

PROPOSED CULVERT REPLACEMENT
Middleton Road Crossing Crooked Pond Stream
Boxford, MA

DRAINAGE ANALYSIS

November 13, 2015

Prepared for:

Noreast Chapter Trout Unlimited

Prepared By:

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SUMMARY

HYDRAULIC ANALYSIS

Middleton Road Crossing Crooked Pond Stream

Boxford, Ma.

Watershed Area: 0.41 square miles (262 acres)

Existing Conditions: Existing 24 inch corrugated metal culvert (CMP) was analyzed for a two year storm event, rainfall intensity 3.2 inches/hour for a 24 hour storm duration. Middleton Road was modeled as a broad crested weir. The immediate area upstream of the culvert was analyzed as a pond to take credit for the available storage up to the elevation of Middleton Road. The 24 inch culvert was analyzed as the outlet to the pond.

Results: Peak Elevation of water 105.80.

Low point on Middleton Road 105.39

Summary: Storm events with greater than 3 inches of rainfall in a 24 hour period will result in overtopping of Middleton Road.

Proposed Conditions: Replace 24 inch CMP with a precast reinforced concrete culvert with inside dimensions of 12 feet x 6 feet. Invert of culvert to be lined with river stone to a minimum depth of 18 inches. Average hydraulic height of culvert opening is 50 inches.

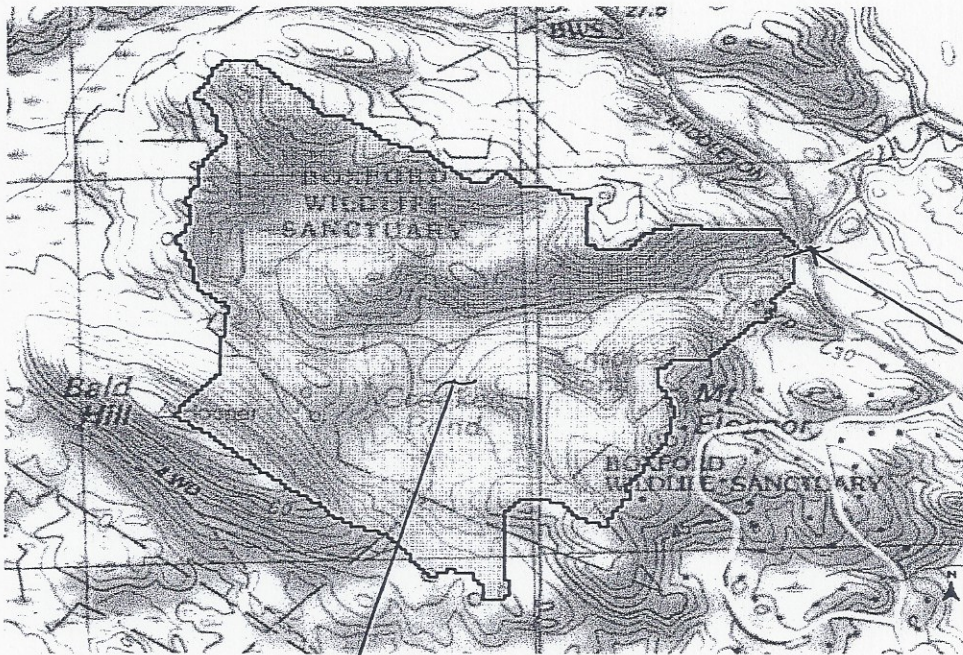
The design storm was taken as 50 years with a rainfall intensity of 7.0 inches in a 24 hour period.

Results: Peak Elevation of headwater upstream of Middleton Road 103.07 feet.

Low point of Middleton Road at this location 105.39. The two foot of free board allows a factor of safety for debris, braches of trees obstructing culvert opening during a 50 year storm event.

The 100 year storm with rainfall intensity was looked at also. The upstream peak water surface elevation was analyzed to be 105.44 which is close to the low point elevation of Middleton Road.

