Village and empties into the Saw Mill River.



The pool area floods when storm water overtops the open channel area and walkway between the lake and the pool building.

Analysis Methodology

Analysis is a combination of hydrology and hydraulics. Hydrology is used to predict the amount of runoff from a rainstorm. Hydraulics is the evaluation of the capacity of the elements in the storm water system that are intended to carry the runoff.

We have used the SCRS TR20 Methodology for predicting runoff from various storm events. This method requires information as follows:

- Watershed Area and Flow Paths – The boundaries of the watershed for Nannahagan Lake, as well as the flow paths for water reaching the lake, have been determined using the Westchester County Topographic Map, supplemented by Google Earth.
- Percentage of Impervious Surface in the Watershed – The percent impervious has been obtained by a sampling process. Squares with an area of 25,000 square feet have been randomly overlaid on an aerial photograph of the watershed and the impervious surfaces (pavement and buildings) have been measured within the squares to calculate the percent of impervious surface.
- Hydrologic Soil Group – The hydrologic soil group of the land within the watershed establishes how pervious the unpaved areas of the watershed are based on type of soil and the area that type of soil encompasses. This has been obtained from mapping available from the Soil

Conservation Service. Areas of the different soil types were measured and an area-weighted soil group derived.

- Runoff Curve Number (CN) – This is a measure of how much water runs off from a watershed and is calculated from the combination of % impervious and the Hydrologic Soil Group.
- Time of Concentration – The Time of Concentration is the amount of time it takes runoff from the furthest reaches of the watershed to reach the lake. We used the "Lag/CN" method to calculate this time. This requires the length and slope of the flow paths which have been determined from the Westchester County Topographic Map, as well as the Runoff Curve Number.

The hydraulic capacity of the drainage system is based on the physical characteristics of the drainage elements. Shapes, sizes and slopes were obtained from surveys provided by the Village. Roughness coefficients were determined based on visual inspection and comparison to standard texts on open channel hydraulics.

Hydrologic and hydraulic calculations were made with Hydrocad Storm Water Software, an industry standard for this type of work.

Analysis / Cause of Problem

The total area of the watershed that drains to Nannahagan Lake is 854 acres. The runoff from the watershed for various storms is as follows:

Return Period	24 Hour Rainfall (inches)	Peak Runoff (cfs)	Total Volume of Runoff (acre feet)
1 Year	2.80	174	39
2 Year	3.60	309	68
5 Year	4.80	541	118
10 Year	5.52	689	152
25 Year	6.72	946	210
50 Year	7.68	1,158	259
100 Year	8.40	1,319	297

Hydraulic modeling of the system through the lake, channel, culvert and brook has determined that the most restrictive element in the system is the culvert running under the pool building. The capacity of the culvert is controlled by the elevation of the water in the channel immediately upstream of the culvert. When the elevation in that channel reaches 345, the water begins to flood across the walkway to the south of the channel. At 346, it will start to flow toward the north side of the building. And at 346.8 it breaches the wall between the walkway and the building and will begin to seriously flood the pool area. The flow rates that drive the water up to these elevations in the channel are:

Elevation	Runoff from Watershed	Approx. Return Period (Years)	Flow into Channel	Flow through Culvert	Flooding Flow
345	480 cfs	4	474 cfs	474 cfs	0 cfs
346	561 cfs	6	552 cfs	518 cfs	34 cfs
346.8	748 cfs	13	737 cfs	551 cfs	186 cfs

At the runoff of 748 cfs, in addition to the wall between the walkway and building being breached, the pond will have reached the top of the berm, or grassy embankment. This leads us to the conclusion that the system can handle a storm with approximately a 10 year return period before causing significant flooding in the pool area. This conclusion aligns with the anecdotal information provided by the Village.

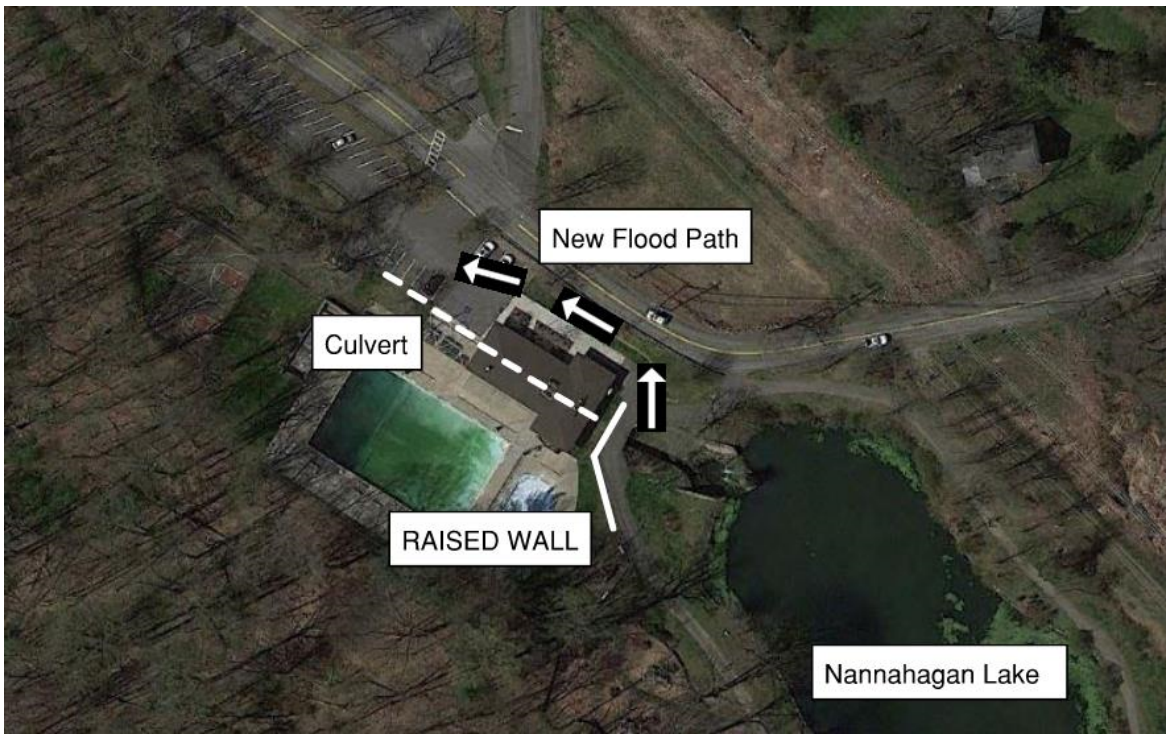
Potential Improvements

Several ideas for reducing the probability of flooding of the pool area have been considered. They include:

1. Increase the detention capacity of the pond.
2. Raise the walls on the west side of the walk between the channel area and the building to force flooding waters to flow around the north side of the pool building and across the parking lot to Nanny Hagen Brook.
3. Raise the walls around the channel area to contain rising waters within that area.
4. Construct a second culvert between the channel area and Nanny Hagen Brook to increase the system capacity between these points.
5. Lengthen the weirs that control the elevation of the pond to increase flow through the pond.

Any potential solution should provide protection against flooding from a larger storm event, so we looked at solutions with respect to their ability to handle 25 year, 50 year and 100 year storms. The potential solutions are discussed in order below:

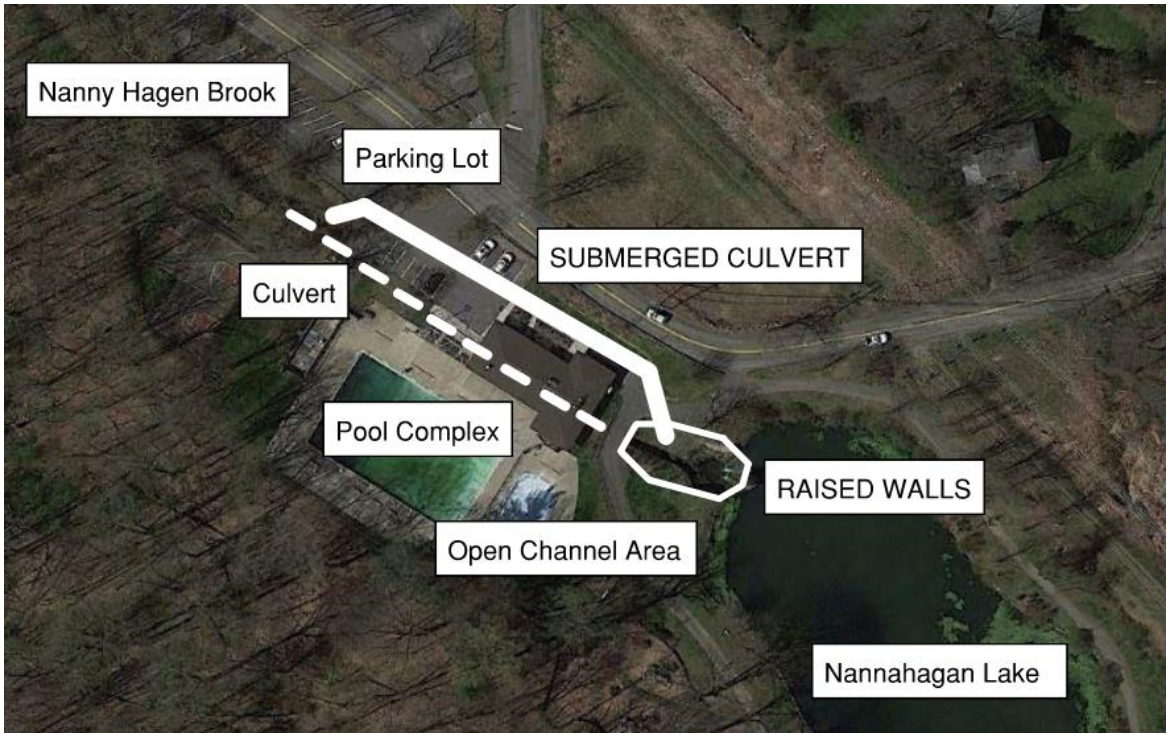
1. Detention Capacity – Prior to storms, the 3-acre pond is typically lowered 2', increasing its storage capacity from about 9 acre feet to 15 acre feet. To limit the flow out of the pond from a 25 year storm to approximately 480 cfs – the flow rate that would not cause any flooding - would require a storage capacity of 45 acre feet. This would require tripling the size of the pond, which is impractical.
2. Raise the wall on the west side of the walkway – Raising the wall on the side of the walkway would force flow to go around the north side of the building. In a 25 year storm, this would direct up to 360 cfs of flow through the walkway on the north side of the building. This would



create a river in this area running about 25’ wide by 1.5’ deep at roughly 10 feet per second. This river would appear as a flash flood and create a very dangerous situation in this area.

3. Raise the walls in the channel area to contain rising waters within that area – Containing water in this area by raising the walls above elevation 349, would increase the capacity of the system to perform without flooding to about 630 cfs. While this represents an improvement from the no flood condition today of 480 cfs, it is still only providing protection from a storm with an 8 or 9 year return period.

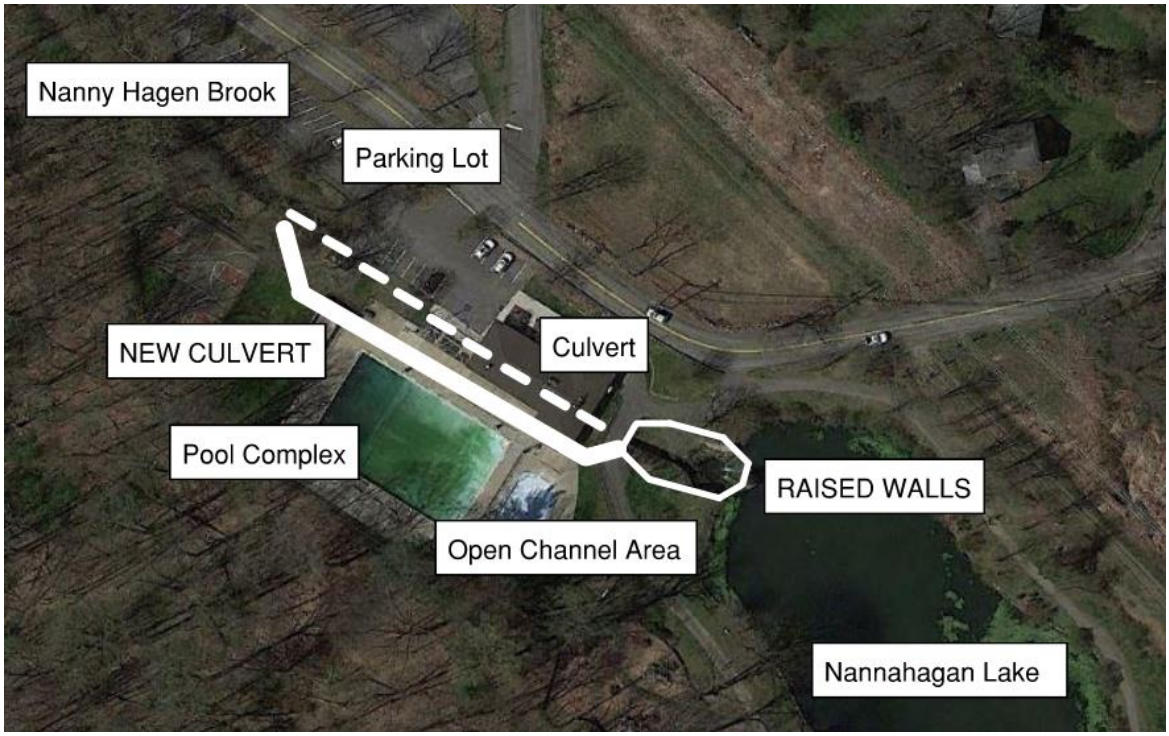
4. Construct a second culvert between the channel and Nanny Hagen Brook – A 60” diameter pipe installed along the north side of the building and under the parking between the channel and Nanny Hagen Brook would provide protection from the 25 year storm – 930 cfs. This approach would also require raising the walls around the channel to elevation 352. At flows higher than 930 cfs the lake would begin to overflow.



5. Construct a second culvert from channel area and lengthen the weirs for the pond – There are currently two (2) 15’ long weirs controlling the flow over the dam. If the weir lengths were expanded the capacity of the system can be increased.

5A) 50 Year storm - Expand weirs by 30' and install 98" x 63" elliptical pipe were added between the channel area and Nanny Hagen Brook.
5B) – 100 Year Storm – Increase weir length by 40' and install to 113" x 72" elliptical pipe.

6. Option 6 is a hybrid of Options 4 and 5. Under this scenario the walls around the channel would be raised as described in Option 4. A new culvert would be constructed around the south side of the pool building through the pool deck. The work would be done as part of the pool project and the culvert would be constructed in place using a poured in place concrete floor, gunite walls, and precast concrete top slabs. The culvert would be sized for the flow from the 100 year storm (8' wide x 5.5' high) , but the weirs at the pond would not be modified at this time. Modifications to the dam/weir structure could be undertaken in the future.



Summary

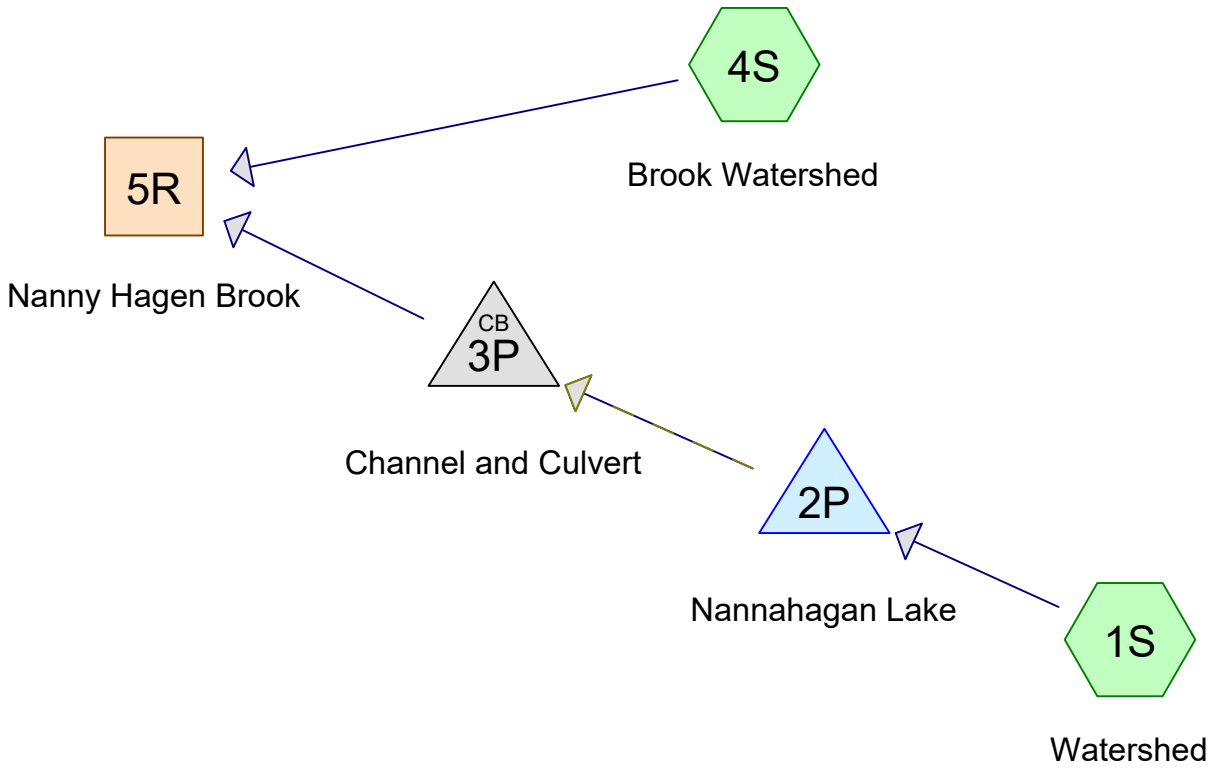
Options 3, 4, 5 and 6 represent the only legitimate improvements from the existing condition. The estimated cost of each option and its improvement over the existing conditions can be summarized as follows:

OPTION	EST. COST	CAPACITY (CFS)	MAX RAINFALL (IN)	RETURN PERIOD (YEARS)	CAPACITY IMPROVEMENT
EXISTING	-	480	4.5	-	-
3	$100,000	640	5.3	8	33%
4	$610,000	950	6.72	25	97%
5A	$890,000	1,160	7.68	50	141%
5B	$1,130,000	1,320	8.4	100	175%
6	$860,000	1,010	7.0	30	104%

APPENDIX A

CALCULATIONS

Existing condition at maximum discharge that will not flood. This is determined by largest storm that will keep channel level below elevation 345



Subcat Reach Pond Link

Routing Diagram for Existing Conditions - No Flooding
Prepared by de Bruin Engineering, P.C., Printed 11/22/2021

Time span=0.00-17.00 hrs, dt=0.01 hrs, 1701 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method

Subcatchment1S: Watershed Runoff Area=854.000 ac Runoff Depth>1.48"
Flow Length=9,200' Slope=0.0340 '/' Tc=121.5 min CN=74 Runoff=480.48 cfs 105.055 af

Pond 2P: Nannahagan Peak Elev=351.22' Storage=9.349 af Inflow=480.48 cfs 104.965 af
Outflow=473.86 cfs 100.130 af

Pond 3P: Channel and Culvert Peak Elev=344.92' Inflow=473.86 cfs 100.032 af
Outflow=473.86 cfs 100.032 af

Subcatchment4S: Brook Watershed Runoff Area=22.590 ac Runoff Depth>1.64"
Flow Length=2,060' Slope=0.0769 '/' Tc=24.4 min CN=74 Runoff=31.95 cfs 3.082 af

Reach 5R: Nanny Avg. Flow Depth=2.80' Max Vel=9.30 fps Inflow=478.33 cfs 103.015 af
n=0.035 L=850.0' S=0.0171 '/' Capacity=1,625.88 cfs Outflow=478.28 cfs 102.704 af

Total Runoff Area = 876.590 ac Runoff Volume = 108.138 af Average Runoff Depth = 1.48"

Summary for Subcatchment 1S: Watershed

Estimated Flow using Rational Formula at site visit was Q=650 cfs.
A=762 Ac
I=140/tc+15 = 140/67 = 2.08
R=0.4

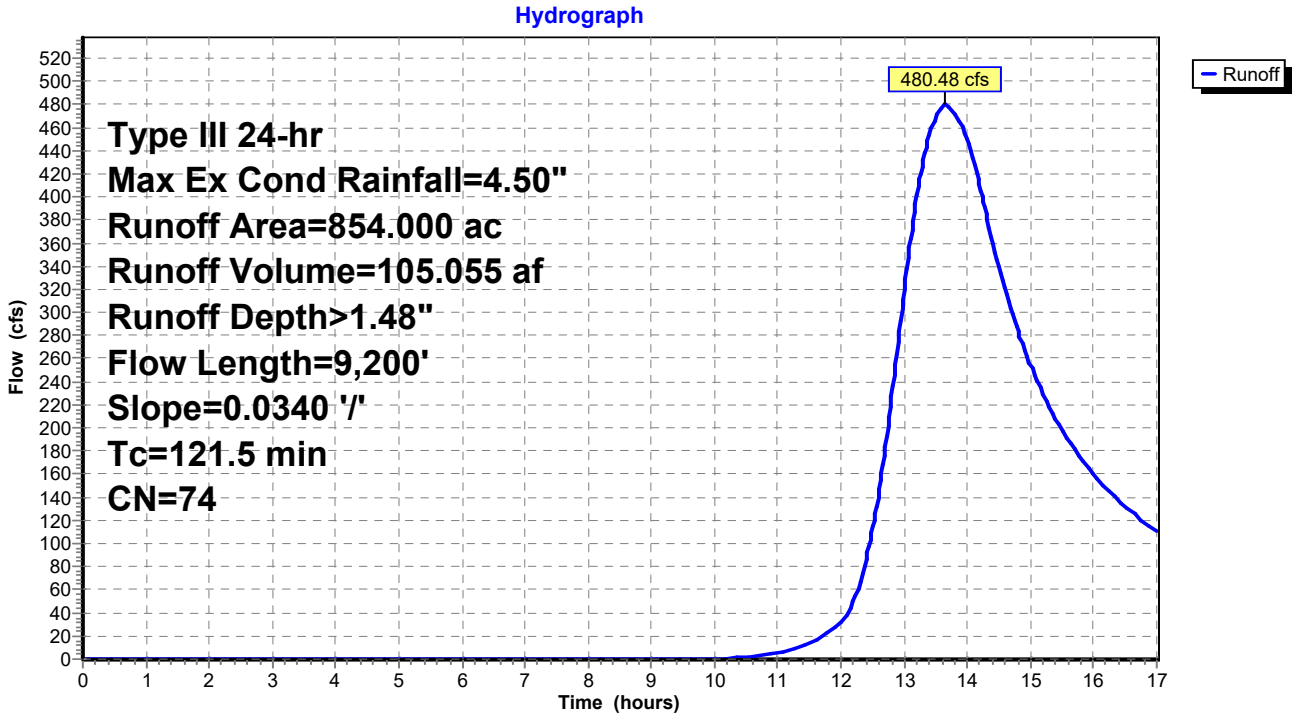
Runoff = 480.48 cfs @ 13.64 hrs, Volume= 105.055 af, Depth> 1.48"
Routed to Pond 2P : Nannahagan Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr Max Ex Cond Rainfall=4.50"

	Area (ac)	CN	Description
*	854.000	74	Watershed Area with TR-55 weighted CN

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
121.5	9,200	0.0340	1.26		**Lag/CN Method, CN Method**

Subcatchment 1S: Watershed



Summary for Pond 2P: Nannahagan Lake

Inflow Area = 854.000 ac, Inflow Depth > 1.47" for Max Ex Cond event
Inflow = 480.48 cfs @ 13.64 hrs, Volume= 104.965 af
Outflow = 473.86 cfs @ 13.79 hrs, Volume= 100.130 af, Atten= 1%, Lag= 9.1 min
Primary = 473.86 cfs @ 13.79 hrs, Volume= 100.130 af
Routed to Pond 3P : Channel and Culvert

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 351.22' @ 13.79 hrs Surf.Area= 2.649 ac Storage= 9.349 af
Flood Elev= 352.00' Surf.Area= 3.024 ac Storage= 11.558 af

Plug-Flow detention time= 18.7 min calculated for 100.130 af (95% of inflow)
Center-of-Mass det. time= 11.6 min (867.9 - 856.3)

Volume	Invert	Avail.Storage	Storage Description
#1	345.84'	14.836 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

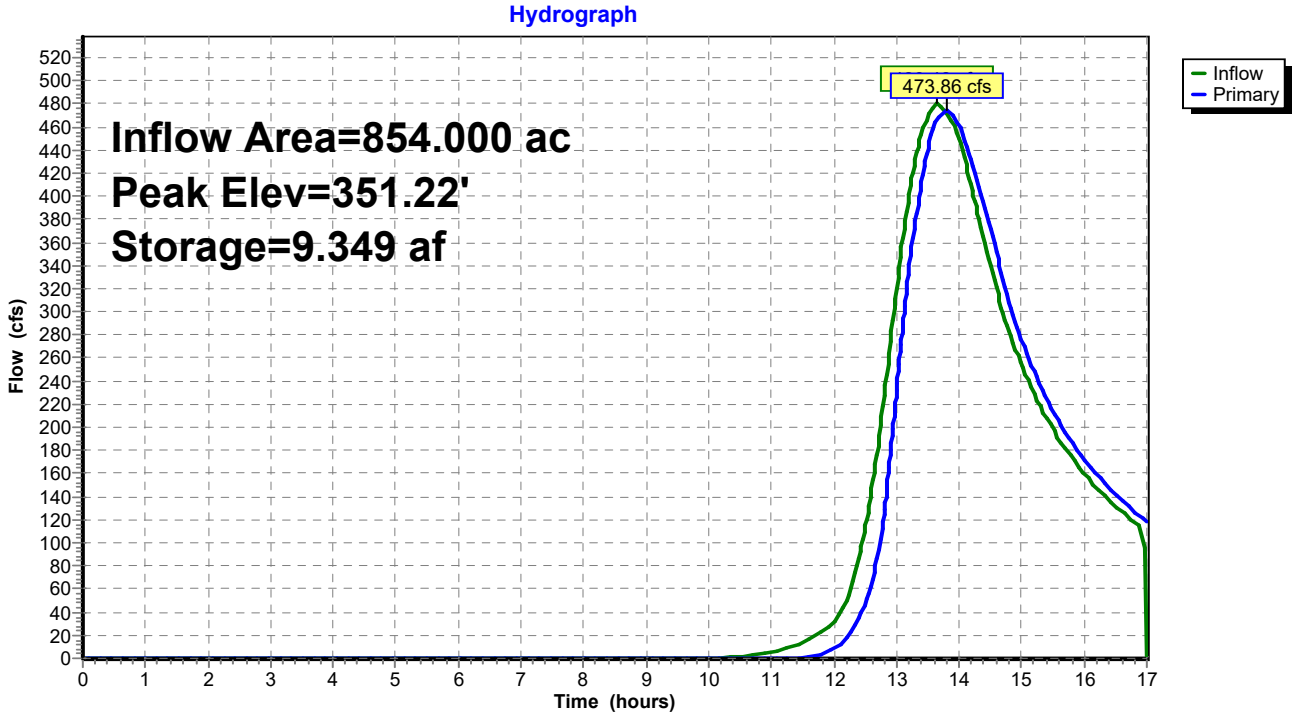
Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
345.84	1.150	1,138.0	0.000	0.000	1.150
347.00	1.350	1,266.0	1.448	1.448	1.713
348.00	1.560	1,488.0	1.454	2.902	2.830
348.95	1.700	1,524.0	1.548	4.450	3.031
353.00	3.540	1,721.0	10.386	14.836	4.209

Device	Routing	Invert	Outlet Devices
#1	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Primary	346.14'	**42.0" Round Chamber Pipe** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 9.62 sf
#4	Primary	346.14'	**42.0" Round Bypass at Brook**

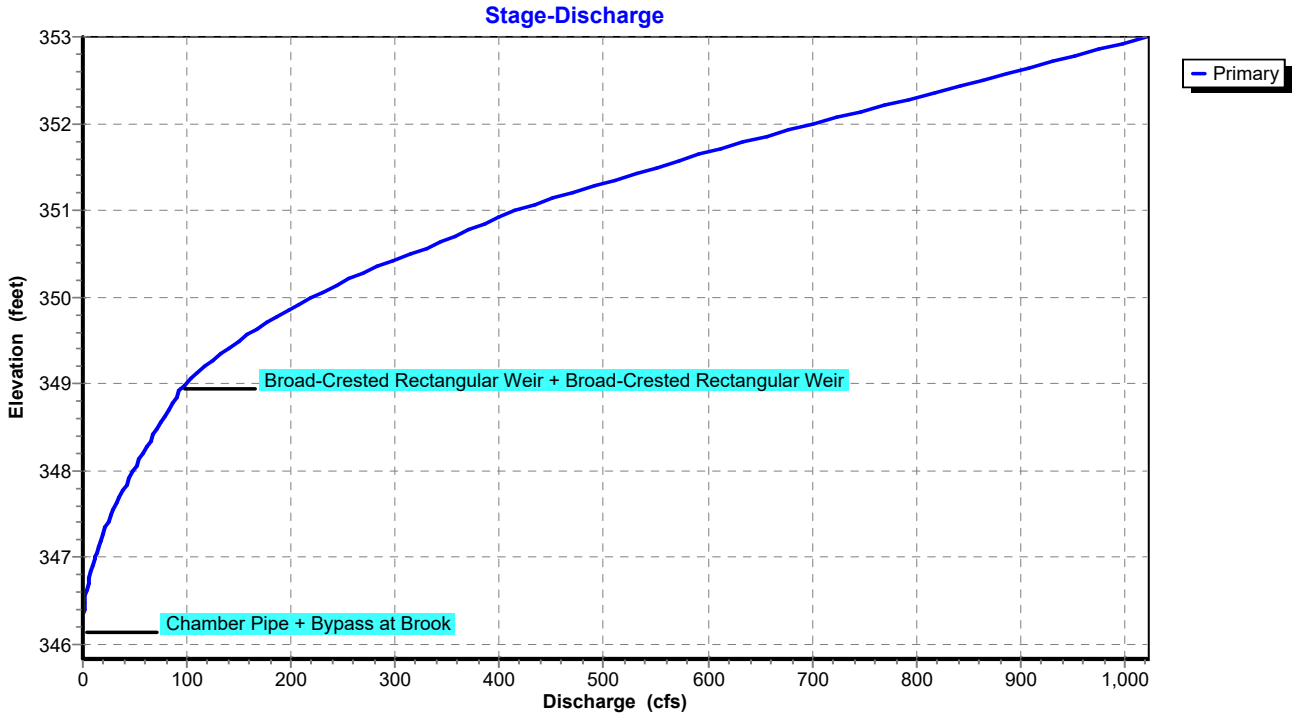
L= 707.0' CPP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/'
Cc= 0.900 n= 0.010, Flow Area= 9.62 sf

Primary OutFlow Max=473.86 cfs @ 13.79 hrs HW=351.22' TW=344.92' (Dynamic Tailwater)
- **1=Broad-Crested Rectangular Weir**(Weir Controls 152.38 cfs @ 4.47 fps)
- **2=Broad-Crested Rectangular Weir**(Weir Controls 152.38 cfs @ 4.47 fps)
- **3=Chamber Pipe** (Inlet Controls 84.54 cfs @ 8.79 fps)
- **4=Bypass at Brook** (Inlet Controls 84.54 cfs @ 8.79 fps)

Pond 2P: Nannahagan Lake



Pond 2P: Nannahagan Lake



Summary for Pond 3P: Channel and Culvert

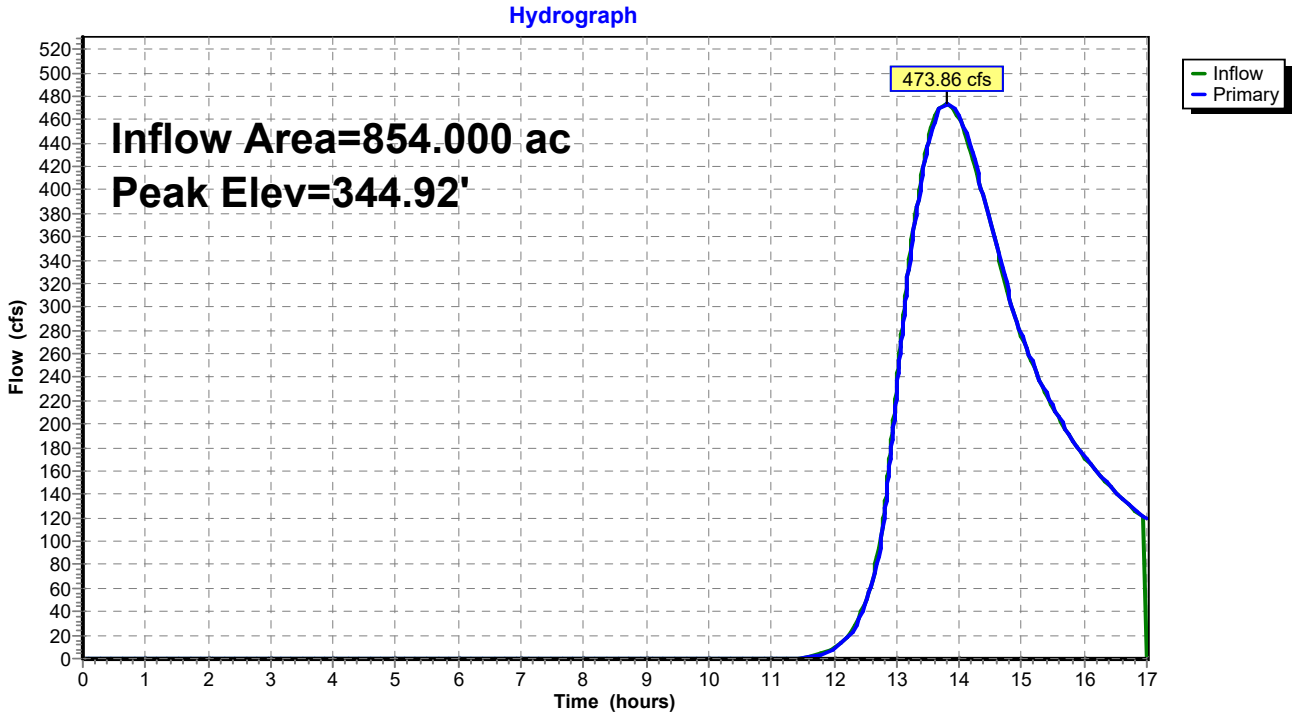
Inflow Area = 854.000 ac, Inflow Depth > 1.41" for Max Ex Cond event
Inflow = 473.86 cfs @ 13.79 hrs, Volume= 100.032 af
Outflow = 473.86 cfs @ 13.80 hrs, Volume= 100.032 af, Atten= 0%, Lag= 0.6 min
Primary = 473.86 cfs @ 13.80 hrs, Volume= 100.032 af
Routed to Reach 5R : Nanny Hagen Brook

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 344.92' @ 13.80 hrs
Flood Elev= 345.00'

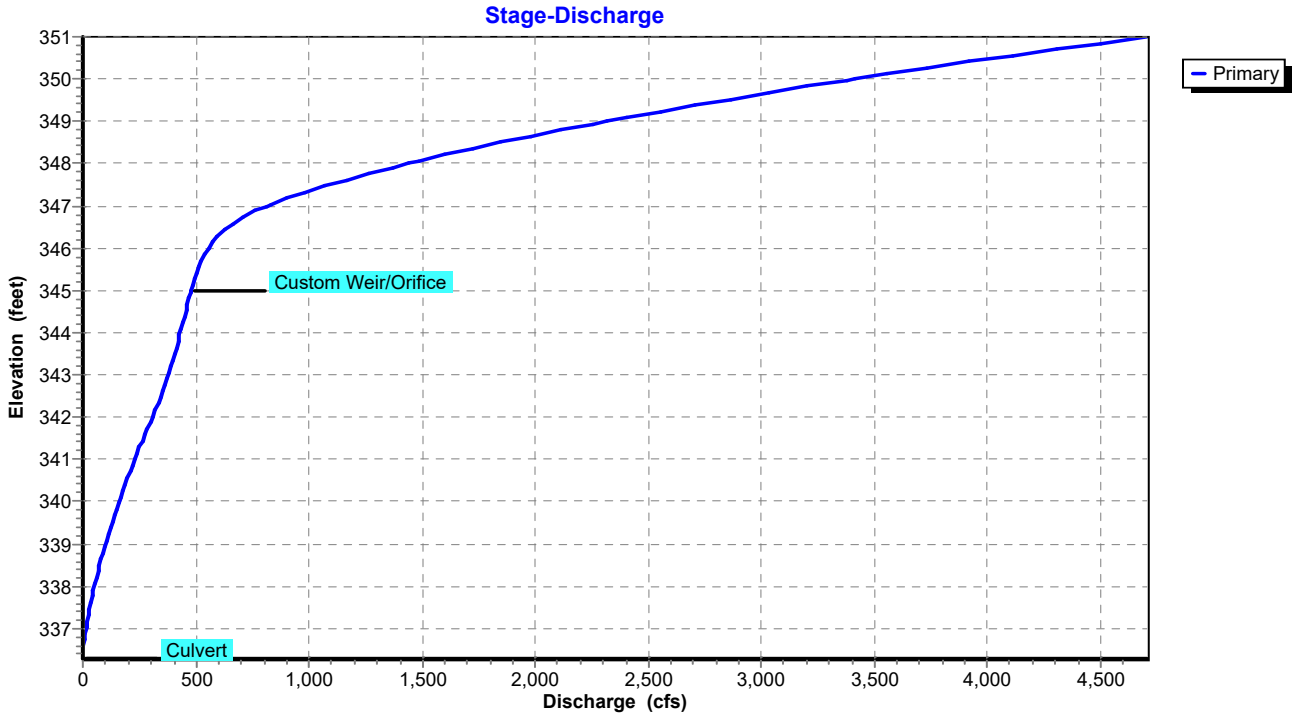
Device	Routing	Invert	Outlet Devices
#1	Primary	336.29'	**84.0" W x 72.0" H Box Culvert** L= 257.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 329.54' S= 0.0263 '/' Cc= 0.900 n= 0.017, Flow Area= 42.00 sf
#2	Primary	345.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 345.00 346.00 347.00 348.00 349.00 350.00 351.00 Width (feet) 5.00 20.00 111.00 118.00 125.00 132.00 139.00

Primary OutFlow Max=473.86 cfs @ 13.80 hrs HW=344.92' TW=332.34' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 473.86 cfs @ 11.28 fps)
└─**2=Custom Weir/Orifice** (Controls 0.00 cfs)

