WIN. 21658.00
MERRILL BRIDGE
(ELM ST/RTE 120) OVER WEST BRANCH ELLIS RIVER

ANDOVER, MAINE

FINAL
HYDROLOGIC AND HYDRAULIC REPORT

October 2018

PREPARED FOR

MaineDOT
16 State House Station
Augusta, ME 04333

PREPARED BY

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Harrisburg, PA 17110
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HNTB

MERRILL BRIDGE OVER WEST BRANCH ELLIS RIVER
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Final Hydrologic and Hydraulic Report
October 2018

STATE OF MAINE
TIMOTHY R. COTE
No. 10671
LICENSED
PROFESSIONAL ENGINEER

11/2/2018
Timothy Cote, P.E.

Prepared For:
Maine Department of Transportation
16 State House Station
Augusta, ME 04333

Prepared By:
HNTB Corporation
4507 North Front Street, Suite 300
Harrisburg, PA 17110

The following is a final report of the hydrologic and hydraulic analysis of the existing and proposed bridges at Merrill Bridge (Bridge No. 3215) over West Branch Ellis River in the town of Andover in Oxford County, Maine.

1.0 Introduction

The Merrill Bridge carries State Route 120 over the West Branch Ellis River. The existing bridge is a through-truss bridge with a cast-in-place concrete deck. The existing bridge was built in 1935 and serves approximately 890 cars per day (2014). The bridge is located approximately 1.80 miles upstream of the confluence with Ellis River.

The bridge spans over the West Branch Ellis River with a total length of approximately 85.2 feet from abutment to abutment. The existing structure features stone abutments and retaining walls with concrete caps. The low chord elevation of the existing bridge is 656.91 feet and occurs at the upstream end of the structure. The existing structure has a hydraulic opening of approximately 1119 square feet.

The proposed structure will be constructed on a new alignment slightly downstream from the existing bridge. The proposed bridge consists of a single 125-foot span from face of abutment to face of abutment and will be supported by integral abutments. The proposed profile of the bridge and approach roadway are proposed to be raised by 1.7 feet on the eastern side of the structure and approximately 1.5 feet on the western side of the structure with a grade of 1.00 % decreasing from east to west. The low chord elevation is proposed to be raised to 657.72 feet. The proposed bridge provides a hydraulic opening of 1434 square feet. The increase in hydraulic area is attributed to the increased span length and increased low chord elevation.

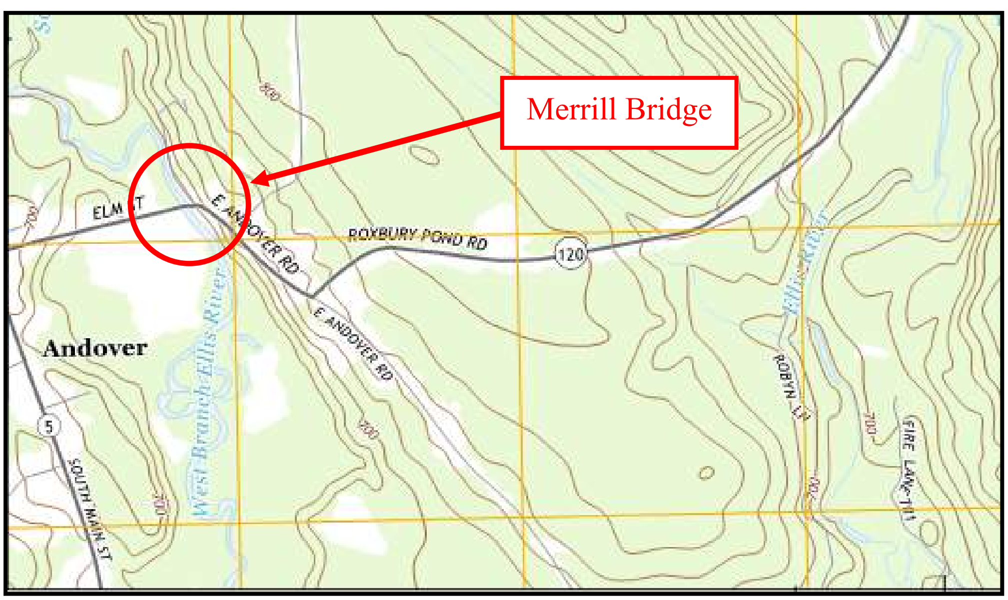


Figure 1 – Project Location Map (USGS Quadrangle – Ellis Pond, ME)

The nearest bridge upstream from Merrill Bridge is the North Andover Road Bridge, approximately 4,300 feet upstream. Approximately 100 feet downstream from Merrill Bridge is a snowmobile bridge. This bridge is a part of the Ellis River Bridge Trail project. The snowmobile bridge is a 140-foot single span and features approximately 3.7 feet of clearance between the low chord and 1.1-year event.

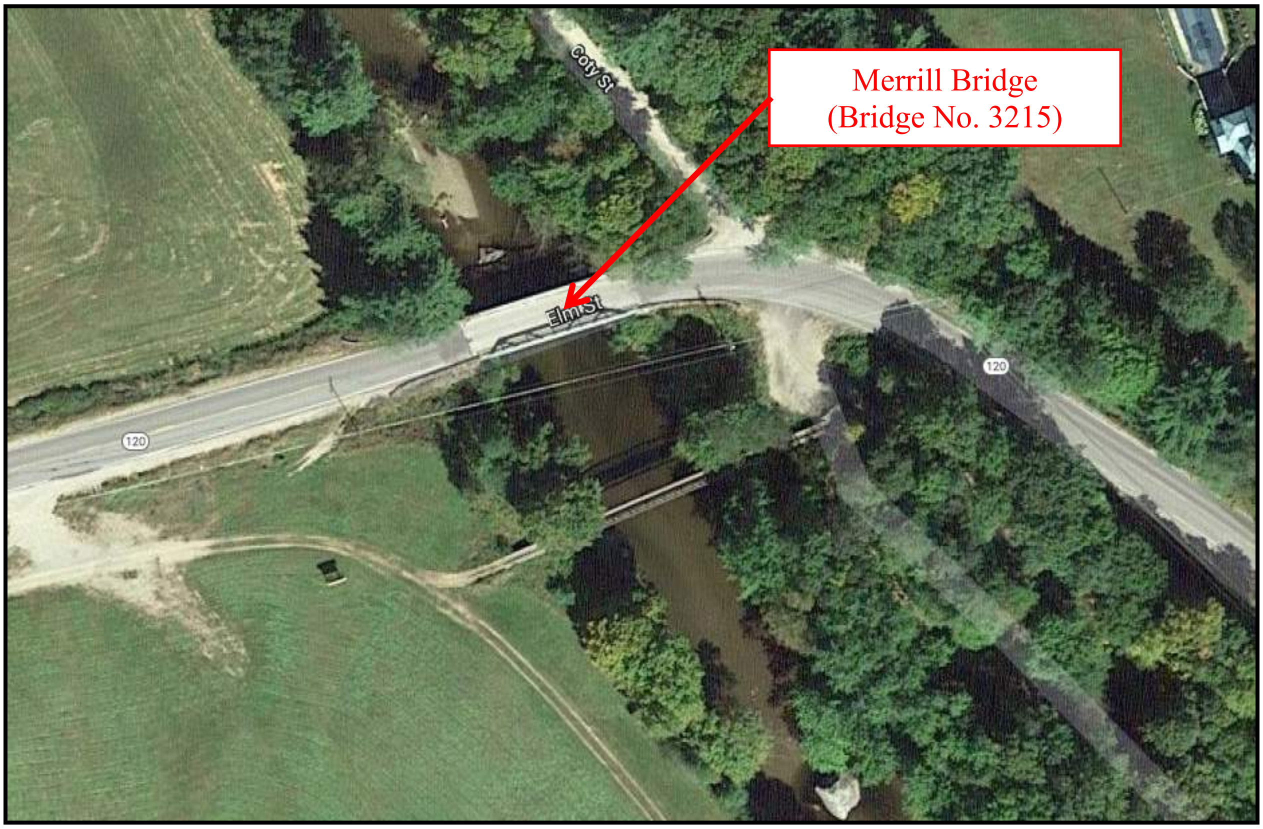


Figure 2 – Aerial image showing project site

2.0 Existing Data Review

The existing site was reviewed for data that can be used in calibrating the model. Photographs are also reviewed for existing site conditions. FEMA information is reviewed to determine if there are any existing flood profiles and/or water surface elevations within the project area. Additionally, the presence of any USGS stream gages were located to better determine existing flows at the site. The following information was reviewed as part of the analysis:

- Site Photographs are provided in **Appendix A** to show the existing condition at the upstream and downstream side of the structure as well as the eastern and western approaches of the roadway. The photos were taken as part of an inspection completed November 15, 2017.

- The FEMA Flood Insurance Rate Map (Effective July 7, 2009) is included in **Appendix B**. The project is in Zone AE indicating base flood elevations have been determined. The map also indicates the project is located within a floodway. A FEMA regulatory floodway is a zone reserved to pass the base flood flows. Development in these areas is regulated to ensure the base flood elevations are not increased. The 100-year flood elevations are shown to be 659 feet downstream of the bridge and 660 feet upstream of the bridge. The FEMA base flood elevations are used as boundary conditions to better calibrate the model to reflect existing conditions.
- There are no nearby USGS Stream gages on the West Branch of the Ellis River. The nearest stream gage is USGS gage 01054300 approximately 4 miles downstream on the Ellis River near South Andover, Maine. The drainage area to this gage is approximately 130 square miles which is approximately 253% larger than the drainage area to Merrill Bridge (51.3 square miles).
- The West Branch Ellis River flows were calculated by combining the site regression analysis with the nearest stream gage flows by area weighting. The hydrology memo summarizing the flows has been included in **Appendix C.**

3.0 Hydrology

The peak flows recommended for design for the West Branch Ellis River at the location of the bridge replacement were calculated based on regression equations since the drainage area to the nearest stream gage is too large for comparison to the project location drainage area. The site regression analysis provided flows that were considerably lower than the flows published in the FEMA Flood Insurance Study (FIS). The USGS procedure was followed and combined the site regression analysis with the nearest stream gage flows by area-weighting to develop flows for the project area. These flows are reasonably similar to the flows provided in the FEMA FIS. The calculated flows using the USGS procedure were used for the hydraulic analysis at Merrill Bridge.

The calculated flows as well as the flows published in the FEMA Flood Insurance Study have been provided in **Table 1**. The hydrology report summarizing the flows can be found in **Appendix C**. A Storm-Discharge graph comparing the results between the calculated flows and the FEMA FIS flows can be found in **Appendix C** of the report.

Figure 3 on the following page shows the total drainage area found using the USGS StreamStats program. The drainage area consists mainly of forest and agricultural land. The drainage area consists only of a small percentage of impervious land cover.

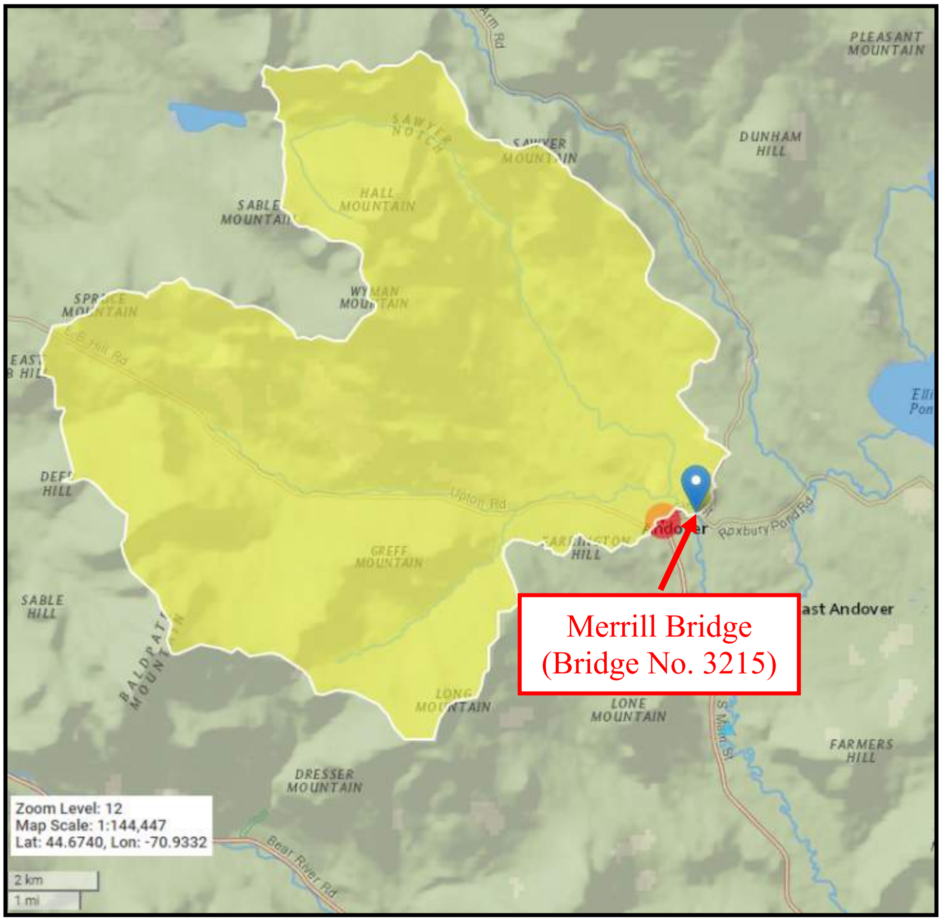


Figure 3 – Watershed above Merrill Bridge over West Branch Ellis River

Table 1: Flood Information
(For calculations see **Appendix C**)

Year Storm	**Calculated Flows (cfs)**	**FEMA FIS (cfs)**
Drainage Area	**51.3 sq. mi.**	**54.2 sq. mi.**
$Q_{1.1}$	**1950**	---
Q_2	**3950**	---
Q_5	**6100**	---
Q_{10}	**7700**	6500
Q_{25}	**9850**	---
Q_{50}	**11550**	10800
Q_{100}	**13350**	12900
Q_{500}	**17850**	18400

4.0 Hydraulic Analysis

Hydraulic calculations for the existing and proposed conditions along the West Branch Ellis River were performed using the U.S. Army Corps of Engineers' software HEC-RAS, version 4.1.0. HEC-RAS supports one-dimensional, steady flow, water surface profiles calculations. Cross-sections were cut from survey gathered for this project.

The downstream boundary condition for the HEC-RAS model was set to known water surface since the FEMA FIS provided flood profiles for the West Branch Ellis River in the area of the project. The downstream water surfaces were pulled from the FEMA flood profiles for the 10-, 50-, 100-, and 500-year storm events. The other storm events were approximated from best-fit curve from a flood-stage graph. The flood-stage graph has been provided in **Appendix C**. The existing conditions were analyzed in HEC-RAS to determine the validity of the known water surface elevations for the downstream boundary conditions. Using the known water surface elevations from FEMA FIS as boundary conditions, the existing conditions analysis returned water surface elevations for the 100-yr flood event of 659.52 feet downstream of the bridge and 660.16 feet upstream of the bridge. These water surface elevations are close to the water surface elevations on the FEMA Flood Insurance Rate Map (FIRM). Therefore, the downstream boundary conditions have been deemed valid for this analysis.

In addition, it was noted that during a preliminary public coordination meeting, the western portion of the existing structure is impacted and approach roadway is overtopped during large snow melts and significant storms. The existing conditions modeled show that events greater than the 5-year event will overtop the roadway to the west of the existing structure. This is consistent with the public coordination regarding the overtopping of the existing roadway and further validates the model.