StreamStats Print Page



- Explanation**
- ▲ GlobalWatershedPoint
 - ◆ NHDHGage
 - ★ NHDHdam
 - huc_nel_Junctions
 - ▲ Gaging Station, Continuous Record
 - ▲ Low Flow, Partial Record
 - ▲ Peak Flow, Partial Record
 - ▲ Peak and Low Flow, Partial Record
 - ▲ Miscellaneous Record
 - ▲ Unknown
 - Dendritic Stream Network
 - streams
 - GlobalWatershed
 - ⊗ Excludopoly
 - hucpoly

24th CMP

8/15/2011 4:49:22 PM

WATERSHED 15 (262.0 ACRES)



Massachusetts StreamStats

Streamstats Ungaged Site Report

Date: Sat Jul 7 2012 09:12:48 Mountain Daylight Time

Site Location: Massachusetts

NAD27 Latitude: 42.6420 (42 38 31)

NAD27 Longitude: -70.9930 (-70 59 35)

NAD83 Latitude: 42.6421 (42 38 32)

NAD83 Longitude: -70.9925 (-70 59 33)

ReachCode: 01090001017604

Measure: 4.59

Drainage Area: 0.41 mi² = 262 ac

Low Flows Basin Characteristics			
100% Statewide Low Flow (0.41 mi ²)			
Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	0.41 (below min value 1.61)	1.61	149
Mean Basin Slope from 250K DEM (percent)	3.68	0.32	24.6
Stratified Drift per Stream Length (square mile per mile)	0	0	1.29
Massachusetts Region (dimensionless)	0	0	1

Warning: Some parameters are outside the suggested range. Estimates will be extrapolations with unknown errors.

Probability of Perennial Flow Basin Characteristics			
100% Perennial Flow Probability (0.41 mi ²)			
Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	0.41	0.01	1.99
Percent Underlain By Sand And Gravel (percent)	0.00	0	100
Percent Forest (percent)	89.65	0	100
Massachusetts Region (dimensionless)	0	0	1

1 sq mi = 640 ac

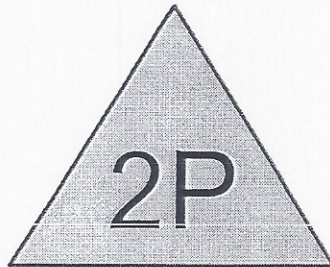
Low Flows Streamflow Statistics					
Statistic	Flow (ft ³ /s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
D50	0.38				
D60	0.23				
D70	0.1				
D75	0.0719				
D80	0.0512				
D85	0.0349				
D90	0.0218				
D95	0.0115				
D98	0.00676				
D99	0.00453				
M7D2Y	0.0125				
AUGD50	0.0361				
M7D10Y	0.00364				

The equation for estimating the probability of perennial flow is applicable for most areas of Massachusetts except eastern Buzzards Bay, Cape Cod, and the Island regions. The estimate obtained from the equation assumes natural flow conditions at the site. The equation also is best used for sites with drainage areas between 0.01 to 1.99 mi², as errors beyond for basins beyond these bounds are unknown.

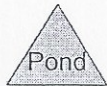
Probability of Perennial Flow Statistics		
Statistic	Value	Standard Error (percent)



Existing Watershed



Storage Upstream of
Existing 24 Inch Culvert



Middleton Road Culvert-Existing Conditions

Type II 24-hr 2 Year Rainfall=3.20"

Prepared by Microsoft

Printed 11/13/2015

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Page 1

Summary for Pond 2P: Storage Upstream of Existing 24 Inch Culvert

Inflow Area = 262.000 ac, 2.14% Impervious, Inflow Depth > 0.95" for 2 Year event
 Inflow = 106.23 cfs @ 13.07 hrs, Volume= 20.717 af
 Outflow = 106.20 cfs @ 13.08 hrs, Volume= 20.630 af, Atten= 0%, Lag= 1.0 min
 Primary = 38.01 cfs @ 13.08 hrs, Volume= 15.099 af
 Secondary = 68.19 cfs @ 13.08 hrs, Volume= 5.530 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Peak Elev= 105.80' @ 13.08 hrs Surf.Area= 0.344 ac Storage= 1.337 af

Plug-Flow detention time= 12.7 min calculated for 20.561 af (99% of inflow)
 Center-of-Mass det. time= 11.3 min (878.4 - 867.1)

Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	1.844 af	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
97.00	0.036	0.000	0.000
105.00	0.240	1.104	1.104
107.00	0.500	0.740	1.844