Pond 3P: Channel and Culvert



Pond 3P: Channel and Culvert



Summary for Subcatchment 4S: Brook Watershed

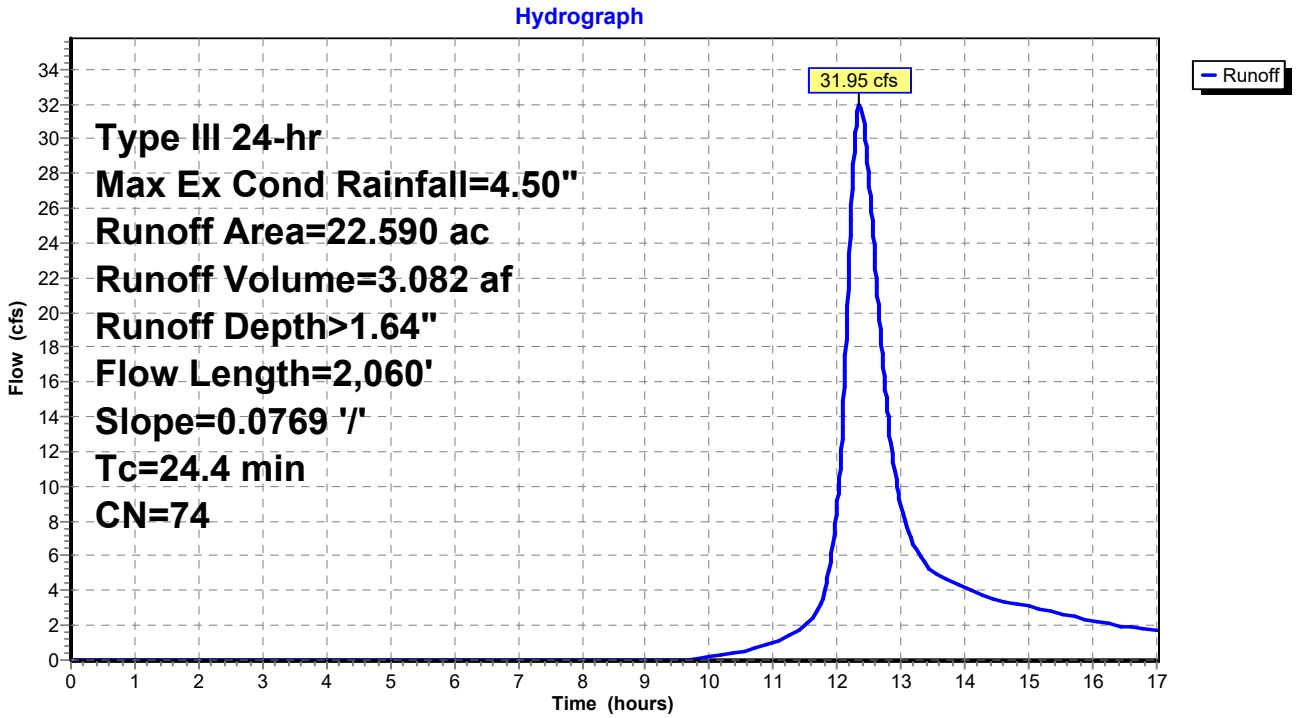
Runoff = 31.95 cfs @ 12.34 hrs, Volume= 3.082 af, Depth> 1.64"
Routed to Reach 5R : Nanny Hagen Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr Max Ex Cond Rainfall=4.50"

	Area (ac)	CN	Description
*	22.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	2,060	0.0769	1.41		**Lag/CN Method,**

Subcatchment 4S: Brook Watershed



Summary for Reach 5R: Nanny Hagen Brook

Channel 2 "ends" at Wood Bridge

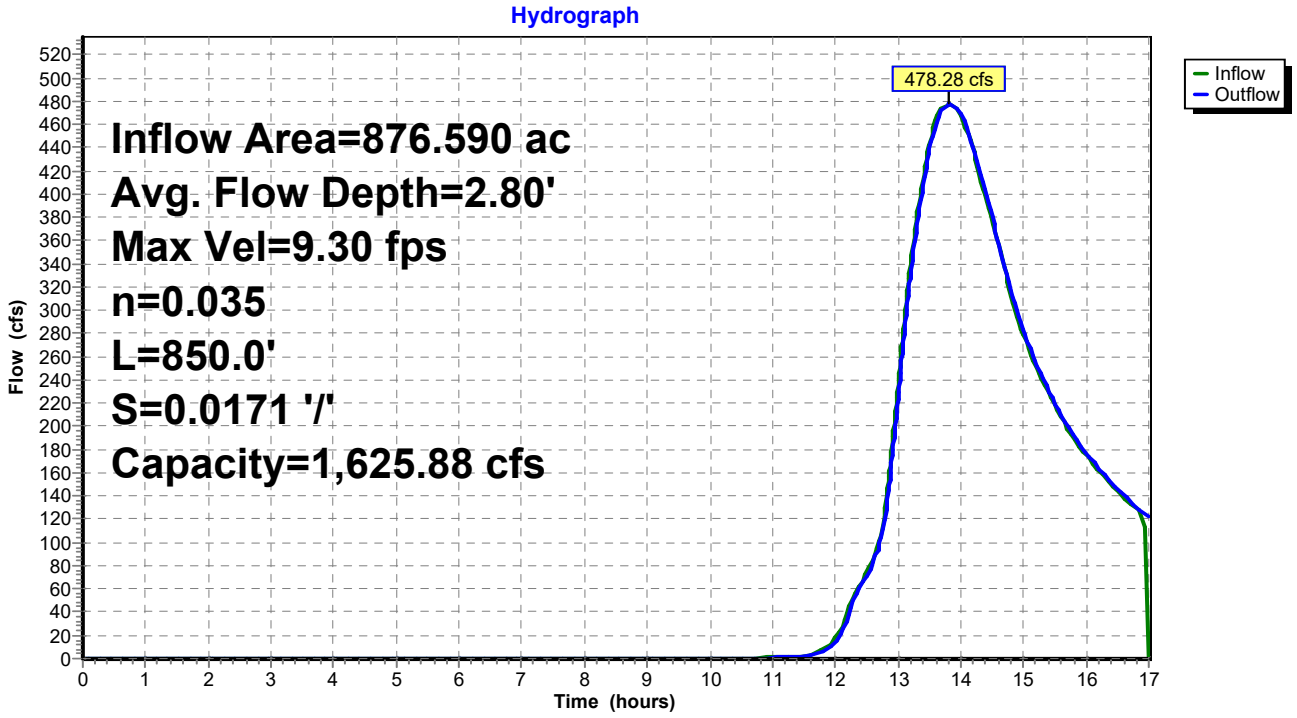
Inflow Area = 876.590 ac, Inflow Depth > 1.41" for Max Ex Cond event
Inflow = 478.33 cfs @ 13.80 hrs, Volume= 103.015 af
Outflow = 478.28 cfs @ 13.81 hrs, Volume= 102.704 af, Atten= 0%, Lag= 1.0 min

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Max. Velocity= 9.30 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 4.93 fps, Avg. Travel Time= 2.9 min

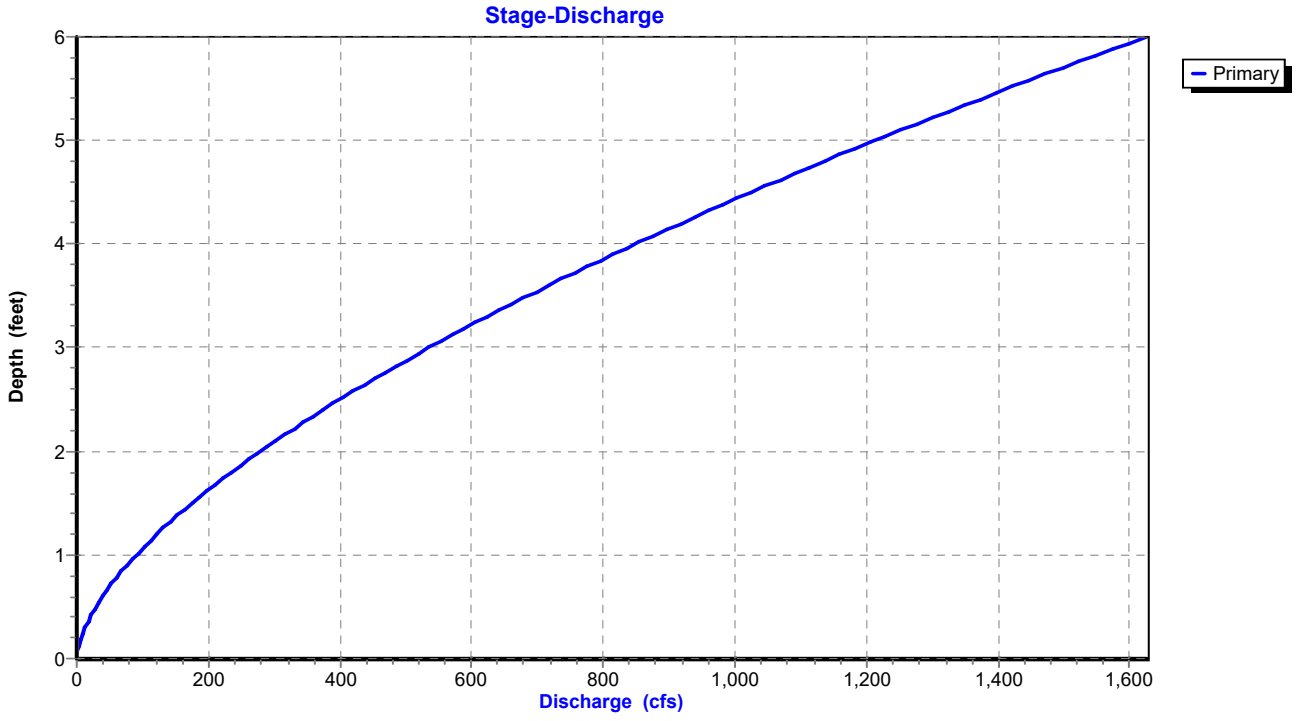
Peak Storage= 43,731 cf @ 13.81 hrs
Average Depth at Peak Storage= 2.80' , Surface Width= 19.80'
Bank-Full Depth= 6.00' Flow Area= 120.0 sf, Capacity= 1,625.88 cfs

17.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 0.0 1.0 '/' Top Width= 23.00'
Length= 850.0' Slope= 0.0171 '/'
Inlet Invert= 329.54', Outlet Invert= 315.00'

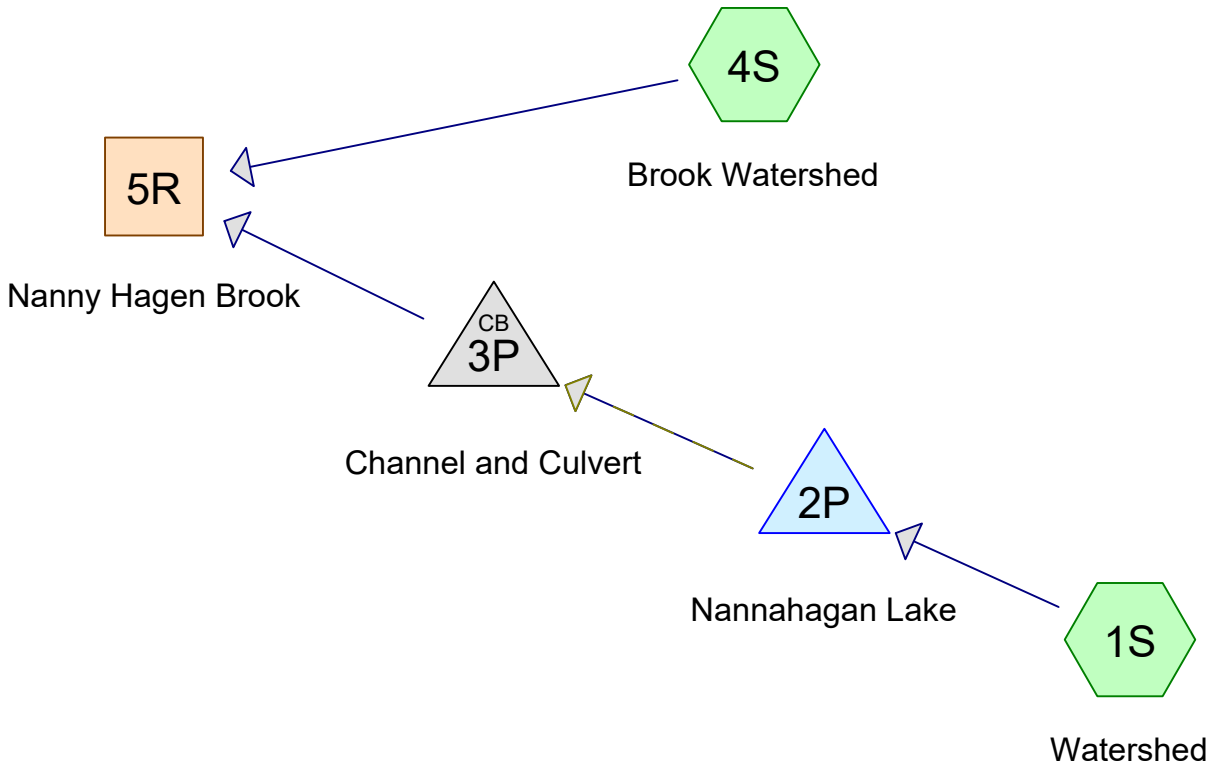
Reach 5R: Nanny Hagen Brook



Reach 5R: Nanny Hagen Brook



Existing condition at maximum discharge that will not significantly affect pool area - Peak Elevation = 346.8



Subcat Reach Pond Link

Routing Diagram for Existing Conditions
Prepared by Microsoft, Printed 11/19/2021

Summary for Subcatchment 1S: Watershed

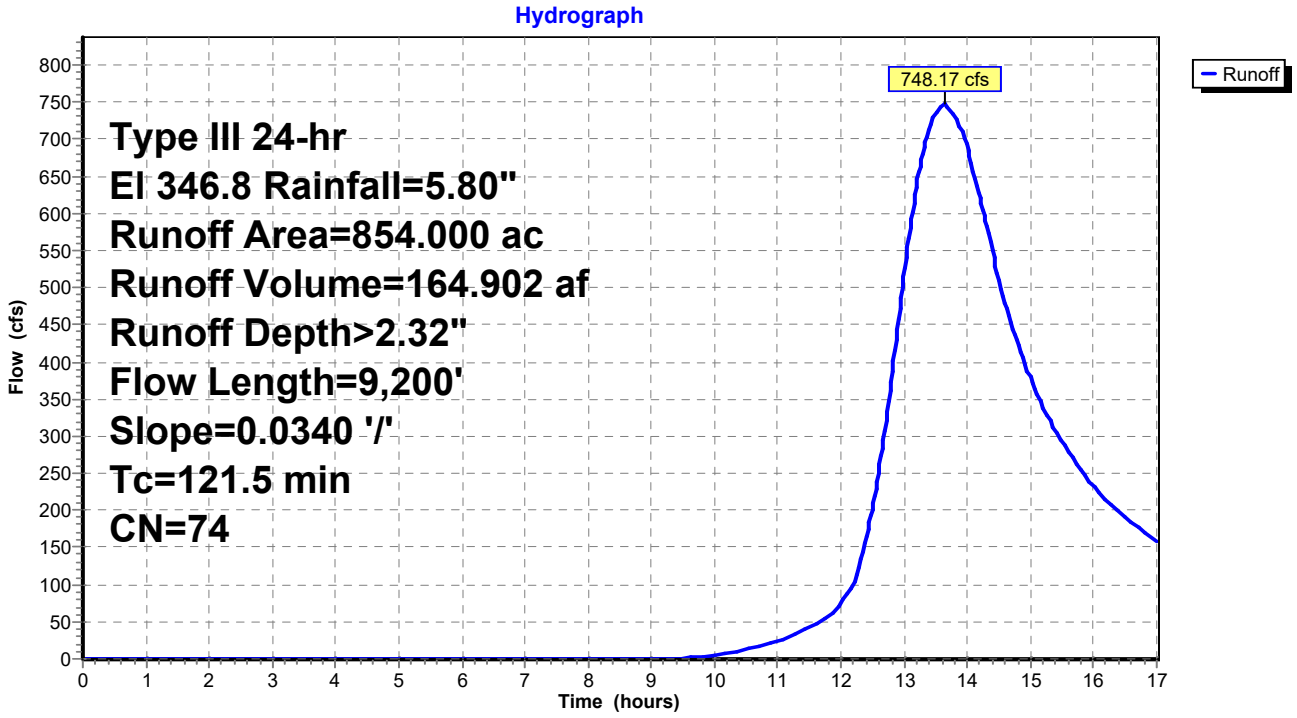
Runoff = 748.17 cfs @ 13.64 hrs, Volume= 164.902 af, Depth> 2.32"
Routed to Pond 2P : Nannahagan Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr El 346.8 Rainfall=5.80"

	Area (ac)	CN	Description
*	854.000	74	Watershed Area with TR-55 weighted CN

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
121.5	9,200	0.0340	1.26		**Lag/CN Method, CN Method**

Subcatchment 1S: Watershed



Summary for Pond 2P: Nannahagan Lake

Inflow Area = 854.000 ac, Inflow Depth > 2.32" for El 346.8 event
Inflow = 748.17 cfs @ 13.64 hrs, Volume= 164.771 af
Outflow = 737.34 cfs @ 13.76 hrs, Volume= 159.175 af, Atten= 1%, Lag= 7.4 min
Primary = 737.34 cfs @ 13.76 hrs, Volume= 159.175 af
Routed to Pond 3P : Channel and Culvert

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 352.18' @ 13.76 hrs Surf.Area= 3.115 ac Storage= 12.121 af
Flood Elev= 352.00' Surf.Area= 3.024 ac Storage= 11.558 af

Plug-Flow detention time= 15.8 min calculated for 159.175 af (97% of inflow)
Center-of-Mass det. time= 10.3 min (860.2 - 849.9)

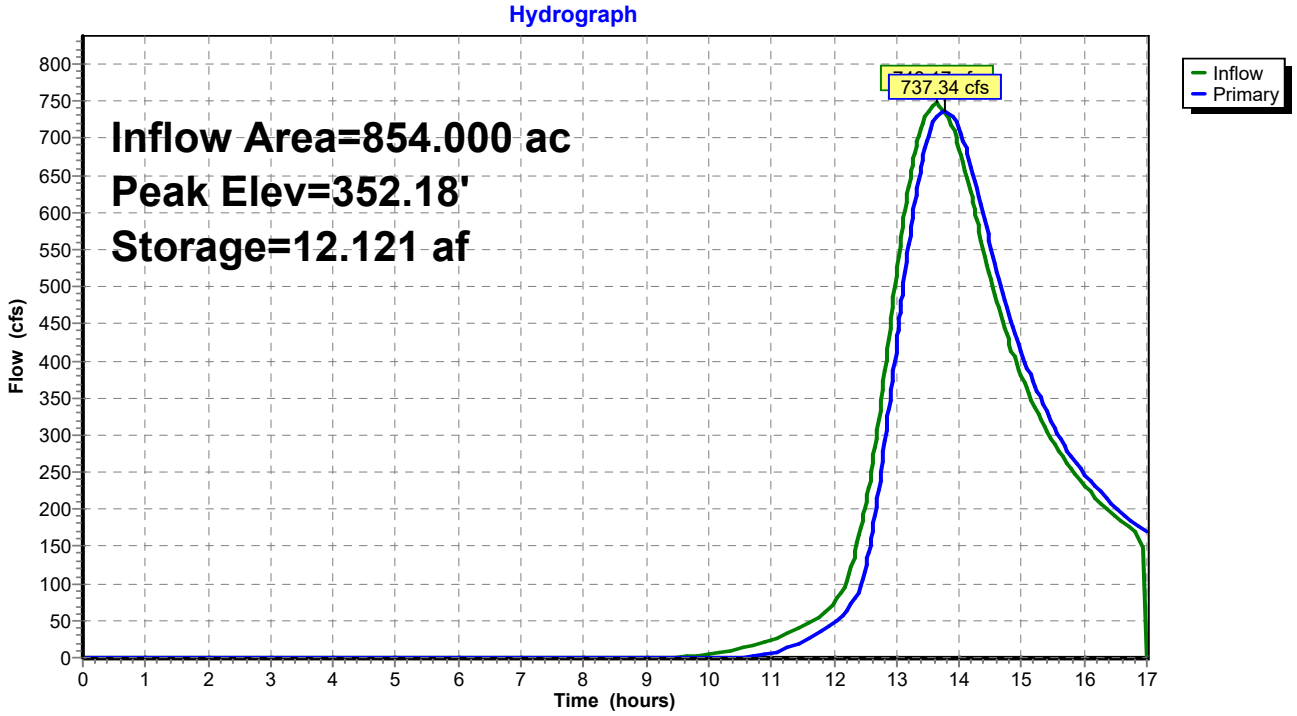
Volume	Invert	Avail.Storage	Storage Description
#1	345.84'	14.836 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
345.84	1.150	1,138.0	0.000	0.000	1.150
347.00	1.350	1,266.0	1.448	1.448	1.713
348.00	1.560	1,488.0	1.454	2.902	2.830
348.95	1.700	1,524.0	1.548	4.450	3.031
353.00	3.540	1,721.0	10.386	14.836	4.209

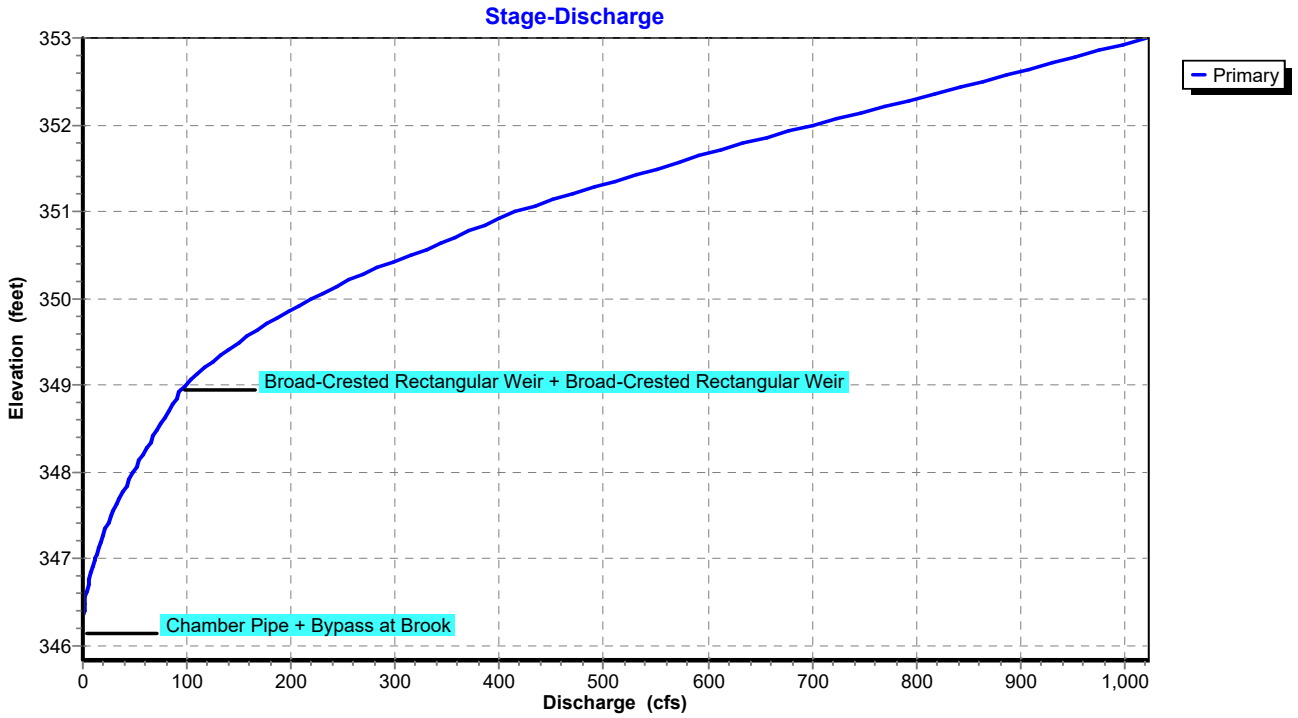
Device	Routing	Invert	Outlet Devices
#1	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Primary	346.14'	**42.0" Round Chamber Pipe** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 9.62 sf
#4	Primary	346.14'	**42.0" Round Bypass at Brook** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.010, Flow Area= 9.62 sf

Primary OutFlow Max=737.33 cfs @ 13.76 hrs HW=352.18' TW=346.81' (Dynamic Tailwater)
- **1=Broad-Crested Rectangular Weir** (Weir Controls 284.01 cfs @ 5.86 fps)
- **2=Broad-Crested Rectangular Weir** (Weir Controls 284.01 cfs @ 5.86 fps)
- **3=Chamber Pipe** (Outlet Controls 79.54 cfs @ 8.27 fps)
- **4=Bypass at Brook** (Outlet Controls 89.77 cfs @ 9.33 fps)

Pond 2P: Nannahagan Lake



Pond 2P: Nannahagan Lake



Summary for Pond 3P: Channel and Culvert

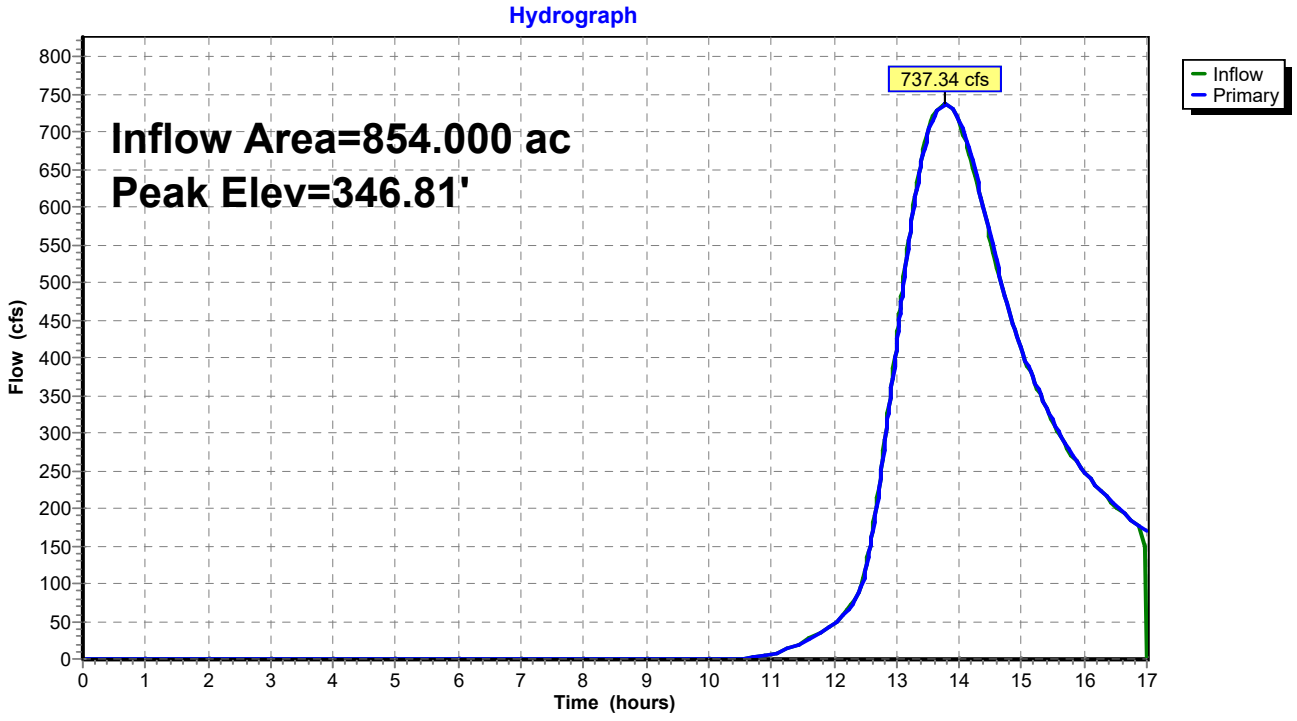
Inflow Area = 854.000 ac, Inflow Depth > 2.23" for El 346.8 event
Inflow = 737.34 cfs @ 13.76 hrs, Volume= 159.035 af
Outflow = 737.34 cfs @ 13.77 hrs, Volume= 159.035 af, Atten= 0%, Lag= 0.6 min
Primary = 737.34 cfs @ 13.77 hrs, Volume= 159.035 af
Routed to Reach 5R : Nanny Hagen Brook

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 346.81' @ 13.77 hrs
Flood Elev= 345.00'

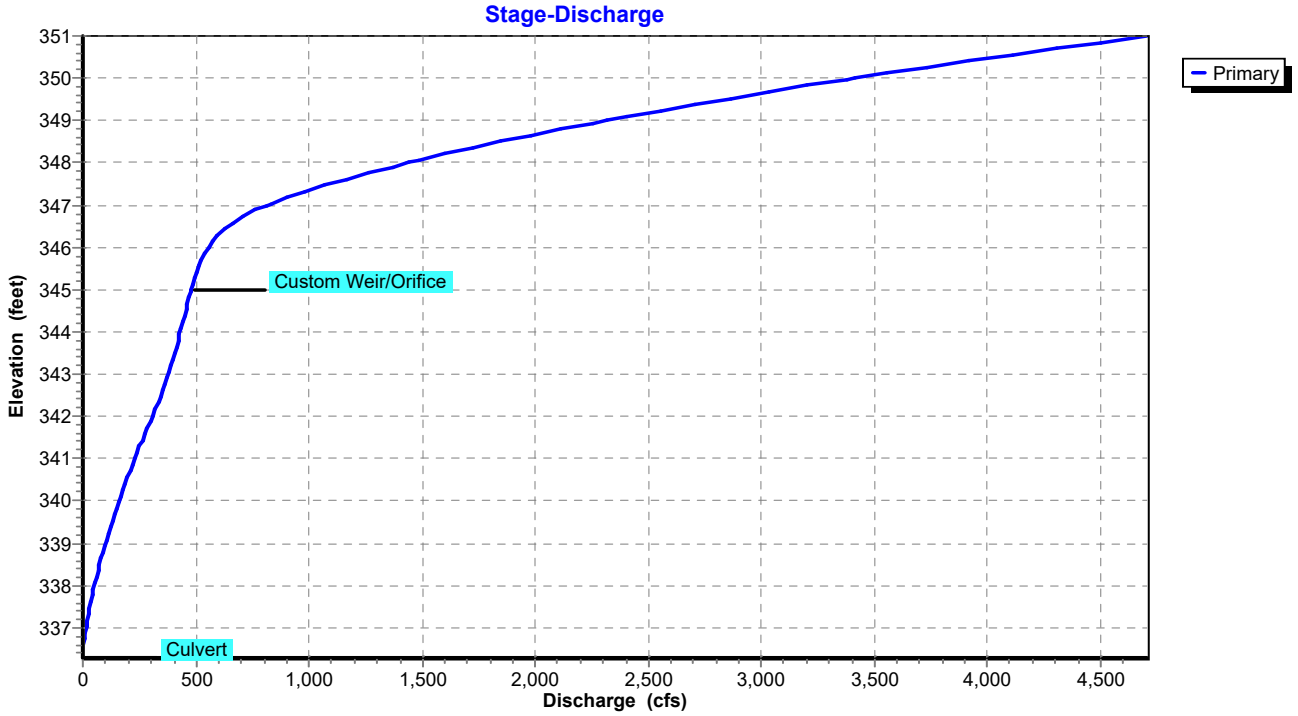
Device	Routing	Invert	Outlet Devices
#1	Primary	336.29'	**84.0" W x 72.0" H Box Culvert** L= 257.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 329.54' S= 0.0263 '/' Cc= 0.900 n= 0.017, Flow Area= 42.00 sf
#2	Primary	345.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 345.00 346.00 347.00 348.00 349.00 350.00 351.00 Width (feet) 5.00 20.00 111.00 118.00 125.00 132.00 139.00

Primary OutFlow Max=737.34 cfs @ 13.77 hrs HW=346.81' TW=333.22' (Dynamic Tailwater)
1=Culvert (Inlet Controls 550.90 cfs @ 13.12 fps)
2=Custom Weir/Orifice (Weir Controls 186.43 cfs @ 3.17 fps)

Pond 3P: Channel and Culvert



Pond 3P: Channel and Culvert



Summary for Subcatchment 4S: Brook Watershed

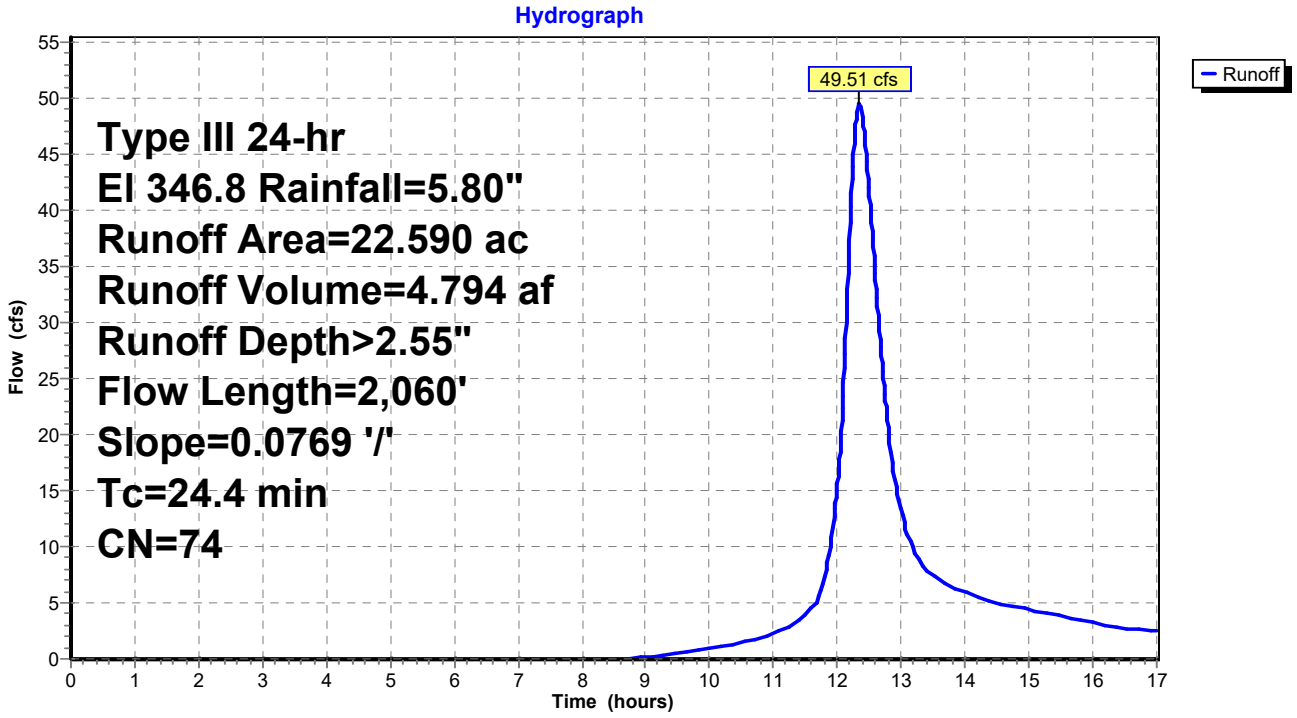
Runoff = 49.51 cfs @ 12.34 hrs, Volume= 4.794 af, Depth> 2.55"
Routed to Reach 5R : Nanny Hagen Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr El 346.8 Rainfall=5.80"

	Area (ac)	CN	Description
*	22.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	2,060	0.0769	1.41		**Lag/CN Method,**

Subcatchment 4S: Brook Watershed



Summary for Reach 5R: Nanny Hagen Brook

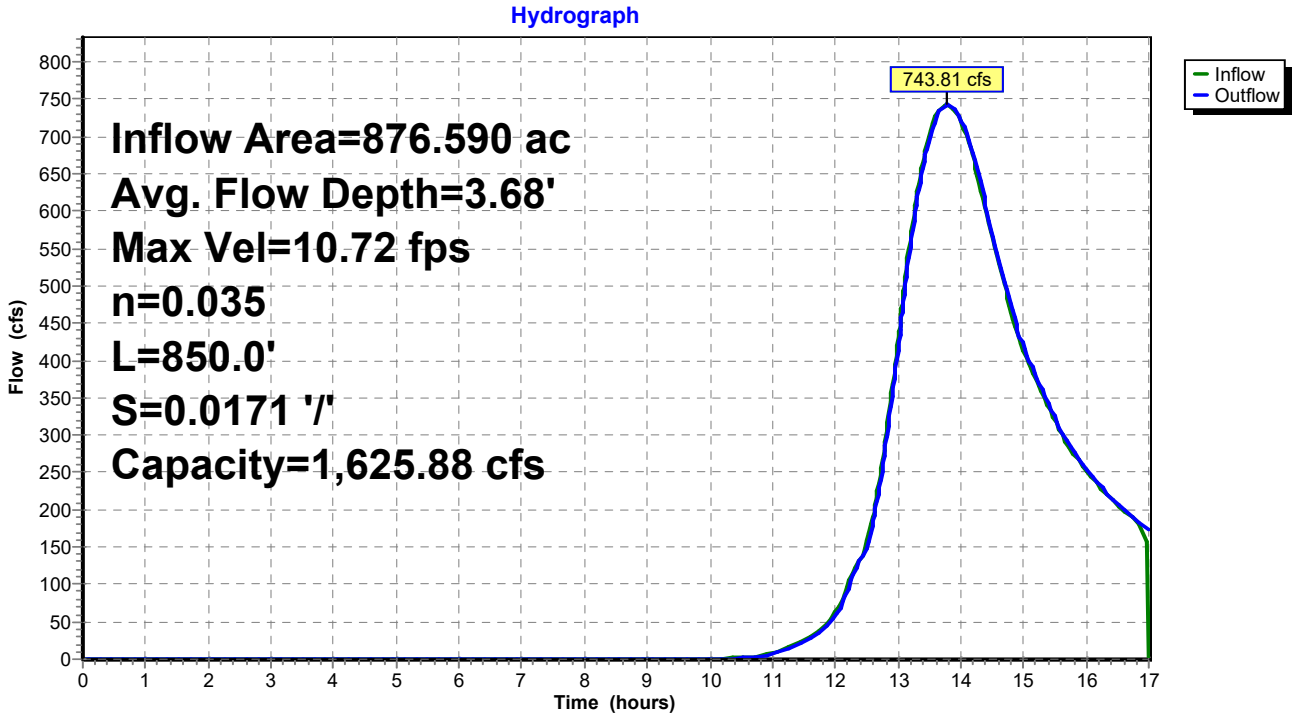
Inflow Area = 876.590 ac, Inflow Depth > 2.24" for El 346.8 event
Inflow = 743.85 cfs @ 13.76 hrs, Volume= 163.687 af
Outflow = 743.81 cfs @ 13.78 hrs, Volume= 163.315 af, Atten= 0%, Lag= 1.0 min

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Max. Velocity= 10.72 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 5.42 fps, Avg. Travel Time= 2.6 min

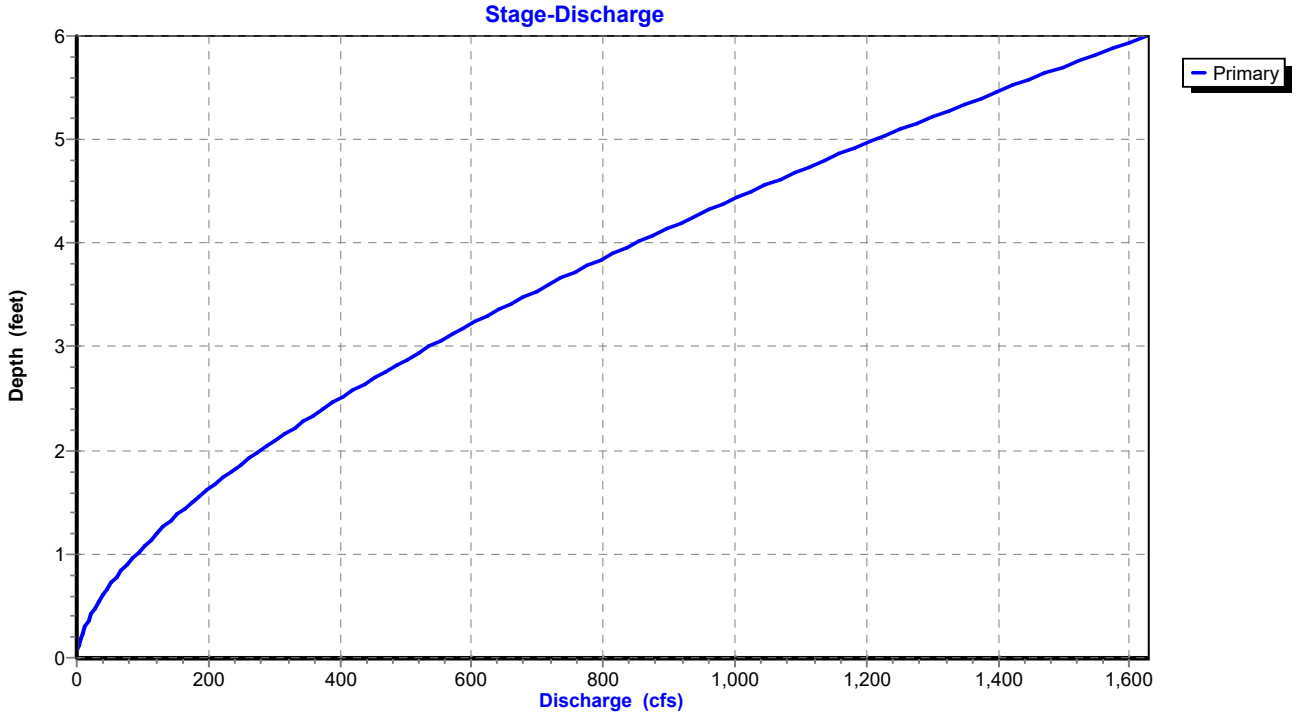
Peak Storage= 59,002 cf @ 13.78 hrs
Average Depth at Peak Storage= 3.68' , Surface Width= 20.68'
Bank-Full Depth= 6.00' Flow Area= 120.0 sf, Capacity= 1,625.88 cfs

17.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 0.0 1.0 '/' Top Width= 23.00'
Length= 850.0' Slope= 0.0171 '/'
Inlet Invert= 329.54', Outlet Invert= 315.00'

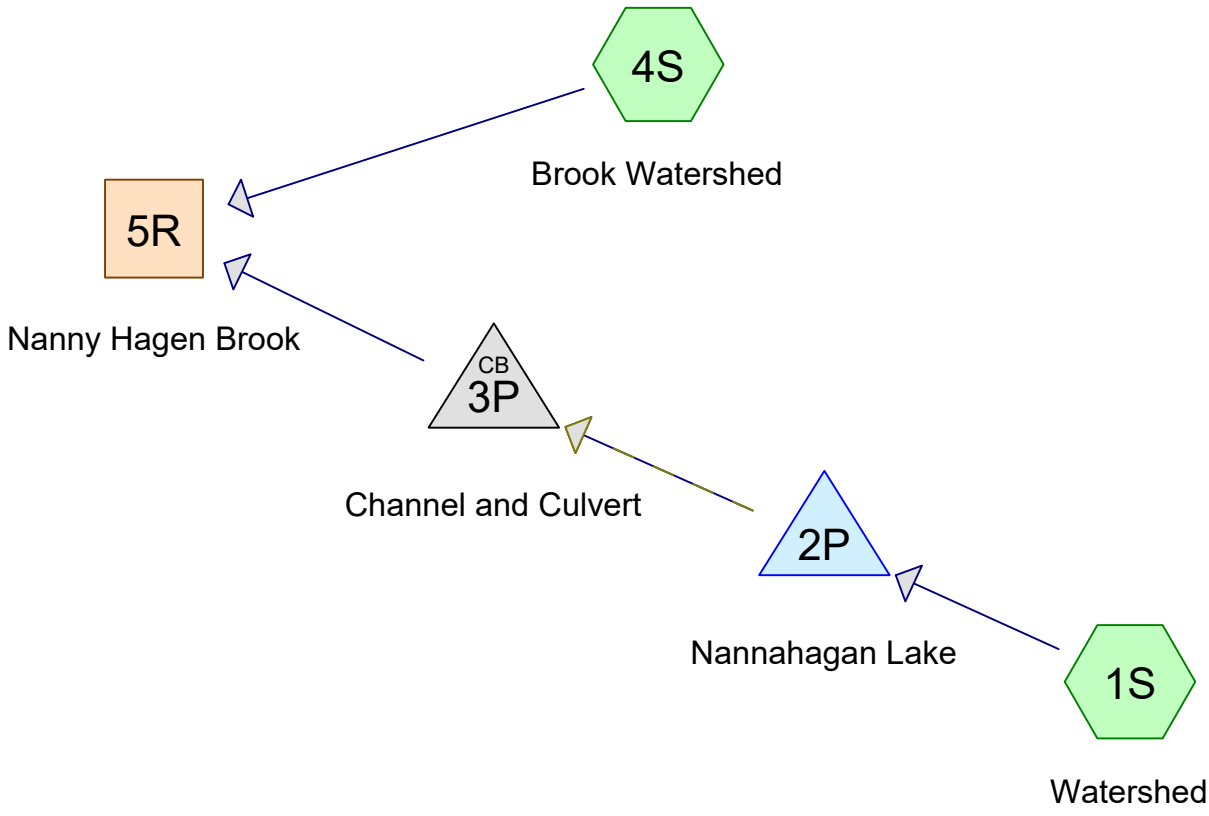
Reach 5R: Nanny Hagen Brook



Reach 5R: Nanny Hagen Brook



Design - 2 - Raise wall west of walkway to direct flow around building. Calculate flow rate around building in 25 year storm.



