

HYDROLOGY REPORT

Flood Brook Bridge (#2288) carries Route 6 (Lakeview Road) over Flood Brook. The Flood Brook watershed extends south from the bridge location. The basin begins near Upper Flood Lake in Talmadge and extends West into Kossuth Township. Flood Brook flows from Upper Flood Lake into Flood Lake approximately 1500 feet downstream. From Flood Lake, Flood Brook Flows north through the bridge location, ending at the East Musquash Lake.

The drainage basin characteristics for this bridge were provided by the MaineDOT Environmental Office, Hydrology Section. Peak flows are calculated using USGS regression equations. No other flow data is available.

SUMMARY

Drainage Area	4.55	mi ²
April Avg. Flow	18.12	ft ³ /s
August Avg. Flow	0.83	ft ³ /s
Ordinary High (Q1.1)	77.9	ft ³ /s
10-year flood (Q10)	323.4	ft ³ /s
25-year flood (Q25)	424.4	ft ³ /s
Design Discharge (Q50)	496.2	ft ³ /s
Check Discharge (Q100)	581.2	ft ³ /s
Scour Discharge (Q500)	785.0	ft ³ /s

Reported by: Bartlett, Benjamin J

Date: April 20, 2018

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

HYDRAULIC REPORT

EXISTING CULVERT

The existing culvert was analyzed using the HY-8 program version 7.30. There are no nearby structures to affect the tailwater. Flood Brook flows into the East Musquash Lake approximately a quarter mile downstream of the bridge location. Per the Federal Insurance Administration's Flood Hazard Boundary Map of 1975, the flood hazard zone for East Musquash Lake extends all the way to the downstream side of the bridge. This indicates that during large flood events, the lake water levels may affect the tailwater conditions. However, with no other flow data besides what was provided from the regression equations, it was assumed that the lake provided no effect to the tailwater. The tailwater conditions are modeled as an irregular channel located just downstream from the outlet of the culvert. Based on topographic maps and survey, the stream slope is approximately 0.0144 ft/ft, or 1.44%.

Using the flows calculated by the MaineDOT Environmental Office and the dimensions of the culvert, the headwater to culvert depth ratio (Hw/D) was calculated at Q50 and Q100. These values are 0.87 for Q50 and 0.96 for Q100. The Q50 value is below the 0.9 that is required per the Bridge Design Guide (BDG), while the Q100 value is just above. At Q100, the freeboard to the edge of the shoulder is 6.75', almost 7 times the 1' minimum required in the BDG. The analysis for the existing bridge shows the road overtopping around 1011 cfs, which is 225 cfs greater than Q500. Based on inspection photos and site visits, the typical water depth inside the culvert is only a few inches.

Bankfull width was determined by the MaineDOT Environmental staff to be 17', making 1.2 times bankfull width equal to approximately 20'.

REHABILITATION WITH INVERT LINING

The first alternative that was analyzed is a concrete invert lining. This alternative was modeled as the existing culvert but with a 5" thick invert lining that extended up the sides to 6" below the vertical centerline. The invert lining was modeled as concrete, and no internal weirs or baffles were included in the analysis. The same downstream cross section was used as the existing culvert.

Just like the existing culvert, the Hw/D ratio was calculated for Q50 and Q100 flows. These values are 0.85 for Q50 and 0.96 for Q100. These values are slightly higher than those for the existing culvert. At Q100, the freeboard to the edge of the shoulder is just under 7', which is well above the 1' minimum required in the BDG. The analysis for the proposed invert lining shows that the road overtops around 952 cfs, which is just under 200 cfs higher than the Q500 flow. This is also approximately 50 cfs lower than with the existing bridge.

REPLACEMENT WITH 1.2 BANKFULL WIDTH BOX CULVERT

The second alternative that was analyzed is a precast concrete box culvert. For environmental purposes, the box was modeled with banks on each side of the box that have a 1.5' wide top width. The banks taper down towards the middle of the box at a 1:1 slope. In between the two slopes will be 2' of special fill, which was modeled by embedding the culvert 2'. The tailwater was modeled using roughly the same irregular channel used to evaluate the existing culvert and the invert lining. The middle of the channel was modified to reflect filling the scour hole with a riprap apron. The top of the special fill layer was set to the same elevations as the existing invert elevations, making the proposed invert elevations 373.89' for the inlet and 372.45' for the outlet. This puts the culvert at a slope of approximately 0.87%. The Hw/D for Q50 is 0.78, which is below the 0.9 required in the BDG. At Q100, the Hw/D is 0.88.

SUMMARY

		Existing Structure	Recommended Structure	Precast Box Culvert 20' x 8'
		10' Vertical Ellipse	Invert Lining	
Total Area of Waterway Opening	ft ²	79.66	73.84	112.8
Headwater elevation @ Q _{1.1} **	ft	379.19	379.23	377.37
Headwater elevation @ Q ₁₀	ft	383.03	382.72	379.41
Headwater elevation @ Q ₂₅ **	ft	384.25	384.04	380.10
Headwater elevation @ Q ₅₀	ft	385.09	384.95	380.59
Headwater elevation @ Q ₁₀₀	ft	386.05	386.02	381.15
Headwater elevation @ Q ₅₀₀	ft	388.47	389.42	382.68
Hw/D @ Q ₅₀	ft	0.87	0.85	0.78
Hw/D @ Q ₁₀₀	ft	0.96	0.96	0.88
Outlet Velocity @ Q _{1.1}	ft/s	6.94	10.32	7.97
Outlet Velocity @ Q ₁₀	ft/s	10.41	14.61	11.85
Outlet Velocity @ Q ₂₅ **	ft/s	11.27	15.27	12.92
Outlet Velocity @ Q ₅₀	ft/s	11.9	15.95	13.50
Outlet Velocity @ Q ₁₀₀	ft/s	12.64	16.61	14.09
Outlet Velocity @ Q ₅₀₀	ft/s	14.18	18.02	15.26

Reported by: Bartlett, Benjamin J

Date: April 3, 2018

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

Appendix E

Hydraulics Data

WIN: 21753.00
 Town: Topsfield
 Route No. ME 6
 Asset ID: 2288
 Lat: 45.4029 Long: -67.8123