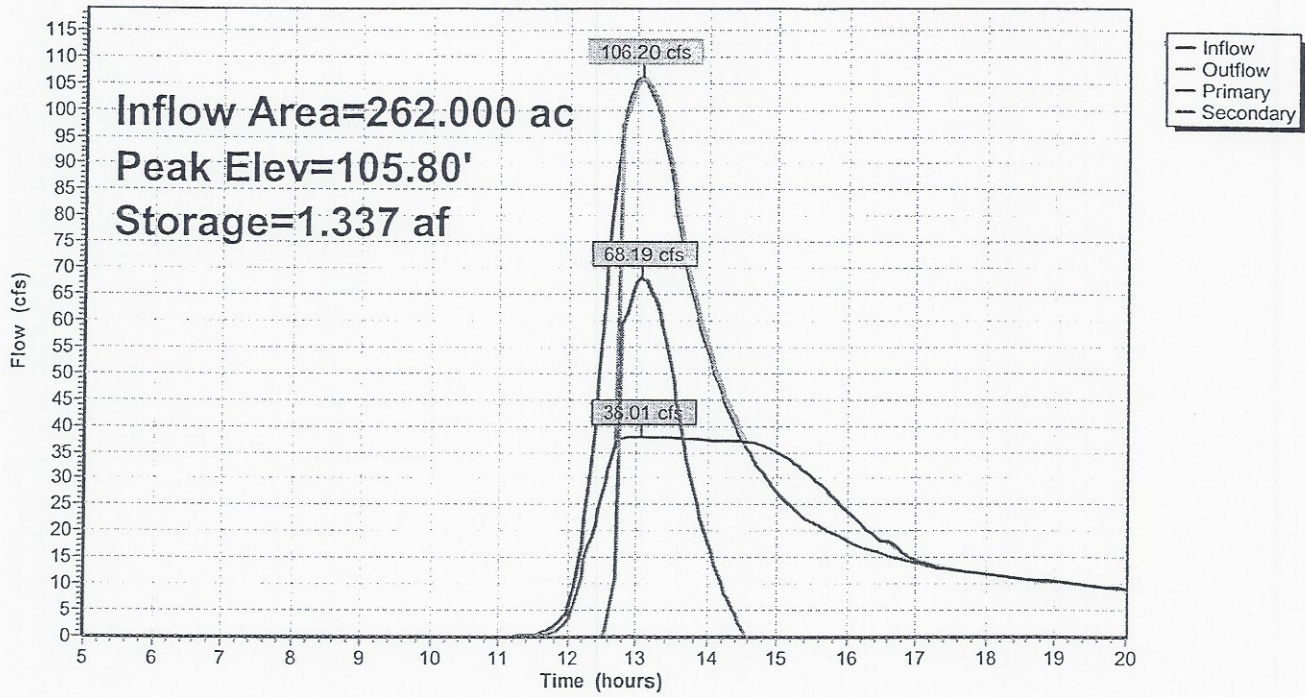
Device	Routing	Invert	Outlet Devices
#1	Primary	97.10'	24.0" Round Culvert L= 64.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 97.10' / 96.10' S= 0.0156 '/ Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior
#2	Secondary	105.40'	100.0' long x 30.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

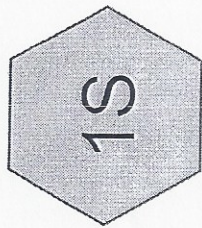
Primary OutFlow Max=38.01 cfs @ 13.08 hrs HW=105.80' (Free Discharge)
 ↑1=Culvert (Barrel Controls 38.01 cfs @ 12.10 fps)

Secondary OutFlow Max=68.06 cfs @ 13.08 hrs HW=105.80' (Free Discharge)
 ↑2=Broad-Crested Rectangular Weir (Weir Controls 68.06 cfs @ 1.71 fps)

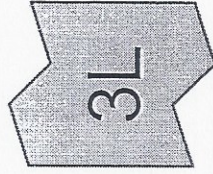
Pond 2P: Storage Upstream of Existing 24 Inch Culvert

Hydrograph

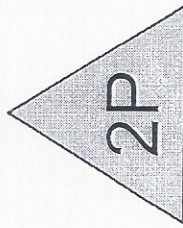




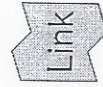
Existing Crooked Pond
Watershed



PROPOSED CULVERT
144" (12 feet wide) x
72" (6 feet) Inside
Dimension. Stone
Paved Invert Min. 18
inches.



Storage Area Upstream
of Culvert at Middleton



Middleton Road Culvert Replacement, Boxford, MA

Prepared by Microsoft

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Page 1

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
262.000	Other	1S
262.000		TOTAL AREA

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Crooked Runoff Area=262.000 ac 2.14% Impervious Runoff Depth=3.77"
Flow Length=6,376' Slope=0.0337 ' /' Tc=88.5 min CN=75 Runoff=391.02 cfs 82.264 af

Pond 2P: Storage Area Upstream of Peak Elev=103.07' Storage=0.688 af Inflow=391.02 cfs 82.264 af
Outflow=390.84 cfs 82.150 af