The model was run using "subcritical" flow due to the Froude numbers at all cross-sections below 1.0. The model was run in "subcritical" flow in order to ensure that the model uses the downstream boundary conditions set by the FEMA FIS flood profiles discussed above. The model covers approximately 175 feet upstream of the existing structure and 150 feet downstream of the existing structure. The proposed alignment is downstream of the existing bridge, with the centerline of the proposed structure is set to be placed approximately 40 feet from the centerline of the existing structure. The new alignment required two of the existing cross sections to be removed from the model as the proposed structure will intersect these cross sections. The proposed model maintains the upstream cross section from the existing model. No cross sections were required to be added due to the location of the proposed structure.

The FEMA FIS also provided values for the Manning's n-values along the West Branch Ellis River. The values provided in the FIS were 0.045-0.075 for the channel and 0.060-0.090 for the overbank areas. These values were reviewed against the survey data, photographs and aerial images of the project area and it was determined that the appropriate Manning's n-values for the channel are 0.045 downstream of the existing bridge and 0.040 upstream of the bridge. The overbank areas throughout the project were set to 0.075.

Ineffective flow areas were set upstream and downstream of the bridge based on contraction and expansion from the bridge in both existing and proposed models. These ineffective flow areas were set to the elevation of the low spot to the west of the bridge and to the roadway elevation on the east side of the bridge. Once these elevations are overtopped, the flow will become effective and the ineffective flow areas are inactive. This allows HEC-RAS to assume it has the full overbank area to calculate the water surface elevation and velocity

The existing structure has a hydraulic opening of 1119 square feet. The existing model is run under energy flow for the lowest storm events (1.1-yr and 2-yr). The energy flow indicates that the flood is running without any impact from the bridge structure or roadway. The 5-yr and 10-yr storms run utilizing the energy/weir equations which means these storms do not flow above the low chord of the structure, but some flow may overtop the roadway which will imitate a weir as the water flows over the roadway. The 25-yr through the 500-yr flood events utilize the pressure/weir flow equations as these events will hit above the low chord elevation and overtop the roadway causing the water to flow over the roadway which acts a weir.

The proposed structure is being constructed on a new alignment slightly downstream of the existing bridge and has a proposed hydraulic opening of 1434 square feet. The proposed model is run under energy flow for the lowest storm events (1.1-yr through 5-yr flood event). The energy flow indicates that the flood is running without any impact from the bridge structure low chord or roadway. The 10-yr and 25-yr flood events run utilizing the energy/weir equations which means these storms do not flow over the low chord of the structure, but some flow may overtop the roadway which will imitate a weir as the water flows over the roadway. The 50-yr to the 500-yr flood events utilize the pressure/weir flow equations as these events will hit above the low chord elevation of the structure and overtop the roadway causing the water to flow over the roadway which acts a weir.

The Bridge Design Guide (BDG) states that bridges that are not major riverine bridges must provide two feet over the 50-year event or one foot over the 100-year event. In order to meet the required clearances, the roadway profile would be required to be raised by approximately 7.10 feet. This would result in additional project impacts to adjacent properties, intersections and natural resources.

The design team concluded to maintain around the low chord of the existing structure rather than meet the required clearances since this is a minor structure. The result was an increase of the roadway profile of approximately 1.5 feet that will limit impacts to the surrounding area. The bridge design was further refined and resulted in the low chord of the proposed structure increasing by approximately 0.81 feet further improving the hydraulic opening of the bridge. Due to the increased span length and increased profile, the water surface elevations upstream and downstream of the structure have been decreased for the 100-year and 500-year events.

The proposed structure does show an increase in the 50-yr flood event upstream of the structure, but these increases are minimal (0.21 feet maximum increase) and will not adversely impact any adjacent property owners upstream of the proposed structure. Although the hydraulic opening increased in the proposed condition, the 50-yr storm event had an increase in water surface elevation likely due to the amount of increased fill on the eastern portion of the project site. Although there is an increase in the 50-yr water surface elevation, there is a decrease in the velocity.

Table 2 provides a summary of the hydraulic analysis of existing and proposed conditions at the Merrill Bridge over the West Branch Ellis River.

Table 2: Hydraulic Analysis Summary

Summary of Hydraulic Data-Merrill Bridge over the West Branch Ellis River	Existing Bridge	Proposed Bridge
Low Chord	656.91	657.72
Floodplain width at Q100, ft	693.08	677.83
Floodplain width at Q500, ft	754.83	748.05
Width at Banks, ft	91.95	91.95
Headwater at Upstream face of bridge, Q10, ft	657.25	657.02
Headwater at Upstream face of bridge, Q25, ft	658.83	658.04
Headwater at Upstream face of bridge, Q50, ft	659.50	659.71
Headwater at Upstream face of bridge, Q100, ft	660.16	659.97
Headwater at Upstream face of bridge, Q500, ft	660.97	660.87
Discharge Velocity at Q10, fps	5.79	5.91
Discharge Velocity at Q25, fps	6.14	6.69
Discharge Velocity at Q50, fps	6.61	6.34
Discharge Velocity at Q100, fps	7.03	7.09
Discharge Velocity at Q500, fps	8.52	8.49
Ordinary High Water Elevation (Q1.1) (US face), ft	655.10	655.09
Discharge Velocity at Q1.1, fps	1.87	1.87
Clearance at Q10, ft (Impact to Low Chord, ft)	0 (-0.34)	0.70
Clearance at Q25, ft (Impact to Low Chord, ft)	0 (-1.92)	0 (-0.32)
Clearance at Q50, ft (Impact to Low Chord, ft)	0 (-2.59)	0 (-1.99)
Clearance at Q100, ft (Impact to Low Chord, ft)	0 (-3.25)	0 (-2.25)
Clearance at Q500, ft (Impact to Low Chord, ft)	0 (-4.06)	0 (-3.15)
Bridge Opening Area, ft^2	1119	1434
Flow area at Q10, ft^2	1872.27	1832.51
Flow area at Q100, ft^2	3497.01	3502.39
Flow area at Q500, ft^2	4055.34	4144.45

The HEC-RAS model was reviewed for errors, warnings, and notes. There were several notes produced by HEC-RAS for the existing and proposed models about multiple critical depths found at several cross-sections. While there were no errors produced, some warnings stated there might be a need for more cross-sections. These warnings were reviewed and were deemed acceptable for this analysis. HEC-RAS outputs including cross-sections and profiles are provided for existing conditions in **Appendix E** and proposed conditions in **Appendix F**.

5.0 Scour Analysis

A scour analysis was performed based on equations from FHWA publication HEC-18 (Fifth Edition). The 100-year and 500-year events were analyzed for scour at the proposed Merrill Bridge crossing. The D_{50} of the streambed material is approximately 2.3 mm or 0.00754 feet. This D_{50} was used to determine whether clear water or live bed scour analysis was to be performed. At the Merrill Bridge, live bed scour was required to be calculated. In addition, local scour was calculated per HEC-18 for the near and far abutments. From the scour analysis, it was found that there was no live bed scour at the proposed project site, only local scour at the near and far abutments.

The total scour depths can be found in **Table 3** and the scour analysis can be found in **Appendix G**.

Table 3: Scour Depths

	100 - year storm	
	Near Abutment	Far Abutment
Aggradation/ Degradation (ft)	0.00	0.00
Contraction/Expansion Scour (ft) *	0.00	0.00
Local Scour (ft)	13.79	11.54
Pressure Flow Scour (ft)	---	---
TOTAL SCOUR (ft)	***13.79***	***11.54***

	500-year storm	
	Near Abutment	Far Abutment
Aggradation/ Degradation (ft)	0.00	0.00
Contraction/Expansion Scour (ft) *	0.00	0.00
Local Scour (ft)	17.10	12.80
Pressure Flow Scour (ft)	---	---
TOTAL SCOUR (ft)	***17.10***	***12.80***

** If calculated y_s returns negative answer, the scour depth equals zero*

The project proposed to protect against scour by placing riprap at the abutments. The velocities of the Q100 and Q500 events are acceptable for the placement of plain riprap at the abutments of the proposed structure.

6.0 Summary

In summary, the existing Merrill Bridge over West Branch Ellis River in Oxford County is proposed to be replaced. The low chord of the existing structure is at 656.91 feet and the Q10-yr and greater year storm events do impact the low chord of the structure. The existing structure offers approximately 1119 square feet of hydraulic opening.

The proposed bridge is designed to be on a new alignment, while raising the existing low chord elevation and lengthening the span. The span length from face of abutment to face of abutment is proposed to be 125 feet. Increasing the span and raising the low chord elevation increases the hydraulic opening to approximately 1434 square feet. The structure passes the Q10-yr storm event under the low chord and decreases the water surface elevation for all storms except for the 50-yr.

The proposed structure and revised profile will improve the hydraulic conditions at the Merrill Bridge over West Branch Ellis River.

Appendix Contents

APPENDIX A

Site Photographs

Photo 1 – Existing Structure– Looking Upstream

Photo 2 – Existing Structure and Snowmobile Bridge – Looking Downstream

Photo 3 – Elm St/ ME 120 – Looking East

Photo 4 – Elm St/ ME 120 – Looking West

APPENDIX B

FEMA FIRM


MAP SCALE 1" = 500'
250 0 500 1000
FEET
0 150 300
ZONE X
ZONE X
ZONE X
ZONE AE
ZONE AE
MERRILL BRIDGE PROJECT SITE
B
B
BLAKIE ROAD
BASE LINE
PROFILE
ELM STREET
FIRE LN
EAST ANDOVER ROAD
ROXBURY POND ROAD
BIRCH STREET
SOUTH MAIN
665
664
663
662
661
660
659
658
657
656
655
504
TOWN OF ANDOVER
230160
NFIP
PANEL 0513D
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
OXFORD COUNTY, MAINE
(ALL JURISDICTIONS)
PANEL 513 OF 1570
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
ANDOVER, TOWN OF 230160 0513 D
Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.
MAP NUMBER 23017C0513D
EFFECTIVE DATE JULY 7, 2009
Federal Emergency Management Agency
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

APPENDIX C

Hydrology

From: Hebson, Charles [mailto:Charles.Hebson@maine.gov]
Sent: Tuesday, November 28, 2017 12:57 PM
To: Timothy Cote <TCote@HNTB.com>; Gustafson, Garrett A <Garrett.A.Gustafson@maine.gov>
Cc: Ashley Stephens <astephens@hntb.com>
Subject: Andover, Merrill #3215, WIN 21658.00 - Revised Hydrology

After much thought, I have a set of flow values for design. Amazingly, they are very close to the FEMA FIS values (I suspect the FIS model may have been calibrated to the Ellis River gage in some way). Anyhow, here is a brief explanation for the table below; I will prepare a final report to include in the PDR.

Thanks,

Charlie

- - -

The "Site Regr" are regression estimates for the project location. As HNTB has noted, these values are much smaller than the FIS and are inconsistent with anecdotal observations.

There is a gage on the Ellis River, downstream of the junction of the West Branch Ellis with the Ellis main stem. This watershed is much larger and therefore (technically, according to USGS guidance) should not be used to extrapolate to the project location. However, I did so since this is the only data available in the watershed. The values in the "Ellis R Gage" column are the 17B values calculated from the gage data using the USGS PeakFQ program and then adjusted for watershed area. These values are very large, even larger than the FIS values.

USGS procedure is to combine the site regression estimates and the gage-based estimates by area-weighting; these values are reported in the "Gage-Regr" column. These values are very close to the FIS values.

The FIS values in the "FIS" column are a bit smaller than reported in the FIS since I adjusted them for the slightly smaller watershed area at the project location.

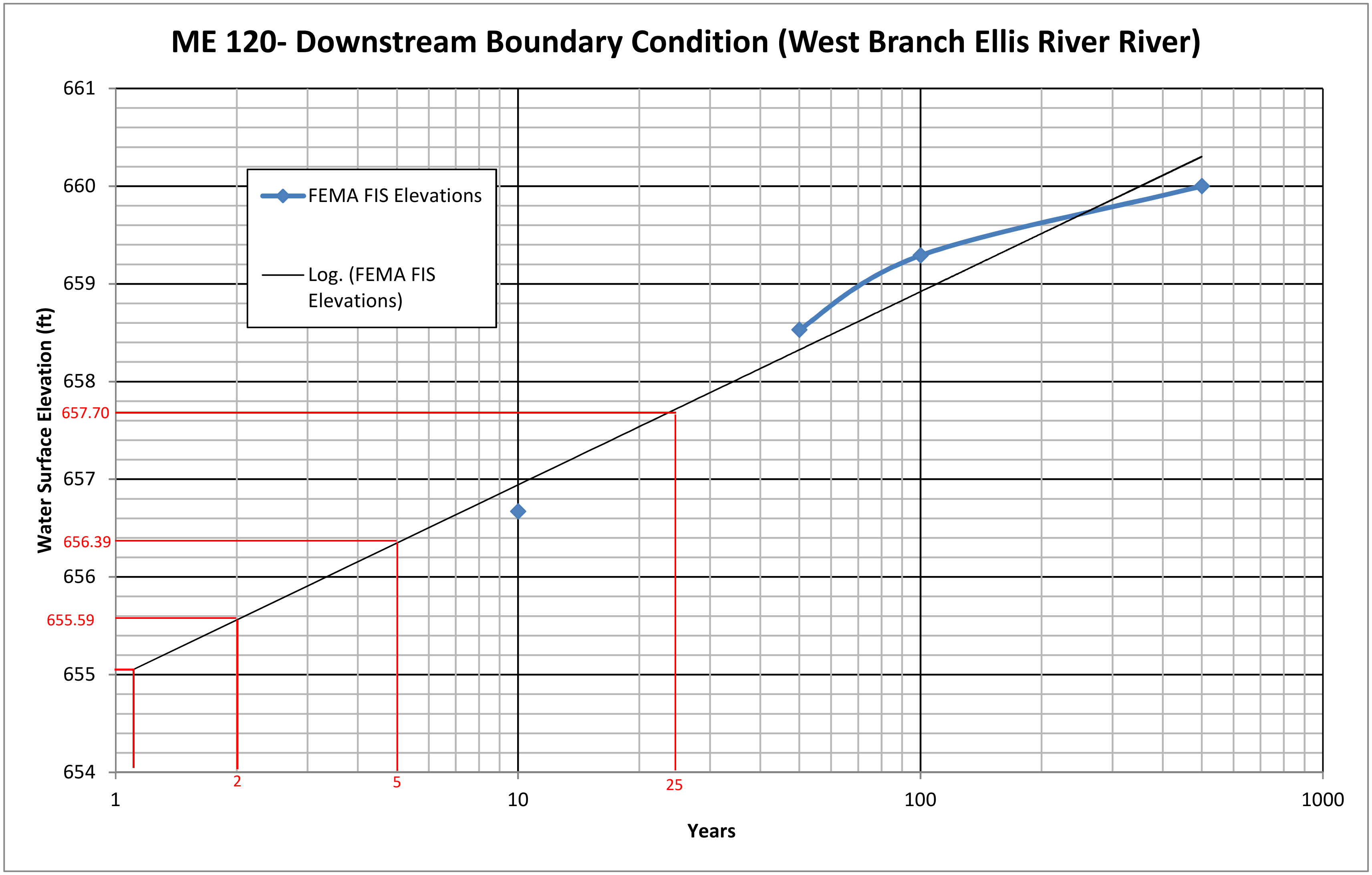
Finally, I also looked at the annual maximum data in the nearby Swift River watershed; the gage is at the junction with the Androscoggin River. The Ellis gage has a shorter record length and also is missing data 1983 – 2000. For the years where the Ellis and Swift records overlap. I extracted the coincident (same date) annual maximums and calculated the flow ratios; the Swift flows were 1.58 times the Ellis flows. I used this multiplier to scale the Swift flows; results are shown in the "Swift R Gage" column. The results are a bit larger than the Gage-Regr weighted average values and the FIS estimates, but very much consistent.

I recommend that we use the "Gage-Regr wt'ed avg" values, rounded to the "clean" values in the "Design" column.