Project Name: Topsfield Flood Brook Bridge
 Stream Name: Flood Brook
 Bridge Name: Flood Brook Bridge
 Analysis by: CSH
 Date: 12/29/2016

Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

	km ²	mi ²	ac
A	11.78	4.55	2912.0
W	0.99	0.4	245.2
P _c	592316	5026051	
County	Washington		
pptA	44.2		
SG	0.00		

Enter data in [mi²]

Watershed Area *DRNAREA*

Wetlands area (by NWI)

watershed centroid (E, N; UTM 19N; meters)

choose county from drop-down menu

mean annual precipitation (inches; by look-up)

sand & gravel aquifer as decimal fraction of watershed A

Worksheet prepared by:

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 Maine Dept. Transportation
 Augusta, ME 04333-0016
 207-557-1052
Charles.Hebson@maine.gov
 ver. 2016 Feb 05

A (km ²)	11.78	Conf Lvl	0.67
W (%)	8.42		

NWI Wetlands % *STORNWI*

References:

Hodgkins, G.A., 1999.
 Estimating the magnitude of peak flows for streams
 in Maine for selected recurrence intervals
WRIR 99-4008, USGS Augusta, ME

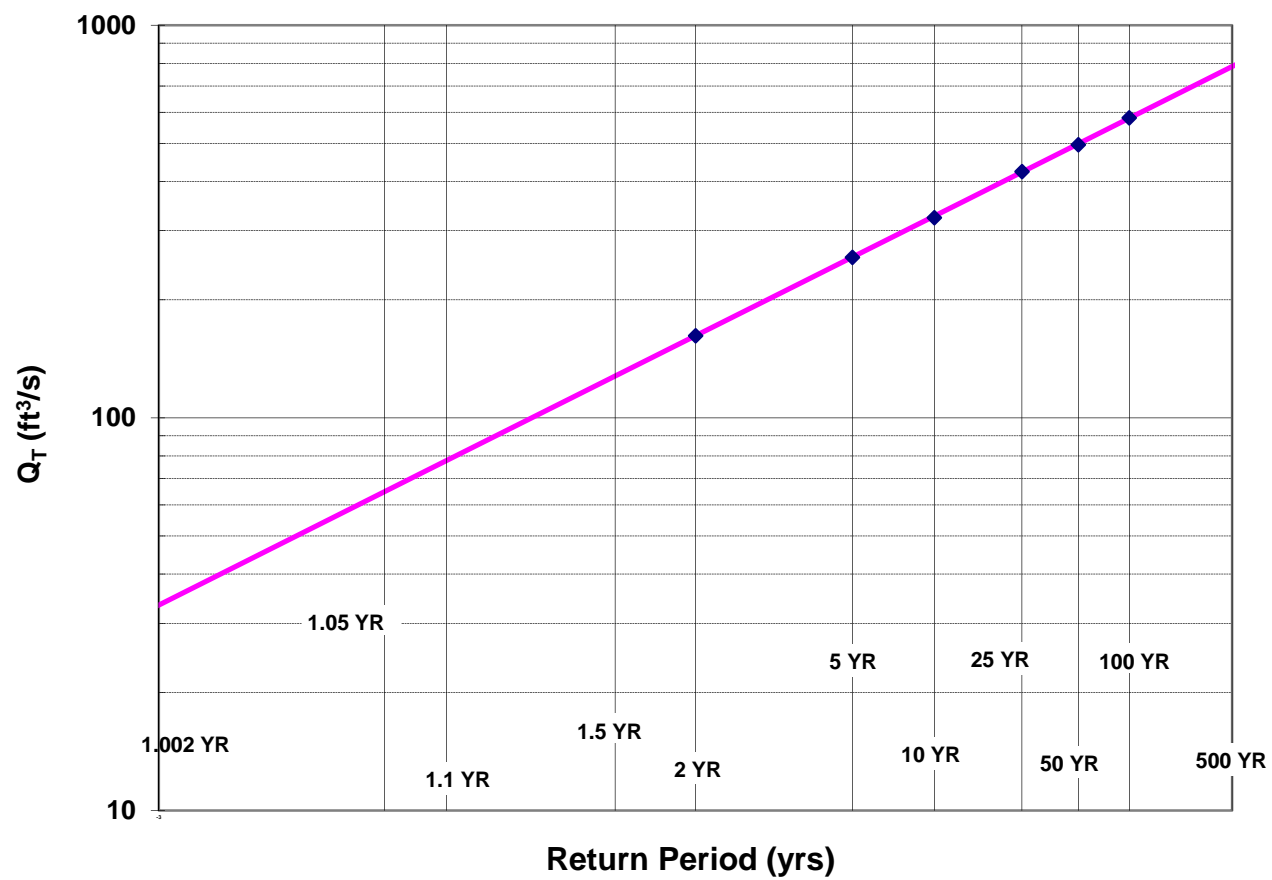
Lombard, P.J. & G.A. Hodgkins, 2015.
 Peak flow regression equations for small, ungaged streams in
 Maine - Comparing map-based to field-based variables
SIR 2015-4059, USGS, Augusta, ME

$$Q_T = b \times A^a \times 10^{-ww}$$

Ret Pd	Peak Flow Estimate		
T (yr)	Lower	Q _T (m ³ /s)	Upper
1.1		2.21	
2		4.59	
5		7.26	
10		9.16	
25		12.02	
50		14.05	
100		16.46	
500		22.23	

Q _T (ft ³ /s)
77.9
161.9
256.4
323.4
424.4
496.2
581.2
785.0

Log-Normal Probability Plot



WIN: 21753.00
 Town: Topsfield
 Route No. ME 6
 Asset ID: 2288
 Lat: 45.40290 Long: -67.8123

Project Name: Topsfield Flood Brook Bridge
 Stream Name: Flood Brook
 Bridge Name: Flood Brook Bridge
 Analysis by: CSH
 Date: 12/29/2016

DO NOT ENTER ANY DATA ON THIS PAGE; EVERYTHING IS CALCULATED

MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004)