Subcat Reach Pond Link

Routing Diagram for Design 2 - 25 Yr - Raise West Wall
Prepared by de Bruin Engineering, P.C., Printed 11/22/2021

Time span=0.00-17.00 hrs, dt=0.01 hrs, 1701 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method

Subcatchment1S: Watershed Runoff Area=854.000 ac Runoff Depth>2.95"
Flow Length=9,200' Slope=0.0340 '/' Tc=121.5 min CN=74 Runoff=946.36 cfs 210.206 af

Pond 2P: Nannahagan Peak Elev=352.82' Storage=14.208 af Inflow=946.36 cfs 210.047 af
Outflow=931.10 cfs 203.984 af

Pond 3P: Channel and Culvert Peak Elev=347.23' Inflow=931.10 cfs 203.815 af
Outflow=931.10 cfs 203.815 af

Subcatchment4S: Brook Watershed Runoff Area=22.590 ac Runoff Depth>3.23"
Flow Length=2,060' Slope=0.0769 '/' Tc=24.4 min CN=74 Runoff=62.47 cfs 6.085 af

Reach 5R: Nanny Avg. Flow Depth=4.26' Max Vel=11.52 fps Inflow=939.04 cfs 209.728 af
n=0.035 L=850.0' S=0.0171 '/' Capacity=1,625.88 cfs Outflow=939.00 cfs 209.318 af

Total Runoff Area = 876.590 ac Runoff Volume = 216.291 af Average Runoff Depth = 2.96"

Summary for Subcatchment 1S: Watershed

Estimated Flow using Rational Formula at site visit was Q=650 cfs.
A=762 Ac
I=140/tc+15 = 140/67 = 2.08
R=0.4

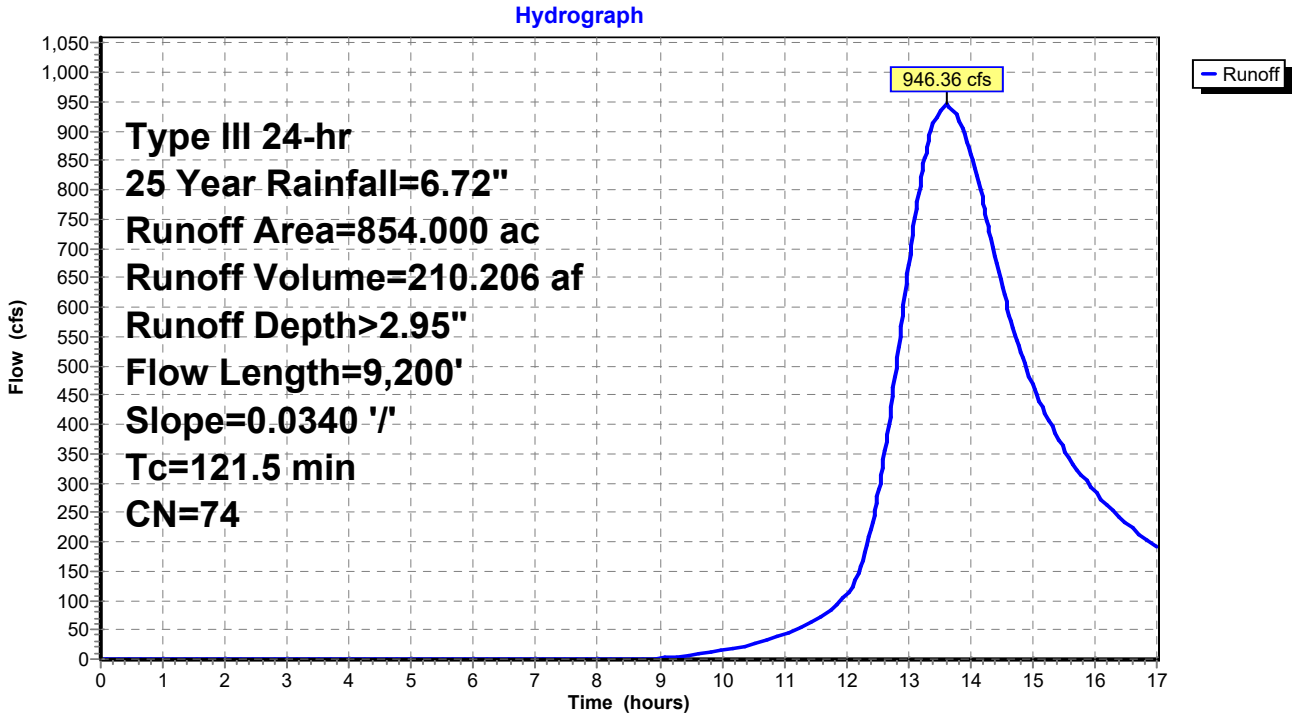
Runoff = 946.36 cfs @ 13.63 hrs, Volume= 210.206 af, Depth> 2.95"
Routed to Pond 2P : Nannahagan Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 Year Rainfall=6.72"

	Area (ac)	CN	Description
*	854.000	74	Watershed Area with TR-55 weighted CN

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
121.5	9,200	0.0340	1.26		**Lag/CN Method, CN Method**

Subcatchment 1S: Watershed



Summary for Pond 2P: Nannahagan Lake

Inflow Area = 854.000 ac, Inflow Depth > 2.95" for 25 Year event
Inflow = 946.36 cfs @ 13.63 hrs, Volume= 210.047 af
Outflow = 931.10 cfs @ 13.75 hrs, Volume= 203.984 af, Atten= 2%, Lag= 7.2 min
Primary = 931.10 cfs @ 13.75 hrs, Volume= 203.984 af
Routed to Pond 3P : Channel and Culvert

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 352.82' @ 13.75 hrs Surf.Area= 3.444 ac Storage= 14.208 af
Flood Elev= 352.00' Surf.Area= 3.024 ac Storage= 11.558 af

Plug-Flow detention time= 14.6 min calculated for 203.864 af (97% of inflow)
Center-of-Mass det. time= 9.8 min (856.0 - 846.2)

Volume	Invert	Avail.Storage	Storage Description
#1	345.84'	14.836 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

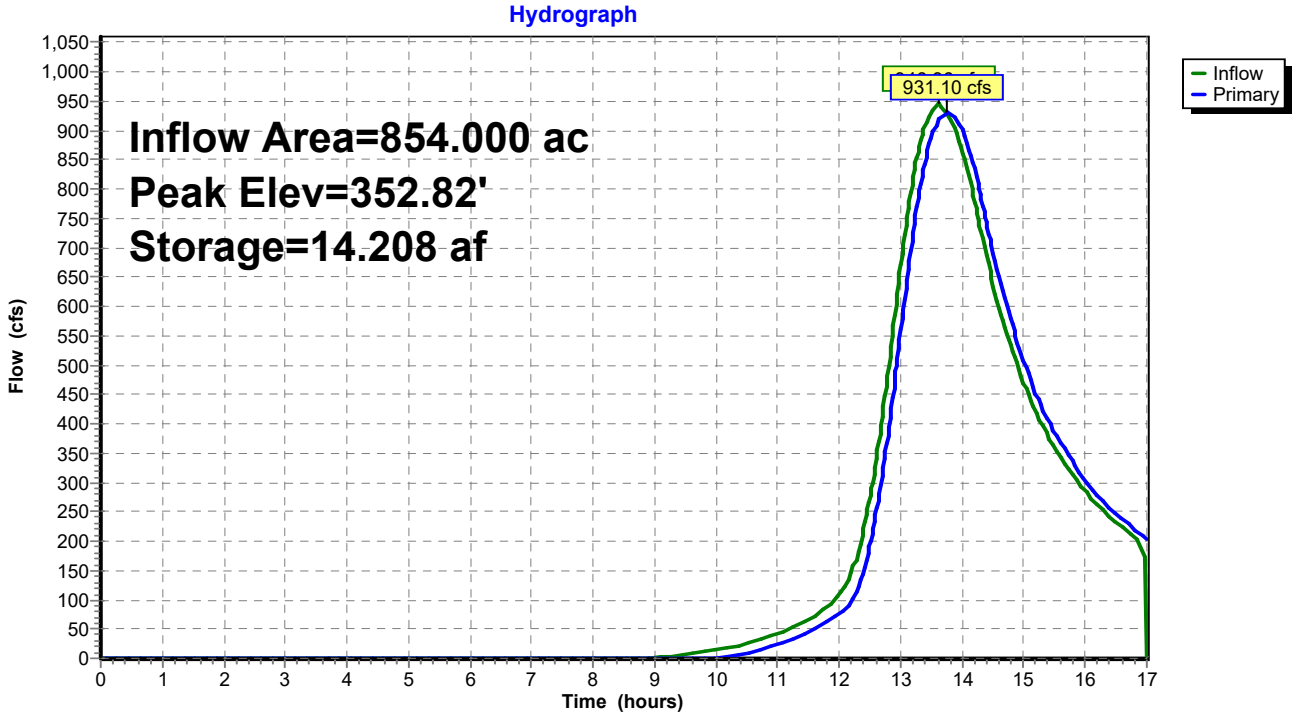
Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
345.84	1.150	1,138.0	0.000	0.000	1.150
347.00	1.350	1,266.0	1.448	1.448	1.713
348.00	1.560	1,488.0	1.454	2.902	2.830
348.95	1.700	1,524.0	1.548	4.450	3.031
353.00	3.540	1,721.0	10.386	14.836	4.209

Device	Routing	Invert	Outlet Devices
#1	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Primary	346.14'	**42.0" Round Chamber Pipe** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 9.62 sf
#4	Primary	346.14'	**42.0" Round Bypass at Brook**

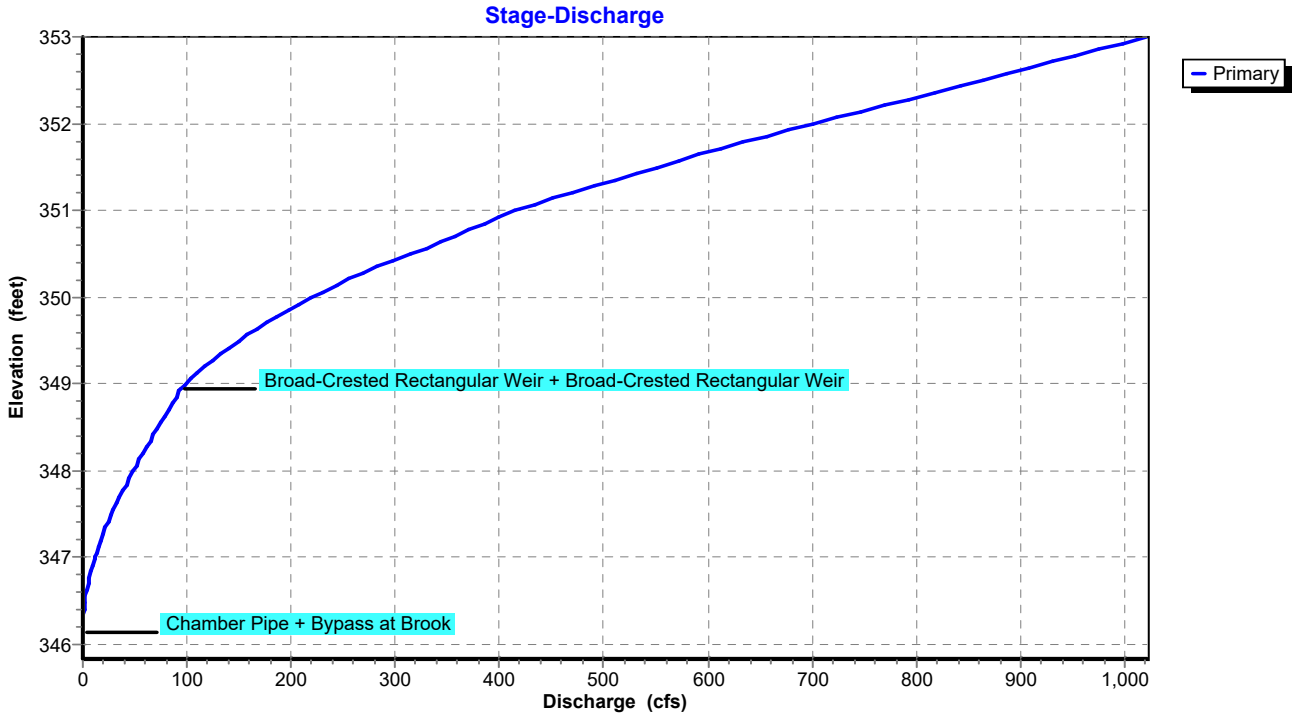
L= 707.0' CPP, square edge headwall, Ke= 0.500
Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/'
Cc= 0.900 n= 0.010, Flow Area= 9.62 sf

Primary OutFlow Max=931.08 cfs @ 13.75 hrs HW=352.82' TW=347.23' (Dynamic Tailwater)
- **1=Broad-Crested Rectangular Weir**(Weir Controls 379.17 cfs @ 6.53 fps)
- **2=Broad-Crested Rectangular Weir**(Weir Controls 379.17 cfs @ 6.53 fps)
- **3=Chamber Pipe** (Outlet Controls 81.15 cfs @ 8.43 fps)
- **4=Bypass at Brook** (Outlet Controls 91.59 cfs @ 9.52 fps)

Pond 2P: Nannahagan Lake



Pond 2P: Nannahagan Lake



Summary for Pond 3P: Channel and Culvert

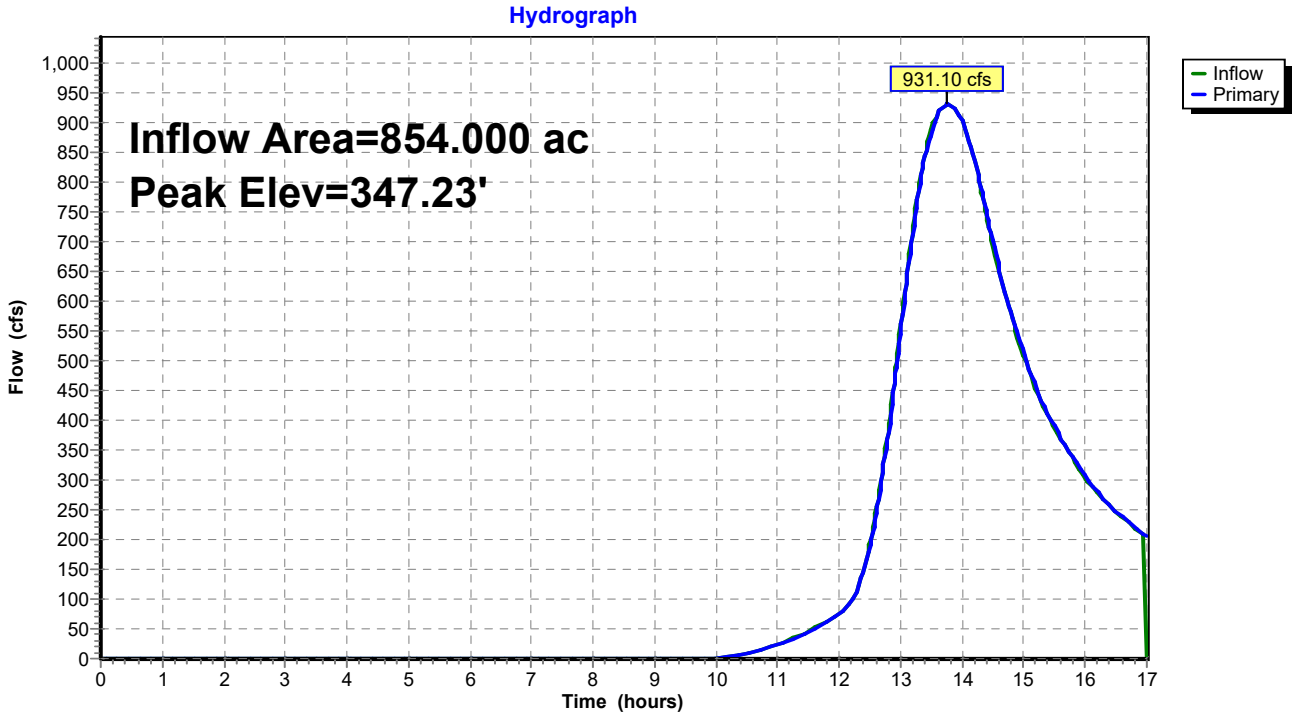
Inflow Area = 854.000 ac, Inflow Depth > 2.86" for 25 Year event
Inflow = 931.10 cfs @ 13.75 hrs, Volume= 203.815 af
Outflow = 931.10 cfs @ 13.76 hrs, Volume= 203.815 af, Atten= 0%, Lag= 0.6 min
Primary = 931.10 cfs @ 13.76 hrs, Volume= 203.815 af
Routed to Reach 5R : Nanny Hagen Brook

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 347.23' @ 13.76 hrs
Flood Elev= 345.00'

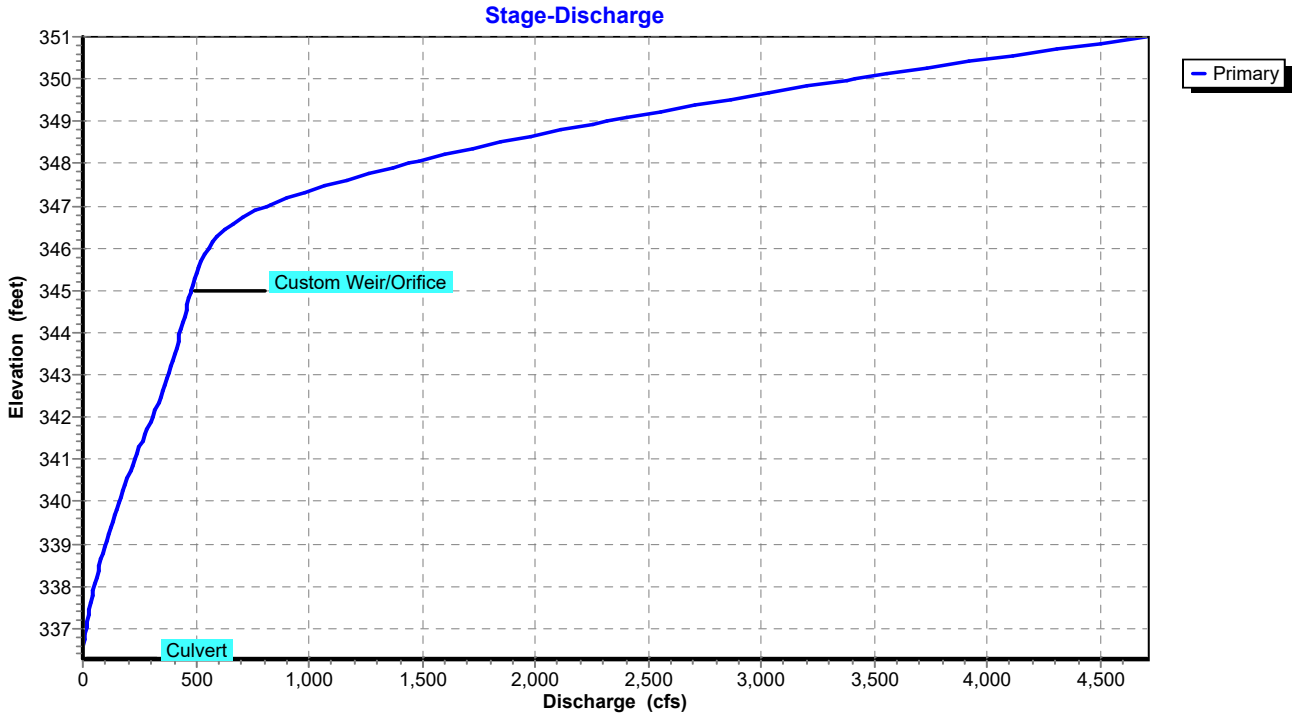
Device	Routing	Invert	Outlet Devices
#1	Primary	336.29'	**84.0" W x 72.0" H Box Culvert** L= 257.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 329.54' S= 0.0263 '/' Cc= 0.900 n= 0.017, Flow Area= 42.00 sf
#2	Primary	345.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Elev. (feet) 345.00 346.00 347.00 348.00 349.00 350.00 351.00 Width (feet) 5.00 20.00 111.00 118.00 125.00 132.00 139.00

Primary OutFlow Max=931.09 cfs @ 13.76 hrs HW=347.23' TW=333.80' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 566.36 cfs @ 13.48 fps)
└─**2=Custom Weir/Orifice** (Weir Controls 364.73 cfs @ 3.52 fps)

Pond 3P: Channel and Culvert



Pond 3P: Channel and Culvert



Summary for Subcatchment 4S: Brook Watershed

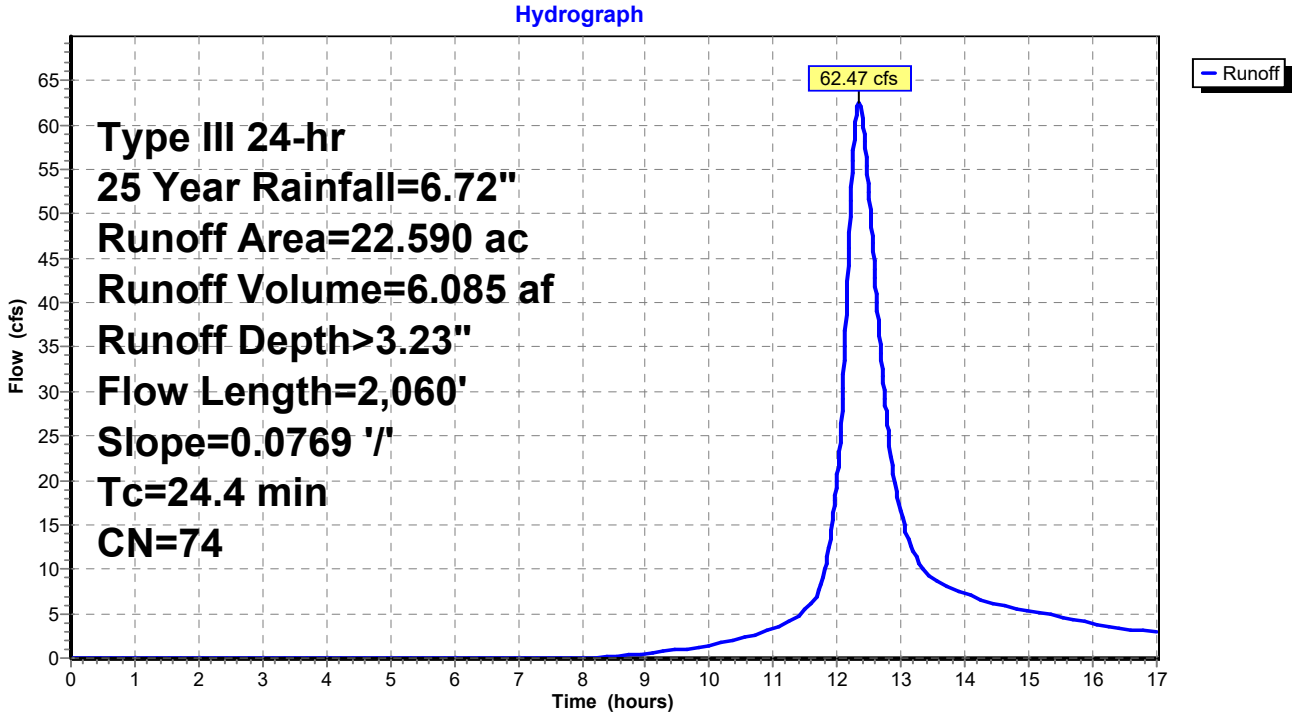
Runoff = 62.47 cfs @ 12.34 hrs, Volume= 6.085 af, Depth> 3.23"
Routed to Reach 5R : Nanny Hagen Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 Year Rainfall=6.72"

	Area (ac)	CN	Description
*	22.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	2,060	0.0769	1.41		**Lag/CN Method,**

Subcatchment 4S: Brook Watershed



Summary for Reach 5R: Nanny Hagen Brook

Channel 2 "ends" at Wood Bridge

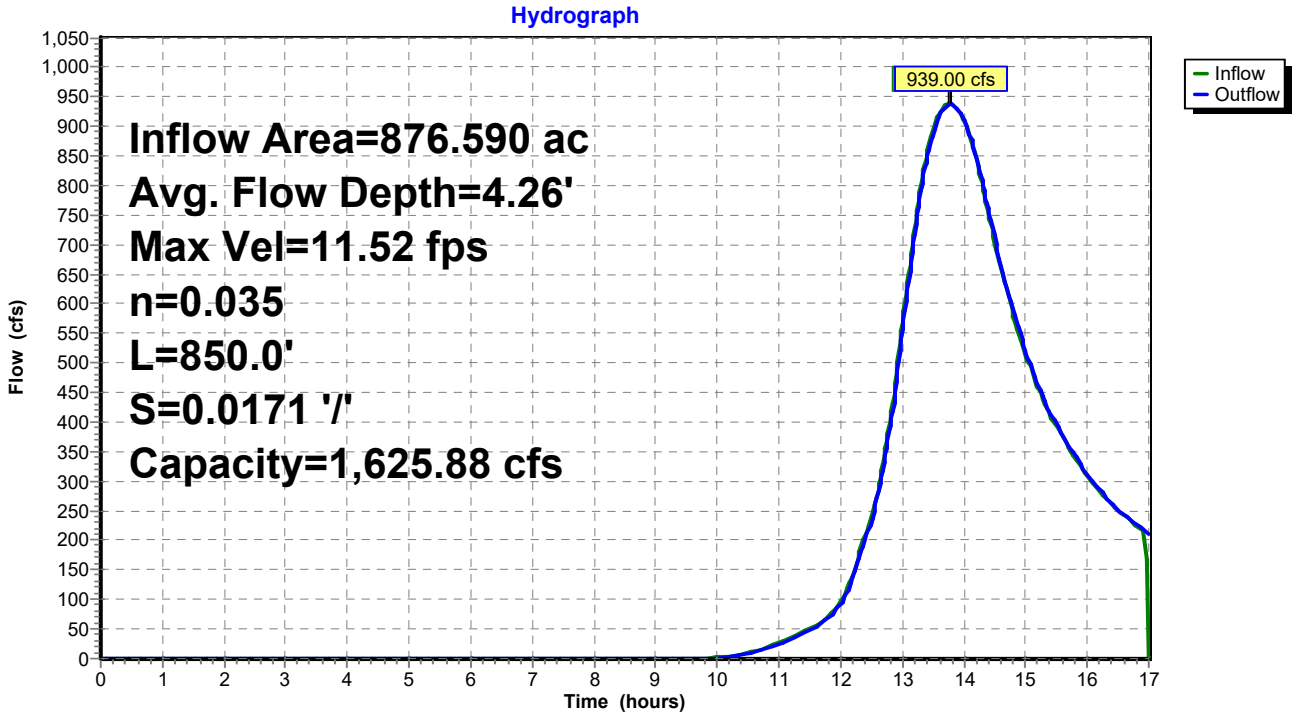
Inflow Area = 876.590 ac, Inflow Depth > 2.87" for 25 Year event
Inflow = 939.04 cfs @ 13.76 hrs, Volume= 209.728 af
Outflow = 939.00 cfs @ 13.78 hrs, Volume= 209.318 af, Atten= 0%, Lag= 0.9 min

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Max. Velocity= 11.52 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 5.70 fps, Avg. Travel Time= 2.5 min

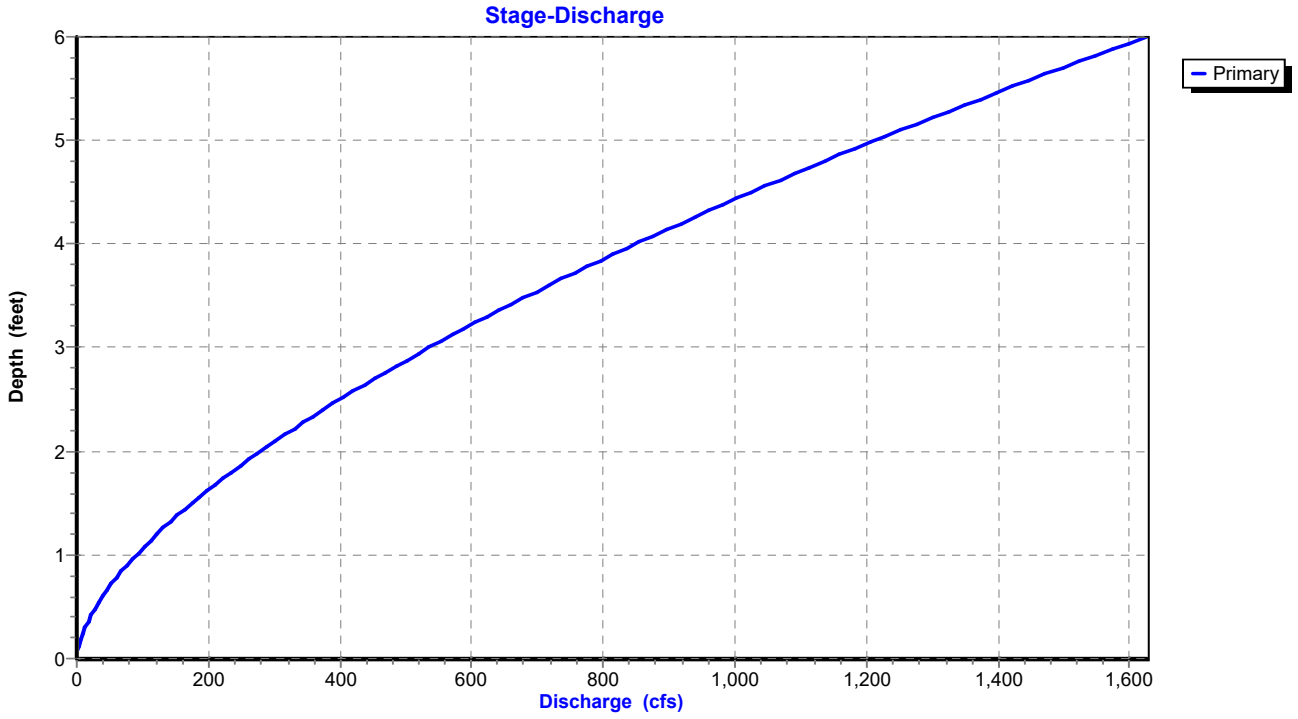
Peak Storage= 69,293 cf @ 13.78 hrs
Average Depth at Peak Storage= 4.26' , Surface Width= 21.26'
Bank-Full Depth= 6.00' Flow Area= 120.0 sf, Capacity= 1,625.88 cfs

17.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 0.0 1.0 '/' Top Width= 23.00'
Length= 850.0' Slope= 0.0171 '/'
Inlet Invert= 329.54', Outlet Invert= 315.00'

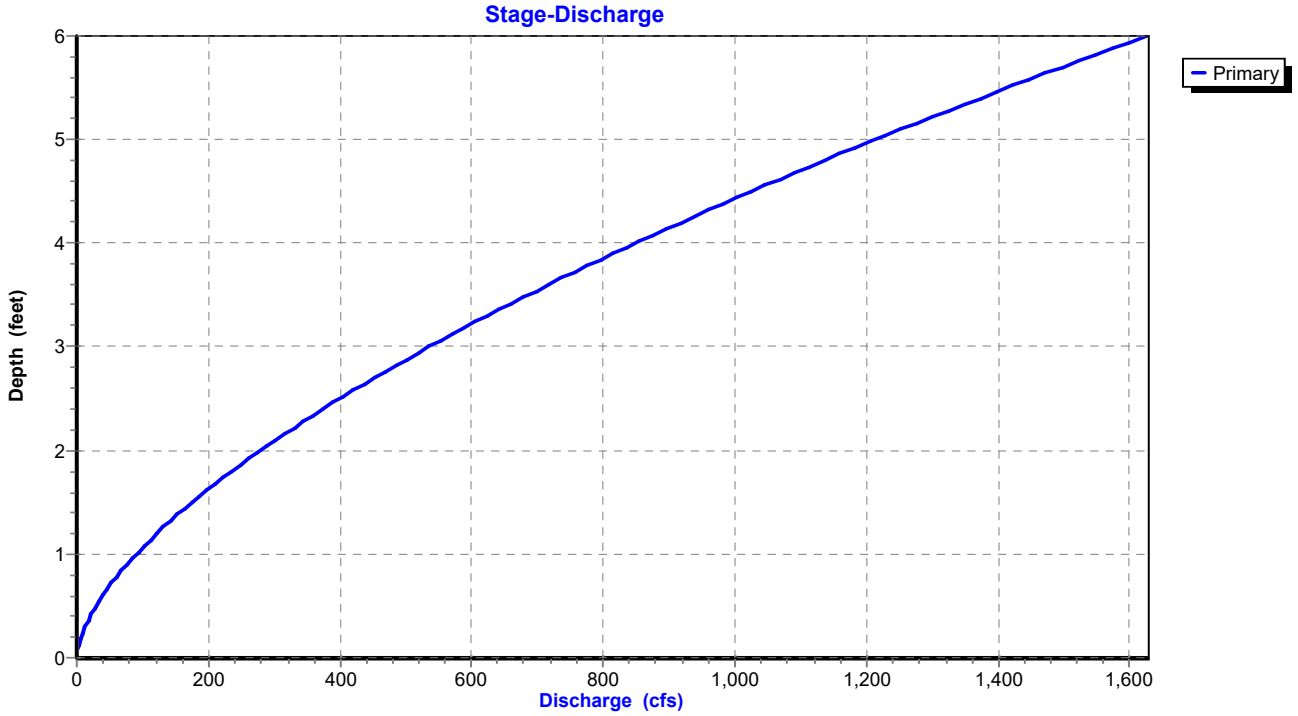
Reach 5R: Nanny Hagen Brook



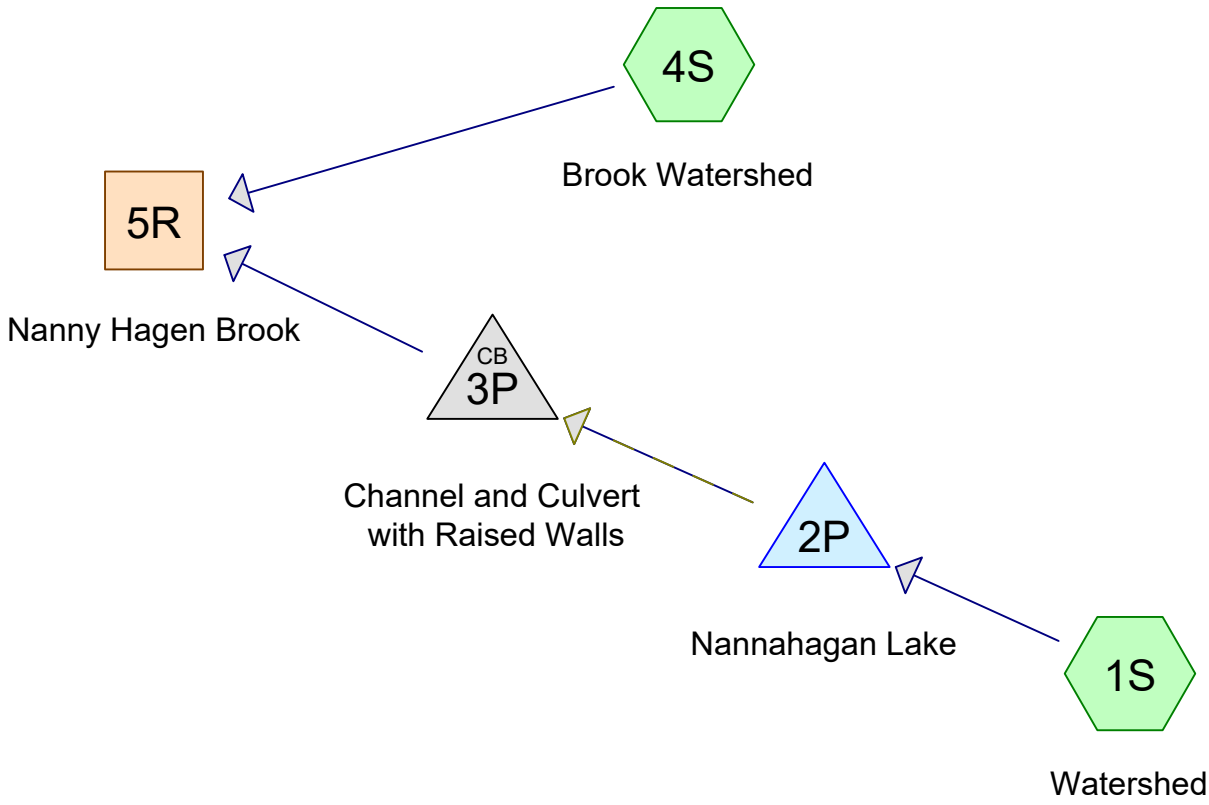
Reach 5R: Nanny Hagen Brook



Reach 5R: Nanny Hagen Brook



Design 3 - Raise walls around discharge channel. Determine maximum flow rate before Nannahagn Lake would overflow berm