T (yr)	**Site Regr**	**Ellis R Gage** (17B; A-adj)	**Gage-Regr wt'ed avg**	**FIS** (A-adj)	**Swift R Gage** (17B; event adj)	**Design**
A (mi^2)	*51.3*	*131*		*124*	*98*	
1.1						*1950*
2	2129	6783	3951		3863	*3950*
5	3337	10440	6119			*6100*
10	4247	13088	7709	6212	6149	*7700*
25	5463	16692	9860		7854	*9850*
50	6427	19534	11560	10345	10203	*11550*
100	7446	22512	13346	12367	12089	*13350*
500	10019	30060	17867	17659	19241	*17850*

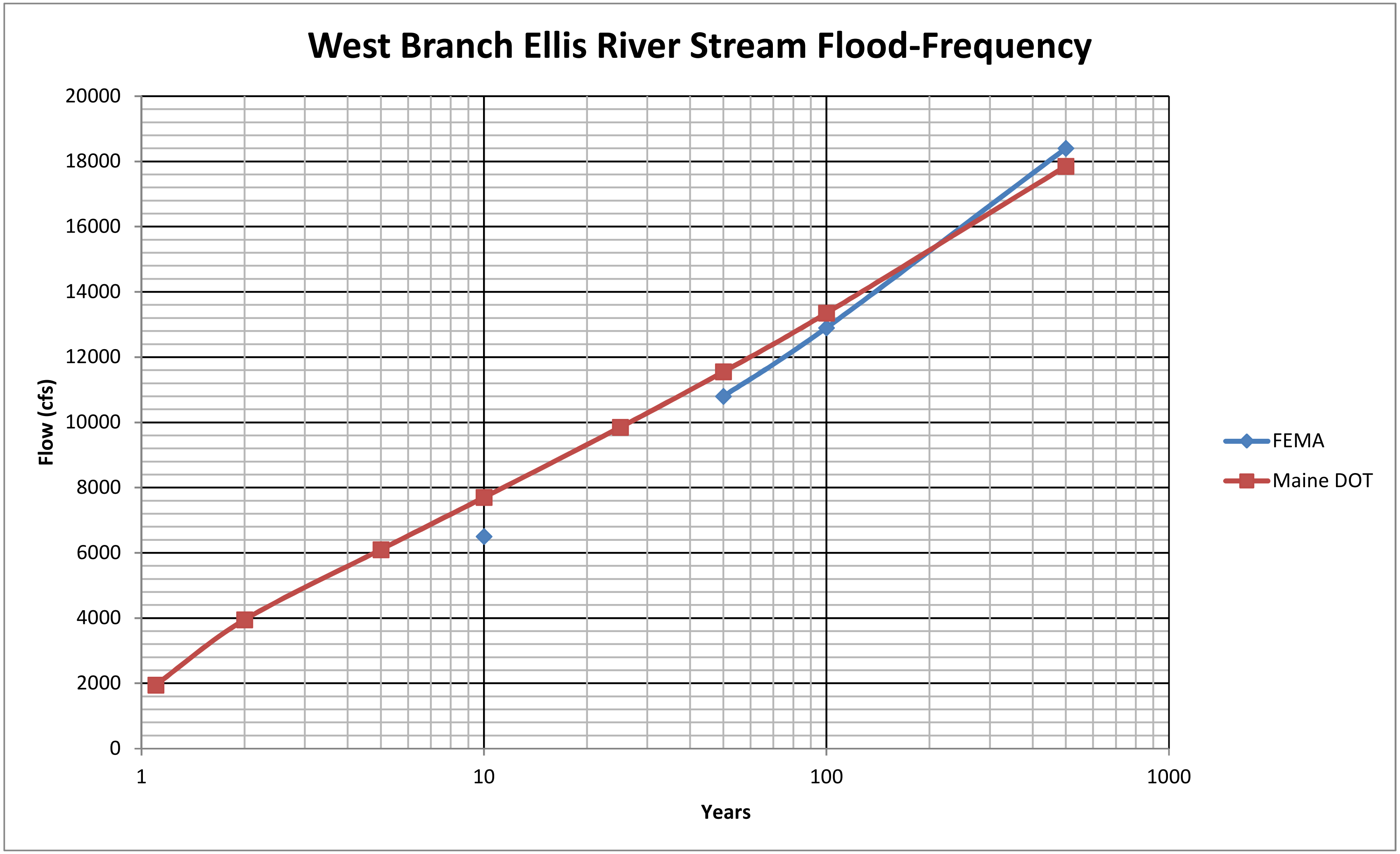
ME120 (Elm St) over West Branch Ellis River – Downstream Boundary Conditions Curve

County	Oxford	Town	Andover
Stream Name	West Branch Ellis River	State Route	ME 120



ME120 (Elm St) over West Branch Ellis River – Flood-Frequency Curve

County	Oxford	Town	Andover
Stream Name	West Branch Ellis River	State Route	ME 120



APPENDIX D

FEMA Flood Insurance Study Information

TABLE 7 – SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQUARE MILES)	PEAK DISCHARGES (CUBIC FEET PER SECOND) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
Thompson Lake Outlet					
At confluence with Little Androscoggin River	47.7	1,250	1,880	2,200	3,070
Tucker Valley Brook					
At Valley Brook Road	3.3	625	1,160	1,410	1,995
At Point Morse Hill Road	2.5	585	1,045	1,255	1,740
Twitchell Brook					
At U.S. Route 2 (State Routes 5 & 26)	1.9	400	670	780	1,030
At approximately 1.0 mile upstream from confluence with Stony Brook	2.5	287	461	545	763
At confluence with Stony Brook	3.1	349	559	661	923
Webb River					
At confluence with Androscoggin River	133.0	4,510	6,800	7,800	10,000
At upstream Dixfield corporate limits	116.0	3,780	5,760	6,620	8,600
West Branch Ellis River					
At its confluence with Ellis River	54.2	6,500	10,800	12,900	18,400
At a point 1,700 feet upstream of the confluence of Stony Brook	26.5	4,900	7,600	8,900	12,000
West Branch Nezinscot River					
At confluence with the Nezinscot River	55.8	*	*	5,370	*
At Paris Hill Road	45.2	*	*	5,070	*
Upstream from Darnit Brook	29.7	*	*	3,620	*

*Data not computed

TABLE 9 – MANNING'S "n" VALUES (continued)

Flooding Source	Channel "n"	Overbanks
Stony Brook (revised)	0.045	0.055-0.09
Sunday River	0.060-0.063	0.065-0.110
Sunday River (Newry)	0.045-0.062	0.065-0.085
Swift River	0.035-0.070	0.040-0.120
Thompson Lake Outlet	0.033-0.038	0.040-0.100
Tucker Valley Brook	0.065-0.067	0.090-0.095
Twitchell Brook (revised)	0.045-0.065	0.09-0.11
Webb River	0.025-0.045	0.025-0.070
West Branch Ellis River	0.045-0.075	0.060-0.090
West Branch Nezinscot River	0.030-0.060	0.050-0.15
Whitney Brook	0.040-0.045	0.055-0.120
Worthley Pond	0.045-0.060	0.025-0.090

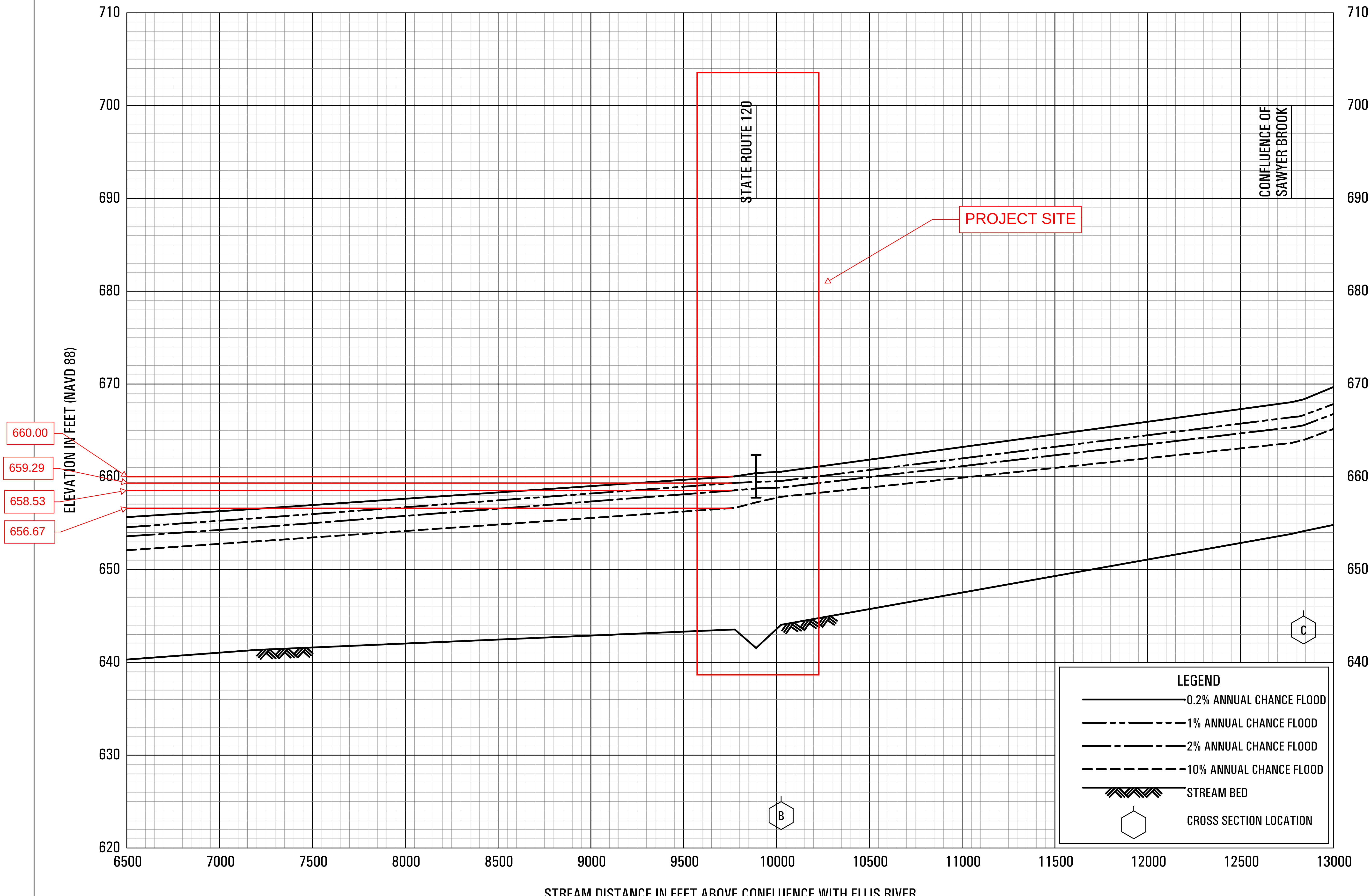
The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD). With the completion of the North American Vertical Datum of 1988 (NAVD), many FIS reports and FIRMs are now prepared using NAVD as the referenced vertical datum.

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD 88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. This can be done by applying a standard conversion factor. The Flood Profiles, and Base (1-percent annual chance) Flood Elevations (BFEs) in the precountywide FIS reports, are in NGVD. These were converted to NAVD by applying the conversion factor of -0.5 feet to each detailed study stream in the effective FIS reports (**NGVD – 0.5 ft. = NAVD**). It is important to note that adjacent communities may be referenced to NGVD 29. This may result in differences in base flood elevations across the corporate limits between the communities. For information regarding conversion between the NGVD 29 and NAVD 88, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242



FLOOD PROFILES

WEST BRANCH ELLIS RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

OXFORD COUNTY, ME

(ALL JURISDICTIONS)