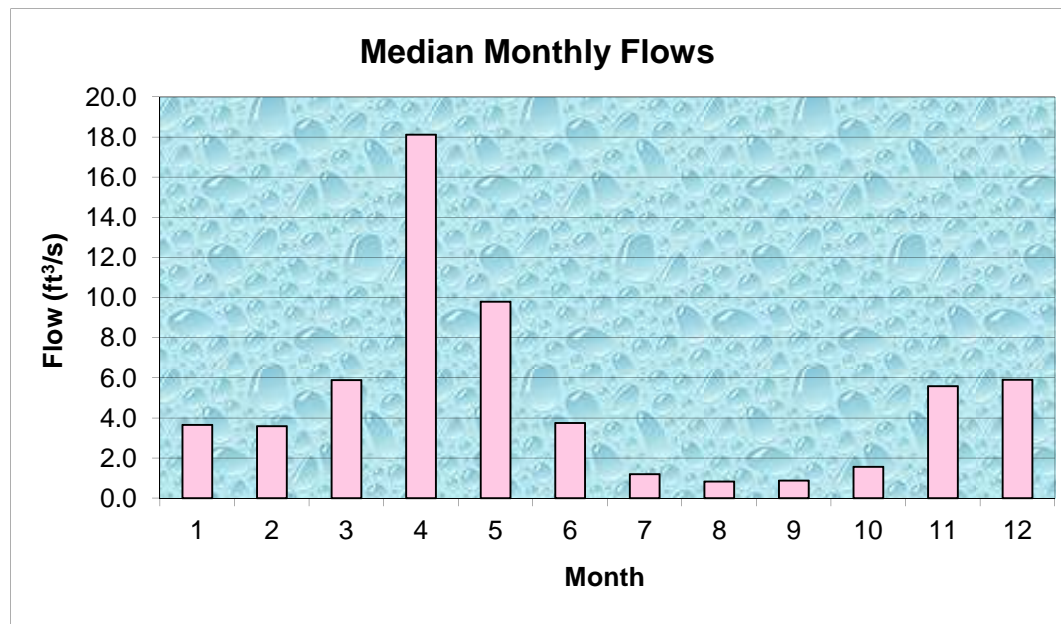
Value	Variable	Explanation
4.55	A	Area (mi ²)
592315.8	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
76.52	$DIST$	Distance from Coastal reference line (mi)
44.2	$pptA$	Mean Annual Precipitation (inches)
0.00	SG	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft ³ /s)	(m ³ /s)
Jan	3.65	0.1035
Feb	3.59	0.1018
Mar	5.89	0.1669
Apr	18.12	0.5136
May	9.79	0.2774
Jun	3.75	0.1062
Jul	1.20	0.0339
Aug	0.83	0.0235
Sep	0.89	0.0251
Oct	1.56	0.0443
Nov	5.59	0.1585
Dec	5.90	0.1672

Q_{bf}	25.5
ann avg	9.3
ann med	4.7
$Q_{1.002}$	33.4
$Q_{1.01}$	45.1
$Q_{1.05}$	64.8
Q_{bf}	67.1

assume $v = 4\text{ft/s}$

W_{bf}	16.9	estimated bankfull width (ft)
d_{bf}	1.0	estimated bankfull depth (ft)
A_{bf}	16.7	estimated bankfull flow area (ft ²)



References

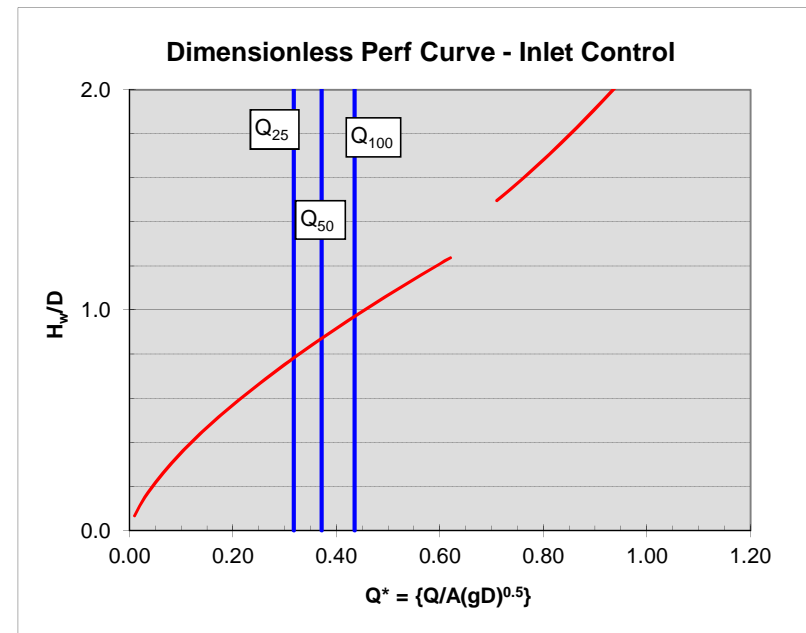
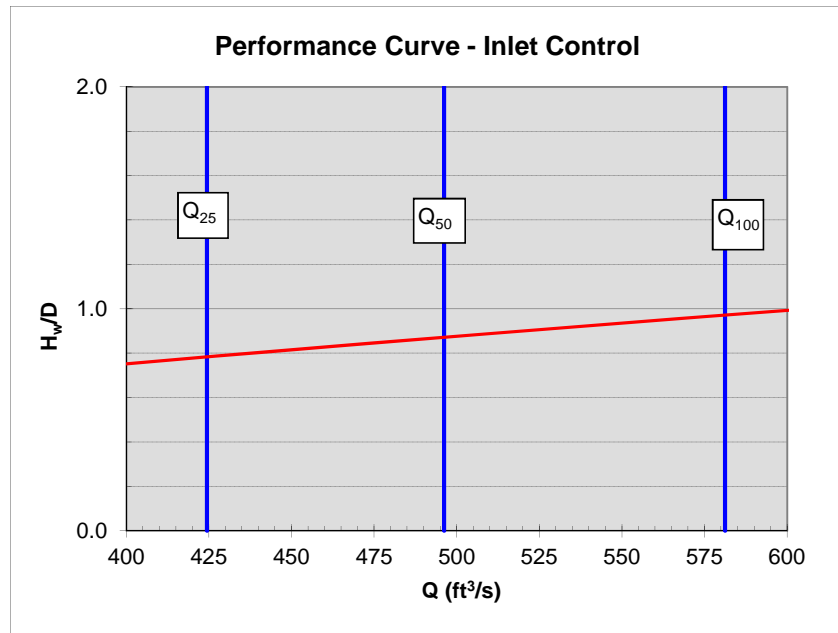
Dudley, R.W., 2004. Hydraulic Geometry Relations ..., SIR 2004-5042
 Dudley, R.W., 2004. Estimating Monthly Streamflows ... , SIR 2004-5026