Link 3L: PROPOSED CULVERT 144" (12 feet wide) x 72" (6 feet) Inside Inflow=390.84 cfs 82.150 af
Primary=390.84 cfs 82.150 af

Total Runoff Area = 262.000 ac Runoff Volume = 82.264 af Average Runoff Depth = 3.77"
97.86% Pervious = 256.400 ac 2.14% Impervious = 5.600 ac

Summary for Subcatchment 1S: Existing Crooked Pond Watershed

Runoff = 391.02 cfs @ 13.18 hrs, Volume= 82.264 af, Depth> 3.77"

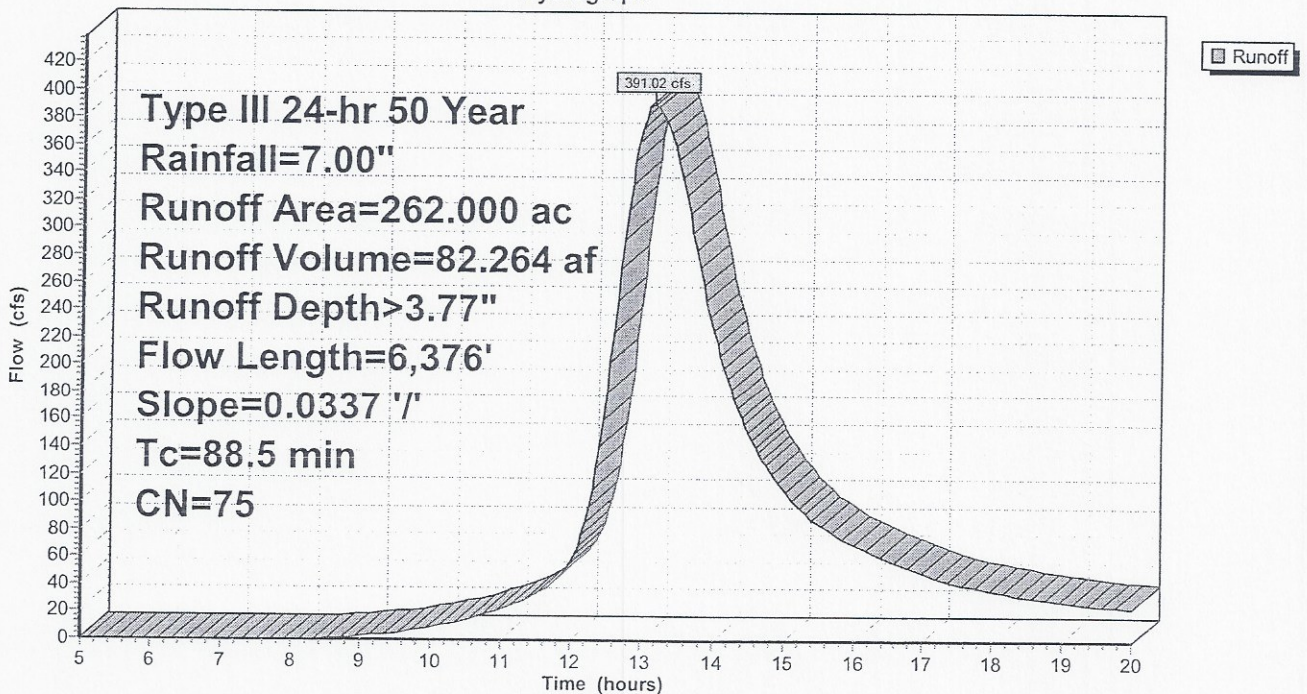
Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 50 Year Rainfall=7.00"

Area (ac)	CN	Description
* 145.000	83	Woods.Poor. Rock Outcrop. Hyd.Soils Gr. D
* 36.900	70	Woods. Good. Hyd.Soils Gr. C
* 59.800	55	Woods. Good. Hyd.Soils Gr. B
* 5.600	98	Water Surface
* 14.700	90	Muck. Hyd. Soil Gr.A/D
262.000	75	Weighted Average
256.400		97.86% Pervious Area
5.600		2.14% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
88.5	6,376	0.0337	1.20		Lag/CN Method,

Subcatchment 1S: Existing Crooked Pond Watershed

Hydrograph



Summary for Pond 2P: Storage Area Upstream of Culvert at Middleton

Inflow Area = 262.000 ac, 2.14% Impervious, Inflow Depth > 3.77" for 50 Year event
 Inflow = 391.02 cfs @ 13.18 hrs, Volume= 82.264 af
 Outflow = 390.84 cfs @ 13.20 hrs, Volume= 82.150 af, Atten= 0%, Lag= 1.2 min
 Primary = 390.84 cfs @ 13.20 hrs, Volume= 82.150 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Peak Elev= 103.07' @ 13.20 hrs Surf.Area= 0.191 ac Storage= 0.688 af