Subcat Reach Pond Link

Routing Diagram for Design 3 - Raise Walls around Channel
Prepared by Microsoft, Printed 11/19/2021

Summary for Subcatchment 1S: Watershed

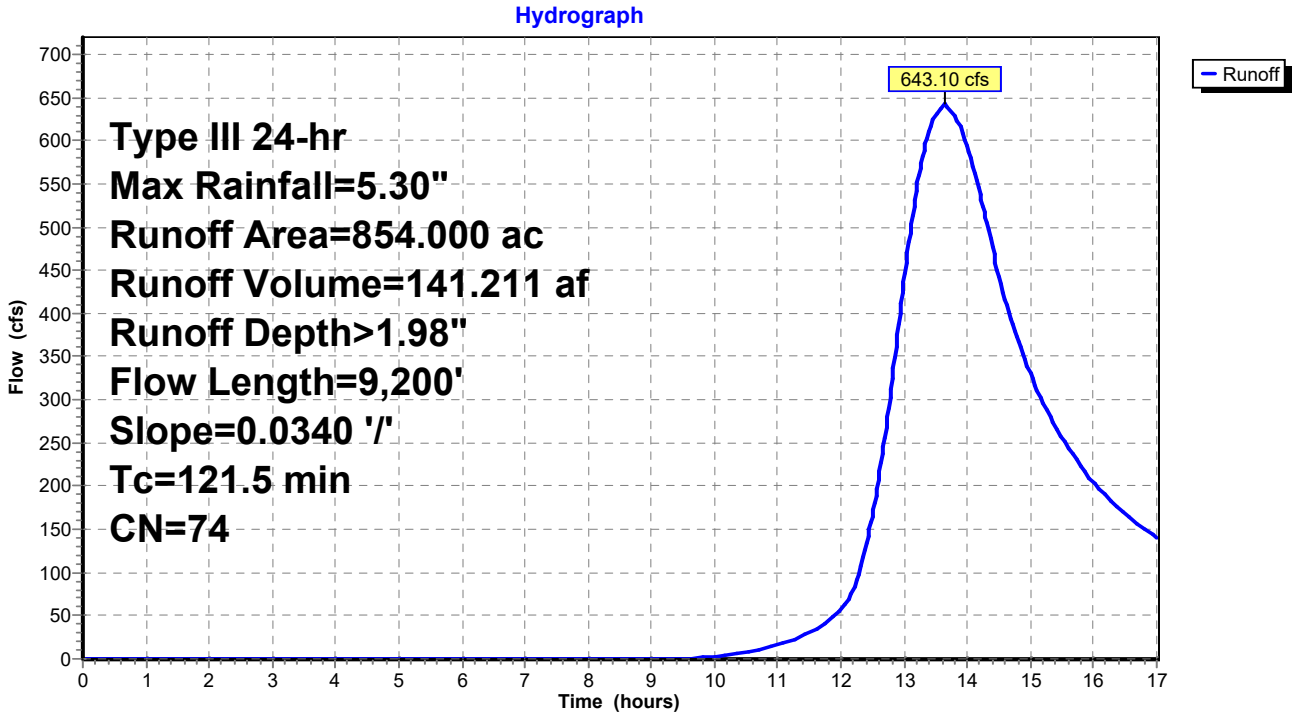
Runoff = 643.10 cfs @ 13.64 hrs, Volume= 141.211 af, Depth> 1.98"
Routed to Pond 2P : Nannahagan Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr Max Rainfall=5.30"

	Area (ac)	CN	Description
*	854.000	74	Watershed Area with TR-55 weighted CN

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
121.5	9,200	0.0340	1.26		**Lag/CN Method, CN Method**

Subcatchment 1S: Watershed



Summary for Pond 2P: Nannahagan Lake

Inflow Area = 854.000 ac, Inflow Depth > 1.98" for Max event
Inflow = 643.10 cfs @ 13.64 hrs, Volume= 141.096 af
Outflow = 626.92 cfs @ 13.82 hrs, Volume= 135.631 af, Atten= 3%, Lag= 11.0 min
Primary = 626.92 cfs @ 13.82 hrs, Volume= 135.631 af
Routed to Pond 3P : Channel and Culvert with Raised Walls

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 351.98' @ 13.83 hrs Surf.Area= 3.014 ac Storage= 11.502 af
Flood Elev= 352.00' Surf.Area= 3.024 ac Storage= 11.558 af

Plug-Flow detention time= 17.0 min calculated for 135.551 af (96% of inflow)
Center-of-Mass det. time= 10.8 min (863.0 - 852.2)

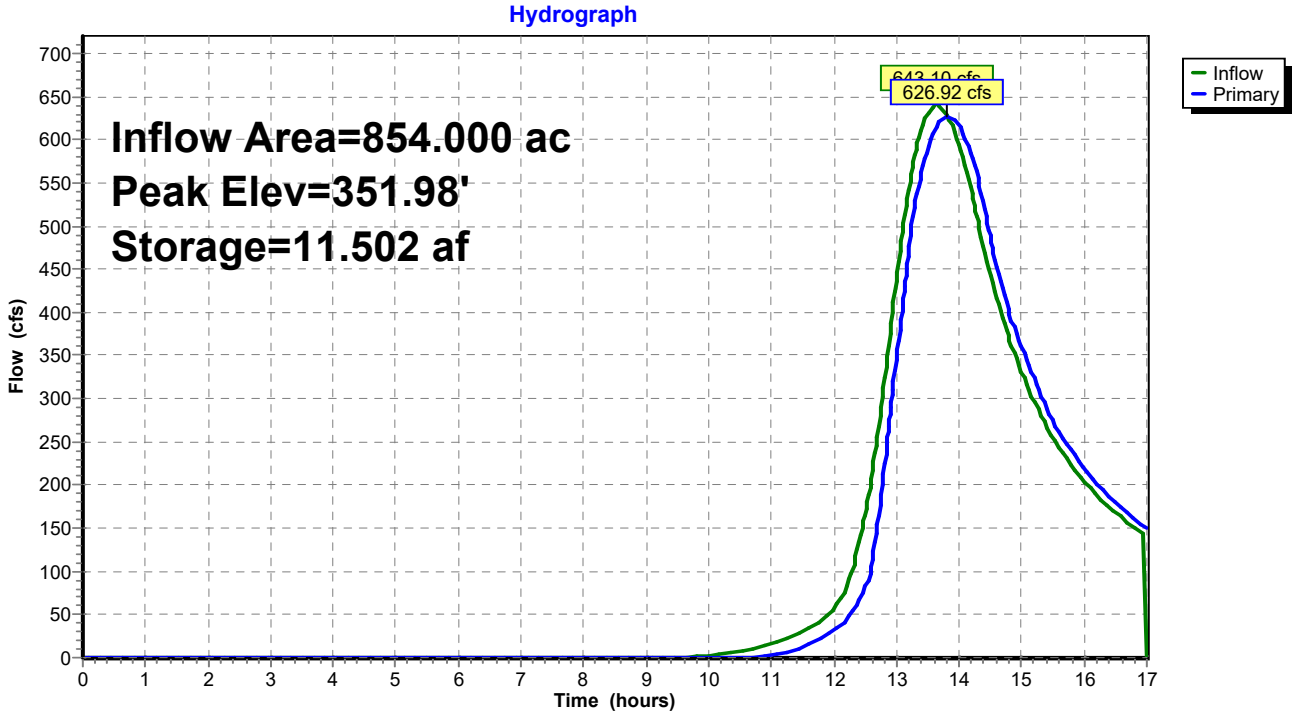
Volume	Invert	Avail.Storage	Storage Description
#1	345.84'	14.836 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
345.84	1.150	1,138.0	0.000	0.000	1.150
347.00	1.350	1,266.0	1.448	1.448	1.713
348.00	1.560	1,488.0	1.454	2.902	2.830
348.95	1.700	1,524.0	1.548	4.450	3.031
353.00	3.540	1,721.0	10.386	14.836	4.209

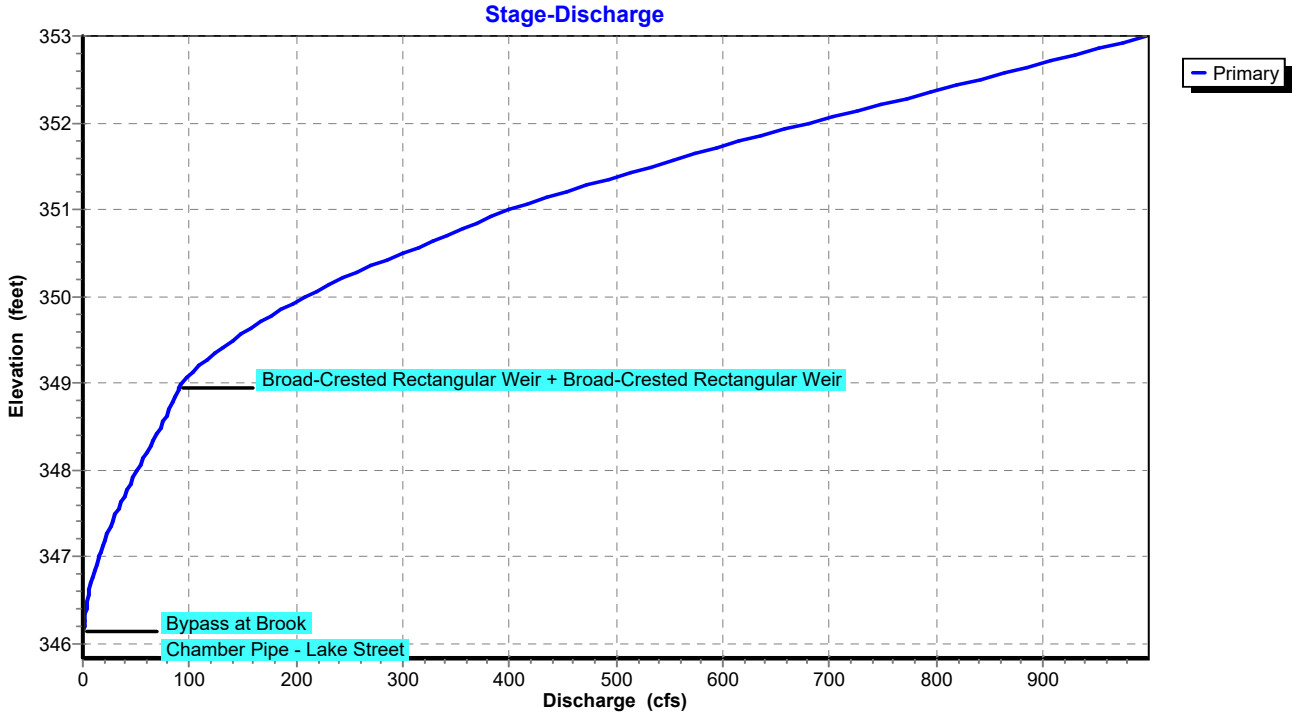
Device	Routing	Invert	Outlet Devices
#1	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Primary	345.85'	**36.0" Round Chamber Pipe - Lake Street** L= 335.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 345.85' / 335.95' S= 0.0296 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 7.07 sf
#4	Primary	346.14'	**42.0" Round Bypass at Brook** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.010, Flow Area= 9.62 sf

Primary OutFlow Max=626.88 cfs @ 13.82 hrs HW=351.98' TW=348.98' (Dynamic Tailwater)
- **1=Broad-Crested Rectangular Weir** (Weir Controls 253.86 cfs @ 5.58 fps)
- **2=Broad-Crested Rectangular Weir** (Weir Controls 253.86 cfs @ 5.58 fps)
- **3=Chamber Pipe - Lake Street** (Outlet Controls 52.02 cfs @ 7.36 fps)
- **4=Bypass at Brook** (Outlet Controls 67.13 cfs @ 6.98 fps)

Pond 2P: Nannahagan Lake



Pond 2P: Nannahagan Lake



Summary for Pond 3P: Channel and Culvert with Raised Walls

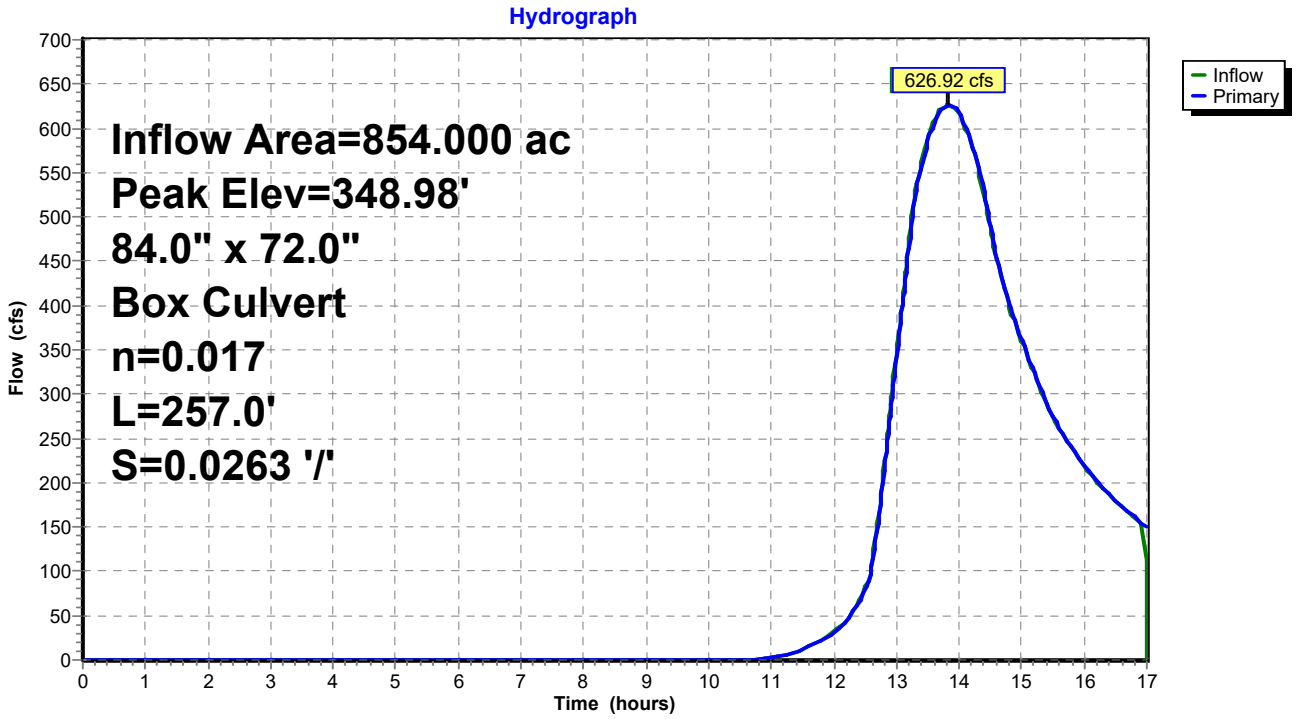
Inflow Area = 854.000 ac, Inflow Depth > 1.90" for Max event
Inflow = 626.92 cfs @ 13.82 hrs, Volume= 135.507 af
Outflow = 626.92 cfs @ 13.83 hrs, Volume= 135.507 af, Atten= 0%, Lag= 0.6 min
Primary = 626.92 cfs @ 13.83 hrs, Volume= 135.507 af
Routed to Reach 5R : Nanny Hagen Brook

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 348.98' @ 13.83 hrs
Flood Elev= 352.00'

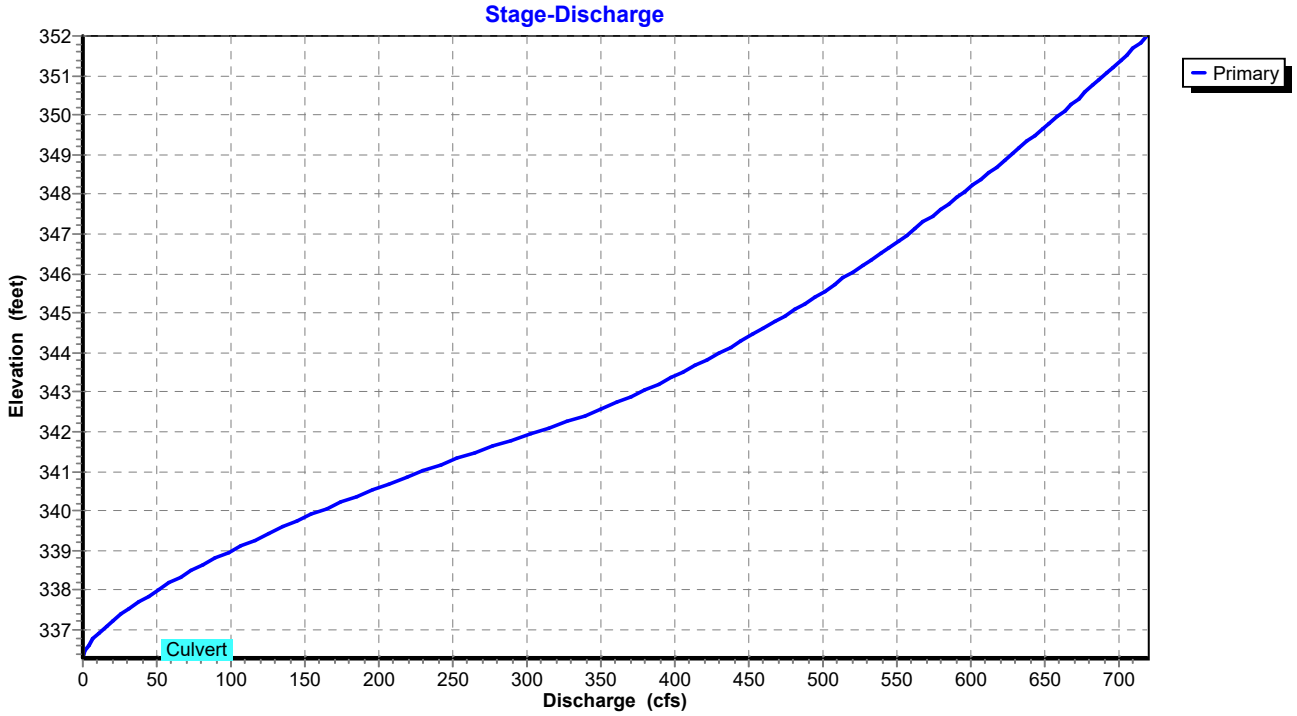
Device	Routing	Invert	Outlet Devices
#1	Primary	336.29'	**84.0" W x 72.0" H Box Culvert** L= 257.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 329.54' S= 0.0263 '/' Cc= 0.900 n= 0.017, Flow Area= 42.00 sf

Primary OutFlow Max=626.92 cfs @ 13.83 hrs HW=348.98' TW=332.87' (Dynamic Tailwater)
1=Culvert (Inlet Controls 626.92 cfs @ 14.93 fps)

Pond 3P: Channel and Culvert with Raised Walls



Pond 3P: Channel and Culvert with Raised Walls



Summary for Subcatchment 4S: Brook Watershed

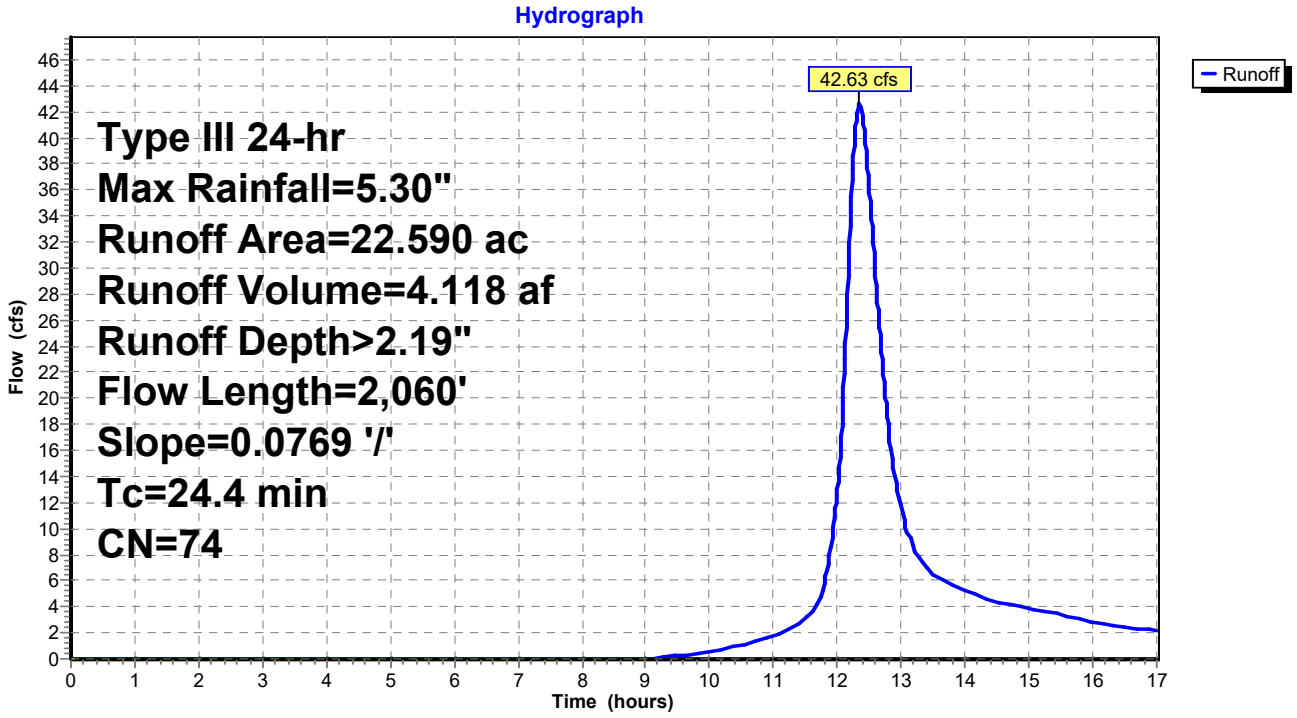
Runoff = 42.63 cfs @ 12.34 hrs, Volume= 4.118 af, Depth> 2.19"
Routed to Reach 5R : Nanny Hagen Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr Max Rainfall=5.30"

	Area (ac)	CN	Description
*	22.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	2,060	0.0769	1.41		**Lag/CN Method,**

Subcatchment 4S: Brook Watershed



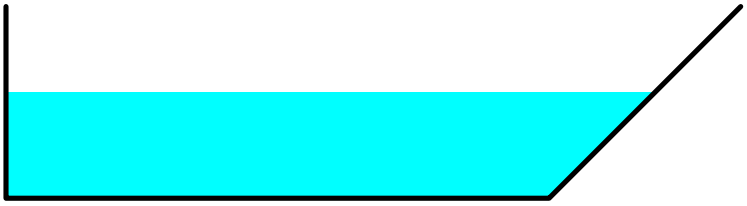
Summary for Reach 5R: Nanny Hagen Brook

Inflow Area = 876.590 ac, Inflow Depth > 1.91" for Max event
Inflow = 632.52 cfs @ 13.83 hrs, Volume= 139.499 af
Outflow = 632.50 cfs @ 13.84 hrs, Volume= 139.148 af, Atten= 0%, Lag= 0.8 min

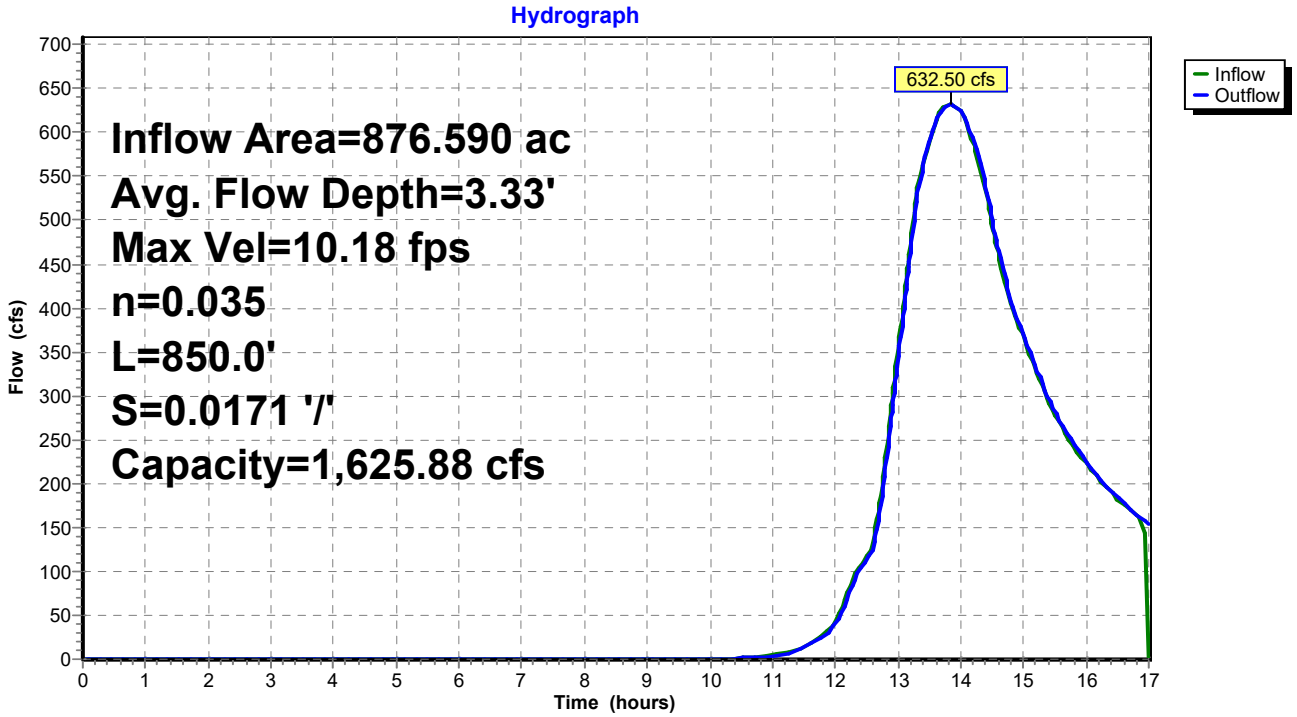
Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Max. Velocity= 10.18 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 5.26 fps, Avg. Travel Time= 2.7 min

Peak Storage= 52,818 cf @ 13.84 hrs
Average Depth at Peak Storage= 3.33' , Surface Width= 20.33'
Bank-Full Depth= 6.00' Flow Area= 120.0 sf, Capacity= 1,625.88 cfs

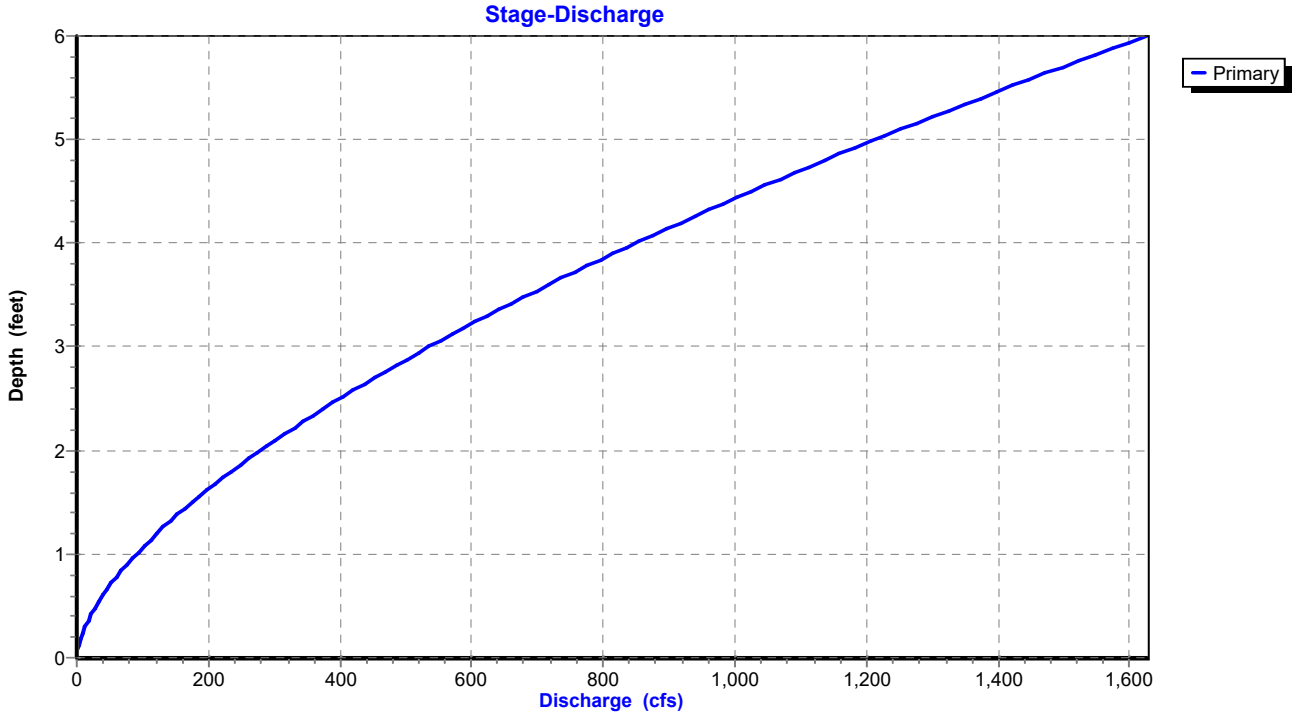
17.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 0.0 1.0 '/' Top Width= 23.00'
Length= 850.0' Slope= 0.0171 '/'
Inlet Invert= 329.54', Outlet Invert= 315.00'



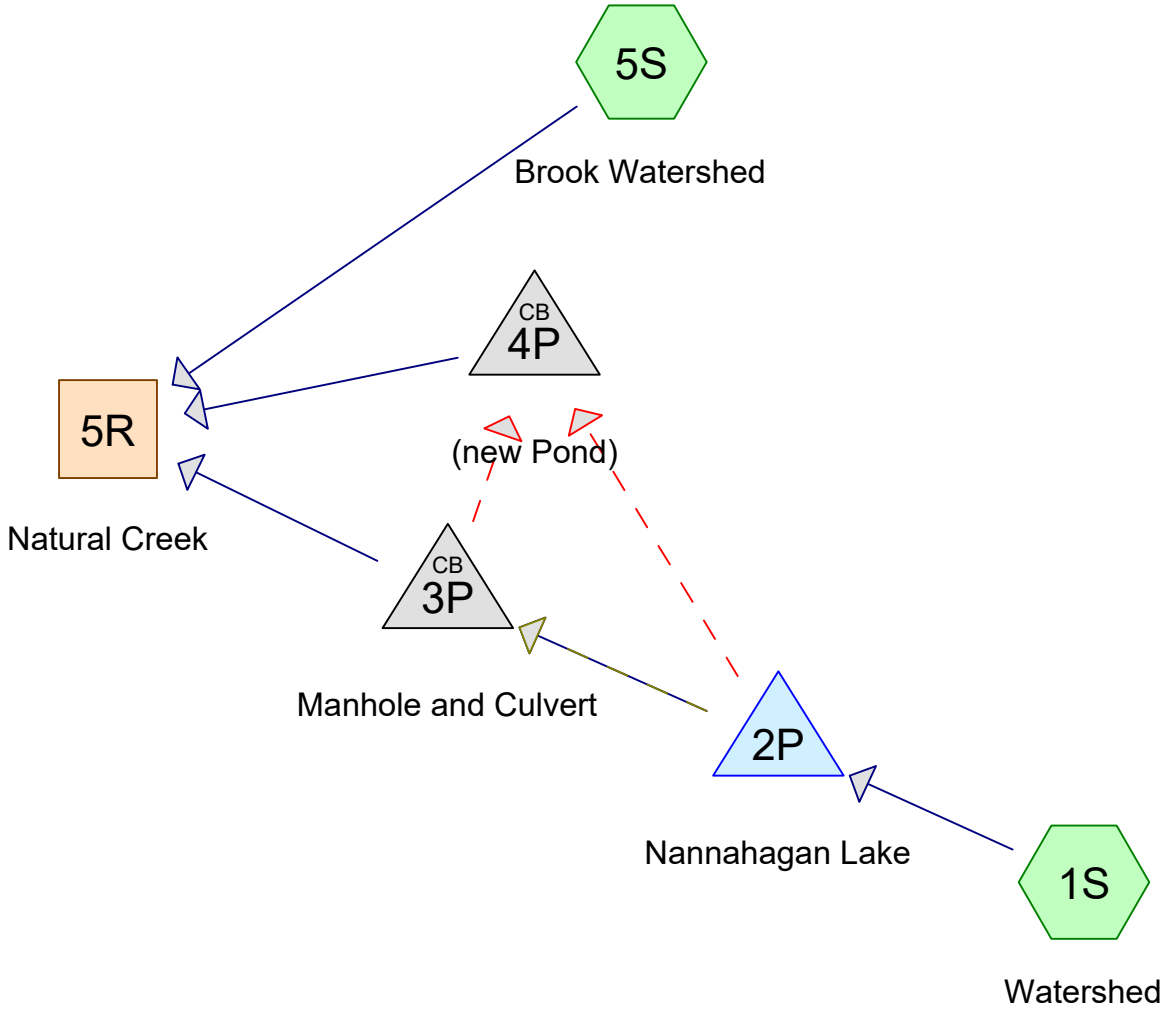
Reach 5R: Nanny Hagen Brook



Reach 5R: Nanny Hagen Brook



Design 4 - Raise walls around discharge channel. Install 72" pipe between channel and Nanny Hagen Brook.