NOTE: This page is for preliminary sizing only.
Final design should be done with HY8 or HDS-5

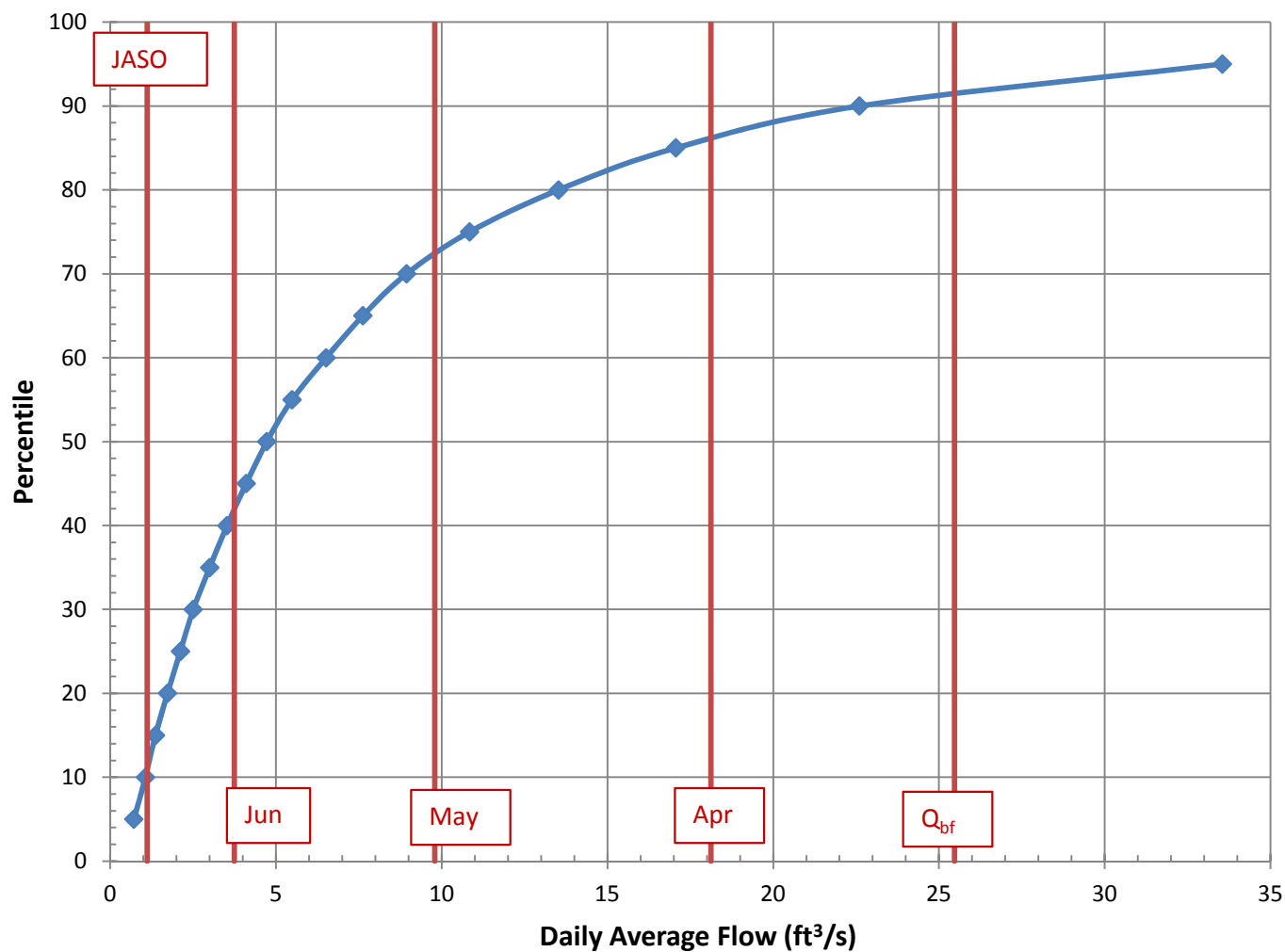
Preliminary Culvert Sizing - Round & Box Culverts

Shape:	Box			
Type:	Box 0 ww			
D or R (ft)	6	Q_{25}	424.4	trial D / R = 9.9 trial w: BFW = 16.9
w (ft)	16 box width	Q_{50}	496.2	
Slope (ft/ft)	0.02	Q_{100}	581.2	
A (ft ²)	96.00			
g (ft/s ²)	32.2			

Note: culvert dimensions are for open flow area; adjust for lost capacity due to embedding / backfilling (min {2' / 25% rise} embedment)



Daily Average Flow Distribution



Daily Avg Flow Dist

$A_{ws} = (mi^2)$ 4.6

Q (ft³/s)