132P

APPENDIX E

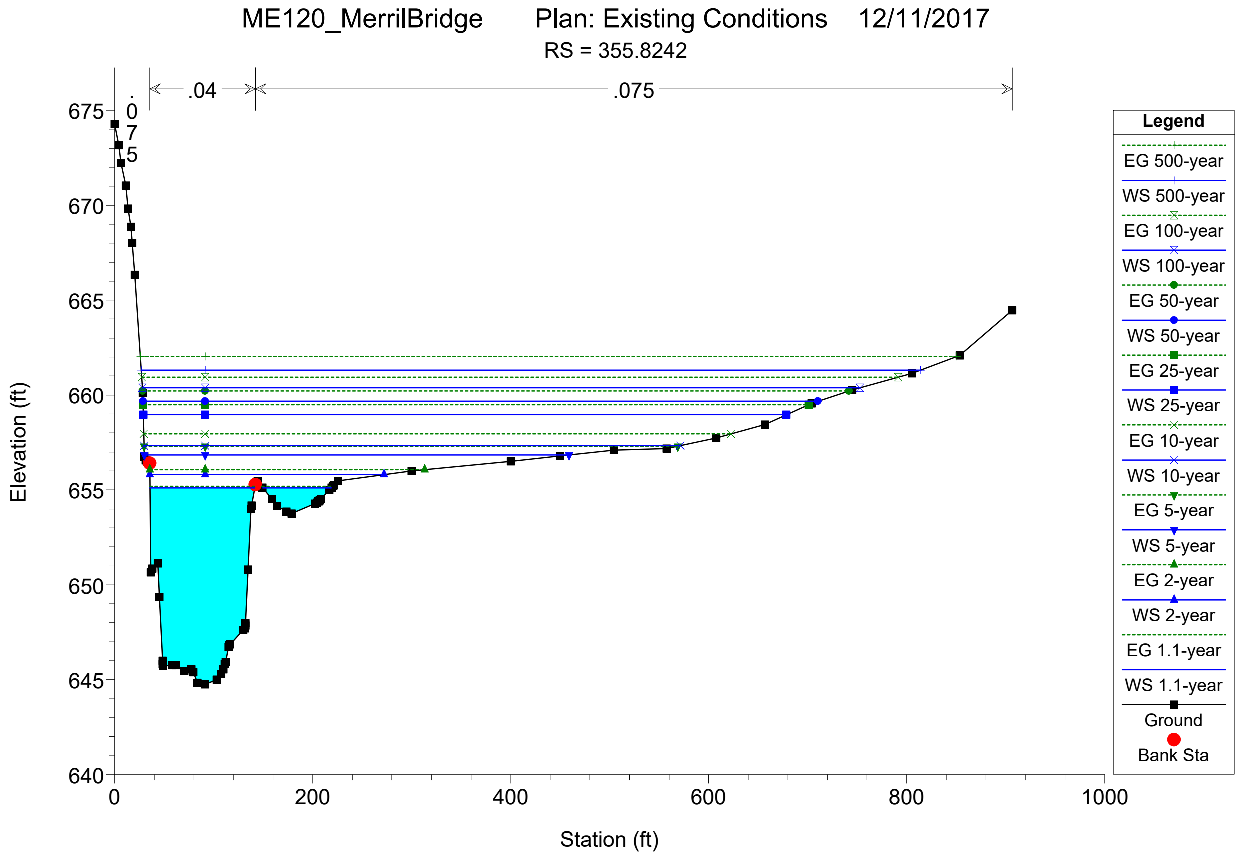
Existing HEC-RAS Analysis

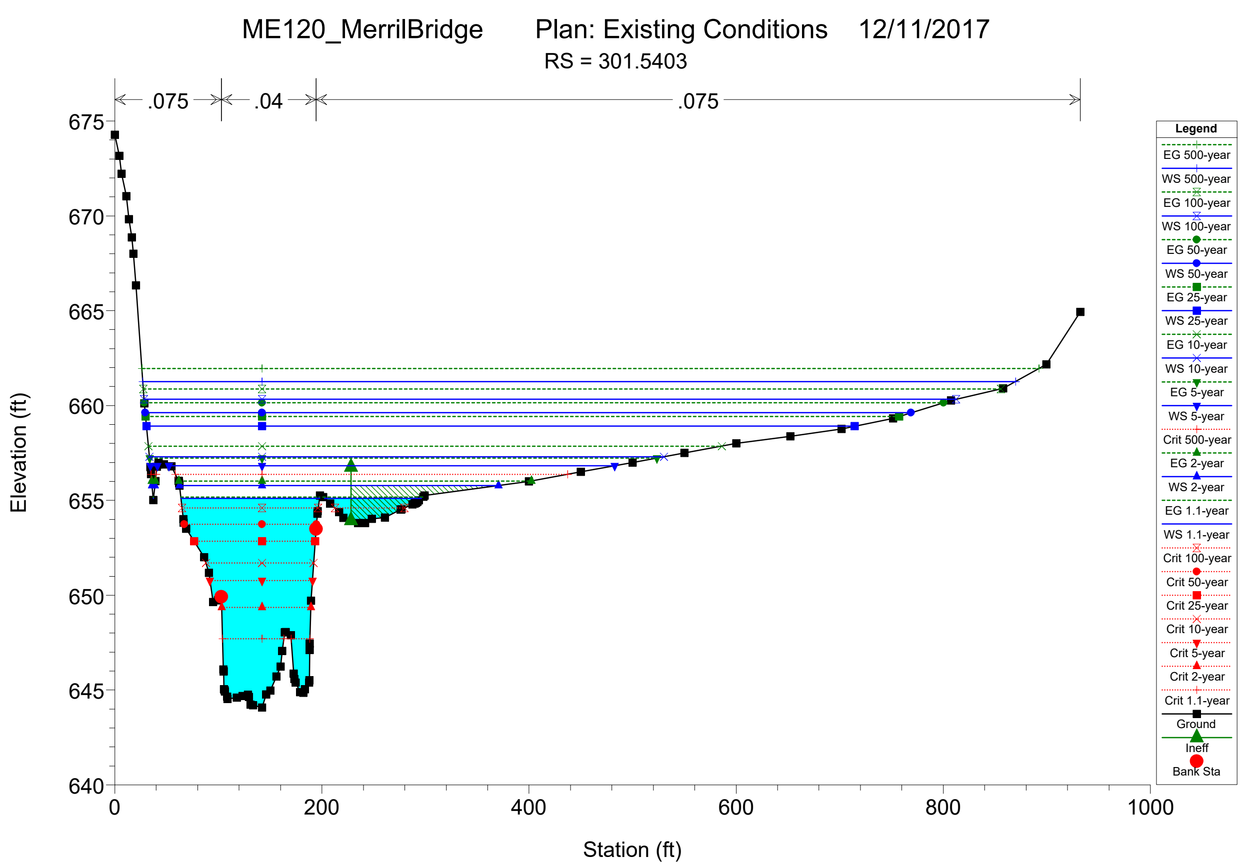
HEC-RAS Plan: Existing River: Stream Reach: Reach

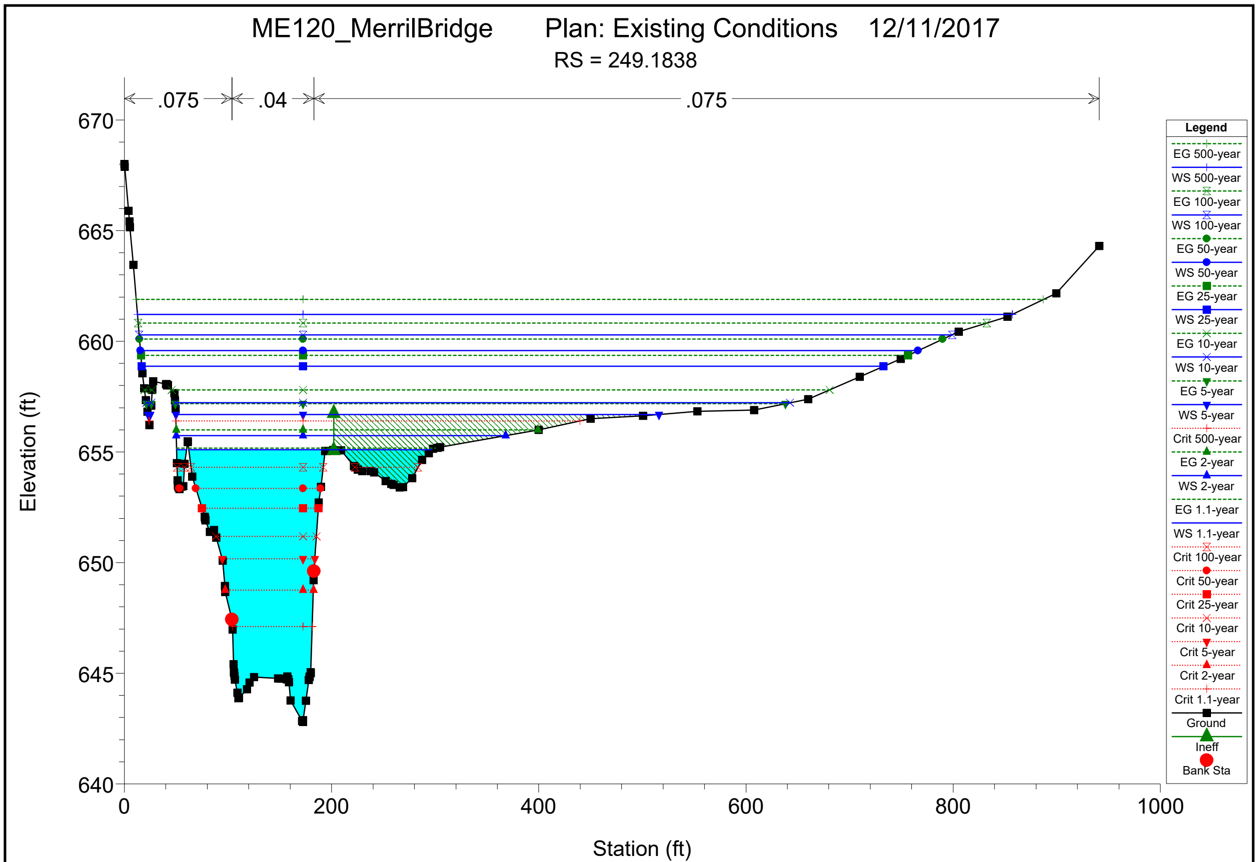
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	355.8242	1.1-year	1950.00	644.76	655.11		655.19	0.000241	2.22	928.66	175.29	0.14
Reach	355.8242	2-year	3950.00	644.76	655.81		656.07	0.000753	4.11	1065.14	236.77	0.24
Reach	355.8242	5-year	6100.00	644.76	656.85		657.31	0.001180	5.53	1410.32	428.94	0.31
Reach	355.8242	10-year	7700.00	644.76	657.34		657.95	0.001536	6.51	1646.36	541.56	0.36
Reach	355.8242	25-year	9850.00	644.76	658.96		659.49	0.001207	6.36	2627.38	649.36	0.32
Reach	355.8242	50-year	11550.00	644.76	659.67		660.22	0.001221	6.65	3099.75	681.71	0.33
Reach	355.8242	100-year	13350.00	644.76	660.38		660.94	0.001224	6.90	3598.14	724.49	0.33
Reach	355.8242	500-year	17850.00	644.76	661.32		662.04	0.001530	8.07	4306.82	787.33	0.38
Reach	301.5403	1.1-year	1950.00	644.08	655.11	647.71	655.18	0.000194	2.17	1005.51	227.76	0.12
Reach	301.5403	2-year	3950.00	644.08	655.78	649.36	656.02	0.000617	4.06	1117.48	311.06	0.23
Reach	301.5403	5-year	6100.00	644.08	656.83	650.78	657.23	0.000950	5.38	1634.79	437.55	0.28
Reach	301.5403	10-year	7700.00	644.08	657.30	651.69	657.86	0.001263	6.38	1857.97	496.77	0.33
Reach	301.5403	25-year	9850.00	644.08	658.91	652.84	659.42	0.001078	6.42	2802.55	683.86	0.31
Reach	301.5403	50-year	11550.00	644.08	659.62	653.73	660.15	0.001108	6.74	3307.74	739.56	0.32
Reach	301.5403	100-year	13350.00	644.08	660.33	654.60	660.87	0.001110	6.97	3852.24	784.20	0.32
Reach	301.5403	500-year	17850.00	644.08	661.27	656.37	661.95	0.001385	8.12	4616.94	842.76	0.36
Reach	249.1838	1.1-year	1950.00	642.80	655.10	647.11	655.17	0.000162	2.20	1032.20	244.32	0.12
Reach	249.1838	2-year	3950.00	642.80	655.74	648.76	655.99	0.000537	4.16	1129.37	318.02	0.22
Reach	249.1838	5-year	6100.00	642.80	656.69	650.17	657.18	0.000942	5.82	1274.36	468.61	0.29
Reach	249.1838	10-year	7700.00	642.80	657.22	651.18	657.80	0.001130	6.56	1946.96	598.38	0.32
Reach	249.1838	25-year	9850.00	642.80	658.87	652.46	659.37	0.000946	6.51	3038.67	715.90	0.30
Reach	249.1838	50-year	11550.00	642.80	659.58	653.35	660.10	0.000970	6.81	3561.07	750.66	0.31
Reach	249.1838	100-year	13350.00	642.80	660.29	654.31	660.82	0.000977	7.05	4110.26	784.80	0.31
Reach	249.1838	500-year	17850.00	642.80	661.21	656.40	661.89	0.001248	8.27	4858.04	844.60	0.36
Reach	209.1155	1.1-year	1950.00	642.43	655.10	646.25	655.16	0.000108	1.87	1099.48	218.61	0.10
Reach	209.1155	2-year	3950.00	642.43	655.76	647.75	655.96	0.000364	3.56	1175.49	298.36	0.18
Reach	209.1155	5-year	6100.00	642.43	656.73	649.10	657.12	0.000662	5.06	1286.30	393.98	0.25
Reach	209.1155	10-year	7700.00	642.43	657.25	649.97	657.73	0.000822	5.79	1872.27	447.21	0.28
Reach	209.1155	25-year	9850.00	642.43	658.83	651.09	659.34	0.000795	6.14	2668.70	608.37	0.28
Reach	209.1155	50-year	11550.00	642.43	659.50	651.90	660.05	0.000870	6.61	3070.20	649.27	0.30
Reach	209.1155	100-year	13350.00	642.43	660.16	652.71	660.77	0.000931	7.03	3497.01	693.08	0.31
Reach	209.1155	500-year	17850.00	642.43	660.97	654.65	661.82	0.001283	8.52	4055.34	754.83	0.36
Reach	180		Bridge									
Reach	152.3317	1.1-year	1950.00	641.87	655.07	646.00	655.14	0.000195	2.10	953.62	529.84	0.11
Reach	152.3317	2-year	3950.00	641.87	655.65	647.82	655.90	0.000663	4.01	1014.19	636.83	0.21
Reach	152.3317	5-year	6100.00	641.87	656.63	649.43	656.87	0.000732	4.46	2523.35	741.59	0.23
Reach	152.3317	10-year	7700.00	641.87	657.02	650.48	657.34	0.000961	5.22	2815.32	778.43	0.26
Reach	152.3317	25-year	9850.00	641.87	658.01	651.78	658.34	0.000978	5.55	3619.64	872.15	0.27
Reach	152.3317	50-year	11550.00	641.87	658.77	652.71	659.11	0.001001	5.82	4323.21	1049.01	0.27
Reach	152.3317	100-year	13350.00	641.87	659.52	653.61	659.85	0.000957	5.90	5150.14	1168.38	0.27
Reach	152.3317	500-year	17850.00	641.87	660.32	656.67	660.71	0.001162	6.73	6185.71	1215.25	0.30
Reach	116.4113	1.1-year	1950.00	642.49	655.07	645.92	655.13	0.000169	1.98	1007.40	507.76	0.11
Reach	116.4113	2-year	3950.00	642.49	655.64	647.58	655.86	0.000578	3.79	1083.25	653.59	0.20
Reach	116.4113	5-year	6100.00	642.49	656.51	649.07	656.82	0.000833	4.78	2128.95	792.93	0.24
Reach	116.4113	10-year	7700.00	642.49	656.85	650.06	657.27	0.001128	5.67	2396.50	845.27	0.28
Reach	116.4113	25-year	9850.00	642.49	657.86	651.25	658.28	0.001130	5.98	3292.34	986.49	0.29
Reach	116.4113	50-year	11550.00	642.49	658.67	652.15	659.06	0.001054	6.00	4112.65	1094.84	0.28
Reach	116.4113	100-year	13350.00	642.49	659.45	653.05	659.81	0.000981	6.00	4974.53	1188.65	0.27
Reach	116.4113	500-year	17850.00	642.49	660.24	657.06	660.66	0.001177	6.80	6072.95	1239.50	0.30
Reach	103.2161	1.1-year	1950.00	642.82	655.07	646.16	655.13	0.000163	2.00	1019.60	439.45	0.11
Reach	103.2161	2-year	3950.00	642.82	655.63	647.80	655.85	0.000560	3.84	1101.99	533.54	0.20
Reach	103.2161	5-year	6100.00	642.82	656.46	649.24	656.81	0.000862	5.00	1940.13	661.00	0.25
Reach	103.2161	10-year	7700.00	642.82	656.76	650.23	657.25	0.001204	6.00	2138.42	708.28	0.30
Reach	103.2161	25-year	9850.00	642.82	657.72	651.39	658.25	0.001289	6.52	2863.93	857.02	0.31
Reach	103.2161	50-year	11550.00	642.82	658.52	652.25	659.03	0.001260	6.69	3576.22	1011.35	0.31
Reach	103.2161	100-year	13350.00	642.82	659.30	653.11	659.78	0.001190	6.73	4398.52	1148.92	0.30
Reach	103.2161	500-year	17850.00	642.82	660.06	655.05	660.63	0.001451	7.68	5409.51	1201.56	0.34
Reach	85.7696	1.1-year	1950.00	643.04	655.07	646.27	655.12	0.000162	1.94	1049.27	551.84	0.11
Reach	85.7696	2-year	3950.00	643.04	655.63	647.87	655.84	0.000553	3.71	1144.71	709.67	0.20
Reach	85.7696	5-year	6100.00	643.04	656.49	649.30	656.78	0.000779	4.63	2309.80	896.76	0.24
Reach	85.7696	10-year	7700.00	643.04	656.81	650.25	657.20	0.001045	5.46	2604.61	939.90	0.28
Reach	85.7696	25-year	9850.00	643.04	657.81	651.42	658.18	0.001018	5.68	3580.41	1088.59	0.28
Reach	85.7696	50-year	11550.00	643.04	658.62	652.29	658.96	0.000934	5.66	4448.08	1171.56	0.27
Reach	85.7696	100-year	13350.00	643.04	659.40	653.13	659.71	0.000854	5.61	5333.53	1225.63	0.26
Reach	85.7696	500-year	17850.00	643.04	660.18	657.02	660.54	0.001044	6.42	6463.73	1275.50	0.29
Reach	69.5		Bridge									