Subcat Reach Pond Link

Routing Diagram for Design 4 - 25 Yr - Raise Walls, Add Culvert, Manhole

Prepared by Microsoft, Printed 11/19/2021

Summary for Subcatchment 1S: Watershed

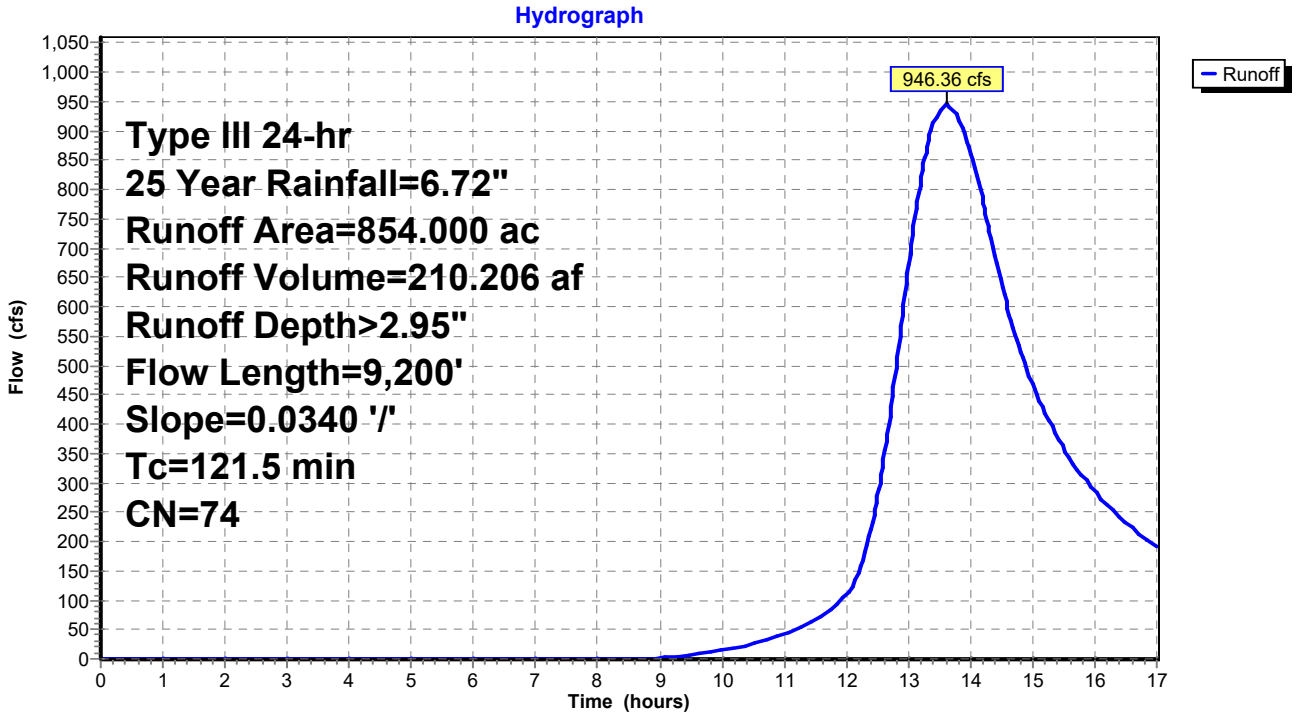
Runoff = 946.36 cfs @ 13.63 hrs, Volume= 210.206 af, Depth> 2.95"
Routed to Pond 2P : Nannahagan Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 Year Rainfall=6.72"

	Area (ac)	CN	Description
*	854.000	74	Watershed Area with TR-55 weighted CN

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
121.5	9,200	0.0340	1.26		**Lag/CN Method, CN Method**

Subcatchment 1S: Watershed



Summary for Pond 2P: Nannahagan Lake

Inflow Area = 854.000 ac, Inflow Depth > 2.95" for 25 Year event
Inflow = 946.36 cfs @ 13.63 hrs, Volume= 210.047 af
Outflow = 936.27 cfs @ 13.70 hrs, Volume= 204.360 af, Atten= 1%, Lag= 4.1 min
Primary = 863.76 cfs @ 13.70 hrs, Volume= 176.595 af
Routed to Pond 3P : Manhole and Culvert
Secondary = 72.52 cfs @ 13.72 hrs, Volume= 27.765 af
Routed to Pond 4P : (new Pond)

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 351.89' @ 13.72 hrs Surf.Area= 2.969 ac Storage= 11.227 af
Flood Elev= 352.00' Surf.Area= 3.024 ac Storage= 11.558 af

Plug-Flow detention time= 12.6 min calculated for 204.239 af (97% of inflow)
Center-of-Mass det. time= 8.1 min (854.3 - 846.2)

Volume	Invert	Avail.Storage	Storage Description
#1	345.84'	14.836 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
345.84	1.150	1,138.0	0.000	0.000	1.150
347.00	1.350	1,266.0	1.448	1.448	1.713
348.00	1.560	1,488.0	1.454	2.902	2.830
348.95	1.700	1,524.0	1.548	4.450	3.031
353.00	3.540	1,721.0	10.386	14.836	4.209

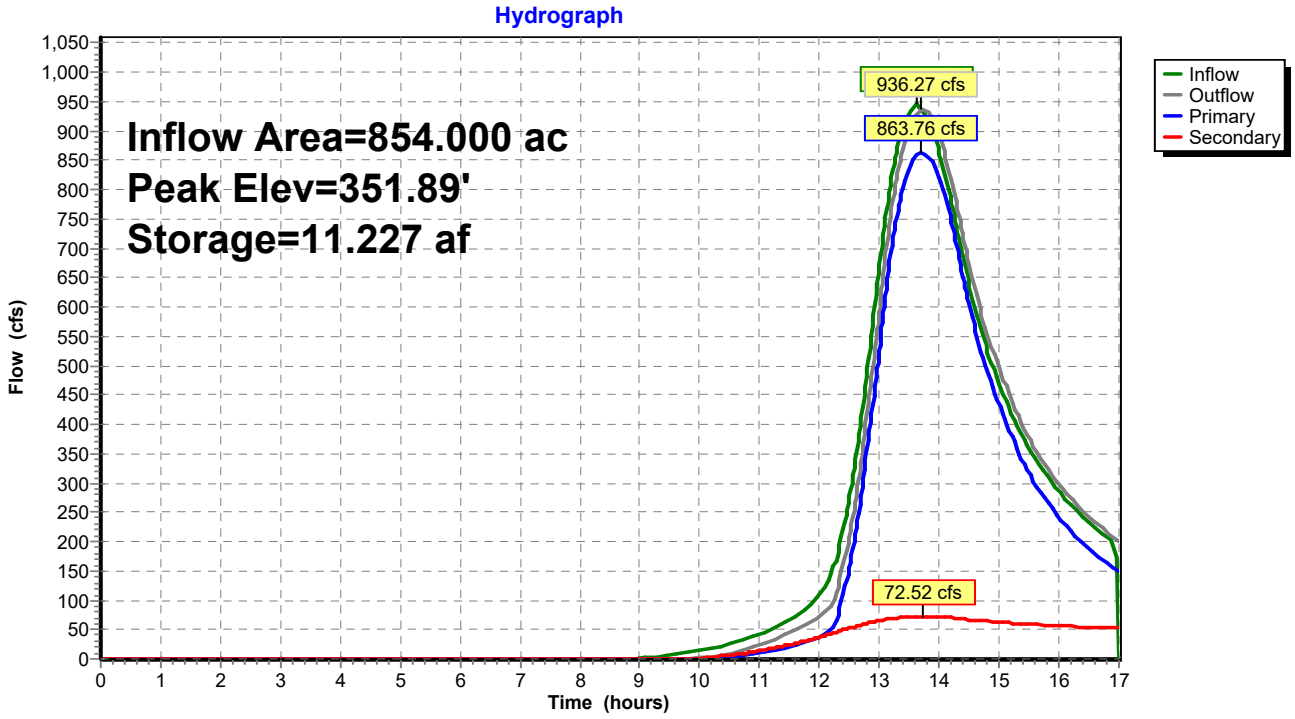
Device	Routing	Invert	Outlet Devices
#1	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Secondary	345.85'	**36.0" Round Chamber Pipe - Lake Street** L= 335.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 345.85' / 335.95' S= 0.0296 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 7.07 sf
#4	Primary	346.14'	**42.0" Round Bypass at Brook** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.010, Flow Area= 9.62 sf
#5	Primary	348.95'	**20.0' long x 2.0' breadth Additional Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50

Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88
2.85 3.07 3.20 3.32

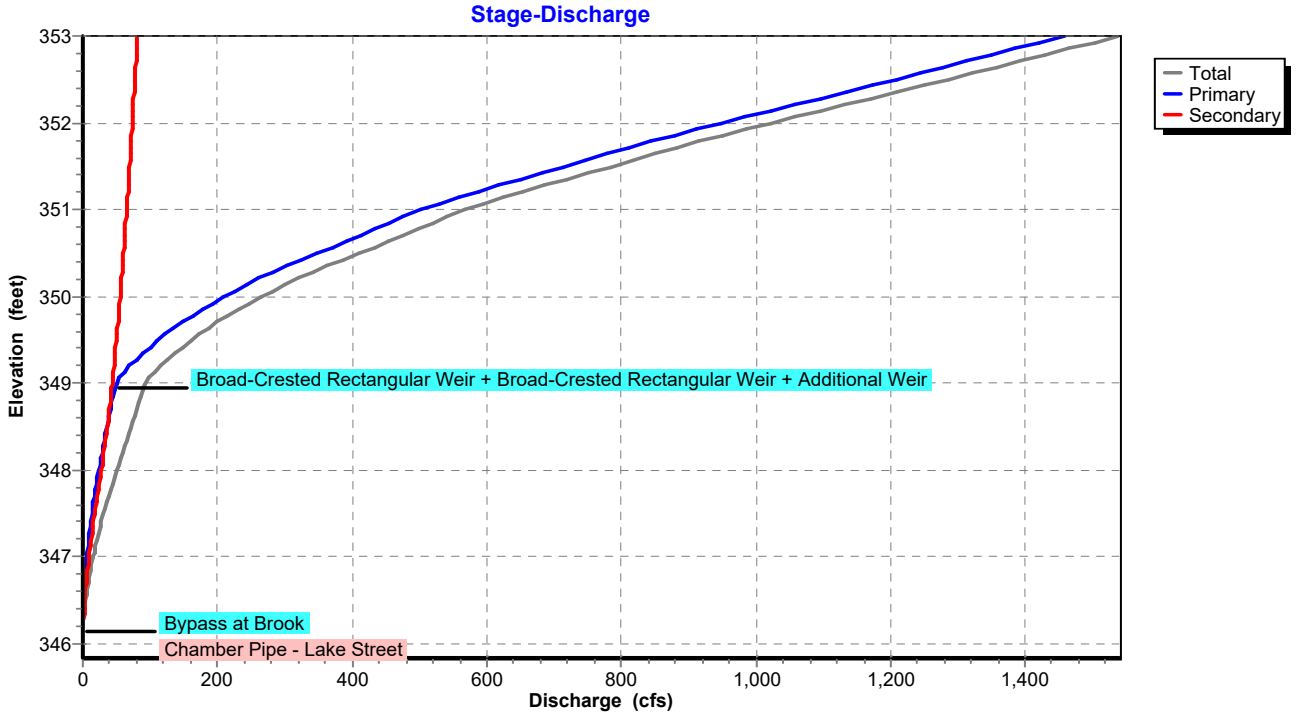
Primary OutFlow Max=863.54 cfs @ 13.70 hrs HW=351.89' TW=349.10' (Dynamic Tailwater)
- **1=Broad-Crested Rectangular Weir** (Weir Controls 239.65 cfs @ 5.44 fps)
- **2=Broad-Crested Rectangular Weir** (Weir Controls 239.65 cfs @ 5.44 fps)
- **4=Bypass at Brook** (Outlet Controls 64.72 cfs @ 6.73 fps)
- **5=Additional Weir** (Weir Controls 319.53 cfs @ 5.44 fps)

Secondary OutFlow Max=72.52 cfs @ 13.72 hrs HW=351.89' TW=343.03' (Dynamic Tailwater)
- **3=Chamber Pipe - Lake Street** (Inlet Controls 72.52 cfs @ 10.26 fps)

Pond 2P: Nannahagan Lake



Pond 2P: Nannahagan Lake



Summary for Pond 3P: Manhole and Culvert

Inflow Area = 854.000 ac, Inflow Depth > 2.48" for 25 Year event
Inflow = 863.76 cfs @ 13.70 hrs, Volume= 176.472 af
Outflow = 863.76 cfs @ 13.71 hrs, Volume= 176.472 af, Atten= 0%, Lag= 0.6 min
Primary = 630.88 cfs @ 13.71 hrs, Volume= 126.153 af
Routed to Reach 5R : Natural Creek
Secondary = 232.89 cfs @ 13.70 hrs, Volume= 50.319 af
Routed to Pond 4P : (new Pond)

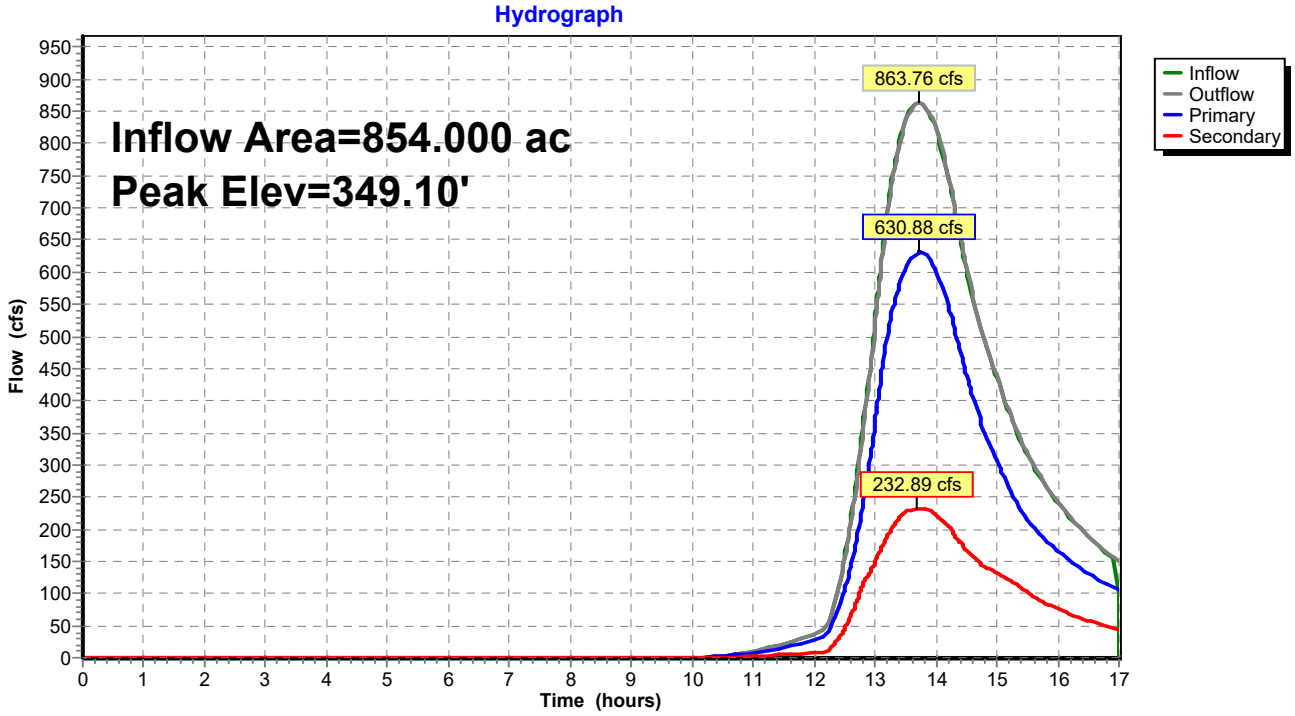
Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 349.10' @ 13.71 hrs
Flood Elev= 352.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	336.29'	**84.0" W x 72.0" H Box Culvert** L= 257.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 329.54' S= 0.0263 '/' Cc= 0.900 n= 0.017, Flow Area= 42.00 sf
#2	Secondary	336.29'	**60.0" Round Culvert** L= 57.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 335.00' S= 0.0226 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 19.63 sf
#3	Primary	350.00'	**60.0' long x 1.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.62 2.64 2.64 2.68 2.75 2.86 2.92 3.07 3.07 3.03 3.28 3.32

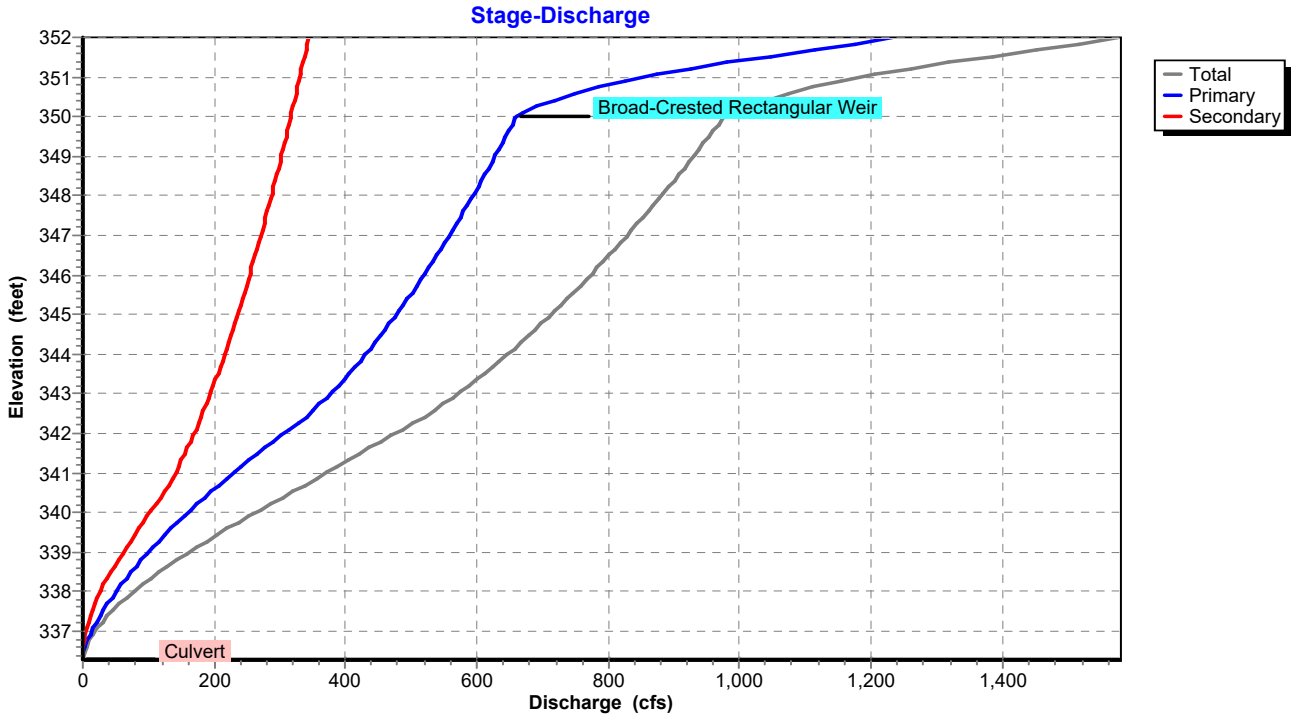
Primary OutFlow Max=630.87 cfs @ 13.71 hrs HW=349.10' TW=333.82' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 630.87 cfs @ 15.02 fps)
└─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Secondary OutFlow Max=232.83 cfs @ 13.70 hrs HW=349.10' TW=343.03' (Dynamic Tailwater)
└─**2=Culvert** (Inlet Controls 232.83 cfs @ 11.86 fps)

Pond 3P: Manhole and Culvert



Pond 3P: Manhole and Culvert



Summary for Pond 4P: (new Pond)

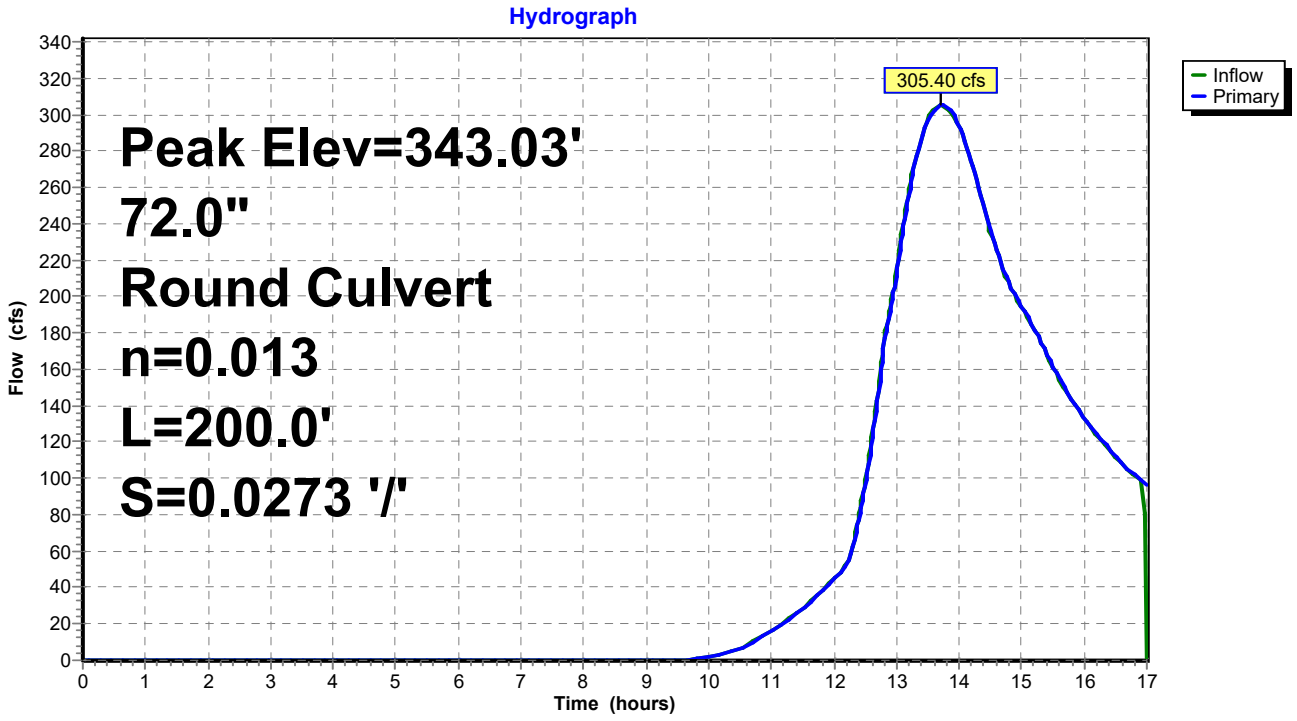
Inflow = 305.40 cfs @ 13.70 hrs, Volume= 78.004 af
Outflow = 305.40 cfs @ 13.71 hrs, Volume= 78.004 af, Atten= 0%, Lag= 0.6 min
Primary = 305.40 cfs @ 13.71 hrs, Volume= 78.004 af
Routed to Reach 5R : Natural Creek

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 343.03' @ 13.71 hrs
Flood Elev= 344.00'

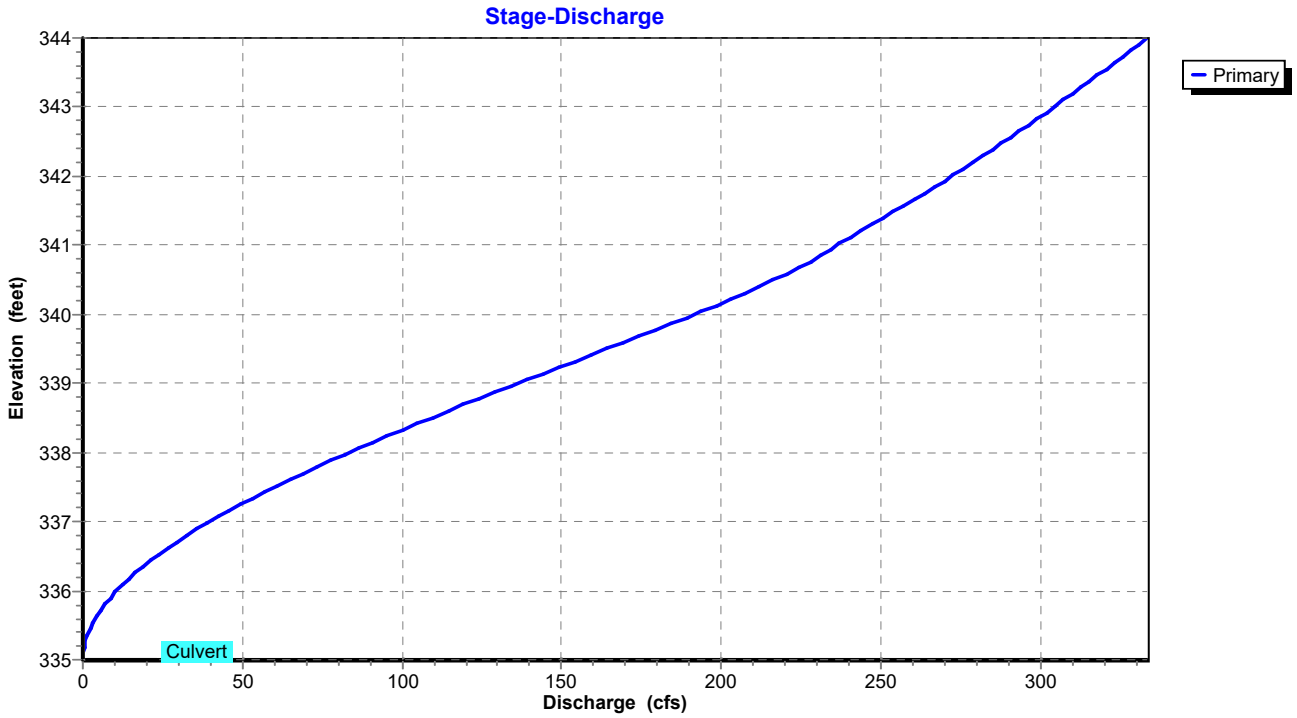
Device	Routing	Invert	Outlet Devices
#1	Primary	335.00'	**72.0" Round Culvert** L= 200.0' Ke= 0.500 Inlet / Outlet Invert= 335.00' / 329.54' S= 0.0273 '/' Cc= 0.900 n= 0.013, Flow Area= 28.27 sf

Primary OutFlow Max=305.40 cfs @ 13.71 hrs HW=343.03' TW=333.82' (Dynamic Tailwater)
1=Culvert (Inlet Controls 305.40 cfs @ 10.80 fps)

Pond 4P: (new Pond)



Pond 4P: (new Pond)



Summary for Reach 5R: Natural Creek

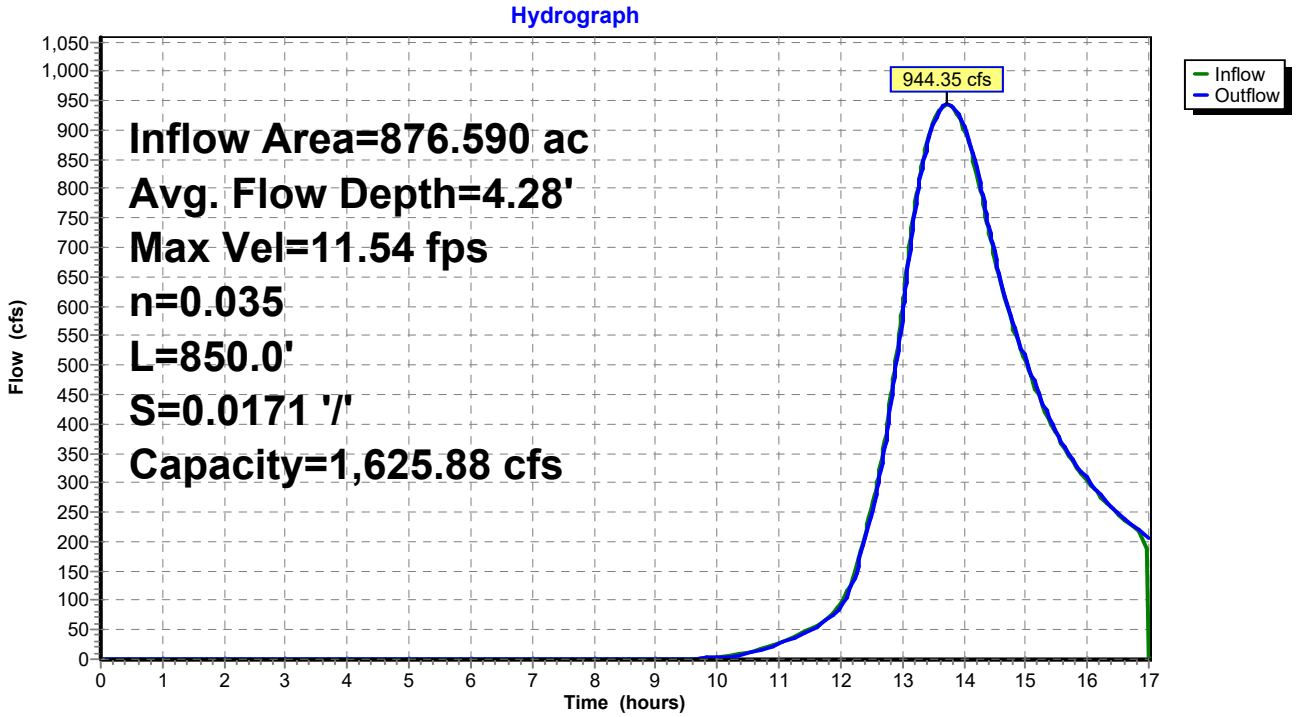
Inflow Area = 876.590 ac, Inflow Depth > 2.88" for 25 Year event
Inflow = 944.39 cfs @ 13.71 hrs, Volume= 210.073 af
Outflow = 944.35 cfs @ 13.72 hrs, Volume= 209.666 af, Atten= 0%, Lag= 0.9 min

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Max. Velocity= 11.54 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 5.72 fps, Avg. Travel Time= 2.5 min

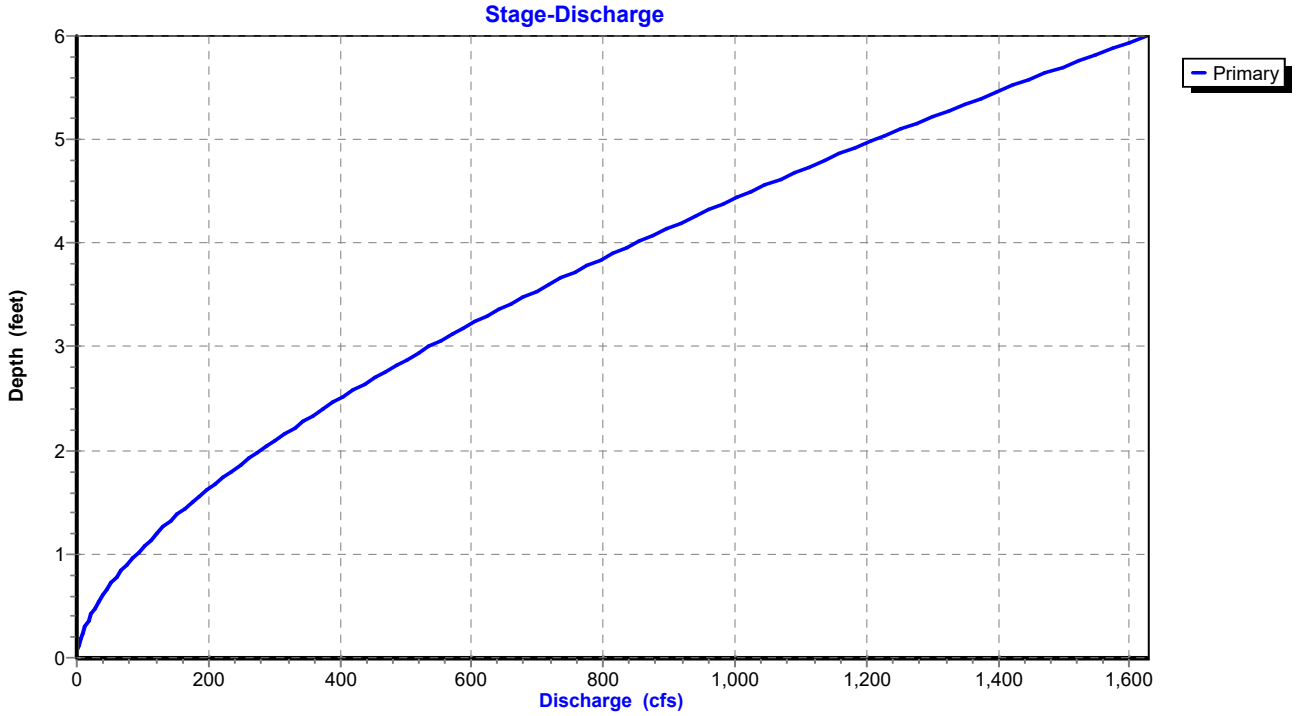
Peak Storage= 69,568 cf @ 13.72 hrs
Average Depth at Peak Storage= 4.28' , Surface Width= 21.28'
Bank-Full Depth= 6.00' Flow Area= 120.0 sf, Capacity= 1,625.88 cfs

17.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 0.0 1.0 '/' Top Width= 23.00'
Length= 850.0' Slope= 0.0171 '/'
Inlet Invert= 329.54', Outlet Invert= 315.00'

Reach 5R: Natural Creek



Reach 5R: Natural Creek



Summary for Subcatchment 5S: Brook Watershed

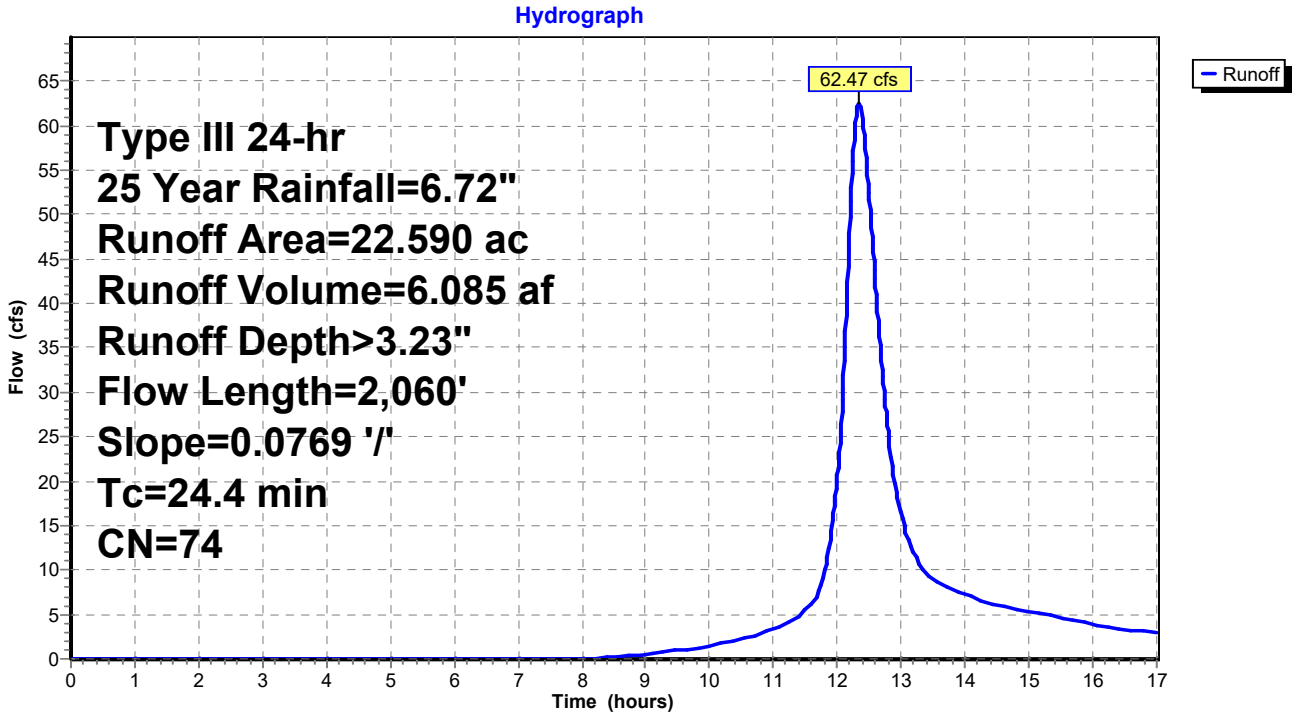
Runoff = 62.47 cfs @ 12.34 hrs, Volume= 6.085 af, Depth> 3.23"
Routed to Reach 5R : Natural Creek

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 Year Rainfall=6.72"

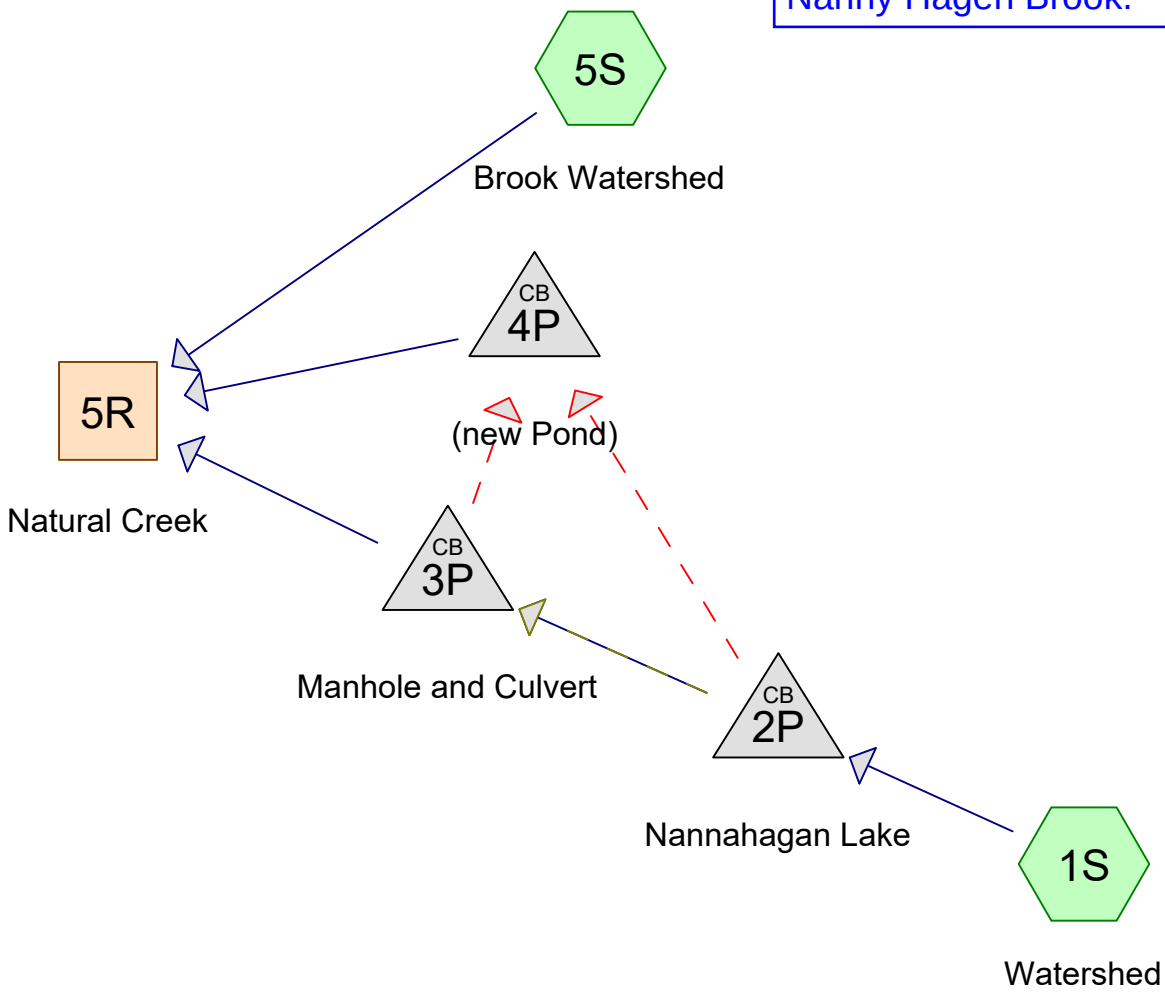
	Area (ac)	CN	Description
*	22.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	2,060	0.0769	1.41		**Lag/CN Method,**

Subcatchment 5S: Brook Watershed



Design 5A - Raise walls around discharge channel. Expand lake weirs by 30'. Install 98" x 63" elliptical pipe between channel and Nanny Hagen Brook.