Plug-Flow detention time= 1.7 min calculated for 81.877 af (100% of inflow)
 Center-of-Mass det. time= 1.2 min (851.5 - 850.3)

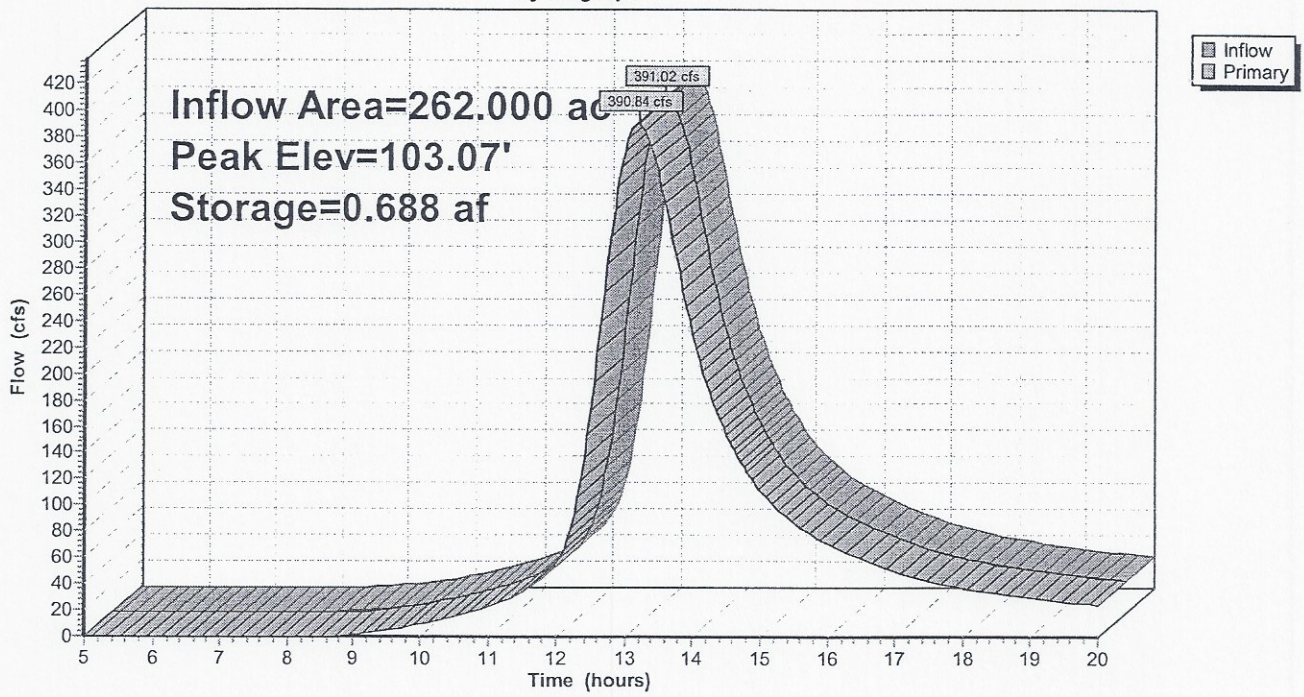
Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	1.844 af	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
97.00	0.036	0.000	0.000
105.00	0.240	1.104	1.104
107.00	0.500	0.740	1.844

Device	Routing	Invert	Outlet Devices
#1	Primary	98.14'	144.0" W x 50.0" H Box Concrete Box Culvert (12'x 6'). Avg. Hyd.Hgt 50" L= 86.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 98.14' / 95.95' S= 0.0255 ' / Cc= 0.900 n= 0.040
#2	Primary	105.00'	50.0' long x 30.0' breadth Middleton Road Overtopping Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=390.79 cfs @ 13.20 hrs HW=103.07' (Free Discharge)
 1=Concrete Box Culvert (12'x 6'). Avg. Hyd.Hgt 50" (Barrel Controls 390.79 cfs @ 8.81 fps)
 2=Middleton Road Overtopping (Controls 0.00 cfs)