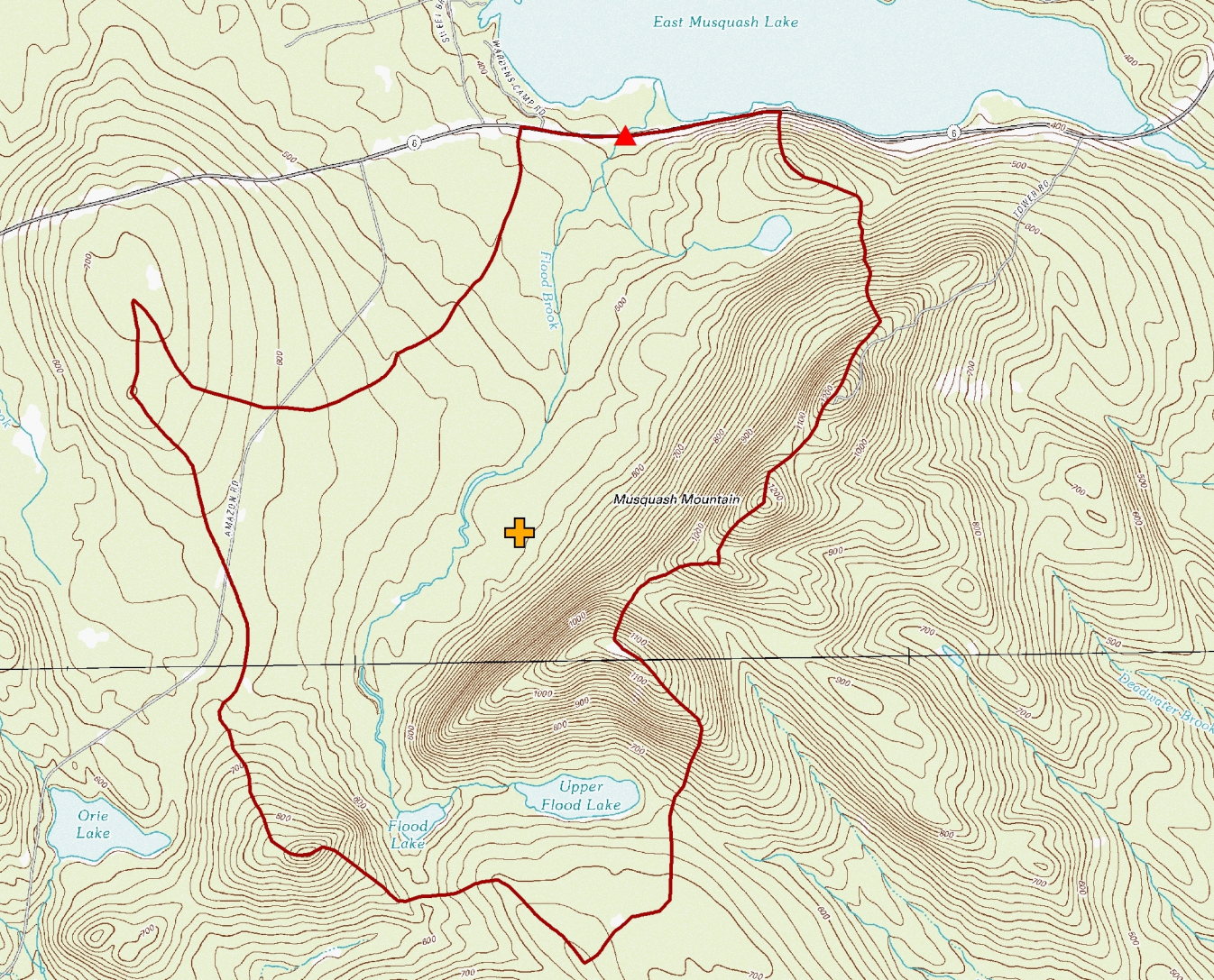
Pctl	Median	84 th pctl
5	0.72	1.15
10	1.06	1.60
15	1.37	2.00
20	1.73	2.42
25	2.12	2.84
30	2.51	3.23
35	3.00	3.70
40	3.52	4.25
45	4.11	4.81
50	4.73	5.67
55	5.49	6.60
60	6.52	7.75
65	7.63	9.03
70	8.95	10.54
75	10.84	12.67
80	13.52	15.13
85	17.06	19.39
90	22.60	26.03
95	33.55	40.48

Q_{bf} 25.5

Q_{1.002} 33.4

Q_{1.1} 77.9

Q₂ 161.9

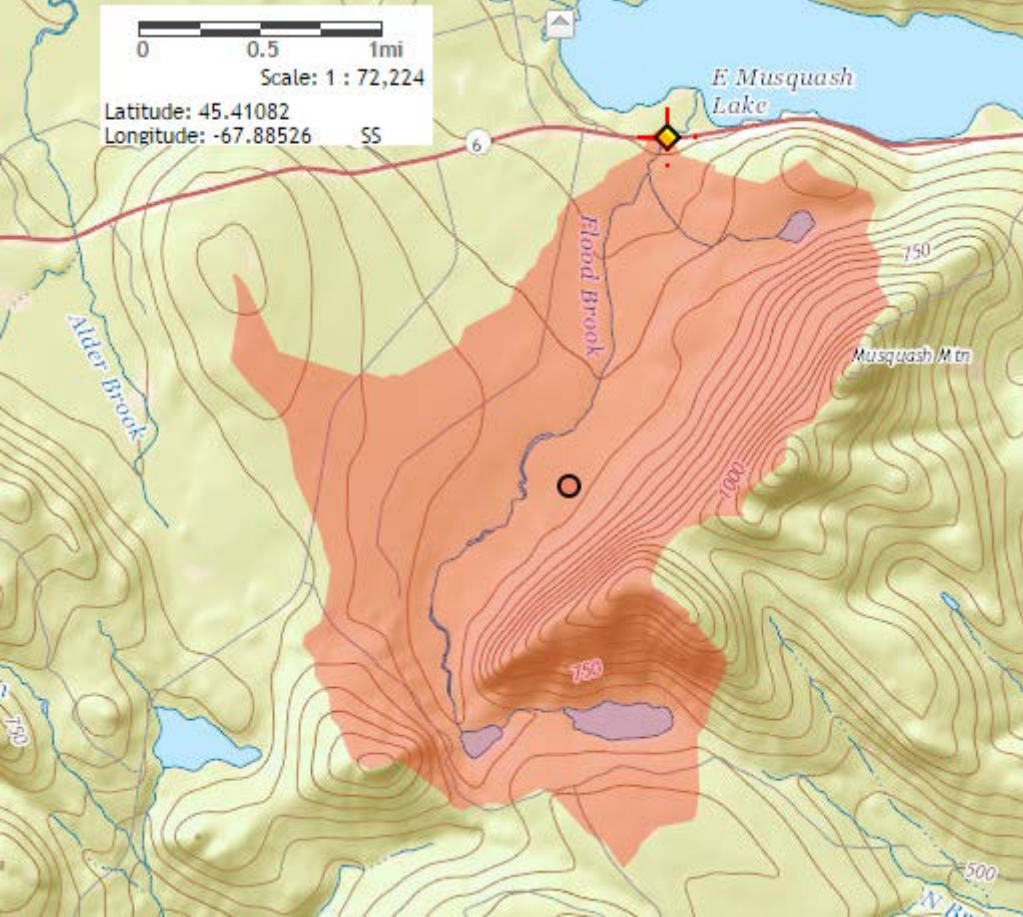


0 0.5 1mi

Scale: 1 : 72,224

Latitude: 45.41082

Longitude: -67.88526 SS



StreamStats Version 3.0

Basin Characteristics Ungaged Site Report

Date: Thurs Dec 29, 2016 3:42:21 PM GMT-5

Study Area: Maine

NAD 1983 Latitude: 45.4029 (45 24 10)