Subcat Reach Pond Link

Routing Diagram for Design 5A - 50 Yr - Raise Walls, Longer Weir, Add Culvert, Manhole

Prepared by Microsoft, Printed 11/30/2021

Summary for Subcatchment 1S: Watershed

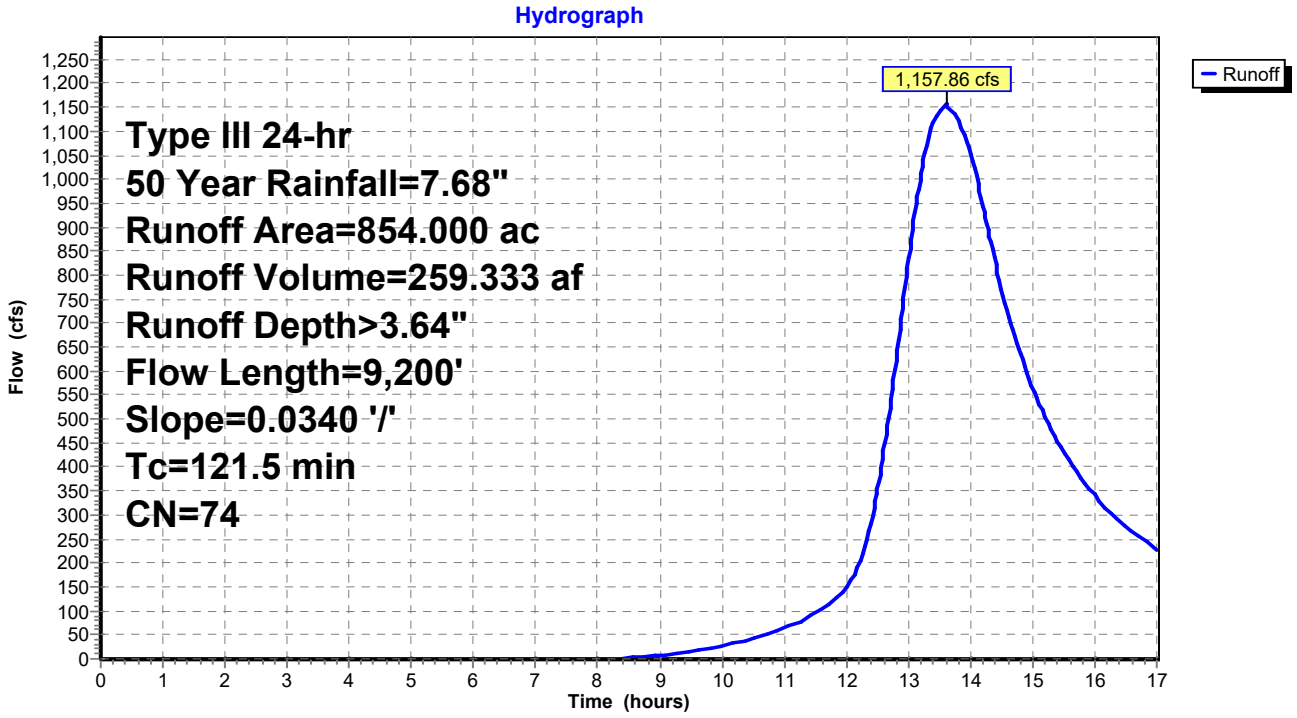
Runoff = 1,157.86 cfs @ 13.63 hrs, Volume= 259.333 af, Depth> 3.64"
Routed to Pond 2P : Nannahagan Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr 50 Year Rainfall=7.68"

	Area (ac)	CN	Description
*	854.000	74	Watershed Area with TR-55 weighted CN

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
121.5	9,200	0.0340	1.26		**Lag/CN Method, CN Method**

Subcatchment 1S: Watershed



Summary for Pond 2P: Nannahagan Lake

Inflow Area = 854.000 ac, Inflow Depth > 3.64" for 50 Year event
Inflow = 1,157.86 cfs @ 13.63 hrs, Volume= 259.145 af
Outflow = 1,157.86 cfs @ 13.64 hrs, Volume= 259.145 af, Atten= 0%, Lag= 0.6 min
Primary = 1,082.54 cfs @ 13.64 hrs, Volume= 227.013 af
Routed to Pond 3P : Manhole and Culvert
Secondary = 75.32 cfs @ 13.65 hrs, Volume= 32.132 af
Routed to Pond 4P : (new Pond)

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 352.25' @ 13.65 hrs
Flood Elev= 352.00'

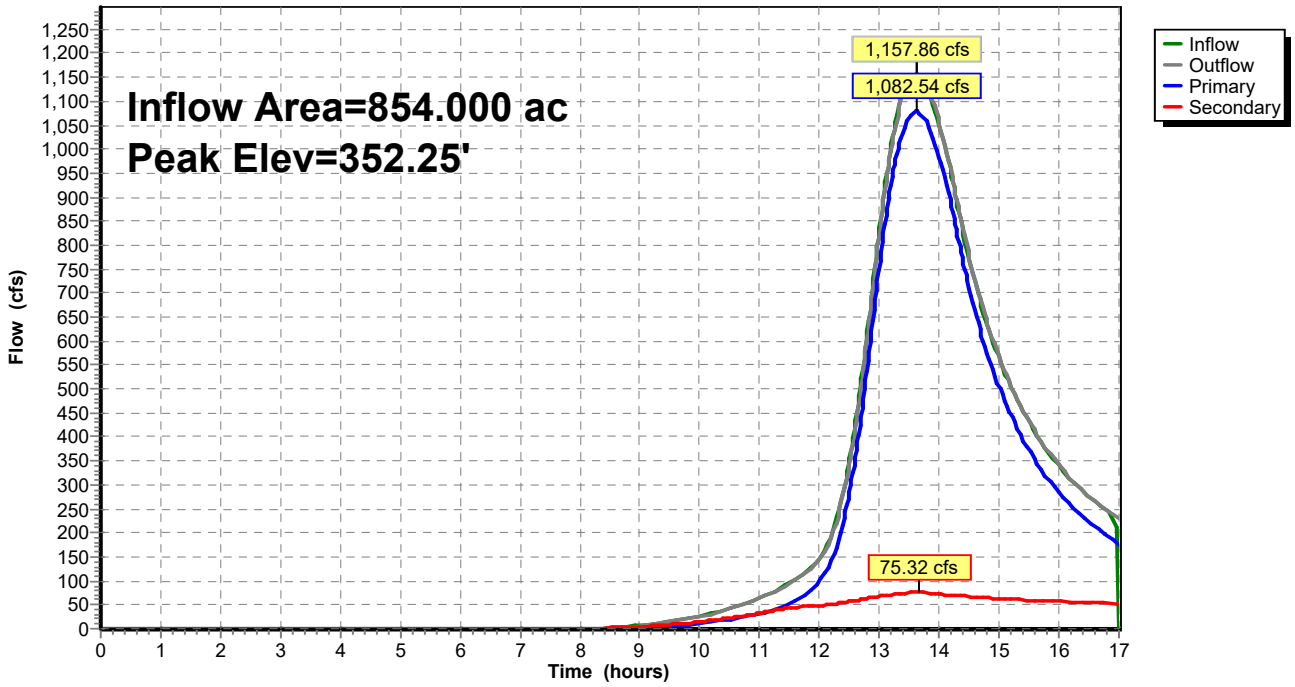
Device	Routing	Invert	Outlet Devices
#1	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Secondary	345.85'	**36.0" Round Chamber Pipe - Lake Street** L= 335.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 345.85' / 335.95' S= 0.0296 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 7.07 sf
#4	Primary	346.14'	**42.0" Round Bypass at Brook** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.010, Flow Area= 9.62 sf
#5	Primary	348.95'	**30.0' long x 2.0' breadth Additional Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=1,081.82 cfs @ 13.64 hrs HW=352.25' TW=350.40' (Dynamic Tailwater)
- **1=Broad-Crested Rectangular Weir** (Weir Controls 257.29 cfs @ 5.20 fps)
- **2=Broad-Crested Rectangular Weir** (Weir Controls 257.29 cfs @ 5.20 fps)
- **4=Bypass at Brook** (Outlet Controls 52.65 cfs @ 5.47 fps)
- **5=Additional Weir** (Weir Controls 514.59 cfs @ 5.20 fps)

Secondary OutFlow Max=75.32 cfs @ 13.65 hrs HW=352.25' TW=345.20' (Dynamic Tailwater)
- **3=Chamber Pipe - Lake Street** (Inlet Controls 75.32 cfs @ 10.66 fps)

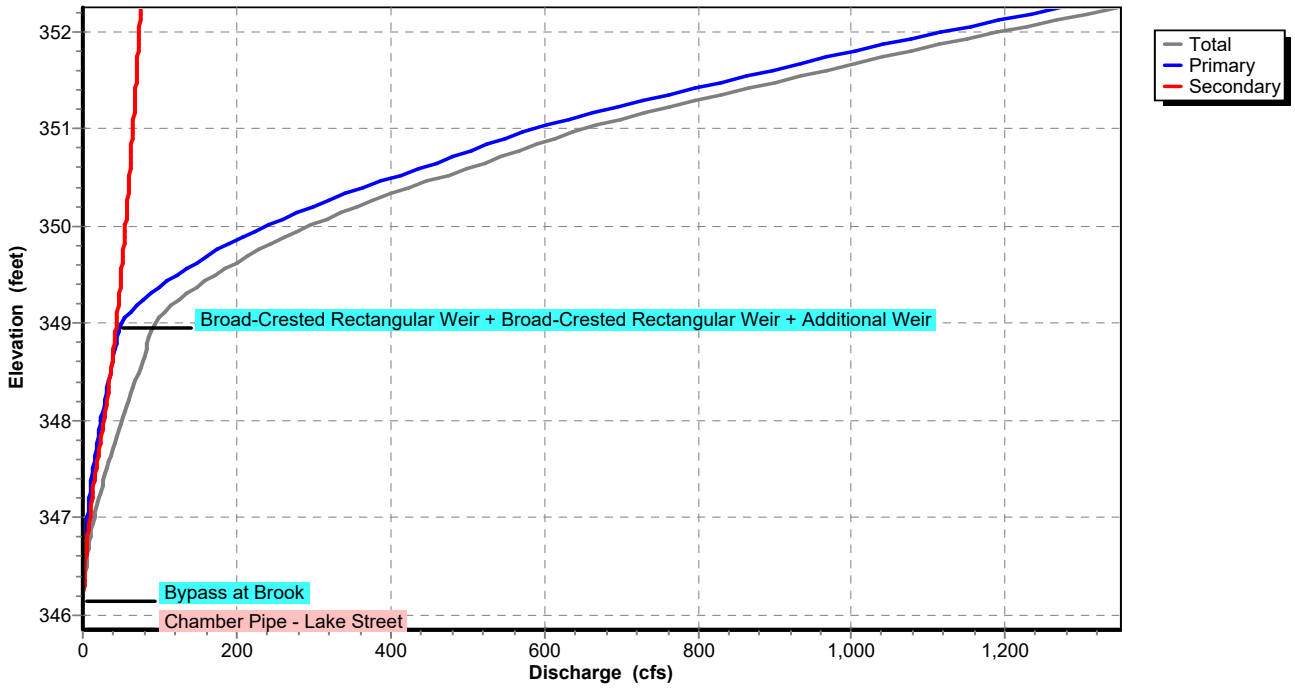
Pond 2P: Nannahagan Lake

Hydrograph



Pond 2P: Nannahagan Lake

Stage-Discharge



Summary for Pond 3P: Manhole and Culvert

Inflow Area = 854.000 ac, Inflow Depth > 3.19" for 50 Year event
Inflow = 1,082.54 cfs @ 13.64 hrs, Volume= 226.868 af
Outflow = 1,082.54 cfs @ 13.65 hrs, Volume= 226.868 af, Atten= 0%, Lag= 0.6 min
Primary = 712.65 cfs @ 13.66 hrs, Volume= 142.682 af
Routed to Reach 5R : Natural Creek
Secondary = 370.02 cfs @ 13.65 hrs, Volume= 84.186 af
Routed to Pond 4P : (new Pond)

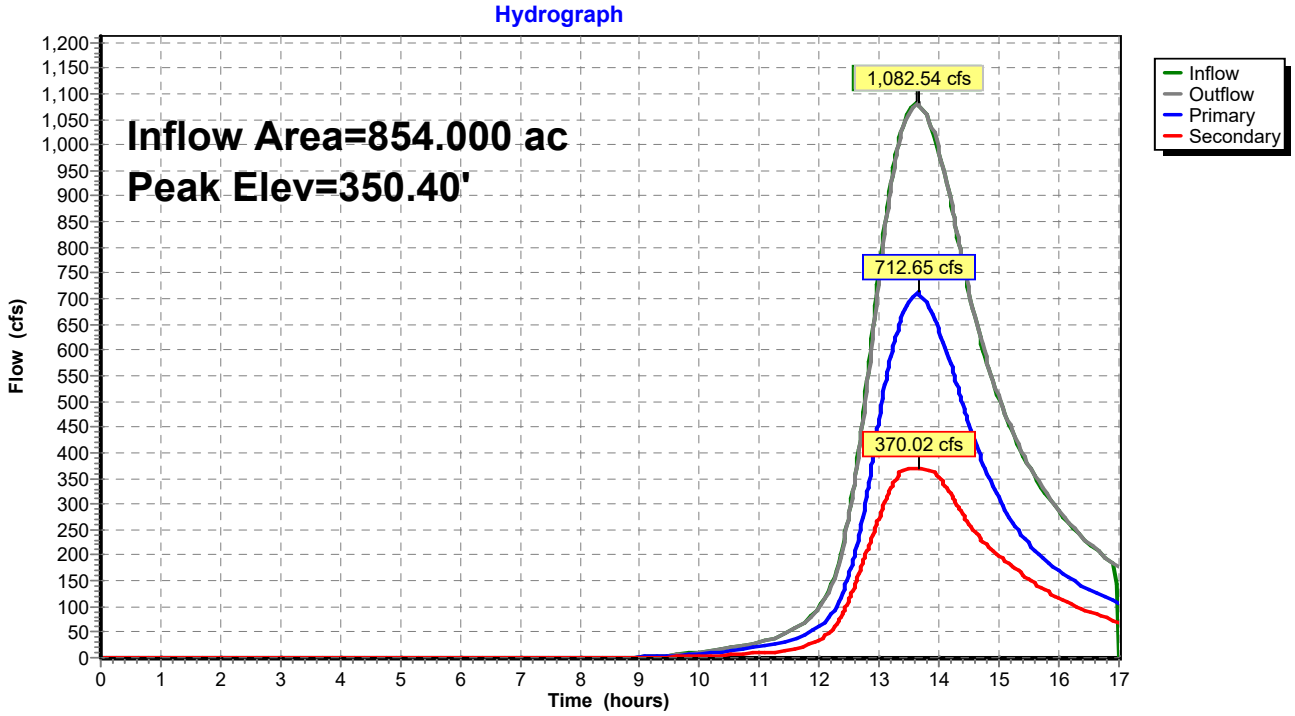
Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 350.40' @ 13.66 hrs
Flood Elev= 352.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	336.29'	**84.0" W x 72.0" H Box Culvert** L= 257.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 329.54' S= 0.0263 '/' Cc= 0.900 n= 0.017, Flow Area= 42.00 sf
#2	Secondary	336.29'	**98.0" W x 63.0" H Ellipse Culvert** L= 57.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 335.00' S= 0.0226 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 33.67 sf
#3	Primary	350.00'	**60.0' long x 1.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.62 2.64 2.64 2.68 2.75 2.86 2.92 3.07 3.07 3.03 3.28 3.32

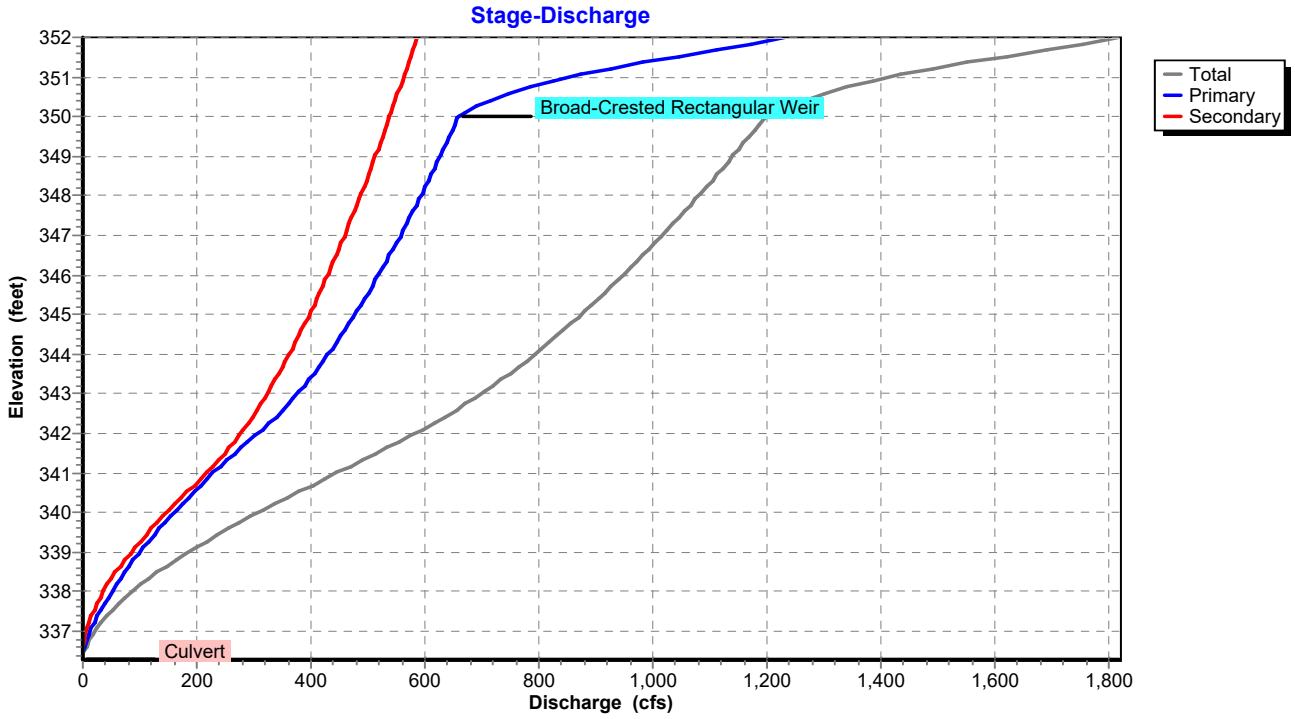
Primary OutFlow Max=712.52 cfs @ 13.66 hrs HW=350.40' TW=334.42' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 672.06 cfs @ 16.00 fps)
└─**3=Broad-Crested Rectangular Weir** (Weir Controls 40.46 cfs @ 1.68 fps)

Secondary OutFlow Max=369.51 cfs @ 13.65 hrs HW=350.40' TW=345.21' (Dynamic Tailwater)
└─**2=Culvert** (Inlet Controls 369.51 cfs @ 10.97 fps)

Pond 3P: Manhole and Culvert



Pond 3P: Manhole and Culvert



Summary for Pond 4P: (new Pond)

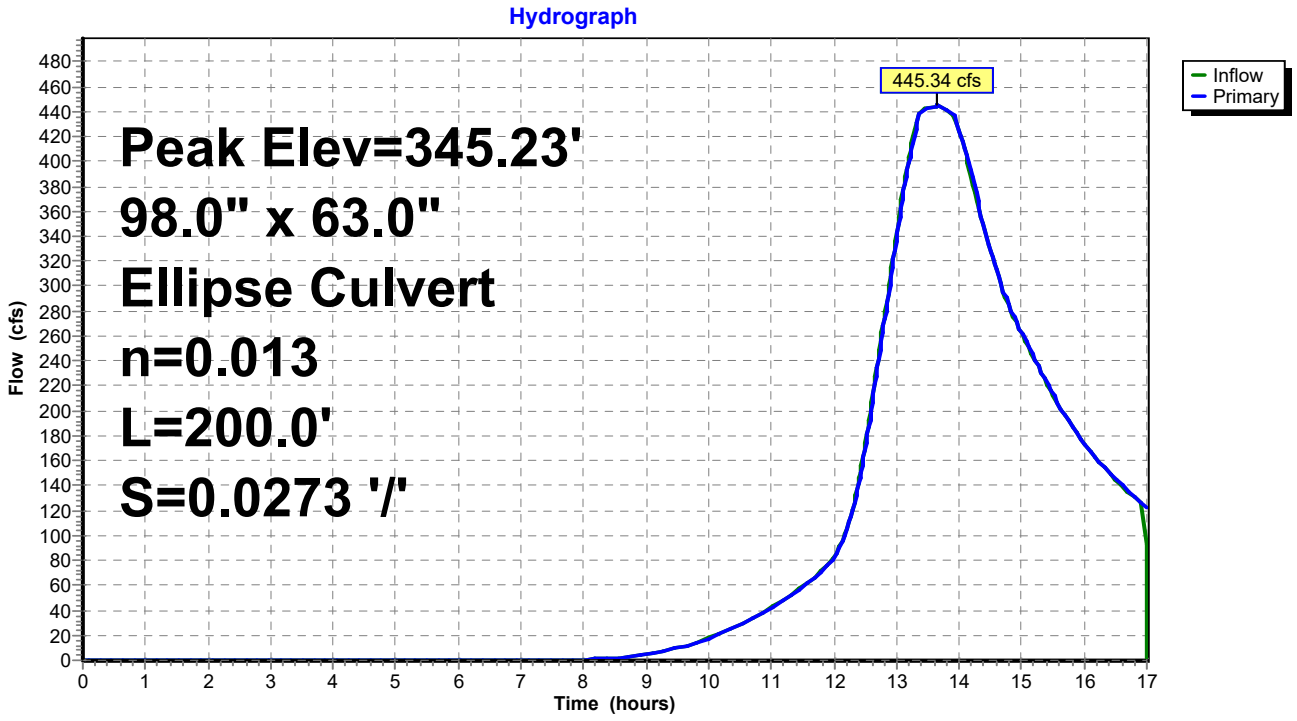
Inflow = 445.34 cfs @ 13.65 hrs, Volume= 116.216 af
Outflow = 445.34 cfs @ 13.66 hrs, Volume= 116.216 af, Atten= 0%, Lag= 0.6 min
Primary = 445.34 cfs @ 13.66 hrs, Volume= 116.216 af
Routed to Reach 5R : Natural Creek

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 345.23' @ 13.66 hrs
Flood Elev= 344.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	335.00'	**98.0" W x 63.0" H Ellipse Culvert** L= 200.0' Ke= 0.500 Inlet / Outlet Invert= 335.00' / 329.54' S= 0.0273 '/' Cc= 0.900 n= 0.013, Flow Area= 33.67 sf

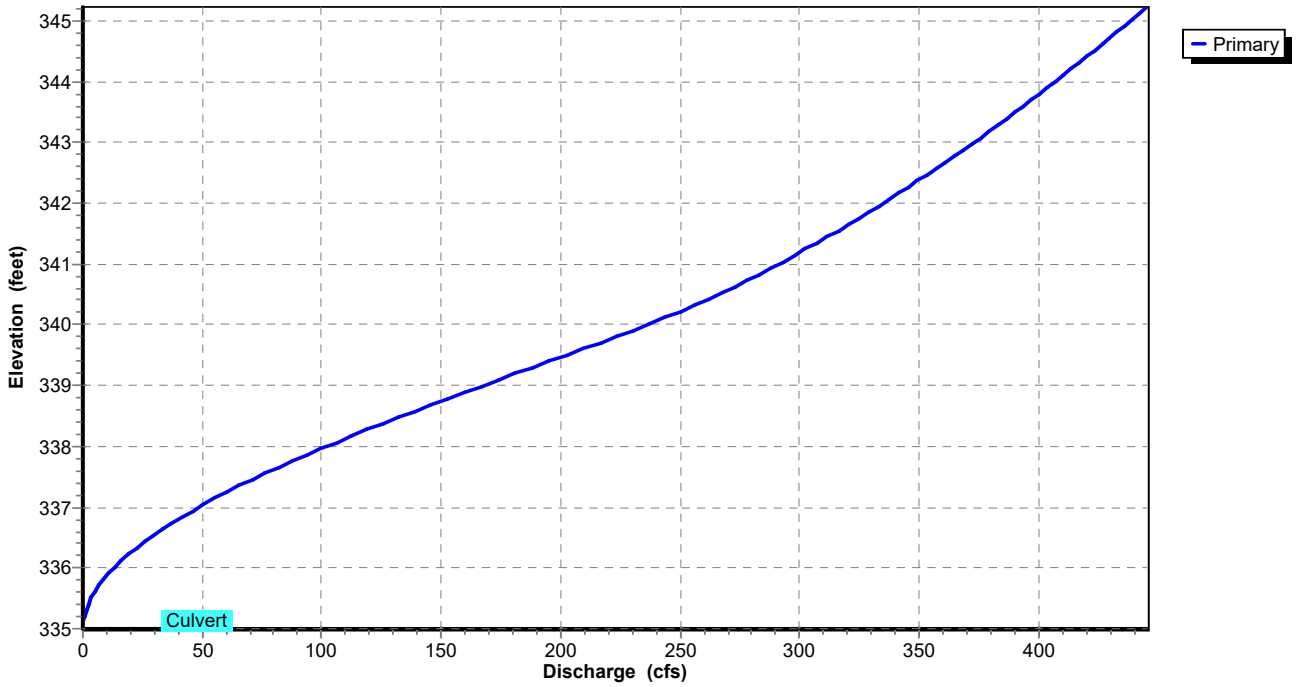
Primary OutFlow Max=445.32 cfs @ 13.66 hrs HW=345.23' TW=334.42' (Dynamic Tailwater)
1=Culvert (Inlet Controls 445.32 cfs @ 13.22 fps)

Pond 4P: (new Pond)



Pond 4P: (new Pond)

Stage-Discharge



Summary for Reach 5R: Natural Creek

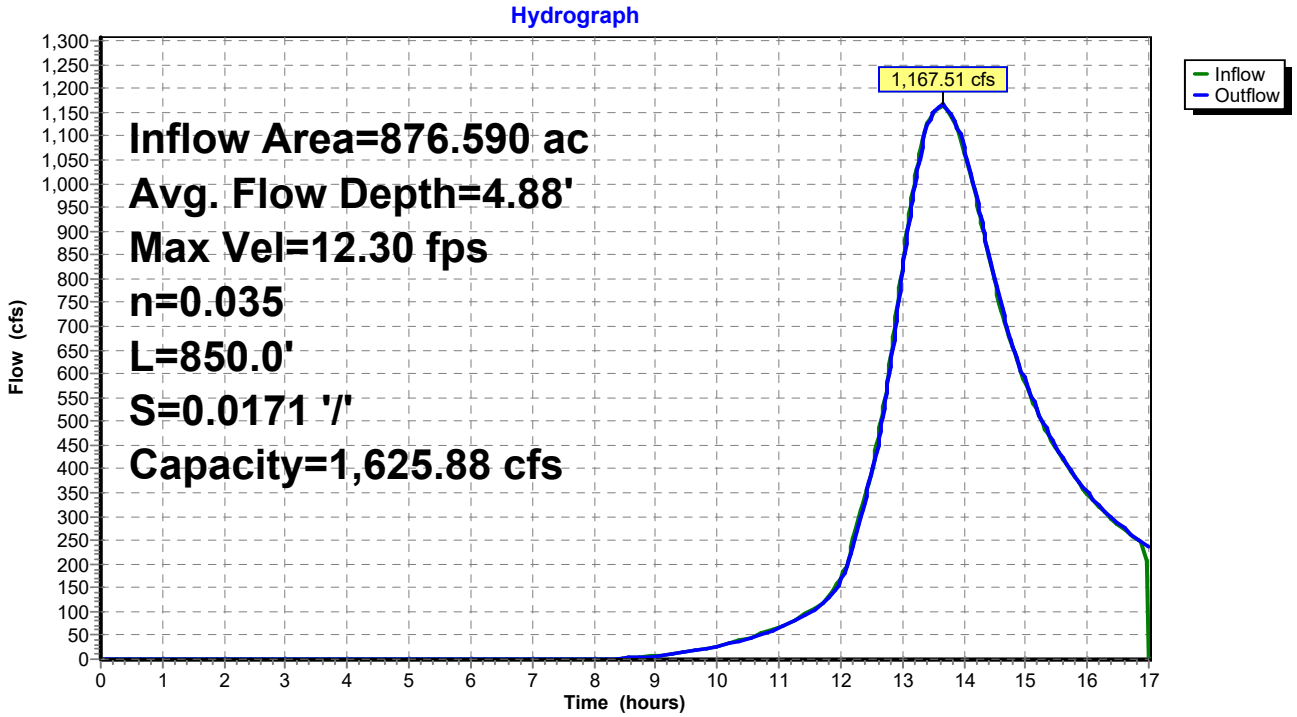
Inflow Area = 876.590 ac, Inflow Depth > 3.64" for 50 Year event
Inflow = 1,167.77 cfs @ 13.66 hrs, Volume= 266.186 af
Outflow = 1,167.51 cfs @ 13.67 hrs, Volume= 265.752 af, Atten= 0%, Lag= 0.7 min

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Max. Velocity= 12.30 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 6.30 fps, Avg. Travel Time= 2.2 min

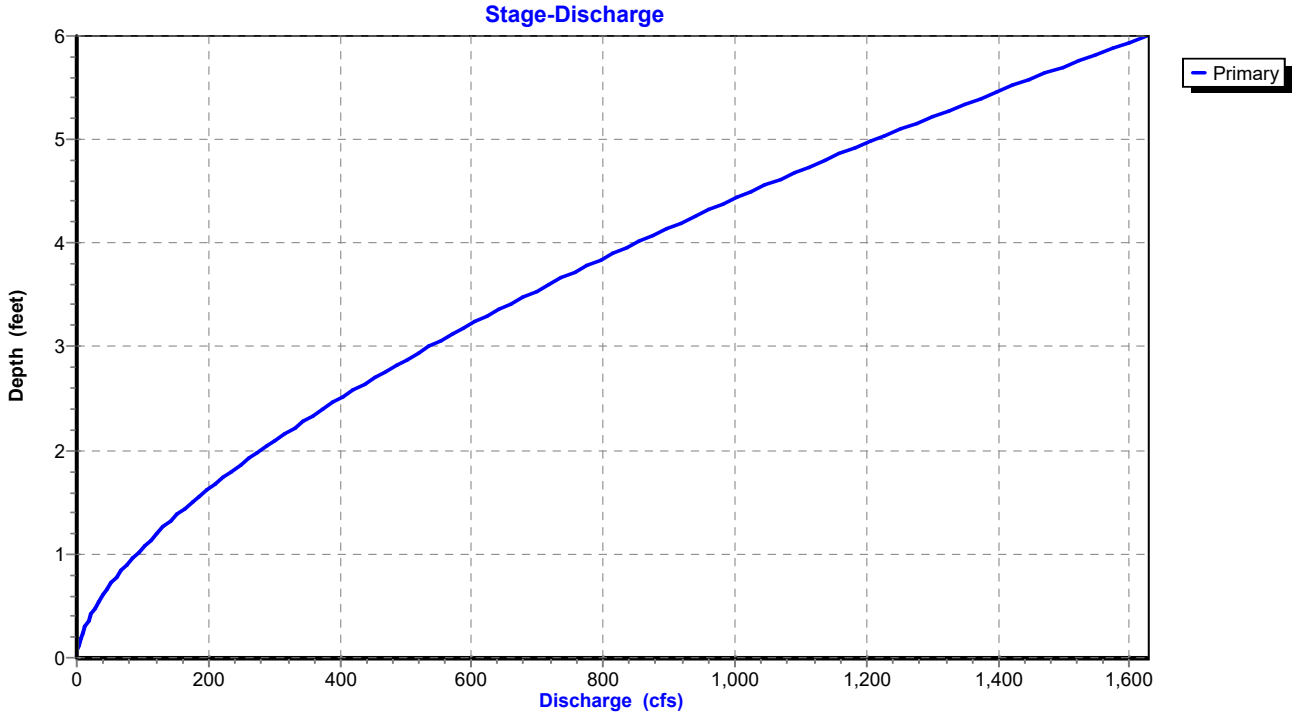
Peak Storage= 80,675 cf @ 13.67 hrs
Average Depth at Peak Storage= 4.88' , Surface Width= 21.88'
Bank-Full Depth= 6.00' Flow Area= 120.0 sf, Capacity= 1,625.88 cfs

17.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 0.0 1.0 '/' Top Width= 23.00'
Length= 850.0' Slope= 0.0171 '/'
Inlet Invert= 329.54', Outlet Invert= 315.00'

Reach 5R: Natural Creek



Reach 5R: Natural Creek



Summary for Subcatchment 5S: Brook Watershed

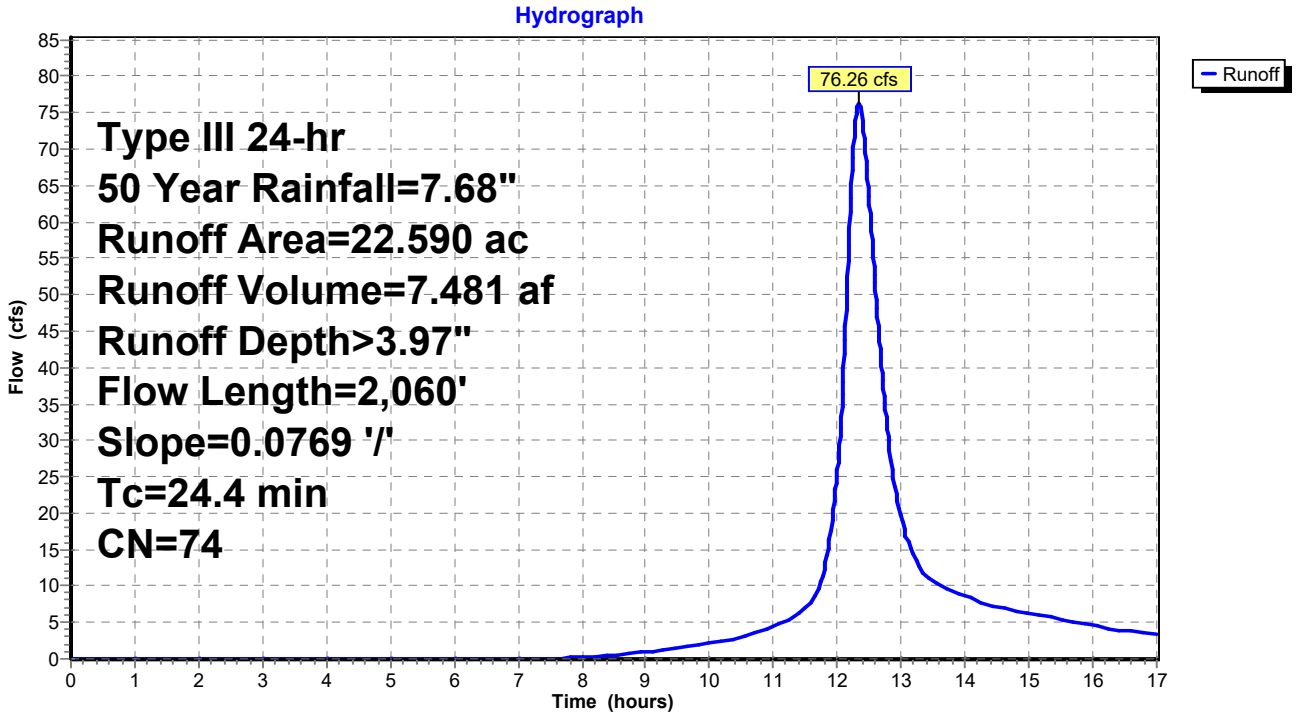
Runoff = 76.26 cfs @ 12.34 hrs, Volume= 7.481 af, Depth> 3.97"
Routed to Reach 5R : Natural Creek

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr 50 Year Rainfall=7.68"

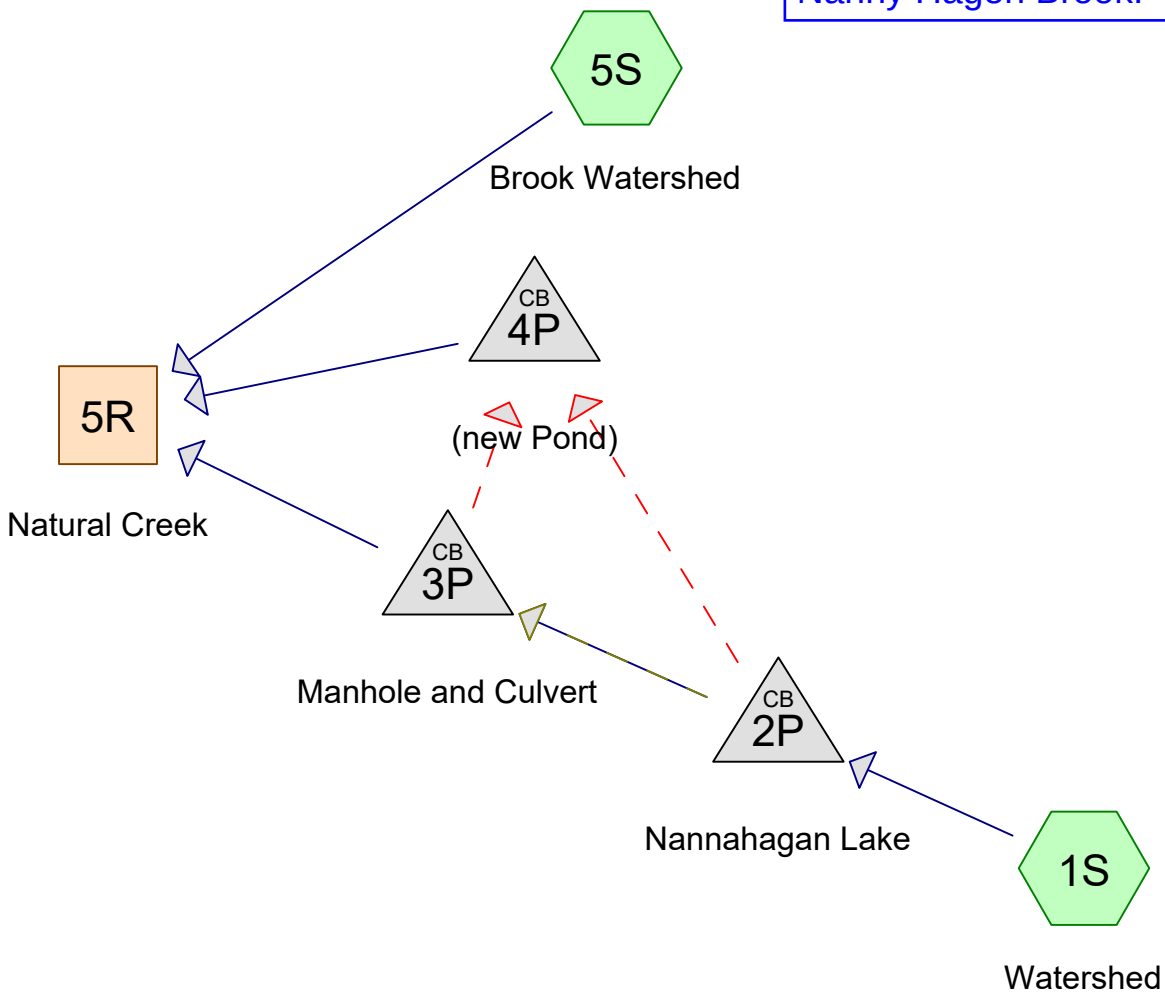
	Area (ac)	CN	Description
*	22.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	2,060	0.0769	1.41		**Lag/CN Method,**

Subcatchment 5S: Brook Watershed



Design 5B - Raise walls around discharge channel. Expand lake weirs by 40'. Install 113" x 72" elliptical pipe between channel and Nanny Hagen Brook.