Pond 2P: Storage Area Upstream of Culvert at Middleton

Hydrograph

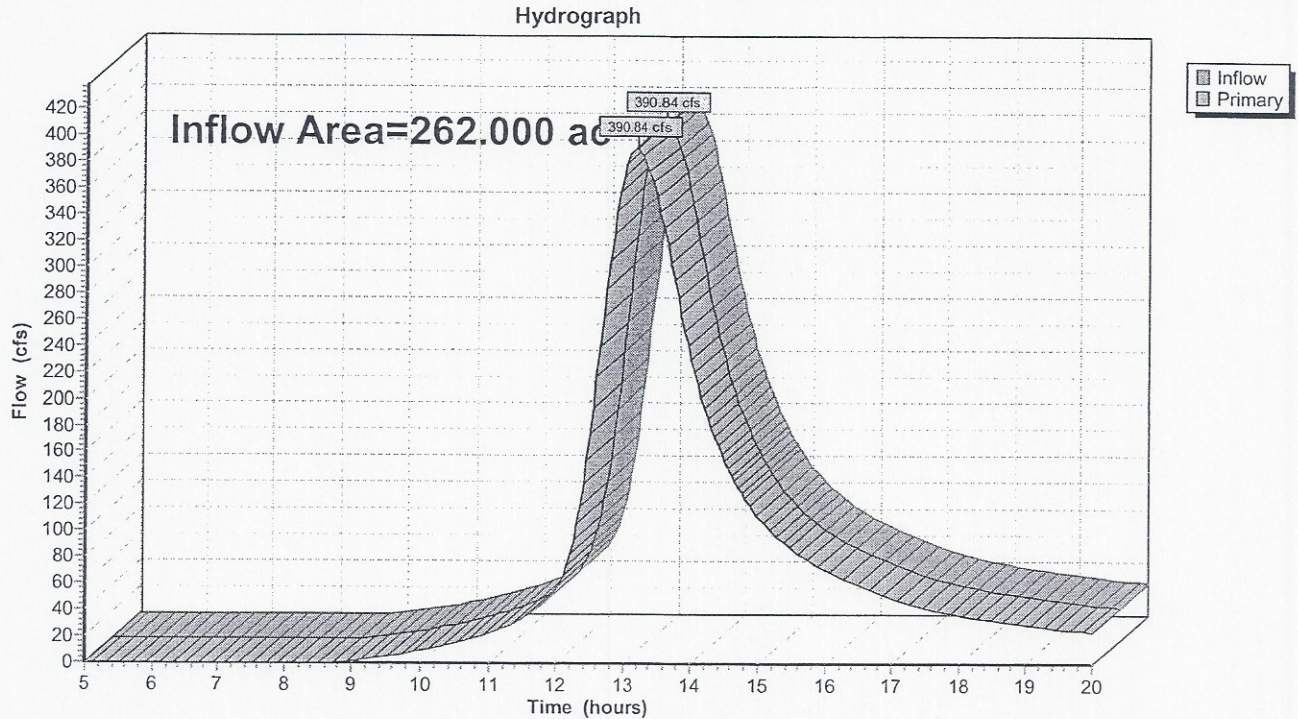


nk 3L: PROPOSED CULVERT 144" (12 feet wide) x 72" (6 feet) Inside Dimension. Stone Paved Invert

Inflow Area = 262.000 ac, 2.14% Impervious, Inflow Depth > 3.76" for 50 Year event
Inflow = 390.84 cfs @ 13.20 hrs, Volume= 82.150 af
Primary = 390.84 cfs @ 13.20 hrs, Volume= 82.150 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

PROPOSED CULVERT 144" (12 feet wide) x 72" (6 feet) Inside Dimension. Stone Paved Invert Min. 1'



Middleton Road Culvert Replacement *Type III 24-hr 100 Year Storm Frequency Rainfall=8.50"*

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Page 7

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Crooked Runoff Area=262.000 ac 2.14% Impervious Runoff Depth>5.02"
Flow Length=6,376' Slope=0.0337 '/ Tc=88.5 min CN=75 Runoff=517.32 cfs 109.499 af

Pond 2P: Storage Area Upstream of Peak Elev=105.44' Storage=1.222 af Inflow=517.32 cfs 109.499 af
Outflow=517.19 cfs 109.375 af

Link 3L: PROPOSED CULVERT 144" (12 feet wide) x 72" (6 feet) Inside Inflow=517.19 cfs 109.375 af
Primary=517.19 cfs 109.375 af

Total Runoff Area = 262.000 ac Runoff Volume = 109.499 af Average Runoff Depth = 5.02"
97.86% Pervious = 256.400 ac 2.14% Impervious = 5.600 ac

Summary for Subcatchment 1S: Existing Crooked Pond Watershed

Runoff = 517.32 cfs @ 13.17 hrs, Volume= 109.499 af, Depth> 5.02"