NAD 1983 Longitude: -67.8123 (-67 48 45)

Label	Value	Units	Definition
DRNAREA	4.4	square miles	Area that drains to a point on a stream
STORNWI	8.42	percent	Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory
ELEV	639.7	feet	Mean Basin Elevation
PRECIP	44.4	inches	Mean Annual Precipitation
SANDGRAVAP	0	percent	Percentage of land surface underlain by sand and gravel aquifers
COASTDIST	77.6	miles	Shortest distance from the coastline to the basin centroid
CENTROIDX	592315.78	State plane coordinates	Basin centroid horizontal (x) location in state plane coordinates
CENTROIDY	5026050.73	State plane coordinates	Basin centroid vertical (y) location in state plane units
SANDGRAVAF	0	dimensionless	Fraction of land surface underlain by sand and gravel aquifers
LC11IMP	0.0147	percent	Average percentage of impervious area determined from NLCD 2011 impervious dataset
LC11DEV	0.17	percent	Percentage of developed (urban) land from NLCD 2011 classes 21-24
LC06WATER	1.67	percent	Percent of open water, class 11, from NLCD 2006
ELEVMAX	1249.5	feet	Maximum basin elevation
BSLDEM10M	11.3	percent	Mean basin slope computed from 10 m DEM
STATSGOA	8.33	percent	Percentage of area of Hydrologic Soil Type A from STATSGO

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U.S. Department of the Interior | U.S. Geological Survey

URL: http://streamstatsags.cr.usgs.gov/v3_beta/BCreport.htm

Page Contact Information: [StreamStats Help](#)

Page Last Modified: 12/06/2016 22:50:12 (Web1)

[Streamstats Status](#) [News](#)



HY-8 Culvert Analysis Report

Tailwater Channel Data - Topsfield

Tailwater Channel Option: Irregular Channel

Channel Slope: 0.0144

User Defined Channel Cross-Section:

Coord No.	Station (ft)	Elevation (ft)	Manning's n
1	0.00	392.00	0.0250
2	30.61	391.00	0.0250
3	34.19	390.00	0.0300
4	37.73	389.00	0.0300
5	41.12	388.00	0.0300
6	44.50	387.00	0.0300
7	47.89	386.00	0.1000
8	51.26	385.00	0.1000
9	54.72	384.00	0.1000
10	58.19	383.00	0.1000
11	61.65	382.00	0.1000
12	65.12	381.00	0.1000
13	69.16	380.00	0.1000
14	73.85	379.00	0.1000
15	78.54	378.00	0.1000
16	89.29	377.00	0.1000
17	93.38	376.00	0.1000
18	94.35	375.00	0.0450
19	95.08	374.00	0.0450
20	96.27	373.00	0.0450
21	99.55	372.00	0.0450
22	101.61	371.00	0.0450
23	107.59	370.00	0.0450
24	112.68	370.00	0.0450
25	116.56	371.00	0.0450
26	118.67	372.00	0.0450
27	119.07	373.00	0.0450
28	119.46	374.00	0.0450
29	121.02	375.00	0.0450
30	122.51	376.00	0.1000
31	195.10	376.00	0.0000

Roadway Data for Crossing: Topsfield

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	700.00	394.87
1	725.00	394.59
2	750.00	394.29
3	775.00	393.97
4	800.00	393.66
5	825.00	393.45
6	850.00	393.26
7	875.00	393.05
8	900.00	392.79

Roadway Surface: Paved

Roadway Top Width: 62.50 ft

Site Data - Existing Culvert

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 375.89 ft

Outlet Station: 163.00 ft

Outlet Elevation: 374.45 ft

Number of Barrels: 1

Culvert Data Summary - Existing Culvert

Barrel Shape: User Defined

Barrel Span: 9.58 ft

Barrel Rise: 10.58 ft

Barrel Material: Corrugated Metal Riveted or Welded

Embedment: 0.00 in

Barrel Manning's n: 0.0350 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: Mitered to Conform to Slope

Inlet Depression: NONE

```
*****
                        Straight Culvert
Inlet Elevation (invert): 375.89 ft,   Outlet Elevation (invert): 374.45 ft

Culvert Length: 163.01 ft,   Culvert Slope: 0.0088
*****
```


Table 1 - Summary of Culvert Flows at Crossing: Topsfield Existing

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Existing Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
379.19	Q 1.1	77.90	77.90	0.00	1
380.76	Q 2	161.90	161.90	0.00	1
382.16	Q 5	256.40	256.40	0.00	1
383.03	Q 10	323.40	323.40	0.00	1
384.25	Q 25	424.40	424.40	0.00	1
385.09	Q 50	496.20	496.20	0.00	1
386.05	Q 100	581.20	581.20	0.00	1
388.47	Q 500	785.00	785.00	0.00	1
392.79	Overtopping	1010.96	1010.96	0.00	Overtopping

Table 2 - Culvert Summary Table: Existing Culvert

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
Q 1.1	77.90	77.90	379.19	2.883	3.304	2-M2c	2.567	2.118	2.118	1.549	6.939	4.133
Q 2	161.90	161.90	380.76	4.243	4.870	2-M2c	3.794	3.089	3.089	2.210	8.454	5.198
Q 5	256.40	256.40	382.16	5.454	6.267	2-M2c	4.935	3.905	3.905	2.776	9.722	5.964
Q 10	323.40	323.40	383.03	6.281	7.137	2-M2c	5.673	4.419	4.419	3.109	10.411	6.404
Q 25	424.40	424.40	384.25	7.528	8.364	2-M2c	6.796	5.123	5.123	3.539	11.270	7.013
Q 50	496.20	496.20	385.09	8.408	9.198	2-M2c	7.659	5.546	5.546	3.820	11.903	7.381
Q 100	581.20	581.20	386.05	9.420	10.162	2-M2c	8.944	6.005	6.005	4.135	12.635	7.759
Q 500	785.00	785.00	388.47	12.248	12.581	7-M2c	10.583	7.034	7.034	4.823	14.184	8.492