Subcat Reach Pond Link

Routing Diagram for Design 5B - 100 Yr - Raise Walls, Longer Weir, Add Culvert, Manhole

Prepared by Microsoft, Printed 11/30/2021
HydroCAD® 10.10-6a s/n 12195 © 2020 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: Watershed

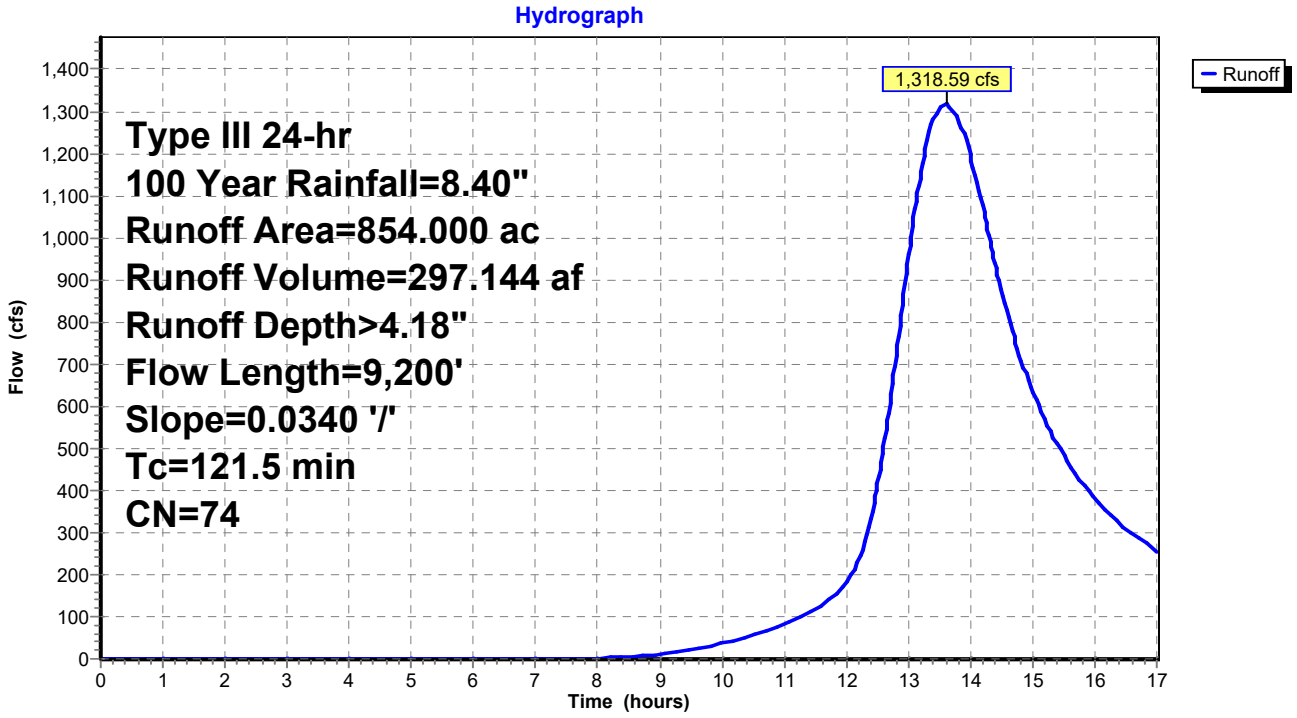
Runoff = 1,318.59 cfs @ 13.63 hrs, Volume= 297.144 af, Depth> 4.18"
Routed to Pond 2P : Nannahagan Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 Year Rainfall=8.40"

	Area (ac)	CN	Description
*	854.000	74	Watershed Area with TR-55 weighted CN

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
121.5	9,200	0.0340	1.26		**Lag/CN Method, CN Method**

Subcatchment 1S: Watershed



Summary for Pond 2P: Nannahagan Lake

Inflow Area = 854.000 ac, Inflow Depth > 4.17" for 100 Year event
Inflow = 1,318.59 cfs @ 13.63 hrs, Volume= 296.934 af
Outflow = 1,318.59 cfs @ 13.64 hrs, Volume= 296.934 af, Atten= 0%, Lag= 0.6 min
Primary = 1,244.55 cfs @ 13.64 hrs, Volume= 263.867 af
Routed to Pond 3P : Manhole and Culvert
Secondary = 74.05 cfs @ 13.65 hrs, Volume= 33.067 af
Routed to Pond 4P : (new Pond)

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 352.08' @ 13.65 hrs
Flood Elev= 352.00'

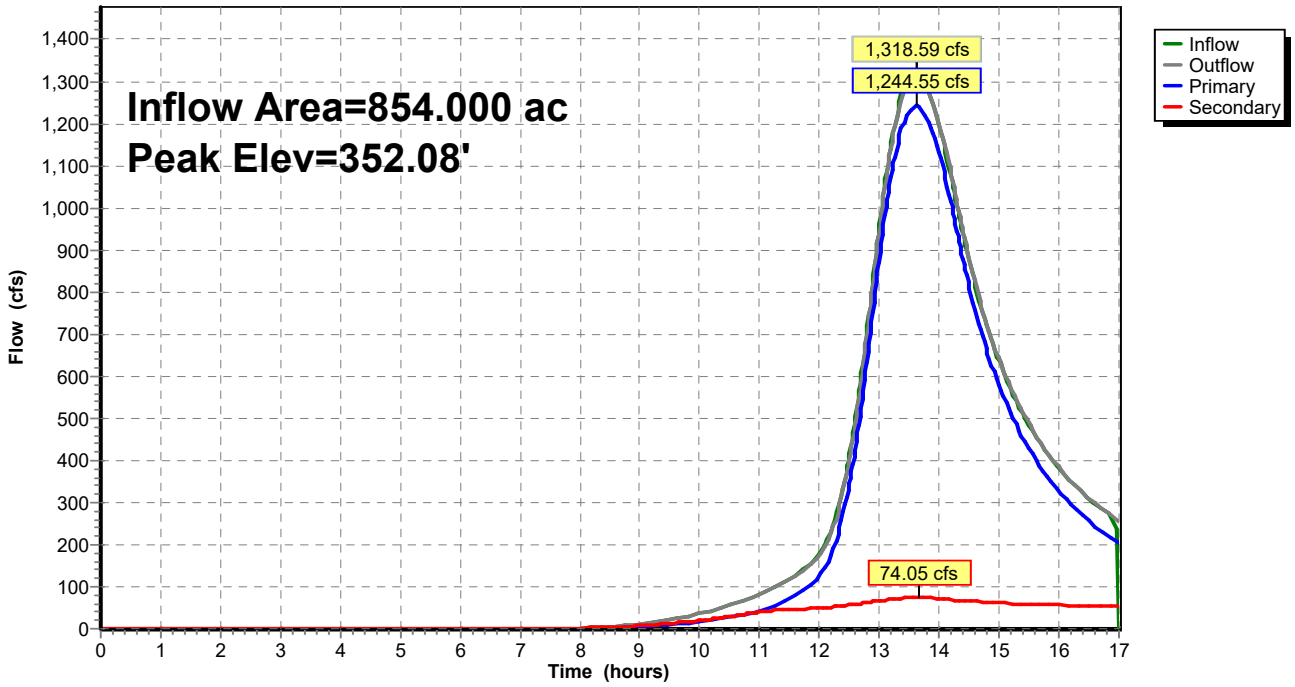
Device	Routing	Invert	Outlet Devices
#1	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Secondary	345.85'	**36.0" Round Chamber Pipe - Lake Street** L= 335.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 345.85' / 335.95' S= 0.0296 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 7.07 sf
#4	Primary	346.14'	**42.0" Round Bypass at Brook** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.010, Flow Area= 9.62 sf
#5	Primary	348.95'	**50.0' long x 2.0' breadth Additional Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=1,243.02 cfs @ 13.64 hrs HW=352.08' TW=350.58' (Dynamic Tailwater)
- **1=Broad-Crested Rectangular Weir** (Weir Controls 224.17 cfs @ 4.77 fps)
- **2=Broad-Crested Rectangular Weir** (Weir Controls 224.17 cfs @ 4.77 fps)
- **4=Bypass at Brook** (Outlet Controls 47.47 cfs @ 4.93 fps)
- **5=Additional Weir** (Weir Controls 747.22 cfs @ 4.77 fps)

Secondary OutFlow Max=74.05 cfs @ 13.65 hrs HW=352.08' TW=345.20' (Dynamic Tailwater)
- **3=Chamber Pipe - Lake Street** (Inlet Controls 74.05 cfs @ 10.48 fps)

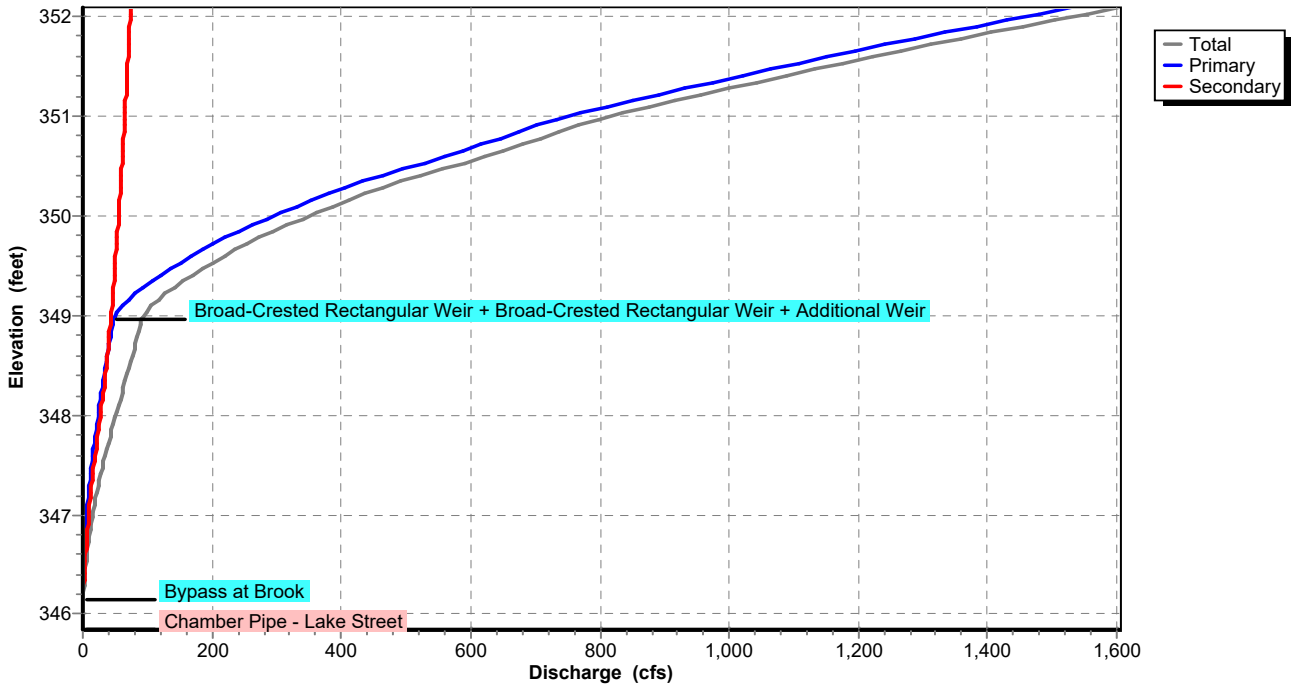
Pond 2P: Nannahagan Lake

Hydrograph



Pond 2P: Nannahagan Lake

Stage-Discharge



Summary for Pond 3P: Manhole and Culvert

Inflow Area = 854.000 ac, Inflow Depth > 3.71" for 100 Year event
Inflow = 1,244.55 cfs @ 13.64 hrs, Volume= 263.699 af
Outflow = 1,244.55 cfs @ 13.65 hrs, Volume= 263.699 af, Atten= 0%, Lag= 0.6 min
Primary = 748.72 cfs @ 13.65 hrs, Volume= 151.469 af
Routed to Reach 5R : Natural Creek
Secondary = 496.13 cfs @ 13.63 hrs, Volume= 112.230 af
Routed to Pond 4P : (new Pond)

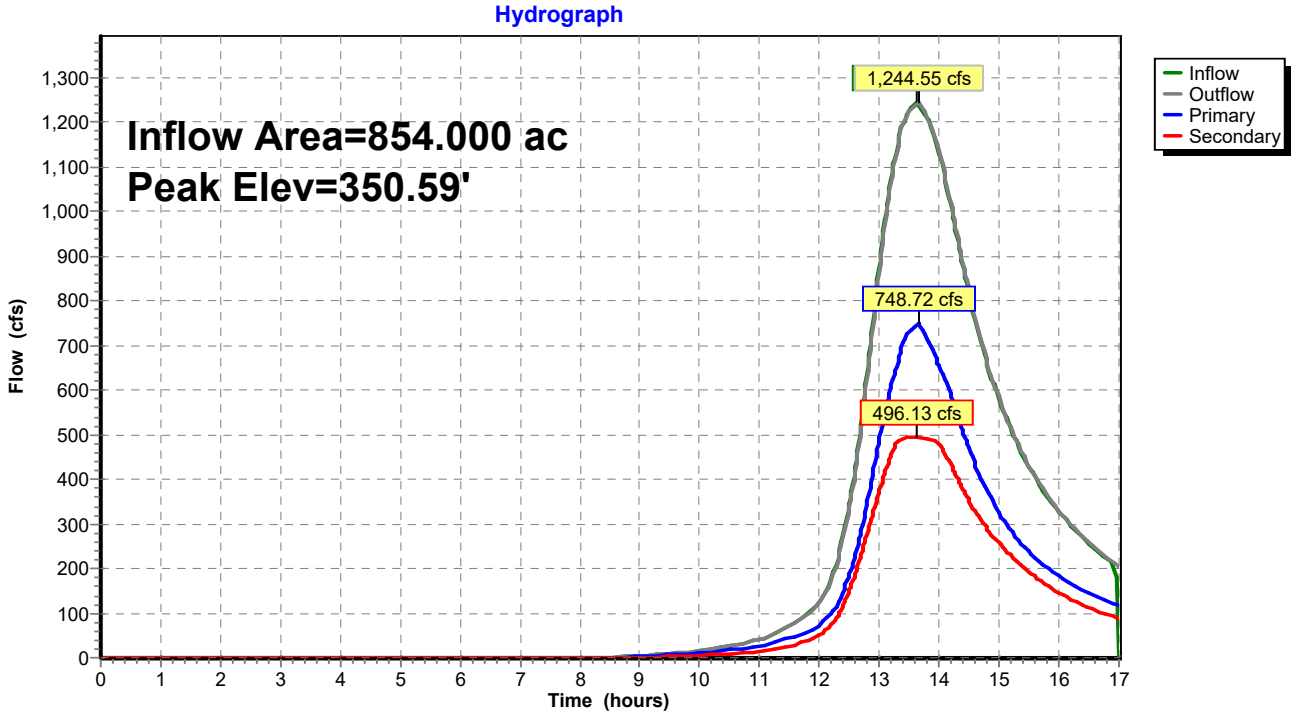
Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 350.59' @ 13.65 hrs
Flood Elev= 352.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	336.29'	**84.0" W x 72.0" H Box Culvert** L= 257.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 329.54' S= 0.0263 '/' Cc= 0.900 n= 0.017, Flow Area= 42.00 sf
#2	Secondary	336.29'	**113.0" W x 72.0" H Ellipse Culvert** L= 57.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 335.00' S= 0.0226 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 44.37 sf
#3	Primary	350.00'	**60.0' long x 1.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.62 2.64 2.64 2.68 2.75 2.86 2.92 3.07 3.07 3.03 3.28 3.32

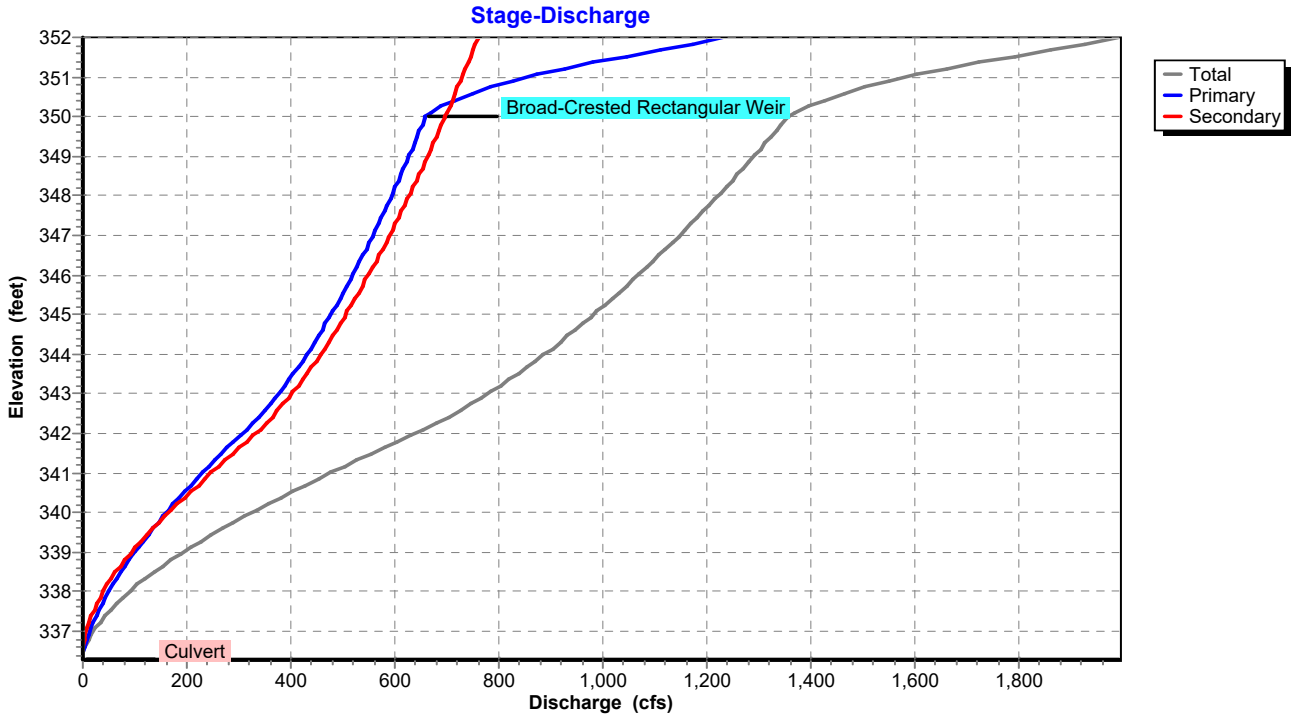
Primary OutFlow Max=748.59 cfs @ 13.65 hrs HW=350.59' TW=334.83' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 677.64 cfs @ 16.13 fps)
└─**3=Broad-Crested Rectangular Weir** (Weir Controls 70.95 cfs @ 2.02 fps)

Secondary OutFlow Max=495.72 cfs @ 13.63 hrs HW=350.58' TW=345.19' (Dynamic Tailwater)
└─**2=Culvert** (Inlet Controls 495.72 cfs @ 11.17 fps)

Pond 3P: Manhole and Culvert



Pond 3P: Manhole and Culvert



Summary for Pond 4P: (new Pond)

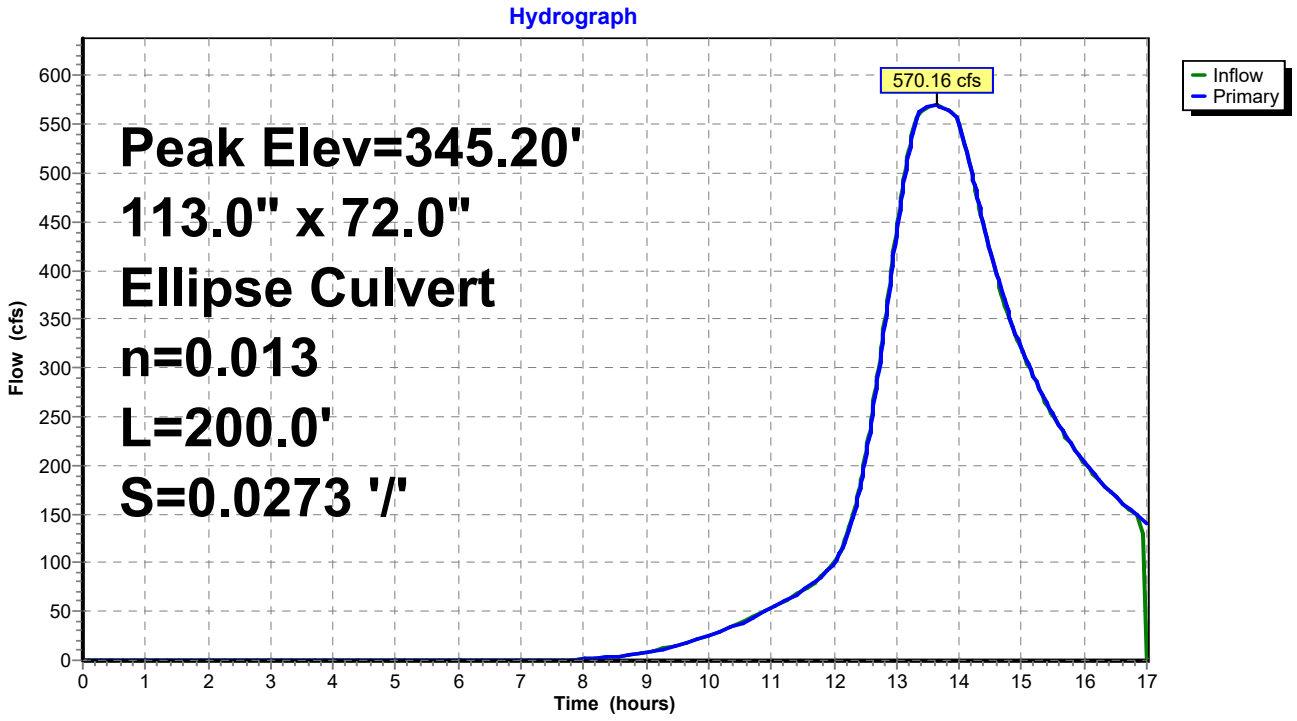
Inflow = 570.16 cfs @ 13.63 hrs, Volume= 145.181 af
Outflow = 570.16 cfs @ 13.64 hrs, Volume= 145.181 af, Atten= 0%, Lag= 0.6 min
Primary = 570.16 cfs @ 13.64 hrs, Volume= 145.181 af
Routed to Reach 5R : Natural Creek

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 345.20' @ 13.64 hrs
Flood Elev= 344.00'

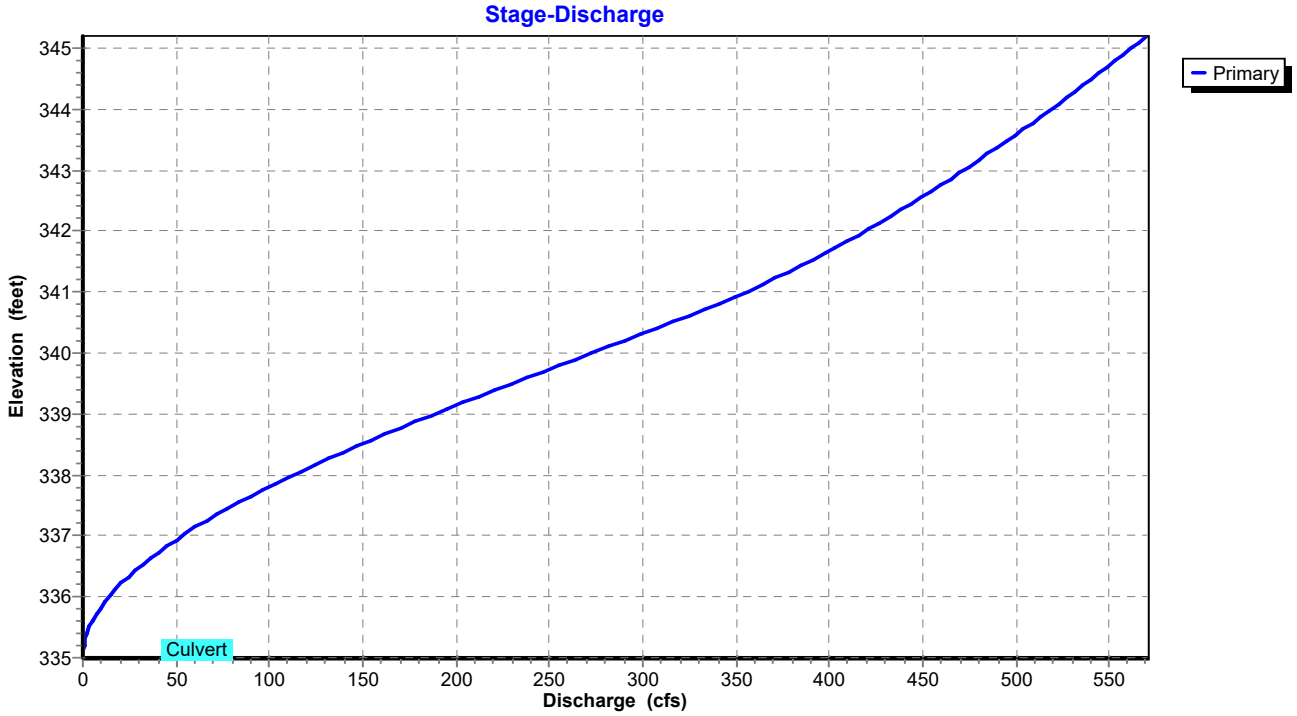
Device	Routing	Invert	Outlet Devices
#1	Primary	335.00'	**113.0" W x 72.0" H Ellipse Culvert** L= 200.0' Ke= 0.500 Inlet / Outlet Invert= 335.00' / 329.54' S= 0.0273 '/' Cc= 0.900 n= 0.013, Flow Area= 44.37 sf

Primary OutFlow Max=570.11 cfs @ 13.64 hrs HW=345.20' TW=334.83' (Dynamic Tailwater)
1=Culvert (Inlet Controls 570.11 cfs @ 12.85 fps)

Pond 4P: (new Pond)



Pond 4P: (new Pond)



Summary for Reach 5R: Natural Creek

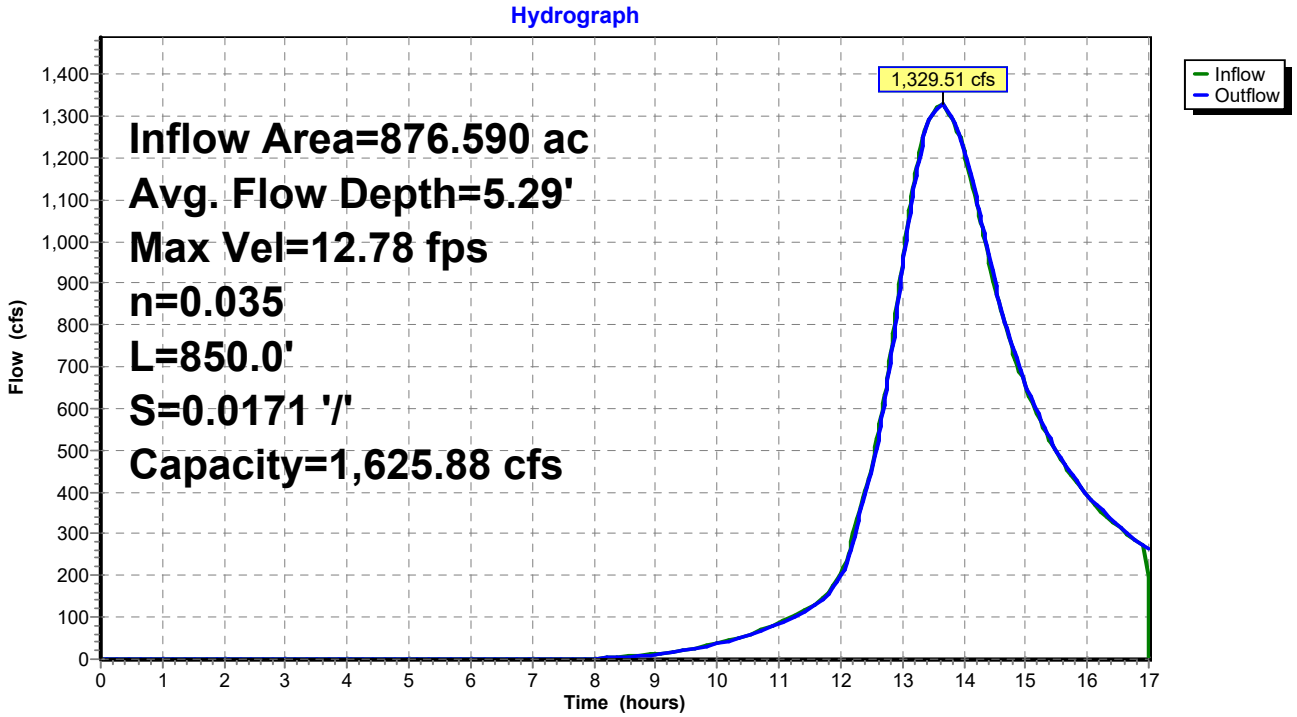
Inflow Area = 876.590 ac, Inflow Depth > 4.18" for 100 Year event
Inflow = 1,329.81 cfs @ 13.65 hrs, Volume= 304.987 af
Outflow = 1,329.51 cfs @ 13.66 hrs, Volume= 304.529 af, Atten= 0%, Lag= 0.7 min

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Max. Velocity= 12.78 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 6.47 fps, Avg. Travel Time= 2.2 min

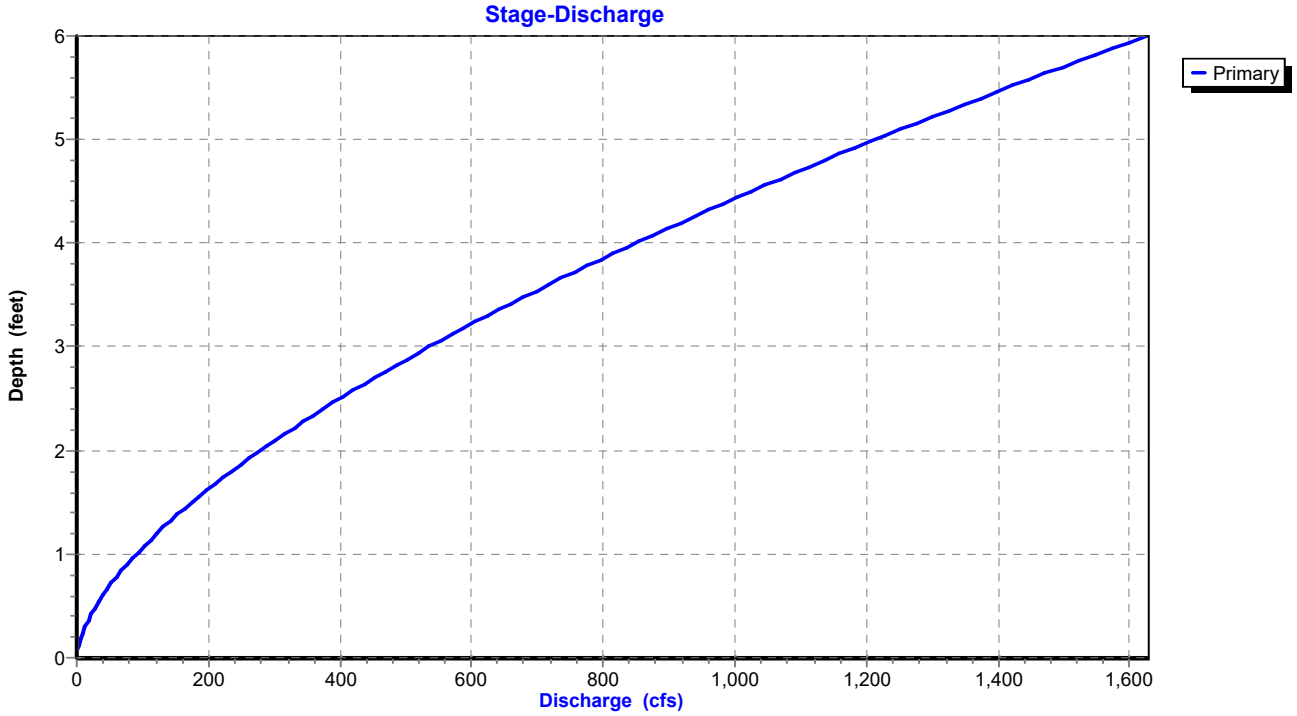
Peak Storage= 88,409 cf @ 13.66 hrs
Average Depth at Peak Storage= 5.29' , Surface Width= 22.29'
Bank-Full Depth= 6.00' Flow Area= 120.0 sf, Capacity= 1,625.88 cfs

17.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 0.0 1.0 '/' Top Width= 23.00'
Length= 850.0' Slope= 0.0171 '/'
Inlet Invert= 329.54', Outlet Invert= 315.00'

Reach 5R: Natural Creek



Reach 5R: Natural Creek



Summary for Subcatchment 5S: Brook Watershed

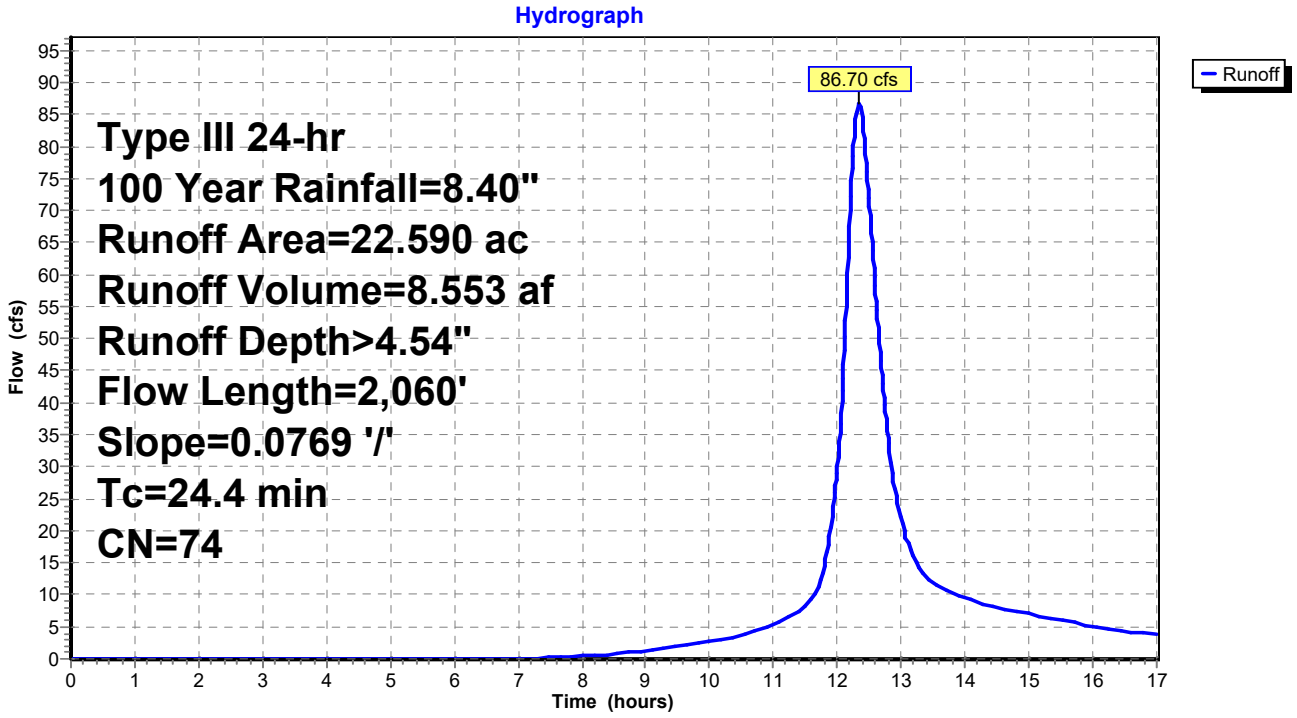
Runoff = 86.70 cfs @ 12.33 hrs, Volume= 8.553 af, Depth> 4.54"
Routed to Reach 5R : Natural Creek

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 Year Rainfall=8.40"

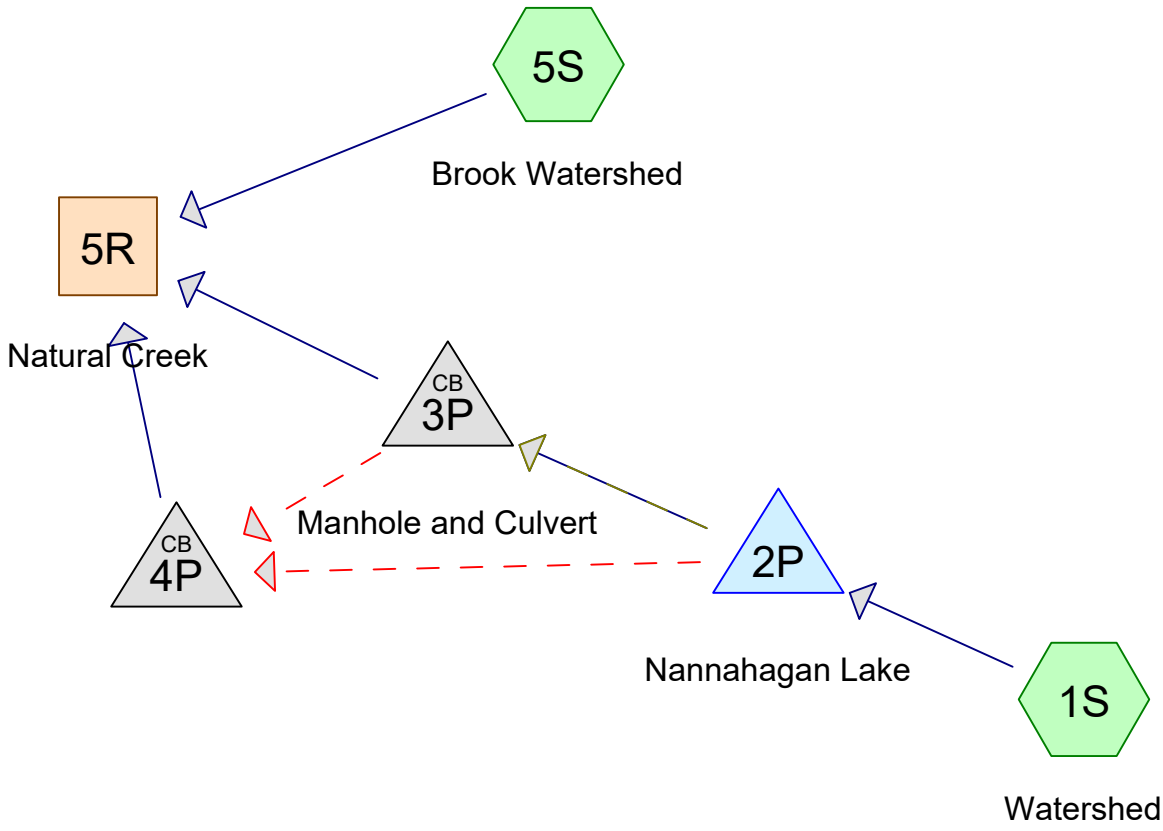
	Area (ac)	CN	Description
*	22.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	2,060	0.0769	1.41		**Lag/CN Method,**

Subcatchment 5S: Brook Watershed



Design 6 - Raise walls around discharge channel. Install 96" x 66" box culvert underneath pool between channel and Nanny Hagen Brook .