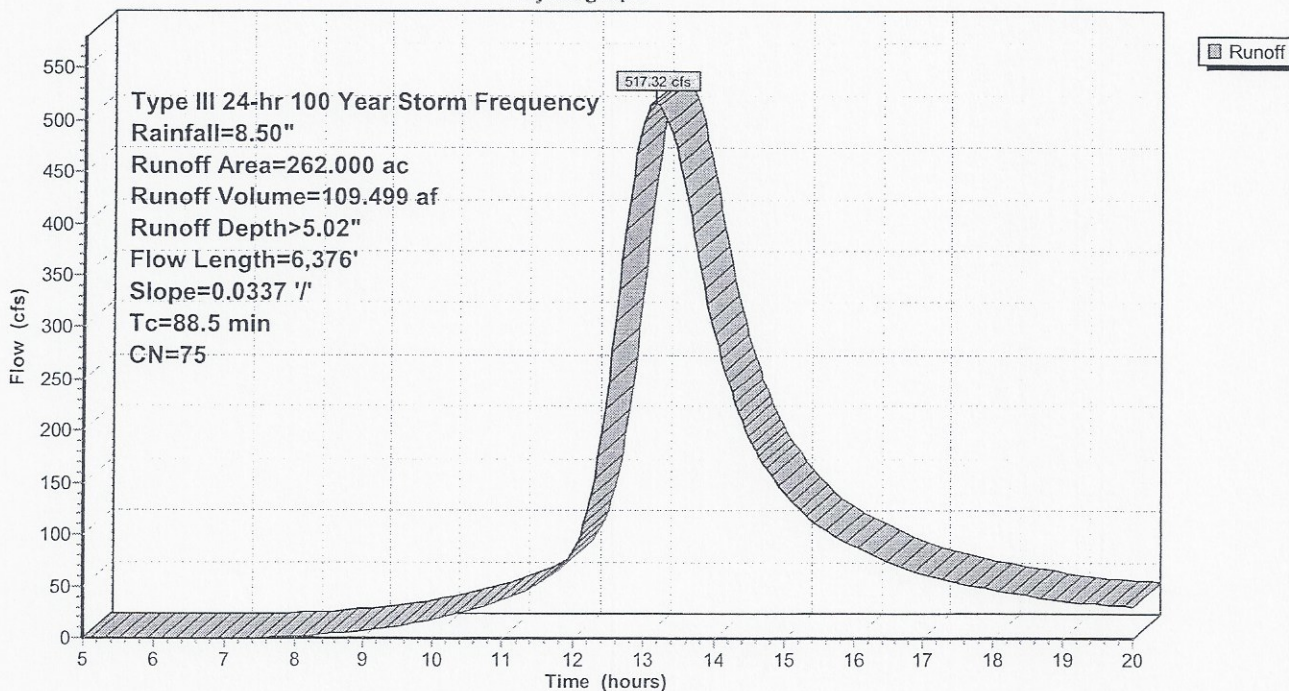
Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Type III 24-hr 100 Year Storm Frequency Rainfall=8.50"

Area (ac)	CN	Description
* 145.000	83	Woods.Poor. Rock Outcrop. Hyd.Soils Gr. D
* 36.900	70	Woods. Good. Hyd.Soils Gr. C
* 59.800	55	Woods. Good. Hyd.Soils Gr. B
* 5.600	98	Water Surface
* 14.700	90	Muck. Hyd. Soil Gr.A/D
262.000	75	Weighted Average
256.400		97.86% Pervious Area
5.600		2.14% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
88.5	6,376	0.0337	1.20		Lag/CN Method,

Subcatchment 1S: Existing Crooked Pond Watershed

Hydrograph



Summary for Pond 2P: Storage Area Upstream of Culvert at Middleton

Inflow Area = 262.000 ac, 2.14% Impervious, Inflow Depth > 5.02" for 100 Year Storm Frequency event
 Inflow = 517.32 cfs @ 13.17 hrs, Volume= 109.499 af
 Outflow = 517.19 cfs @ 13.18 hrs, Volume= 109.375 af, Atten= 0%, Lag= 1.0 min
 Primary = 517.19 cfs @ 13.18 hrs, Volume= 109.375 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Peak Elev= 105.44' @ 13.18 hrs Surf.Area= 0.297 ac Storage= 1.222 af

Plug-Flow detention time= 1.7 min calculated for 109.375 af (100% of inflow)
 Center-of-Mass det. time= 1.4 min (845.4 - 844.1)

Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	1.844 af	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
97.00	0.036	0.000	0.000
105.00	0.240	1.104	1.104
107.00	0.500	0.740	1.844

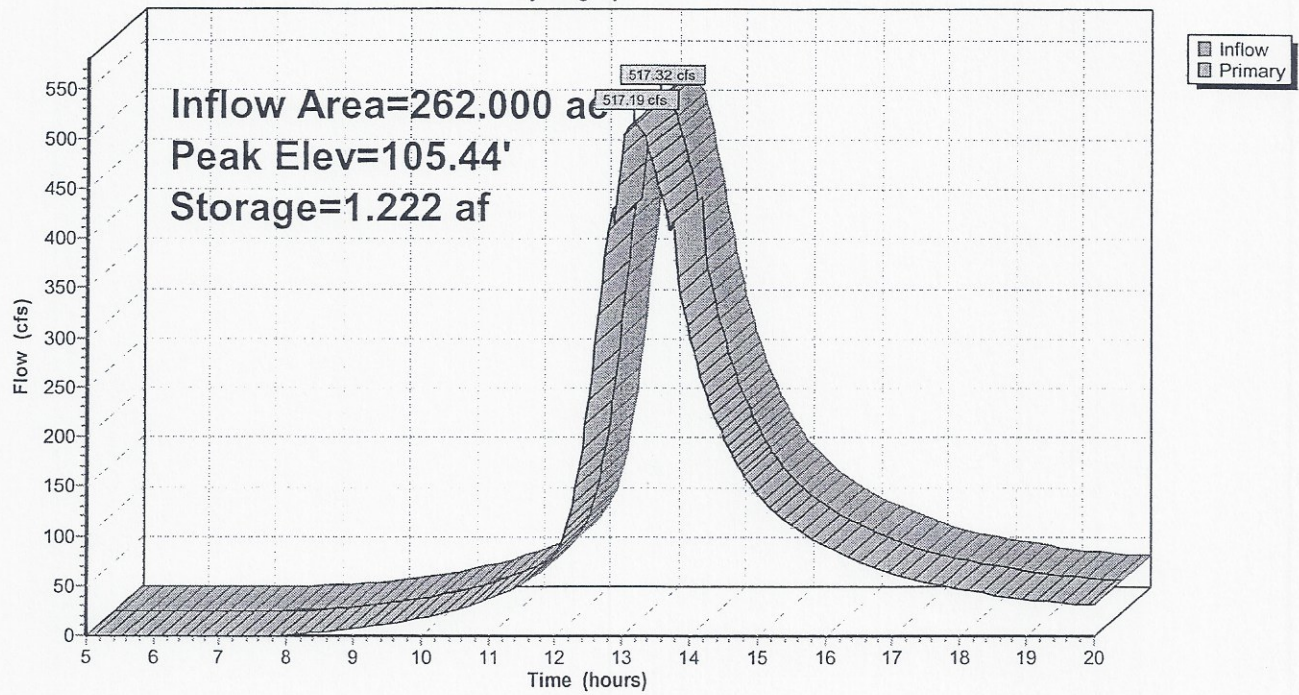
Device	Routing	Invert	Outlet Devices
#1	Primary	98.14'	144.0" W x 50.0" H Box Concrete Box Culvert (12'x 6'). Avg. Hyd.Hgt 50" L= 86.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 98.14' / 95.95' S= 0.0255 '/' Cc= 0.900 n= 0.040
#2	Primary	105.00'	50.0' long x 30.0' breadth Middleton Road Overtopping Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=516.79 cfs @ 13.18 hrs HW=105.44' (Free Discharge)

- └─1=Concrete Box Culvert (12'x 6'). Avg. Hyd.Hgt 50" (Barrel Controls 477.77 cfs @ 9.56 fps)
- └─2=Middleton Road Overtopping (Weir Controls 39.03 cfs @ 1.79 fps)

Pond 2P: Storage Area Upstream of Culvert at Middleton

Hydrograph



nk 3L: PROPOSED CULVERT 144" (12 feet wide) x 72" (6 feet) Inside Dimension. Stone Paved Invert

Inflow Area = 262.000 ac, 2.14% Impervious, Inflow Depth > 5.01" for 100 Year Storm Frequency event
 Inflow = 517.19 cfs @ 13.18 hrs, Volume= 109.375 af
 Primary = 517.19 cfs @ 13.18 hrs, Volume= 109.375 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

PROPOSED CULVERT 144" (12 feet wide) x 72" (6 feet) Inside Dimension. Stone Paved Invert Min. 18"

Hydrograph