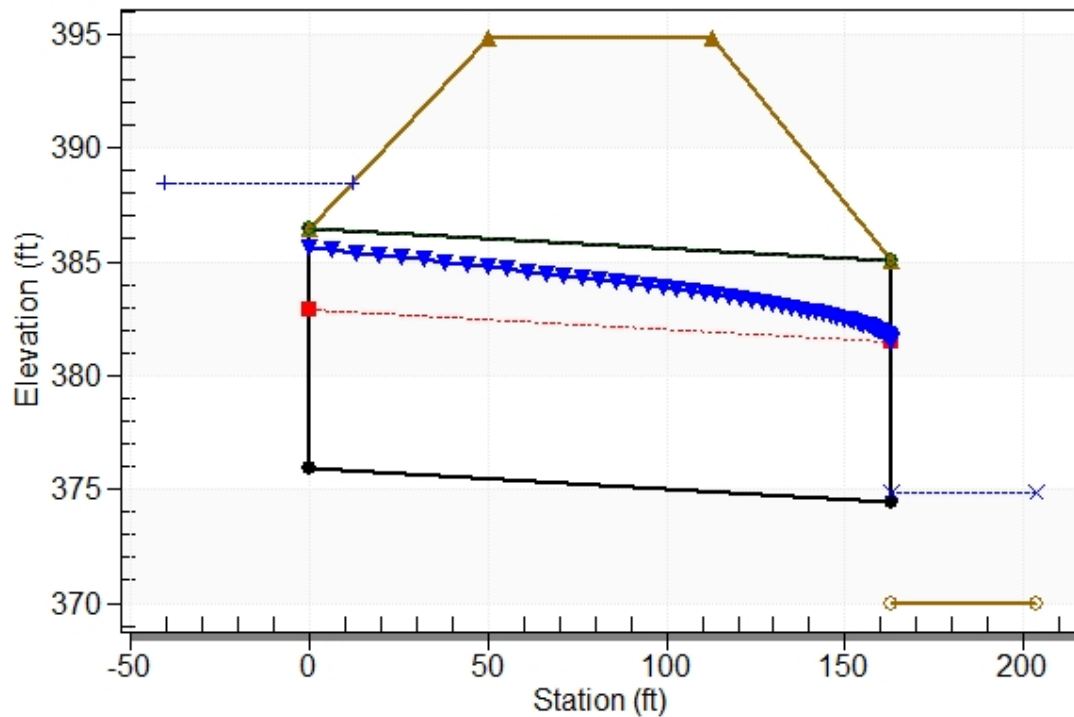
Table 3 - Downstream Channel Rating Curve (Crossing: Topsfield Existing)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
77.90	371.55	1.55	4.13	1.39	0.70
161.90	372.21	2.21	5.20	1.99	0.73
256.40	372.78	2.78	5.96	2.49	0.75
323.40	373.11	3.11	6.40	2.79	0.76
424.40	373.54	3.54	7.01	3.18	0.77
496.20	373.82	3.82	7.38	3.43	0.78
581.20	374.13	4.13	7.76	3.72	0.79
785.00	374.82	4.82	8.49	4.33	0.80

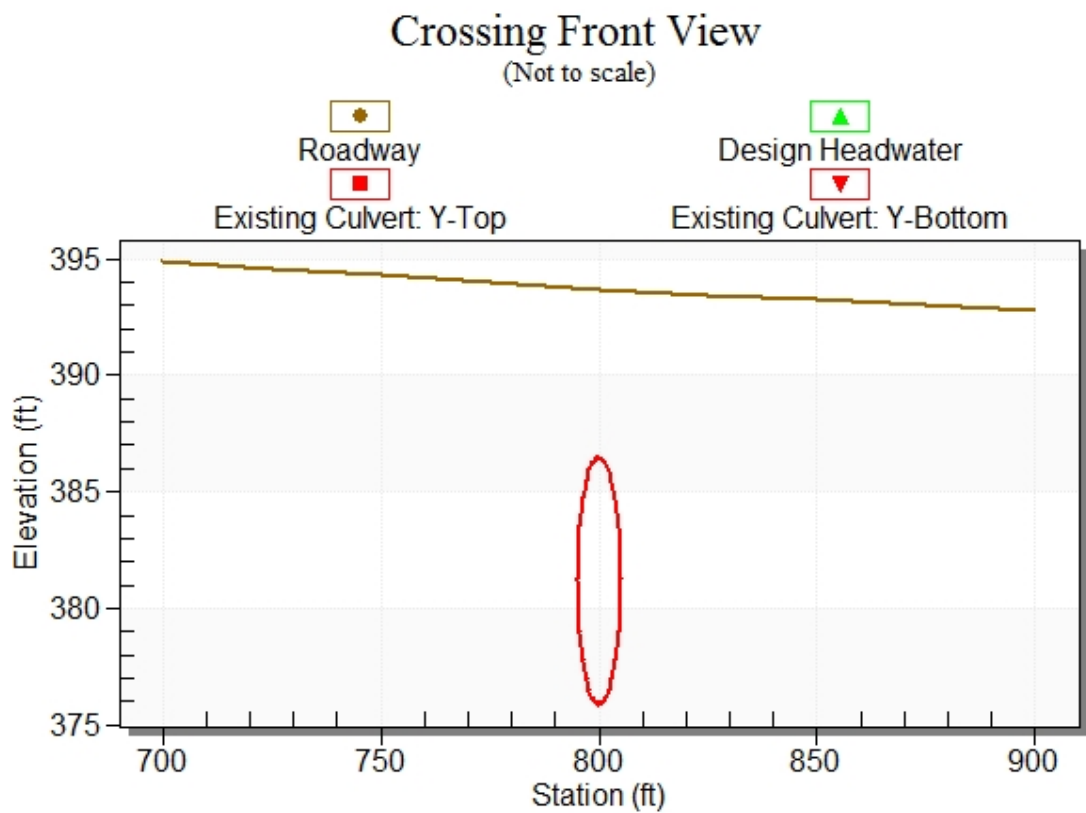
Water Surface Profile Plot for Culvert: Existing Culvert