Subcat Reach Pond Link

Routing Diagram for Design 6 - 100 Yr - Raise Walls, Add Culvert, Manhole
Prepared by Microsoft, Printed 12/21/2021

Summary for Subcatchment 1S: Watershed

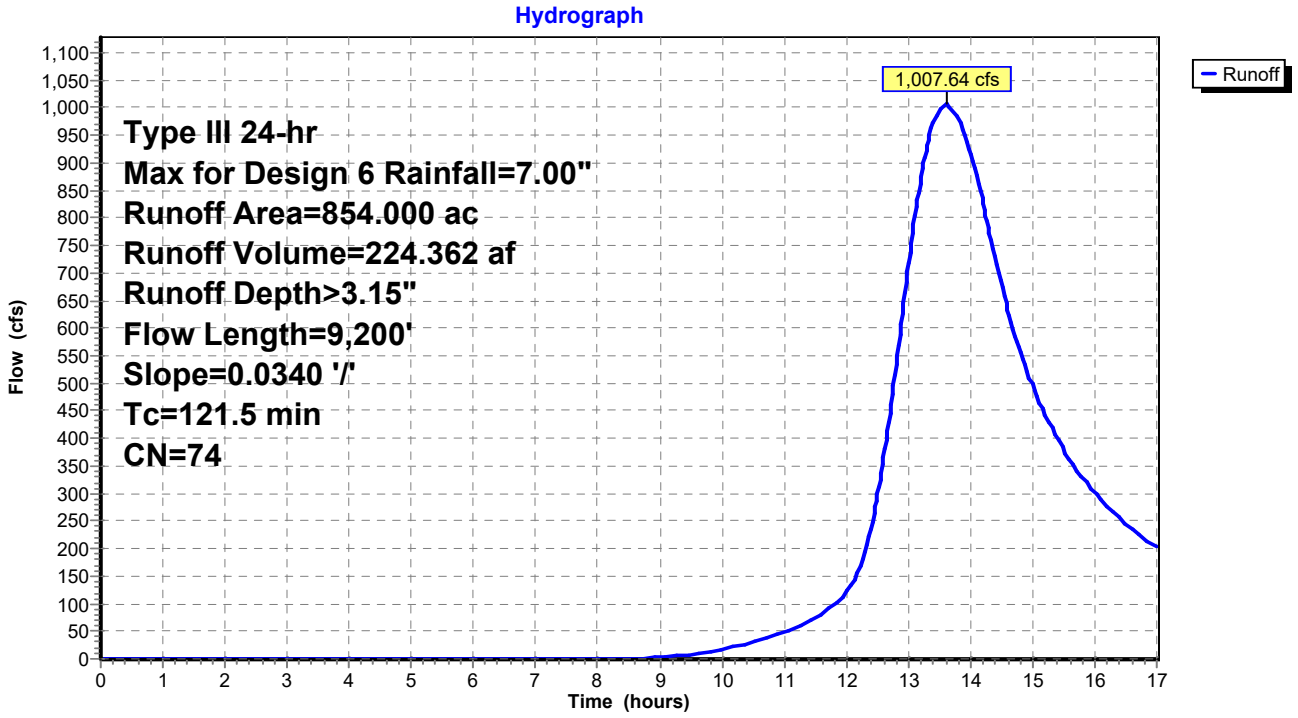
Runoff = 1,007.64 cfs @ 13.63 hrs, Volume= 224.362 af, Depth> 3.15"
Routed to Pond 2P : Nannahagan Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr Max for Design 6 Rainfall=7.00"

	Area (ac)	CN	Description
*	854.000	74	Watershed Area with TR-55 weighted CN

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
121.5	9,200	0.0340	1.26		**Lag/CN Method, CN Method**

Subcatchment 1S: Watershed



Summary for Pond 2P: Nannahagan Lake

Inflow Area = 854.000 ac, Inflow Depth > 3.15" for Max for Design 6 event
Inflow = 1,007.64 cfs @ 13.63 hrs, Volume= 224.194 af
Outflow = 1,001.19 cfs @ 13.68 hrs, Volume= 218.412 af, Atten= 1%, Lag= 3.0 min
Primary = 907.73 cfs @ 13.68 hrs, Volume= 184.152 af
Routed to Pond 3P : Manhole and Culvert
Secondary = 93.46 cfs @ 13.69 hrs, Volume= 34.260 af
Routed to Pond 4P :

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 351.96' @ 13.69 hrs Surf.Area= 3.004 ac Storage= 11.437 af
Flood Elev= 353.00' Surf.Area= 3.540 ac Storage= 14.836 af

Plug-Flow detention time= 12.2 min calculated for 218.284 af (97% of inflow)
Center-of-Mass det. time= 7.9 min (853.1 - 845.2)

Volume	Invert	Avail.Storage	Storage Description
#1	345.84'	14.836 af	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
345.84	1.150	1,138.0	0.000	0.000	1.150
347.00	1.350	1,266.0	1.448	1.448	1.713
348.00	1.560	1,488.0	1.454	2.902	2.830
348.95	1.700	1,524.0	1.548	4.450	3.031
353.00	3.540	1,721.0	10.386	14.836	4.209

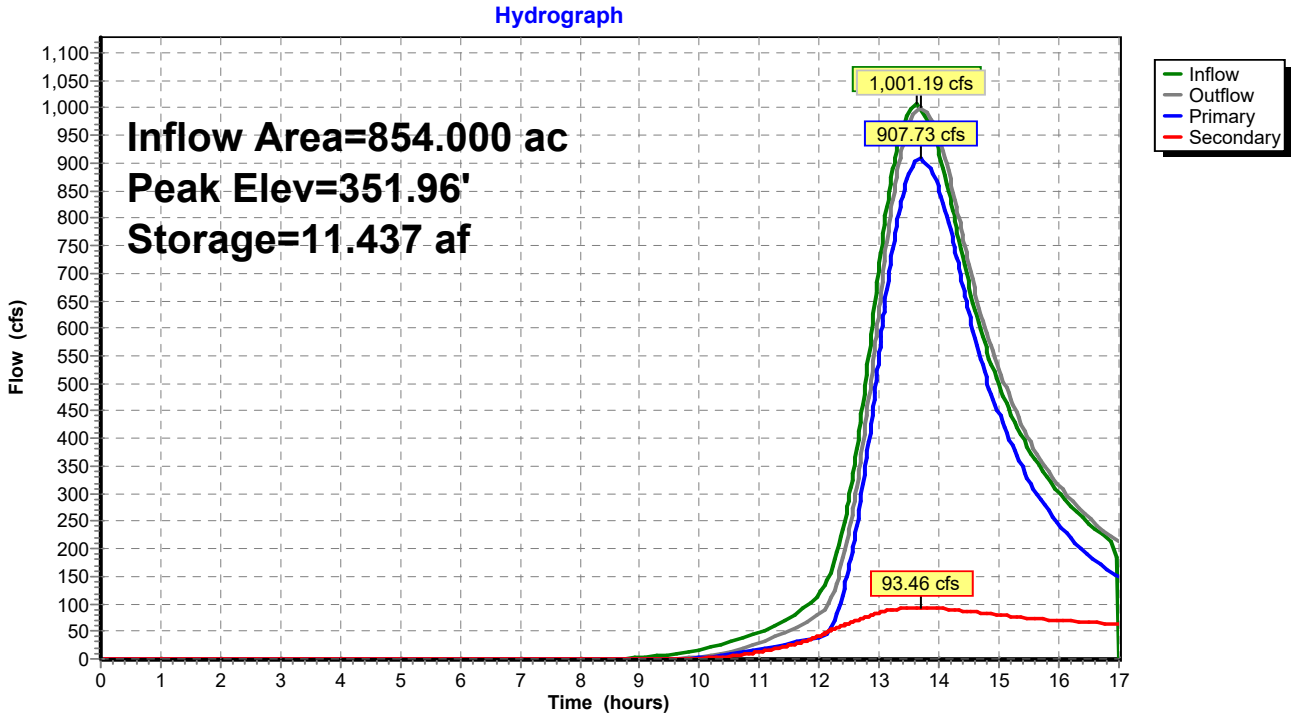
Device	Routing	Invert	Outlet Devices
#1	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#2	Primary	348.95'	**15.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#3	Secondary	346.14'	**42.0" Round Bypass at Brook** L= 707.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.14' / 336.05' S= 0.0143 '/' Cc= 0.900 n= 0.010, Flow Area= 9.62 sf
#4	Primary	348.95'	**20.0' long x 2.0' breadth Additional Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32
#5	Primary	345.85'	**36.0" Round Chamber Pipe - Lake Street** L= 335.0' CPP, square edge headwall, Ke= 0.500

Inlet / Outlet Invert= 345.85' / 335.95' S= 0.0296 '/' Cc= 0.900
n= 0.012, Flow Area= 7.07 sf

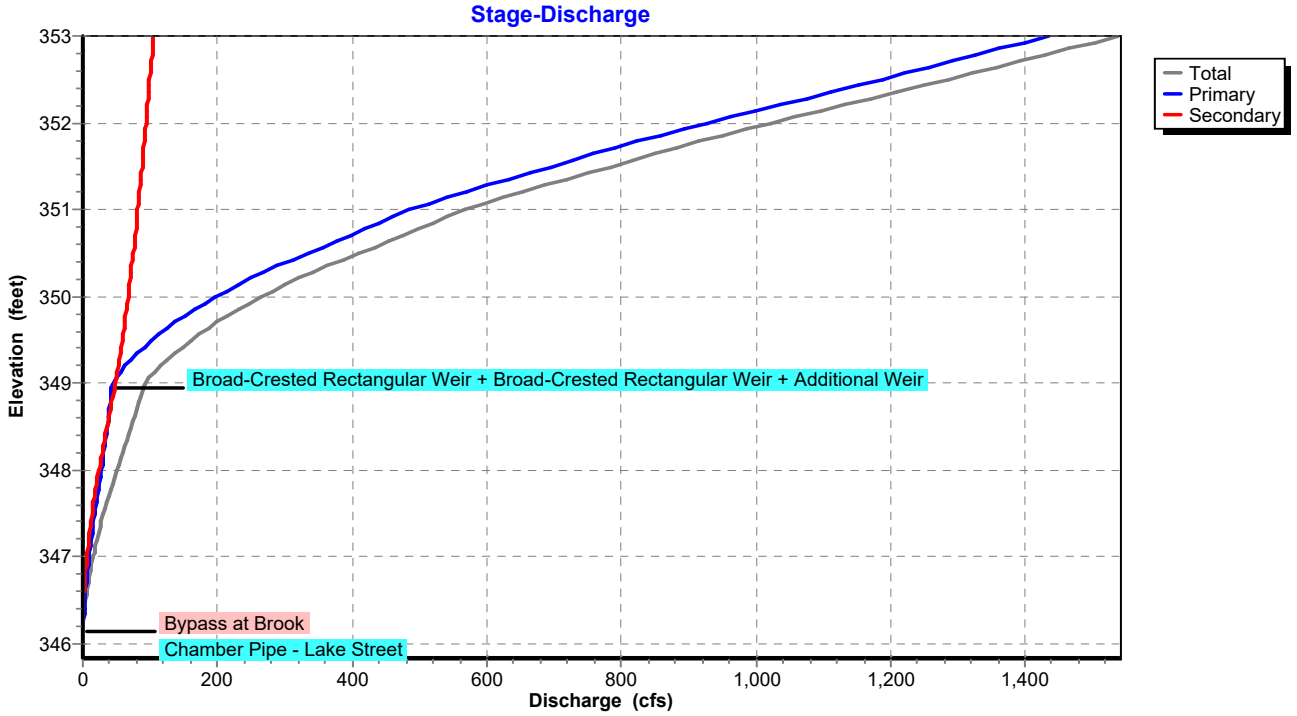
Primary OutFlow Max=907.67 cfs @ 13.68 hrs HW=351.96' TW=346.27' (Dynamic Tailwater)
- **1=Broad-Crested Rectangular Weir** (Weir Controls 250.82 cfs @ 5.56 fps)
- **2=Broad-Crested Rectangular Weir** (Weir Controls 250.82 cfs @ 5.56 fps)
- **4=Additional Weir** (Weir Controls 334.43 cfs @ 5.56 fps)
- **5=Chamber Pipe - Lake Street** (Outlet Controls 71.60 cfs @ 10.13 fps)

Secondary OutFlow Max=93.46 cfs @ 13.69 hrs HW=351.96' TW=343.09' (Dynamic Tailwater)
- **3=Bypass at Brook** (Inlet Controls 93.46 cfs @ 9.71 fps)

Pond 2P: Nannahagan Lake



Pond 2P: Nannahagan Lake



Summary for Pond 3P: Manhole and Culvert

Inflow Area = 854.000 ac, Inflow Depth > 2.59" for Max for Design 6 event
Inflow = 907.73 cfs @ 13.68 hrs, Volume= 184.030 af
Outflow = 907.73 cfs @ 13.69 hrs, Volume= 184.030 af, Atten= 0%, Lag= 0.6 min
Primary = 530.10 cfs @ 13.70 hrs, Volume= 105.492 af
Routed to Reach 5R : Natural Creek
Secondary = 377.65 cfs @ 13.69 hrs, Volume= 78.538 af
Routed to Pond 4P :

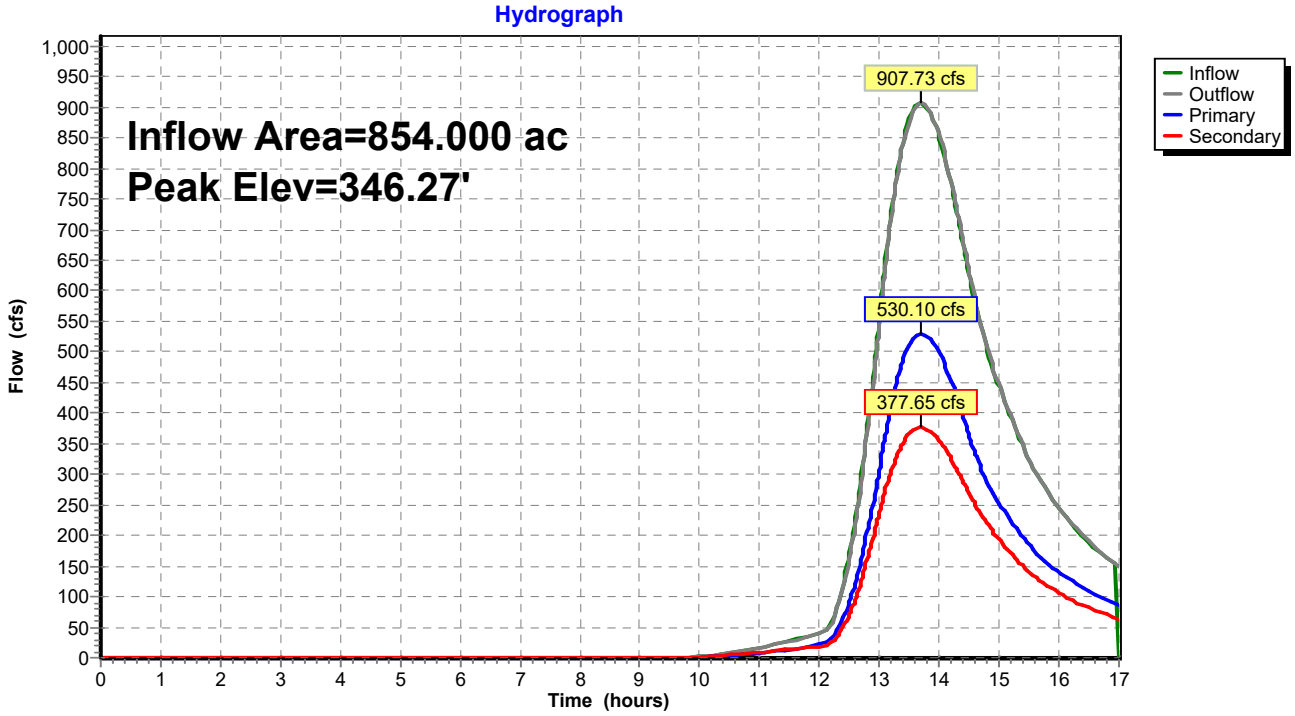
Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 346.27' @ 13.70 hrs
Flood Elev= 353.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	336.29'	**84.0" W x 72.0" H Box Culvert** L= 257.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 329.54' S= 0.0263 '/' Cc= 0.900 n= 0.017, Flow Area= 42.00 sf
#2	Secondary	336.29'	**96.0" W x 66.0" H Box Culvert** L= 50.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 336.29' / 335.22' S= 0.0214 '/' Cc= 0.900 n= 0.013, Flow Area= 44.00 sf

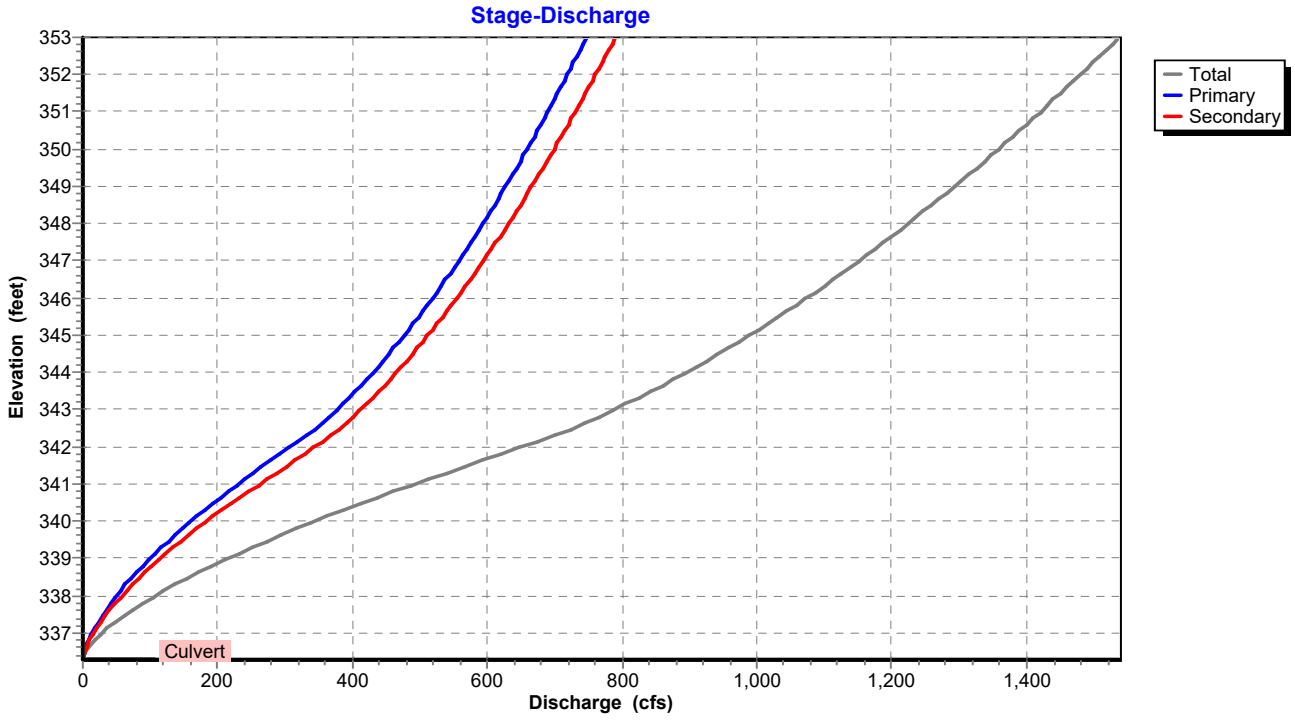
Primary OutFlow Max=530.09 cfs @ 13.70 hrs HW=346.27' TW=334.00' (Dynamic Tailwater)
1=Culvert (Inlet Controls 530.09 cfs @ 12.62 fps)

Secondary OutFlow Max=377.52 cfs @ 13.69 hrs HW=346.27' TW=343.10' (Dynamic Tailwater)
2=Culvert (Inlet Controls 377.52 cfs @ 8.58 fps)

Pond 3P: Manhole and Culvert



Pond 3P: Manhole and Culvert



Summary for Pond 4P:

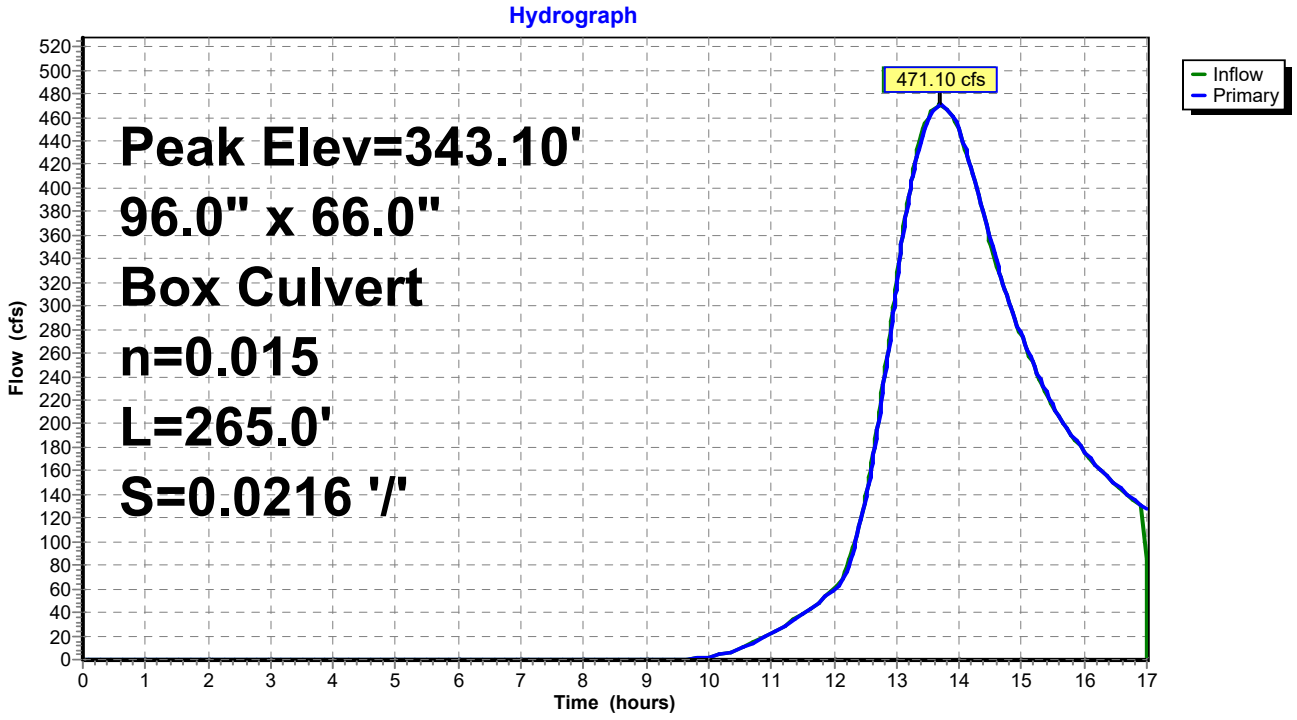
Inflow = 471.10 cfs @ 13.69 hrs, Volume= 112.692 af
Outflow = 471.10 cfs @ 13.70 hrs, Volume= 112.692 af, Atten= 0%, Lag= 0.6 min
Primary = 471.10 cfs @ 13.70 hrs, Volume= 112.692 af
Routed to Reach 5R : Natural Creek

Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Peak Elev= 343.10' @ 13.70 hrs
Flood Elev= 345.00'

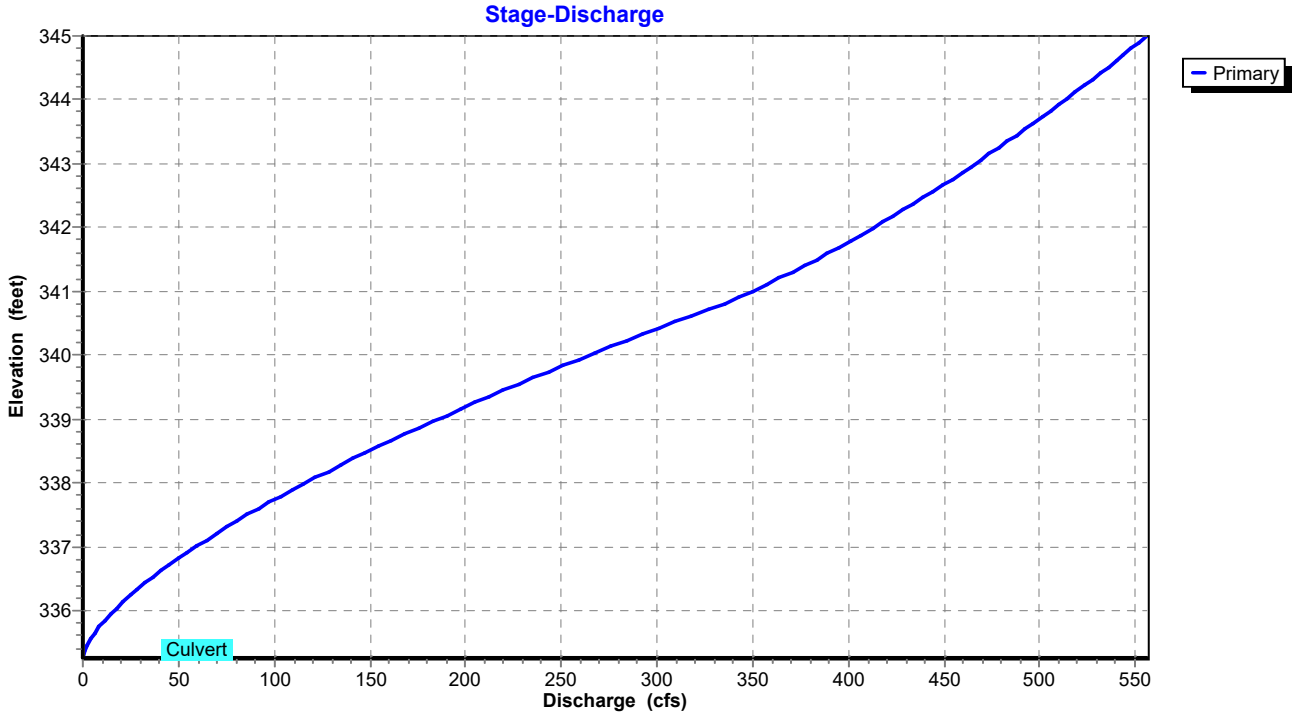
Device	Routing	Invert	Outlet Devices
#1	Primary	335.27'	**96.0" W x 66.0" H Box Culvert** L= 265.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 335.27' / 329.54' S= 0.0216 '/' Cc= 0.900 n= 0.015, Flow Area= 44.00 sf

Primary OutFlow Max=471.10 cfs @ 13.70 hrs HW=343.10' TW=334.00' (Dynamic Tailwater)
1=Culvert (Inlet Controls 471.10 cfs @ 10.71 fps)

Pond 4P:



Pond 4P:


Stage-Discharge
Elevation (feet)
345
344
343
342
341
340
339
338
337
336
Culvert
0
50
100
150
200
250
300
350
400
450
500
550
Discharge (cfs)
Primary

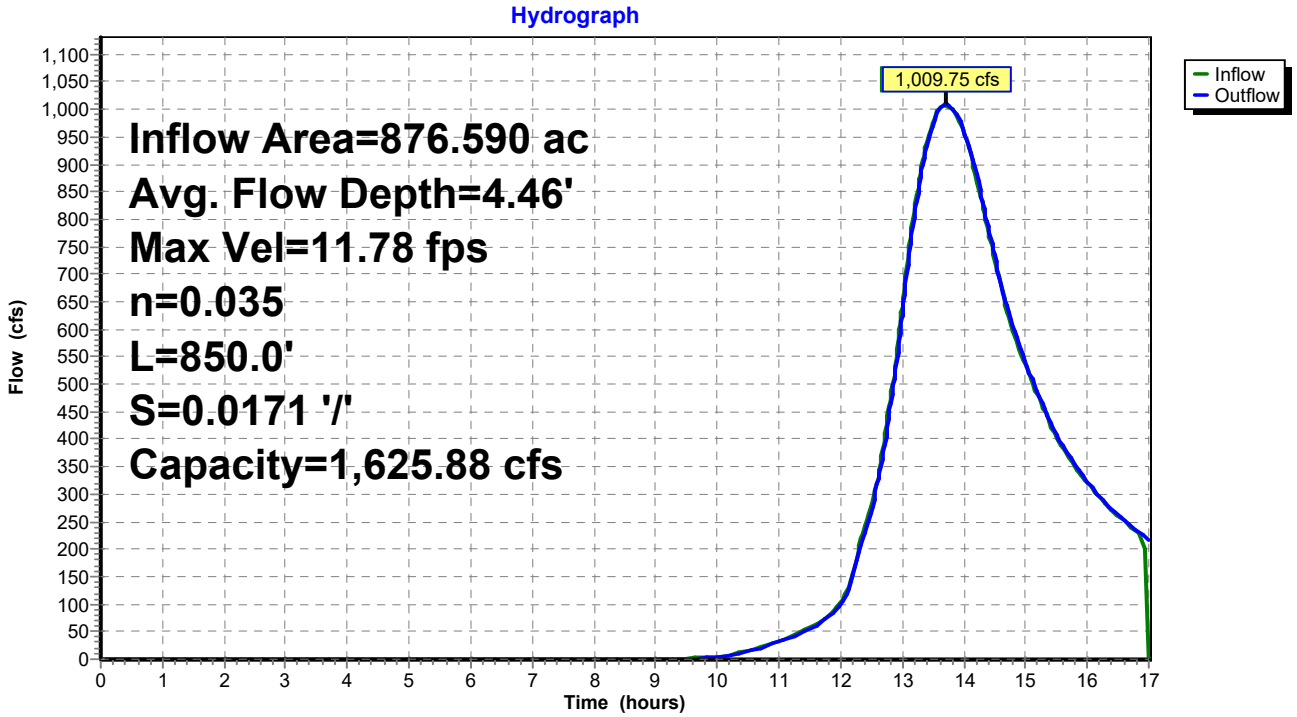
Summary for Reach 5R: Natural Creek

Inflow Area = 876.590 ac, Inflow Depth > 3.07" for Max for Design 6 event
Inflow = 1,009.81 cfs @ 13.69 hrs, Volume= 224.494 af
Outflow = 1,009.75 cfs @ 13.71 hrs, Volume= 224.077 af, Atten= 0%, Lag= 0.9 min

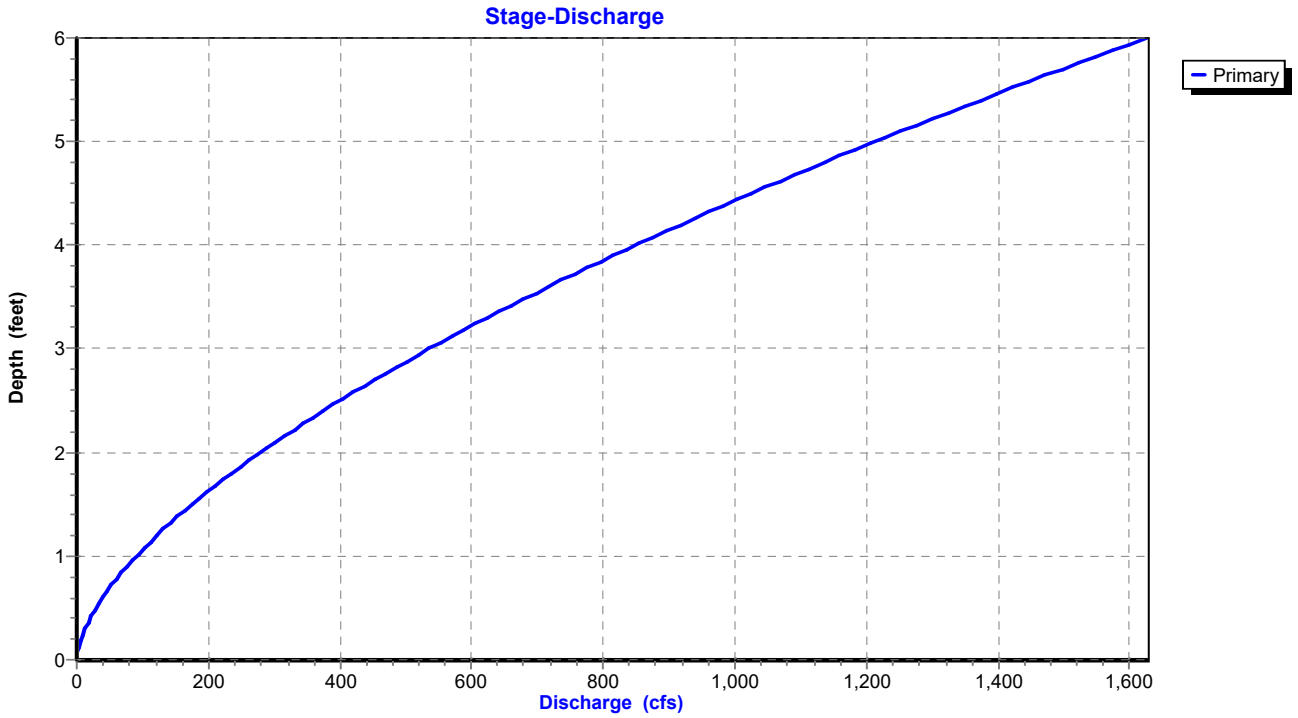
Routing by Sim-Route method, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Max. Velocity= 11.78 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 5.79 fps, Avg. Travel Time= 2.4 min

Peak Storage= 72,885 cf @ 13.71 hrs
Average Depth at Peak Storage= 4.46' , Surface Width= 21.46'
Bank-Full Depth= 6.00' Flow Area= 120.0 sf, Capacity= 1,625.88 cfs

17.00' x 6.00' deep channel, n= 0.035
Side Slope Z-value= 0.0 1.0 '/' Top Width= 23.00'
Length= 850.0' Slope= 0.0171 '/'
Inlet Invert= 329.54', Outlet Invert= 315.00'



Reach 5R: Natural Creek



Summary for Subcatchment 5S: Brook Watershed

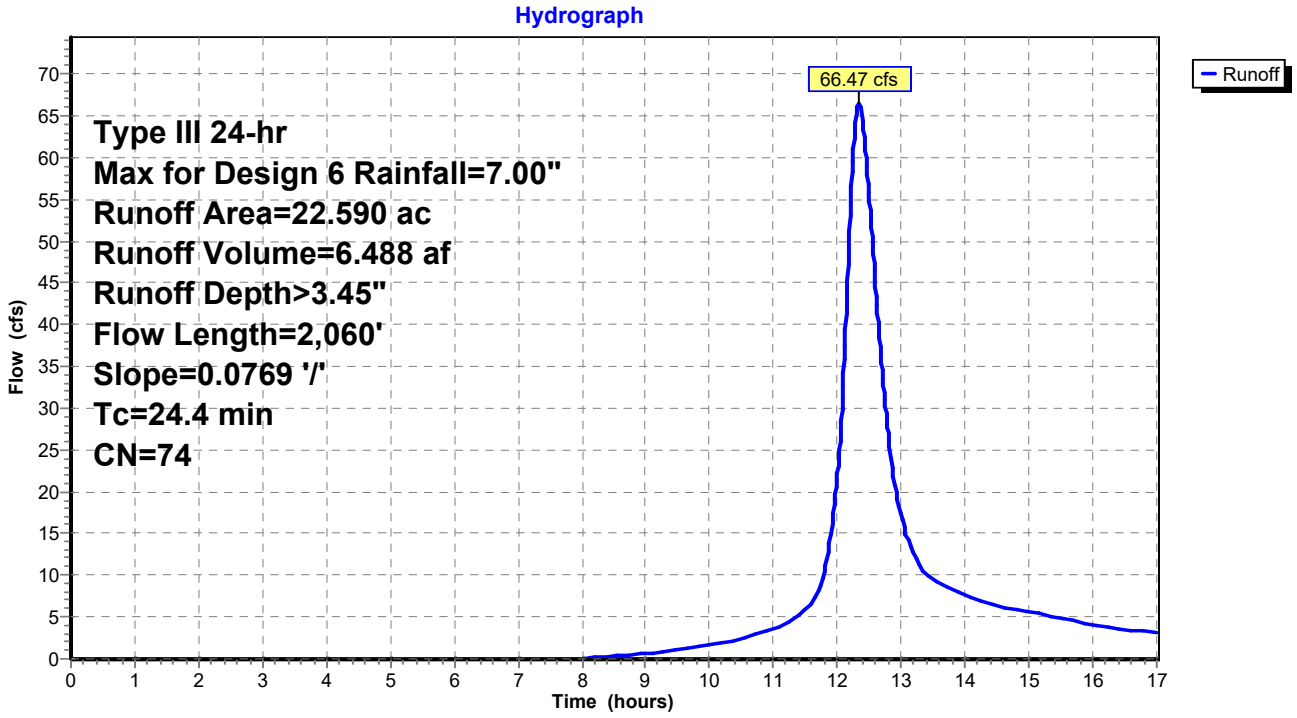
Runoff = 66.47 cfs @ 12.34 hrs, Volume= 6.488 af, Depth> 3.45"
Routed to Reach 5R : Natural Creek

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-17.00 hrs, dt= 0.01 hrs
Type III 24-hr Max for Design 6 Rainfall=7.00"

	Area (ac)	CN	Description
*	22.590	74	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.4	2,060	0.0769	1.41		**Lag/CN Method,**

Subcatchment 5S: Brook Watershed



APPENDIX B

COST ESTIMATES

NANNAHAGAN LAKE - OPTION 3 COST ESTIMATE					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**QUANTITY**	**UNIT PRICE**	**COST**
1	Walls around Channel	CY	65	$ 960.00	$ 62,400.00
2	Fencing at New Walls	LF	95	$ 100.00	$ 9,500.00
3	Restoration - Lawn	SY	35	$ 15.00	$ 525.00
	Sub-Total				**$ 72,425.00**
	Contingency			**20%**	**$ 14,485.00**
	Sub-Total				**$ 86,910.00**
	Soft Costs			**15%**	**$ 13,037.00**
	Total				**$ 99,947.00**
	Budget				**$ 100,000.00**

NANNAHAGAN LAKE - OPTION 4 COST ESTIMATE					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**QUANTITY**	**UNIT PRICE**	**COST**
1	Walls around Channel	CY	80	$ 960.00	$ 76,800.00
2	Fencing at New Walls	LF	95	$ 100.00	$ 9,500.00
3	36" Drain	LF	25	$ 200.00	$ 5,000.00
4	60" Drain	LF	15	$ 665.00	$ 9,975.00
5	72" Drain	LF	265	$ 700.00	$ 185,500.00
6	Manholes	EA	3	$ 15,000.00	$ 45,000.00
7	New Catch Basins in Parking Lot	EA	2	$ 15,000.00	$ 30,000.00
8	Headwall at Creek	CY	34	$ 960.00	$ 32,640.00
9	Restoration - Asphalt Walkway	SF	1,000	$ 9.00	$ 9,000.00
10	Restoration - Concrete Walkway	SF	1,050	$ 15.00	$ 15,750.00
11	Restoration - Lawn	SY	85	$ 15.00	$ 1,275.00
12	Restoration - Parking Lot	SF	1,550	$ 9.00	$ 13,950.00
	Sub-Total				**$ 434,390.00**
	Contingency			**20%**	**$ 86,878.00**
	Sub-Total				**$ 521,268.00**
	Soft Costs			**15%**	**$ 78,190.00**
	Total				**$ 599,458.00**
	Budget				**$ 600,000.00**

NANNAHAGAN LAKE - OPTION 5A COST ESTIMATE					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**QUANTITY**	**UNIT PRICE**	**COST**
1	Walls around Channel and New Weir	CY	125	$ 960.00	$ 120,000.00
2	Lower Existing Wall from 353 to 349 on South Side	CY	7	$ 500.00	$ 3,500.00
3	Additional Weir	CY	3	$ 960.00	$ 2,880.00
4	98"x63" Elliptical Pipe	LF	285	$ 1,000.00	$ 285,000.00
5	36" Drain	LF	25	$ 200.00	$ 5,000.00
6	Manholes	EA	3	$ 20,000.00	$ 60,000.00
7	New Catch Basins in Parking Lot	EA	2	$ 15,000.00	$ 30,000.00
8	Headwall at Creek	CY	40	$ 960.00	$ 38,400.00
9	Utility Relocation - Sewer	LF	82	$ 250.00	$ 20,500.00
10	Utility Relocation - Sewer Manhole	EA	2	$ 15,000.00	$ 30,000.00
11	Utility Relocation - Gas	LS	1	$ 1,500.00	$ 1,500.00
12	Utility Relocation - Drainage	LS	1	$ 5,000.00	$ 5,000.00
13	Restoration - Asphalt Walkway	SF	1,100	$ 9.00	$ 9,900.00
14	Restoration - Concrete Walkway	SF	1,010	$ 15.00	$ 15,150.00
15	Restoration - Lawn	SY	50	$ 15.00	$ 750.00
16	Restoration - Parking Lot	SF	1,900	$ 9.00	$ 17,100.00
	Sub-Total				**$ 644,680.00**
	Contingency			**20%**	**$ 128,936.00**
	Sub-Total				**$ 773,616.00**
	Soft Costs			**15%**	**$ 116,042.00**
	Total				**$ 889,658.00**
	Budget				**$ 890,000.00**

NANNAHAGAN LAKE - OPTION 5B COST ESTIMATE					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**QUANTITY**	**UNIT PRICE**	**COST**
1	Walls around Channel and New Weir	CY	125	$ 960.00	$ 120,000.00
2	Lower Existing Wall from 353 to 342 on South Side	CY	16	$ 500.00	$ 8,000.00
3	Additional Weir	CY	20	$ 960.00	$ 19,200.00
4	113"x72" Elliptical Pipe (or 7'x6' Box)	LF	285	$ 1,500.00	$ 427,500.00
5	36" Drain	LF	25	$ 200.00	$ 5,000.00
6	Manholes	EA	3	$ 20,000.00	$ 60,000.00
7	New Catch Basins in Parking Lot	EA	2	$ 15,000.00	$ 30,000.00
8	Headwall at Creek	CY	44	$ 960.00	$ 42,240.00
9	Utility Relocation - Sewer	LF	82	$ 250.00	$ 20,500.00
10	Utility Relocation - Sewer Manhole	EA	2	$ 15,000.00	$ 30,000.00
11	Utility Relocation - Gas	LS	1	$ 1,500.00	$ 1,500.00
12	Utility Relocation - Water	LS	1	$ 5,000.00	$ 5,000.00
13	Restoration - Asphalt Walkway	SF	1,100	$ 9.00	$ 9,900.00
14	Restoration - Concrete Walkway	SF	1,010	$ 15.00	$ 15,150.00
15	Restoration - Lawn	SY	55	$ 15.00	$ 825.00
16	Restoration - Parking Lot	SF	2,200	$ 9.00	$ 19,800.00
	Sub-Total				**$ 814,615.00**
	Contingency			**20%**	**$ 162,923.00**
	Sub-Total				**$ 977,538.00**
	Soft Costs			**15%**	**$ 146,631.00**
	Total				**$ 1,124,169.00**
	Budget				**$ 1,130,000.00**

NANNAHAGAN LAKE - OPTION 6 COST ESTIMATE					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**QUANTITY**	**UNIT PRICE**	**COST**
1	Walls around Channel and New Weir	CY	80	$ 960.00	$ 76,800.00
2	Wall at West Side of Walk	CY	20	$ 960.00	$ 19,200.00
3	Excavation for Culvert	CY	1,900	$ 50.00	$ 95,000.00
4	Allowance for Sheeting	LS	1	$ 5,000.00	$ 5,000.00
5	Gravel Below Culvert	CY	80	$ 75.00	$ 6,000.00
6	Concrete for Culvert Floor	CY	115	$ 500.00	$ 57,500.00
7	Gunite for Culvert	CY	85	$ 2,000.00	$ 170,000.00
8	Precast Top Slab for Culvert	SF	3,100	$ 25.00	$ 77,500.00
9	Backfill for Culvert	CY	1,000	$ 25.00	$ 25,000.00
10	Disposal of Excess Material	CY	900	$ 50.00	$ 45,000.00
11	Headwall	CY	44	$ 960.00	$ 42,240.00
12	Restoration - Asphalt Walkway	SF	300	$ 9.00	$ 2,700.00
	Sub-Total				**$ 621,940.00**
	Contingency			**20%**	**$ 124,388.00**
	Sub-Total				**$ 746,328.00**
	Soft Costs			**15%**	**$ 111,949.00**
	Total				**$ 858,277.00**
	Budget				**$ 860,000.00**