Crossing - Topsfield, Design Discharge - 785.0 cfs

Culvert - Existing Culvert, Culvert Discharge - 785.0 cfs



Crossing Front View (Roadway Profile): Topsfield



Site Data - Proposed Invert Lining

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 375.89 ft

Outlet Station: 163.00 ft

Outlet Elevation: 374.45 ft

Number of Barrels: 1

Culvert Data Summary – Proposed Invert Lining

Barrel Shape: User Defined

Barrel Span: 9.58 ft

Barrel Rise: 10.17 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120 (top and sides)

Manning's n: 0.0120 (bottom)

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: NONE

Straight Culvert

Inlet Elevation (invert): 375.89 ft, Outlet Elevation (invert): 374.45 ft

Culvert Length: 163.01 ft, Culvert Slope: 0.0088

Table 4 - Summary of Culvert Flows at Crossing: Topsfield Invert Lining

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Existing Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
378.72	Q 1.1	77.90	77.90	0.00	1
380.06	Q 2	161.90	161.90	0.00	1
381.31	Q 5	256.40	256.40	0.00	1
382.34	Q 10	323.40	323.40	0.00	1
383.89	Q 25	424.40	424.40	0.00	1
384.91	Q 50	496.20	496.20	0.00	1
386.10	Q 100	581.20	581.20	0.00	1
389.00	Q 500	785.00	785.00	0.00	1
392.79	Overtopping	1001.88	1001.88	0.00	Overtopping

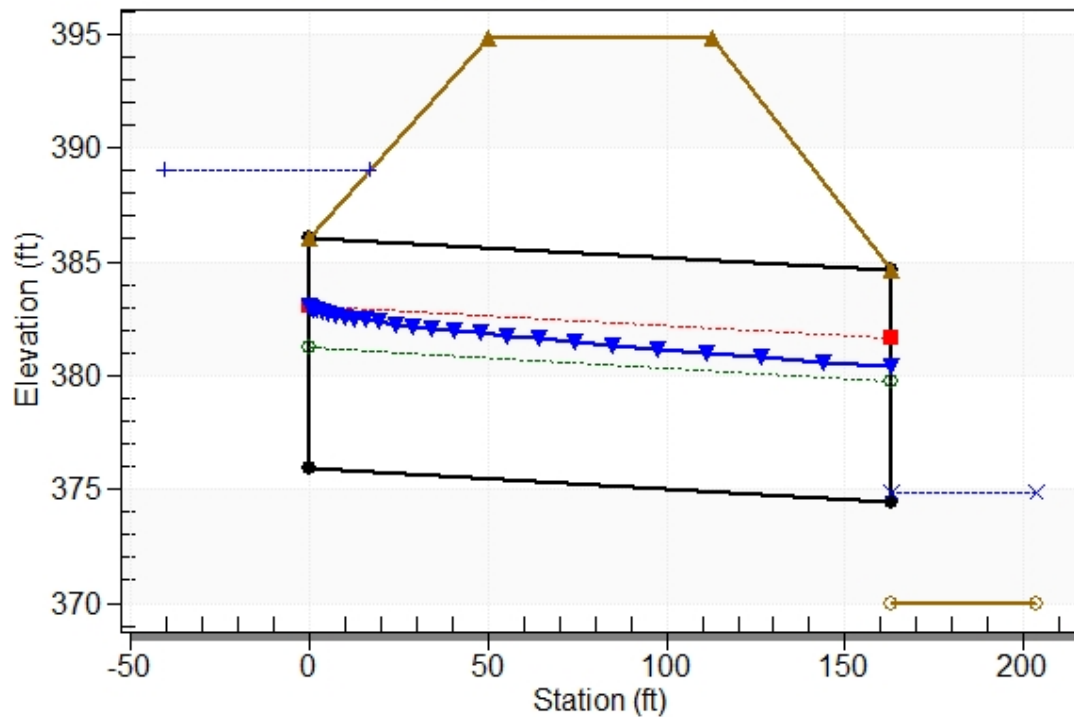
Table 5 - Culvert Summary Table: Proposed Invert Lining

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
Q 1.1	77.90	77.90	378.72	2.833	0.787	1-S2n	1.494	2.185	1.636	1.549	10.318	4.133
Q 2	161.90	161.90	380.06	4.169	1.915	1-S2n	2.269	3.175	2.419	2.210	12.595	5.198
Q 5	256.40	256.40	381.31	5.419	3.073	1-S2n	2.837	4.062	3.135	2.776	13.953	5.964
Q 10	323.40	323.40	382.34	6.448	3.929	1-S2n	3.239	4.652	3.596	3.109	14.613	6.404
Q 25	424.40	424.40	383.89	7.999	5.101	1-S2n	3.765	5.306	4.250	3.539	15.268	7.013
Q 50	496.20	496.20	384.91	9.019	5.959	1-S2n	4.120	5.711	4.621	3.820	15.952	7.381
Q 100	581.20	581.20	386.10	10.206	7.046	5-S2n	4.535	6.170	5.028	4.135	16.611	7.759
Q 500	785.00	785.00	389.00	13.113	9.974	5-S2n	5.320	7.189	5.940	4.823	18.017	8.492

Table 6 - Downstream Channel Rating Curve (Crossing: Proposed Invert Lining)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
77.90	371.55	1.55	4.13	1.39	0.70
161.90	372.21	2.21	5.20	1.99	0.73
256.40	372.78	2.78	5.96	2.49	0.75
323.40	373.11	3.11	6.40	2.79	0.76
424.40	373.54	3.54	7.01	3.18	0.77
496.20	373.82	3.82	7.38	3.43	0.78
581.20	374.13	4.13	7.76	3.72	0.79
785.00	374.82	4.82	8.49	4.33	0.80

Water Surface Profile Plot for Culvert: Existing Culvert
Crossing - Topsfield, Design Discharge - 785.0 cfs
 Culvert - Existing Culvert, Culvert Discharge - 785.0 cfs



Crossing Front View (Roadway Profile): Topsfield