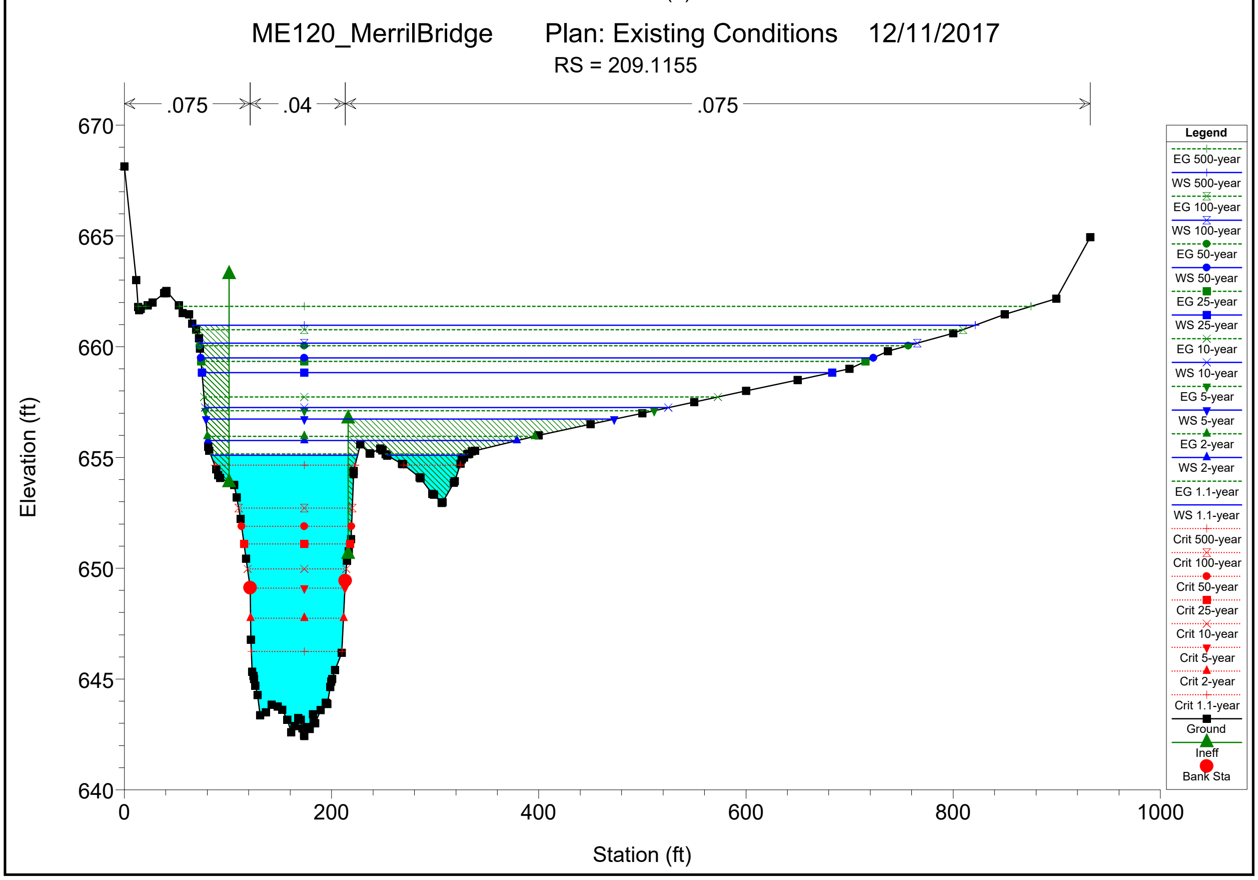
HEC-RAS Plan: Existing River: Stream Reach: Reach (Continued)

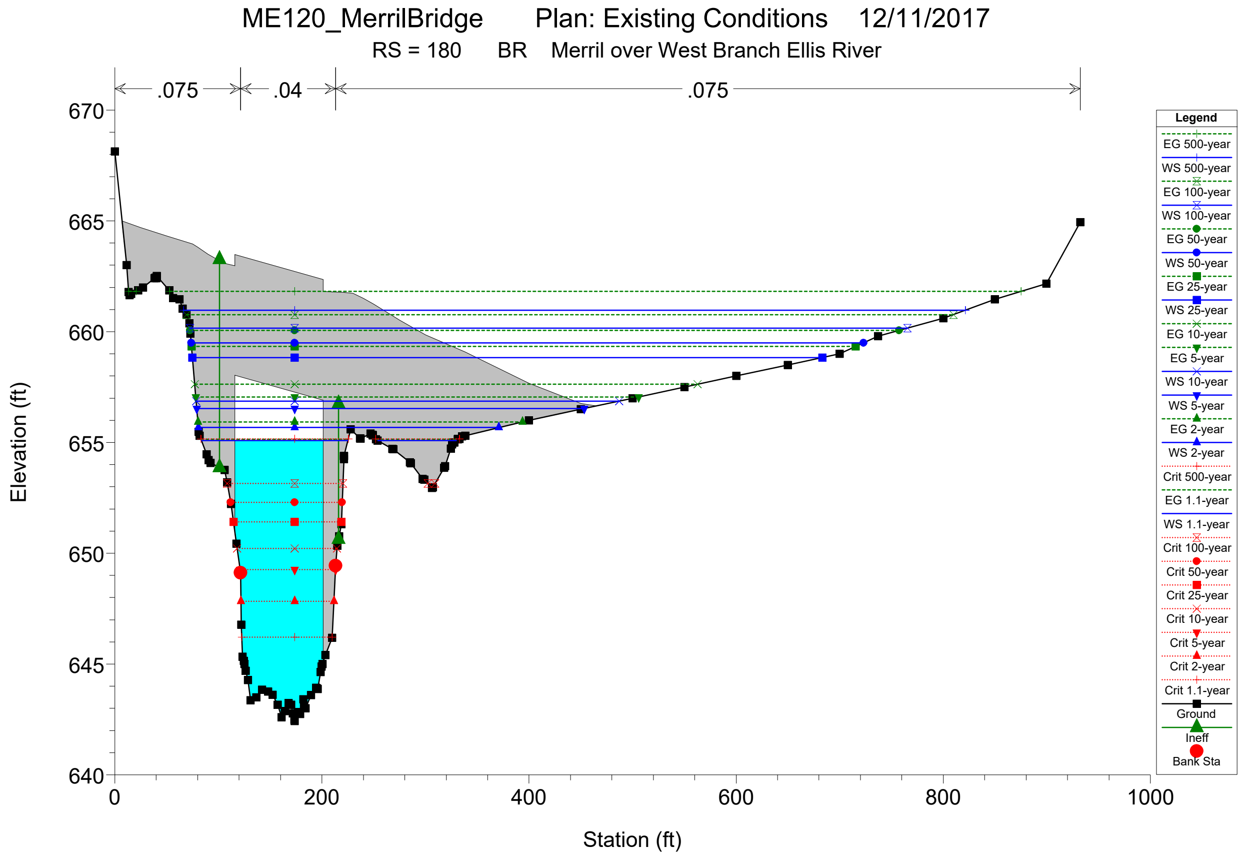
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	56.9144	1.1-year	1950.00	643.17	655.06		655.12	0.000175	1.94	1223.59	539.38	0.11
Reach	56.9144	2-year	3950.00	643.17	655.63		655.82	0.000550	3.58	1573.66	703.72	0.20
Reach	56.9144	5-year	6100.00	643.17	656.45		656.75	0.000867	4.73	2233.97	909.50	0.25
Reach	56.9144	10-year	7700.00	643.17	656.75		657.16	0.001175	5.60	2522.00	980.45	0.29
Reach	56.9144	25-year	9850.00	643.17	657.76		658.14	0.001114	5.77	3618.49	1193.98	0.29
Reach	56.9144	50-year	11550.00	643.17	658.60		658.92	0.000954	5.57	4641.98	1246.46	0.27
Reach	56.9144	100-year	13350.00	643.17	659.36		659.64	0.000851	5.46	5607.61	1285.58	0.26
Reach	56.9144	500-year	17850.00	643.17	660.10		660.44	0.001056	6.29	6566.34	1314.41	0.29
Reach	37.8550	1.1-year	1950.00	643.52	655.05	647.14	655.11	0.000205	2.07	1160.00	540.50	0.12
Reach	37.8550	2-year	3950.00	643.52	655.59	648.97	655.80	0.000649	3.81	1490.42	685.20	0.21
Reach	37.8550	5-year	6100.00	643.52	656.39	650.34	656.73	0.001014	5.01	2110.40	857.12	0.27
Reach	37.8550	10-year	7700.00	643.52	656.67	651.27	657.13	0.001387	5.95	2358.22	913.21	0.31
Reach	37.8550	25-year	9850.00	643.52	657.70	652.36	658.12	0.001273	6.05	3376.17	1047.17	0.30
Reach	37.8550	50-year	11550.00	643.52	658.53	653.11	658.89	0.001120	5.92	4283.18	1138.34	0.29
Reach	37.8550	100-year	13350.00	643.52	659.29	654.00	659.61	0.001017	5.86	5179.78	1219.20	0.28
Reach	37.8550	500-year	17850.00	643.52	660.00	657.30	660.41	0.001289	6.82	6068.68	1283.20	0.31


ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 355.8242
.04
.075
.075
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
WS 10-year
EG 5-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Ground
Bank Sta
Elevation (ft)
Station (ft)

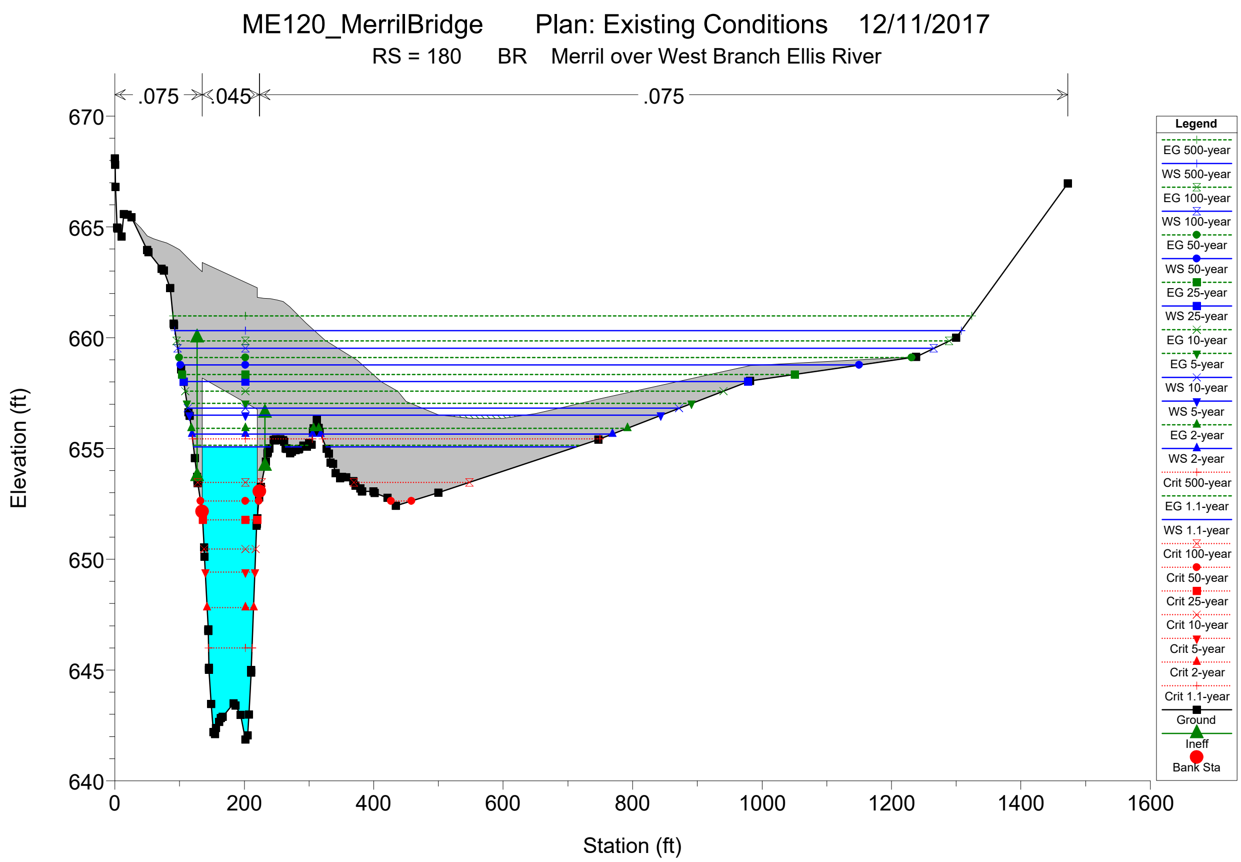

ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 301.5403
.075
.04
.075
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
WS 10-year
EG 5-year
WS 5-year
Crit 500-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 249.1838
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
WS 10-year
EG 5-year
WS 5-year
Crit 500-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta

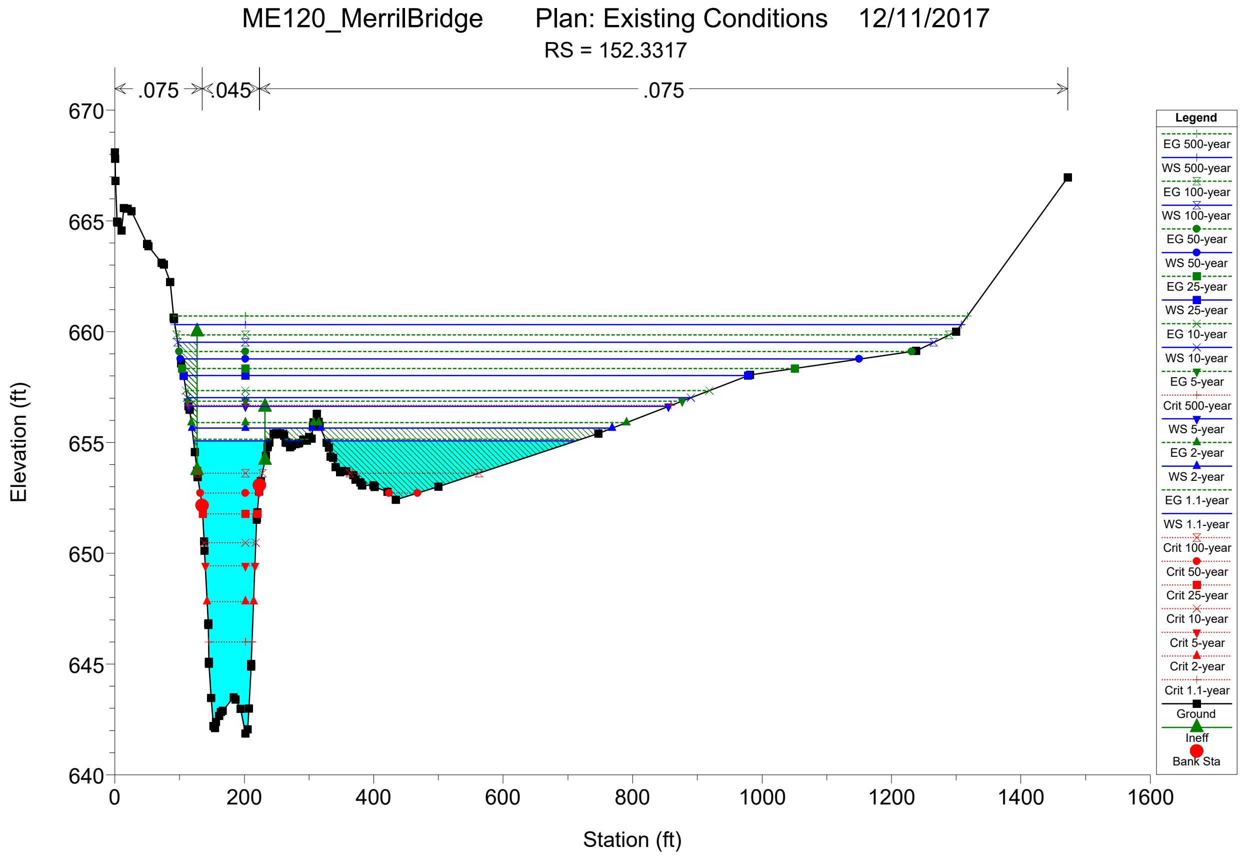

ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 209.1155
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
WS 10-year
EG 5-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 500-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta

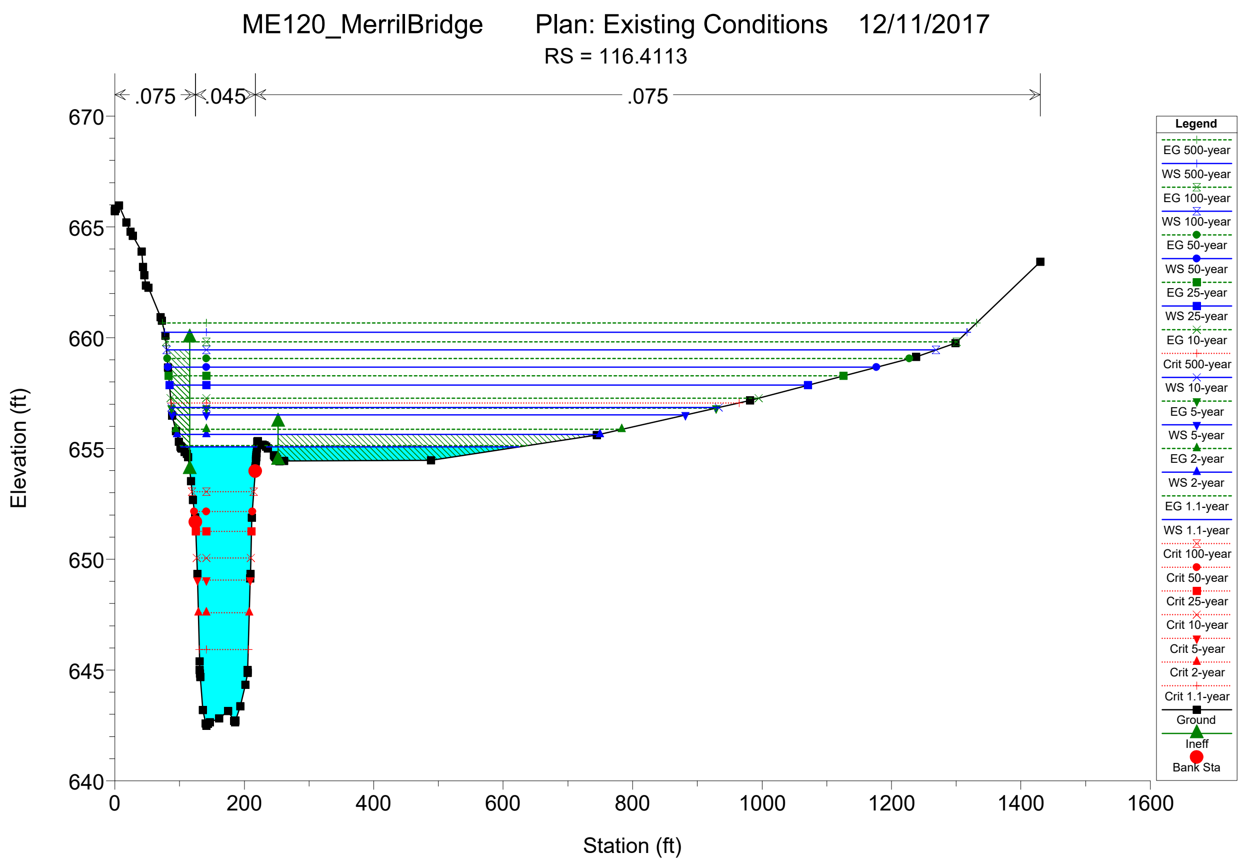


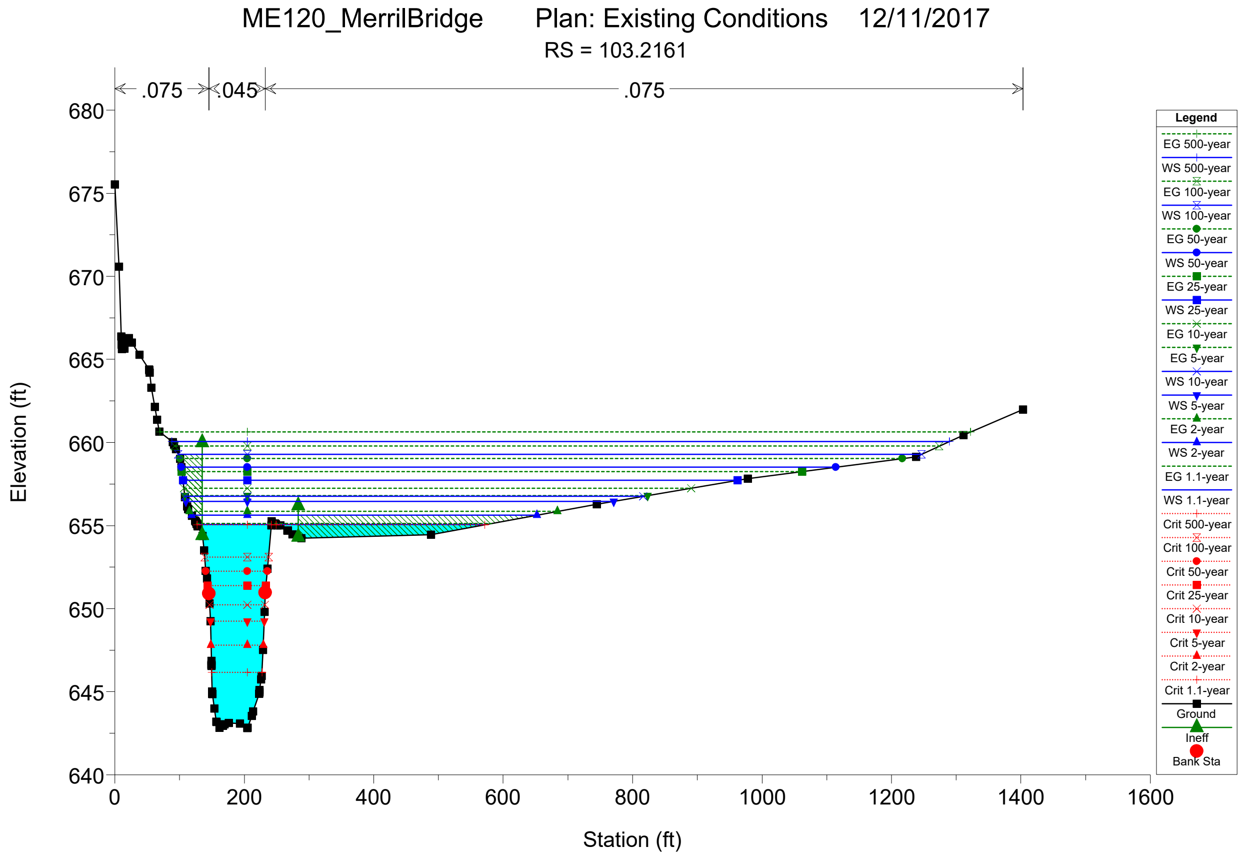
ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 180 BR Merril over West Branch Ellis River
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
Crit 500-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta

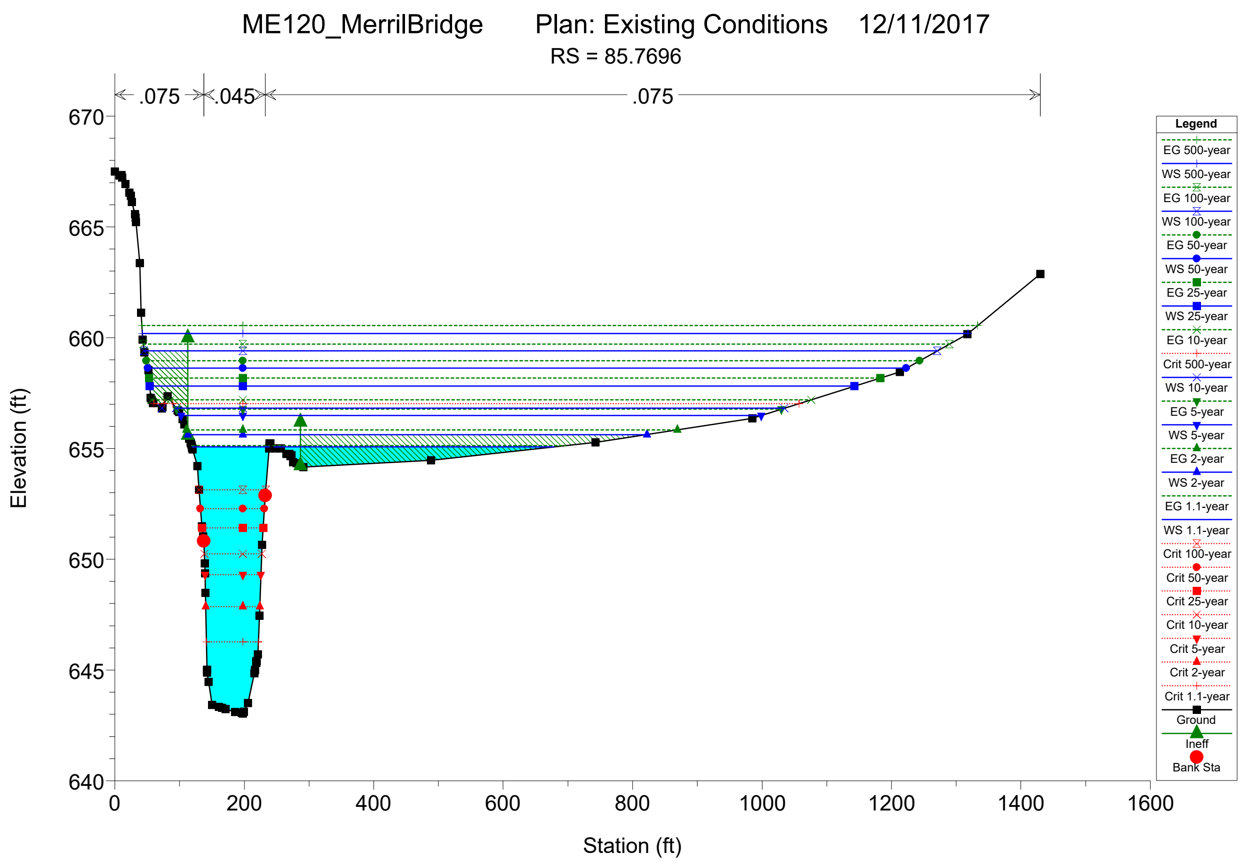


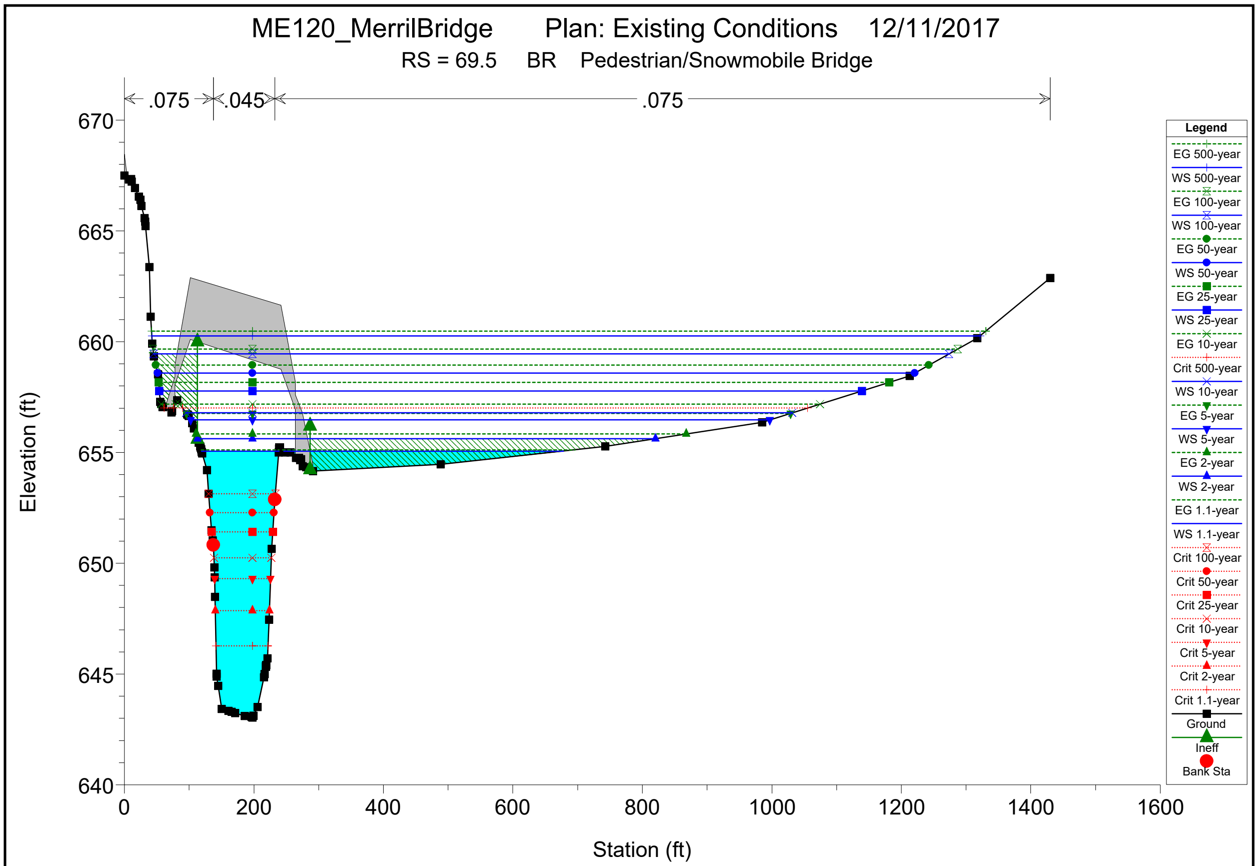
ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 180 BR Merril over West Branch Ellis River
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
Crit 500-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta

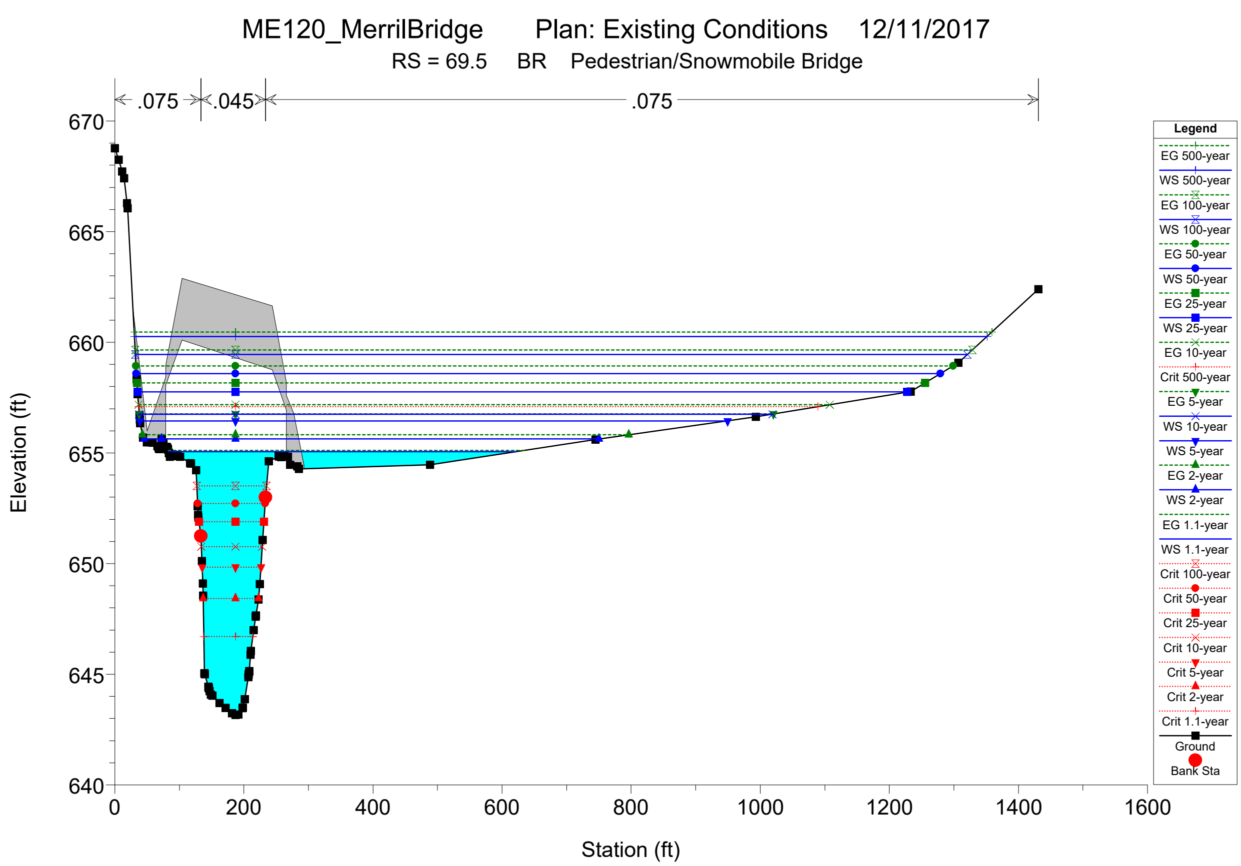

ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 152.3317
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
WS 10-year
EG 5-year
Crit 500-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta

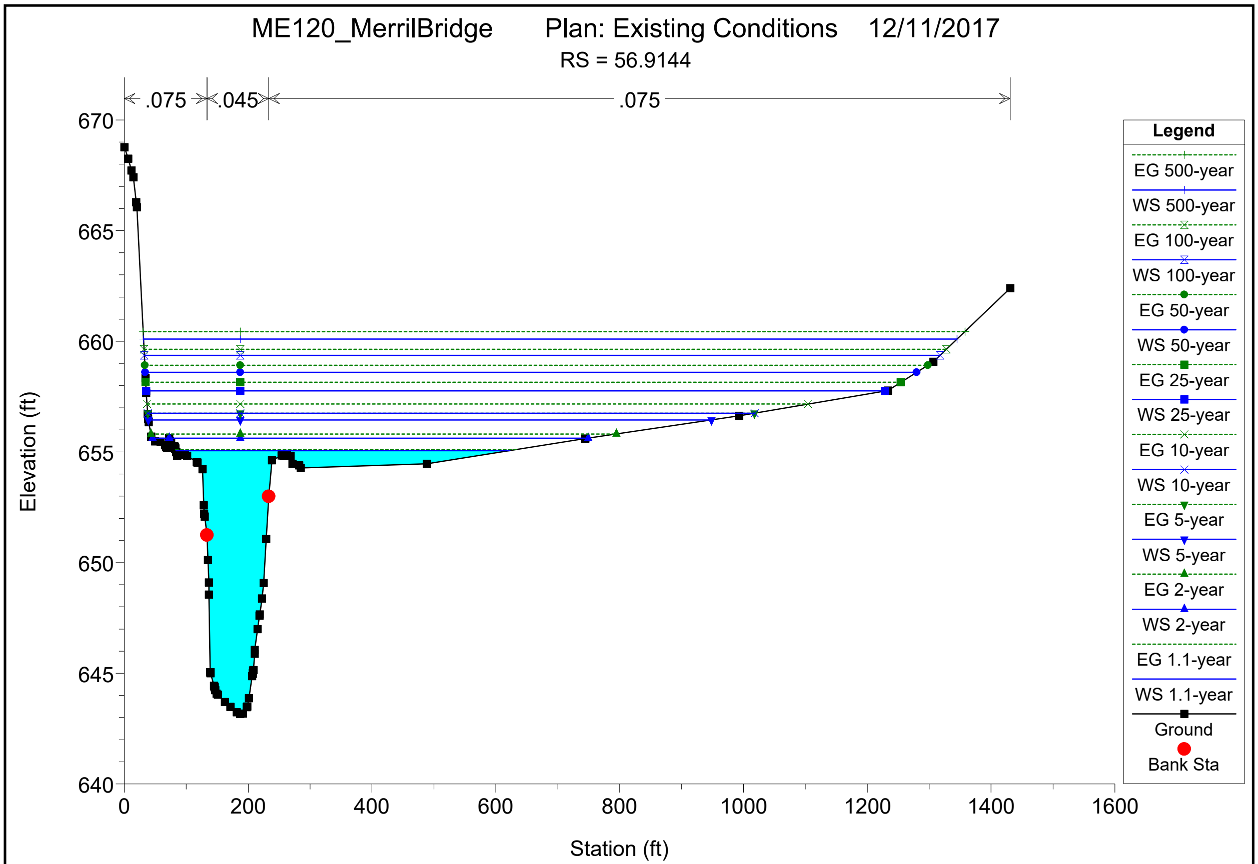

ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 116.4113
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
Crit 500-year
WS 10-year
EG 5-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta


ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 103.2161
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 500-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta


ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 85.7696
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
Crit 500-year
WS 10-year
EG 5-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta


ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 69.5 BR Pedestrian/Snowmobile Bridge
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
Crit 500-year
WS 10-year
EG 5-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta


ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 69.5 BR Pedestrian/Snowmobile Bridge
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
Crit 500-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Bank Sta



ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 56.9144
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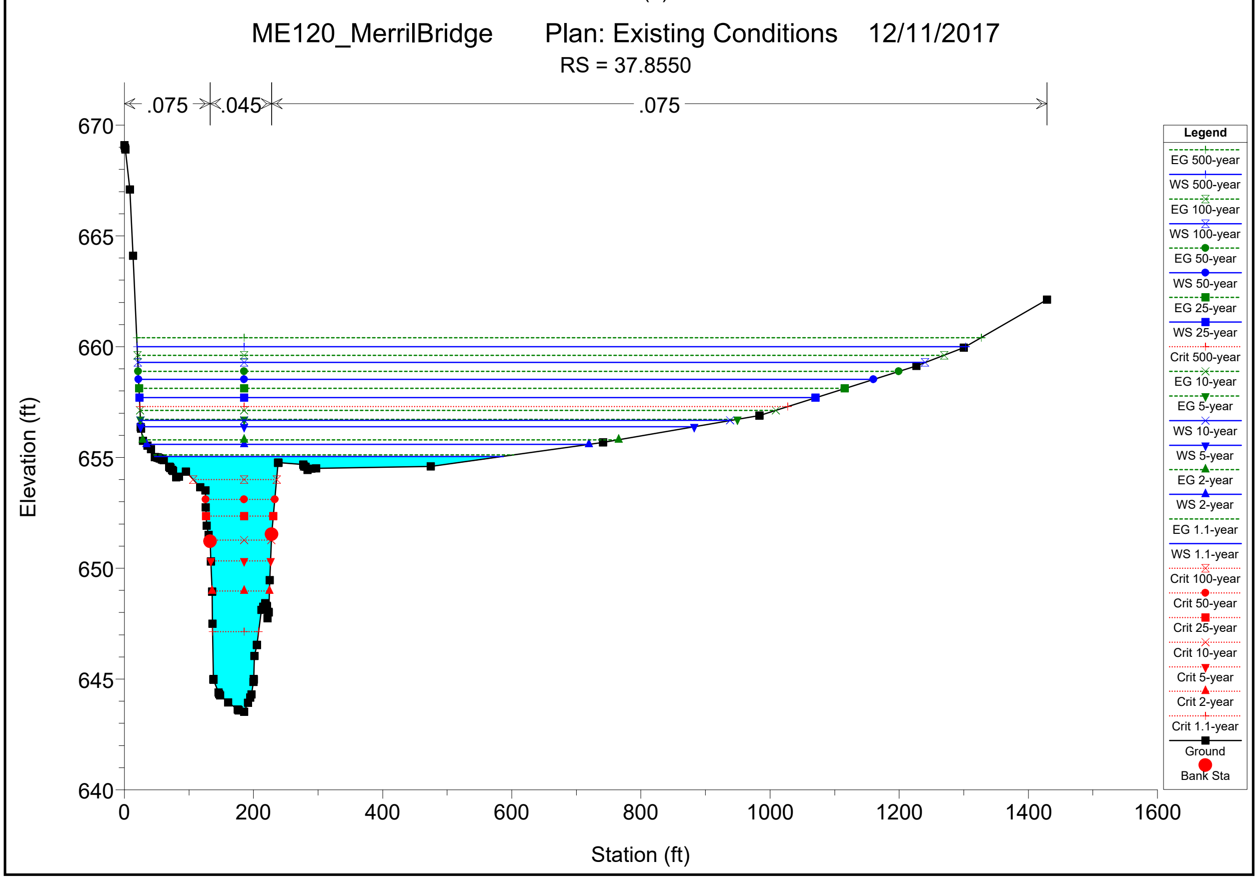
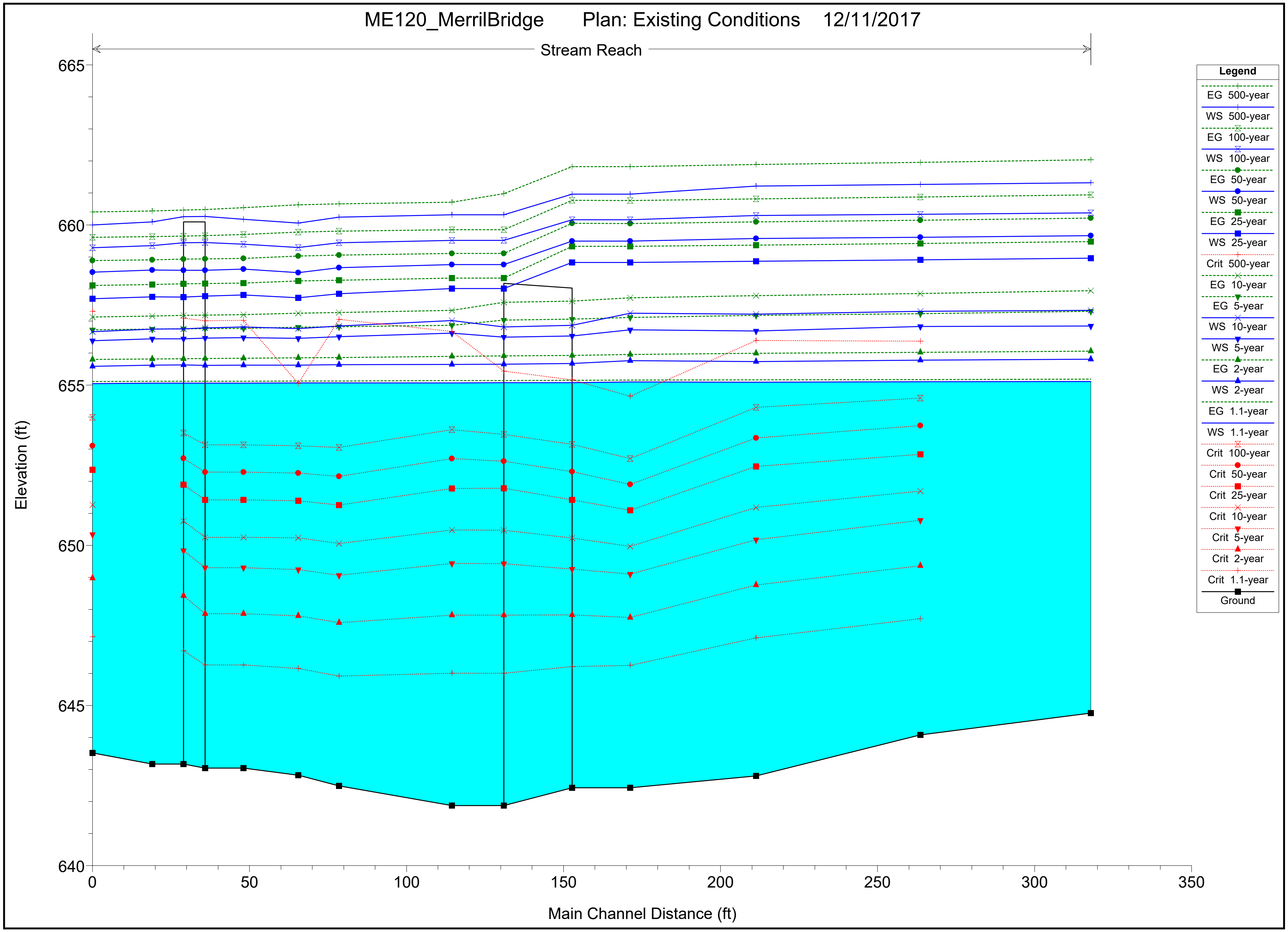
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
WS 10-year
EG 5-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Ground
Bank Sta



ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
RS = 37.8550
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
Crit 500-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Bank Sta



ME120_MerrilBridge Plan: Existing Conditions 12/11/2017
Stream Reach
665
660
655
650
645
640
Elevation (ft)
0
50
100
150
200
250
300
350
Main Channel Distance (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
Crit 500-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground

APPENDIX F

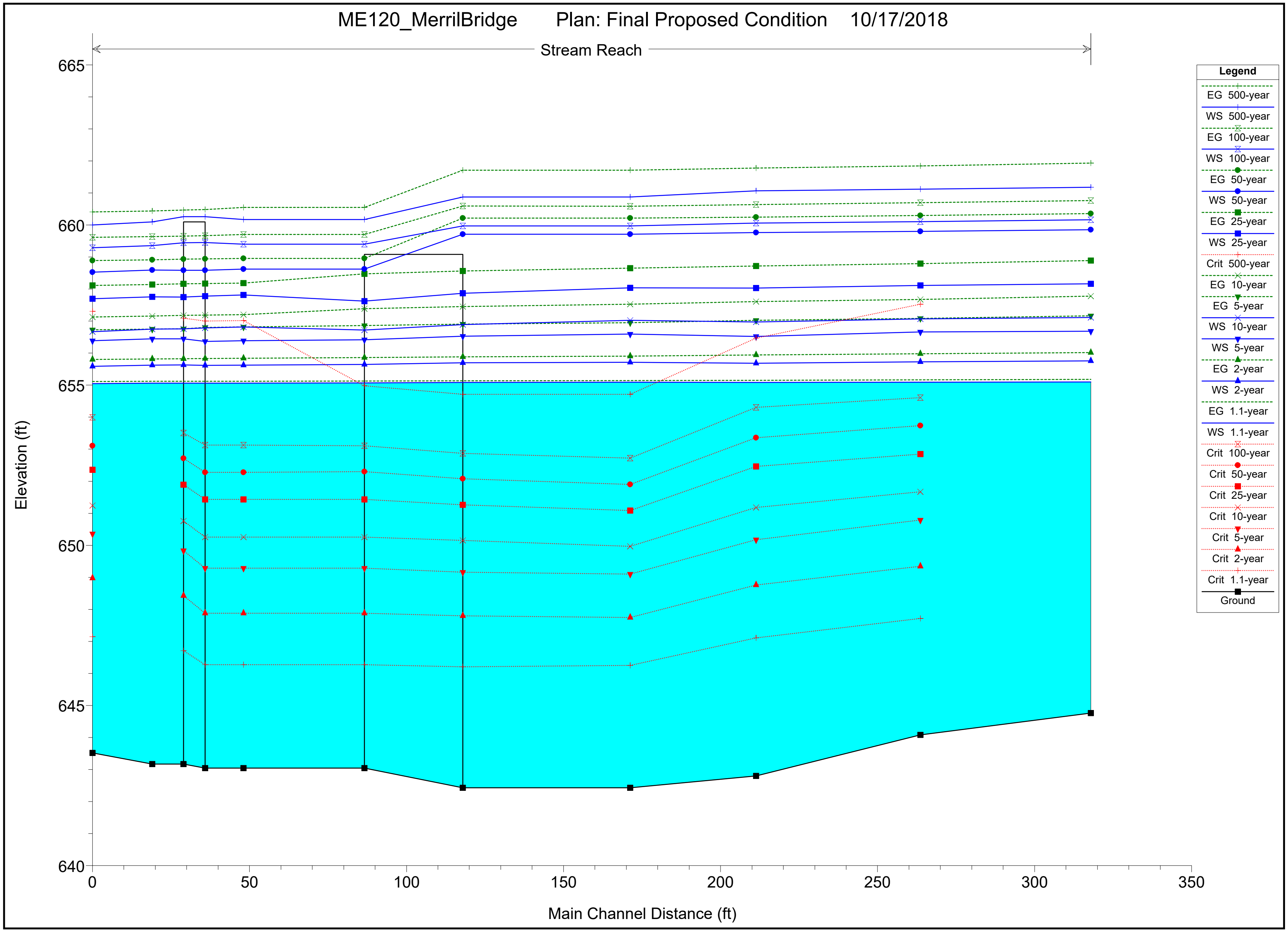
Proposed HEC-RAS Analysis

HEC-RAS Plan: Final Proposed Condition River: Stream Reach: Reach

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	355.8242	1.1-year	1950.00	644.76	655.10		655.18	0.000242	2.22	926.43	174.81	0.14
Reach	355.8242	2-year	3950.00	644.76	655.76		656.02	0.000767	4.14	1053.57	229.64	0.25
Reach	355.8242	5-year	6100.00	644.76	656.68		657.16	0.001266	5.66	1341.19	399.83	0.32
Reach	355.8242	10-year	7700.00	644.76	657.11		657.78	0.001687	6.73	1528.47	481.47	0.37
Reach	355.8242	25-year	9850.00	644.76	658.16		658.89	0.001727	7.27	2123.69	607.40	0.38
Reach	355.8242	50-year	11550.00	644.76	659.85		660.36	0.001134	6.47	3222.93	692.14	0.32
Reach	355.8242	100-year	13350.00	644.76	660.16		660.77	0.001336	7.13	3440.29	710.20	0.35
Reach	355.8242	500-year	17850.00	644.76	661.18		661.93	0.001613	8.24	4197.66	780.09	0.38
Reach	301.5403	1.1-year	1950.00	644.08	655.09	647.71	655.16	0.000194	2.17	1008.26	227.10	0.12
Reach	301.5403	2-year	3950.00	644.08	655.73	649.35	655.98	0.000627	4.08	1116.51	304.13	0.23
Reach	301.5403	5-year	6100.00	644.08	656.66	650.79	657.09	0.001012	5.49	1563.23	415.98	0.29
Reach	301.5403	10-year	7700.00	644.08	657.07	651.67	657.68	0.001391	6.60	1745.46	473.16	0.34
Reach	301.5403	25-year	9850.00	644.08	658.11	652.85	658.79	0.001486	7.23	2292.71	583.51	0.36
Reach	301.5403	50-year	11550.00	644.08	659.80	653.74	660.30	0.001027	6.55	3445.73	750.81	0.31
Reach	301.5403	100-year	13350.00	644.08	660.10	654.61	660.70	0.001214	7.22	3675.39	769.16	0.34
Reach	301.5403	500-year	17850.00	644.08	661.12	657.53	661.85	0.001466	8.30	4494.52	837.78	0.37
Reach	249.1838	1.1-year	1950.00	642.80	655.08	647.11	655.15	0.000163	2.20	1030.58	243.99	0.12
Reach	249.1838	2-year	3950.00	642.80	655.69	648.76	655.95	0.000546	4.19	1128.01	311.78	0.22
Reach	249.1838	5-year	6100.00	642.80	656.52	650.17	657.03	0.000988	5.91	1263.69	410.97	0.30
Reach	249.1838	10-year	7700.00	642.80	656.97	651.18	657.61	0.001252	6.81	1802.14	569.52	0.34
Reach	249.1838	25-year	9850.00	642.80	658.03	652.46	658.72	0.001324	7.40	2458.49	659.65	0.35
Reach	249.1838	50-year	11550.00	642.80	659.77	653.36	660.25	0.000899	6.61	3703.68	759.68	0.30
Reach	249.1838	100-year	13350.00	642.80	660.06	654.31	660.64	0.001069	7.30	3930.08	773.77	0.33
Reach	249.1838	500-year	17850.00	642.80	661.06	656.47	661.78	0.001317	8.45	4733.86	836.67	0.37
Reach	209.1155	1.1-year	1950.00	642.43	655.09	646.25	655.14	0.000109	1.87	1130.60	217.87	0.10
Reach	209.1155	2-year	3950.00	642.43	655.71	647.75	655.91	0.000368	3.57	1224.07	293.88	0.18
Reach	209.1155	5-year	6100.00	642.43	656.60	649.10	656.95	0.000635	4.92	1662.10	380.80	0.24
Reach	209.1155	10-year	7700.00	642.43	657.02	649.97	657.53	0.000876	5.91	1833.31	424.12	0.29
Reach	209.1155	25-year	9850.00	642.43	658.04	651.09	658.66	0.001016	6.69	2317.59	527.72	0.31
Reach	209.1155	50-year	11550.00	642.43	659.71	651.90	660.21	0.000786	6.34	3327.50	659.62	0.28
Reach	209.1155	100-year	13350.00	642.43	659.97	652.73	660.59	0.000962	7.09	3502.31	677.83	0.31
Reach	209.1155	500-year	17850.00	642.43	660.87	654.71	661.72	0.001284	8.49	4144.04	748.05	0.36
Reach	180		Bridge									

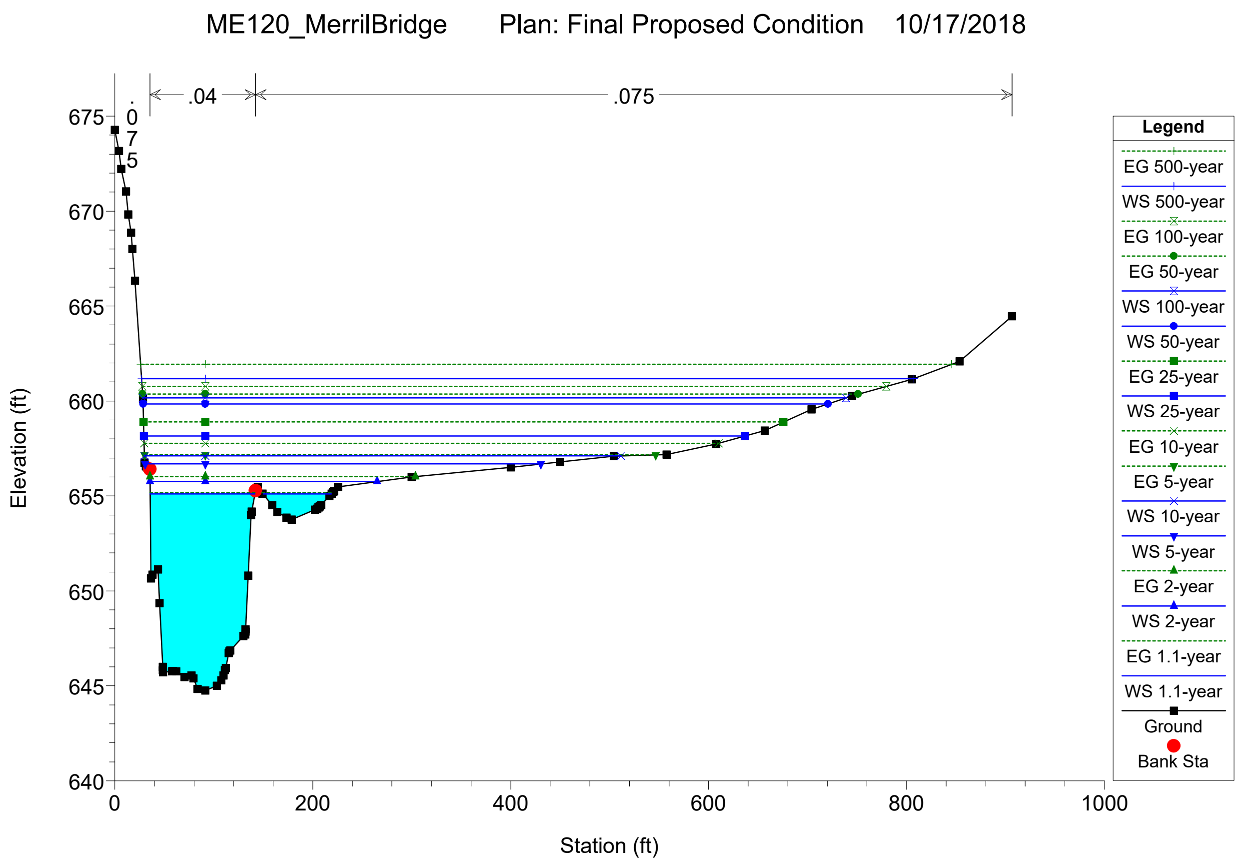
HEC-RAS Plan: Final Proposed Condition   River: Stream   Reach: Reach (Continued)

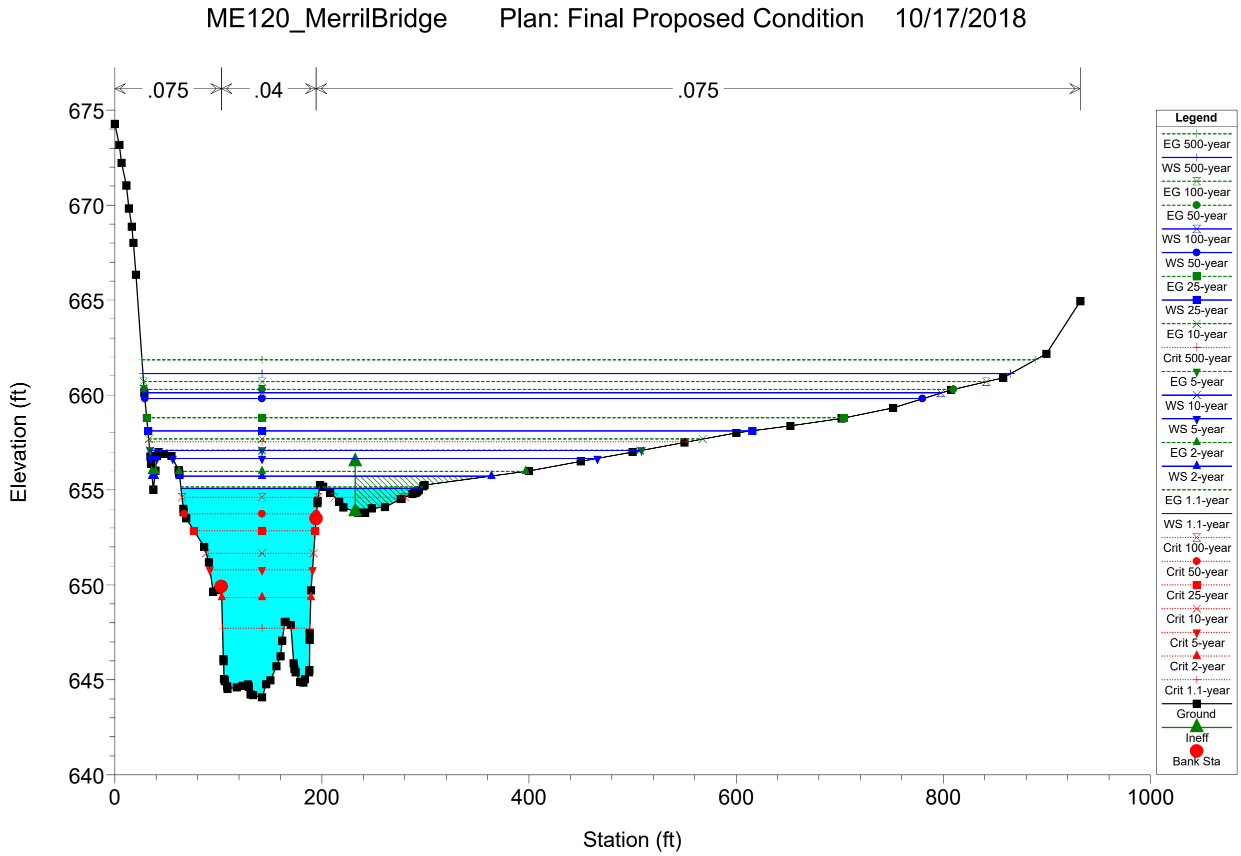
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	85.7696	1.1-year	1950.00	643.04	655.07	646.27	655.12	0.000162	1.94	1038.52	551.78	0.11
Reach	85.7696	2-year	3950.00	643.04	655.63	647.88	655.84	0.000556	3.72	1124.68	709.26	0.20
Reach	85.7696	5-year	6100.00	643.04	656.38	649.29	656.82	0.001041	5.33	1245.18	883.90	0.27
Reach	85.7696	10-year	7700.00	643.04	656.81	650.26	657.20	0.001045	5.46	2605.83	939.91	0.28
Reach	85.7696	25-year	9850.00	643.04	657.81	651.43	658.18	0.001017	5.68	3582.82	1088.62	0.28
Reach	85.7696	50-year	11550.00	643.04	658.62	652.27	658.96	0.000933	5.66	4451.19	1171.57	0.27
Reach	85.7696	100-year	13350.00	643.04	659.40	653.13	659.71	0.000853	5.61	5337.49	1225.64	0.26
Reach	85.7696	500-year	17850.00	643.04	660.17	657.02	660.55	0.001078	6.52	6243.51	1275.01	0.29
Reach	69.5		Bridge									
Reach	56.9144	1.1-year	1950.00	643.17	655.06		655.12	0.000175	1.94	1223.59	539.38	0.11
Reach	56.9144	2-year	3950.00	643.17	655.63		655.82	0.000550	3.58	1573.66	703.72	0.20
Reach	56.9144	5-year	6100.00	643.17	656.45		656.75	0.000867	4.73	2233.97	909.50	0.25
Reach	56.9144	10-year	7700.00	643.17	656.75		657.16	0.001175	5.60	2522.06	980.46	0.29
Reach	56.9144	25-year	9850.00	643.17	657.76		658.14	0.001114	5.77	3618.49	1193.98	0.29
Reach	56.9144	50-year	11550.00	643.17	658.60		658.92	0.000954	5.57	4641.98	1246.46	0.27
Reach	56.9144	100-year	13350.00	643.17	659.36		659.64	0.000851	5.46	5607.61	1285.58	0.26
Reach	56.9144	500-year	17850.00	643.17	660.10		660.44	0.001056	6.29	6566.34	1314.41	0.29
Reach	37.8550	1.1-year	1950.00	643.52	655.05	647.14	655.11	0.000205	2.07	1160.00	540.50	0.12
Reach	37.8550	2-year	3950.00	643.52	655.59	648.97	655.80	0.000649	3.81	1490.42	685.20	0.21
Reach	37.8550	5-year	6100.00	643.52	656.39	650.36	656.73	0.001014	5.01	2110.40	857.12	0.27
Reach	37.8550	10-year	7700.00	643.52	656.67	651.24	657.13	0.001387	5.95	2358.22	913.21	0.31
Reach	37.8550	25-year	9850.00	643.52	657.70	652.36	658.12	0.001273	6.05	3376.17	1047.17	0.30
Reach	37.8550	50-year	11550.00	643.52	658.53	653.11	658.89	0.001120	5.92	4283.18	1138.34	0.29
Reach	37.8550	100-year	13350.00	643.52	659.29	654.00	659.61	0.001017	5.86	5179.78	1219.20	0.28
Reach	37.8550	500-year	17850.00	643.52	660.00	657.30	660.41	0.001289	6.82	6068.68	1283.20	0.31

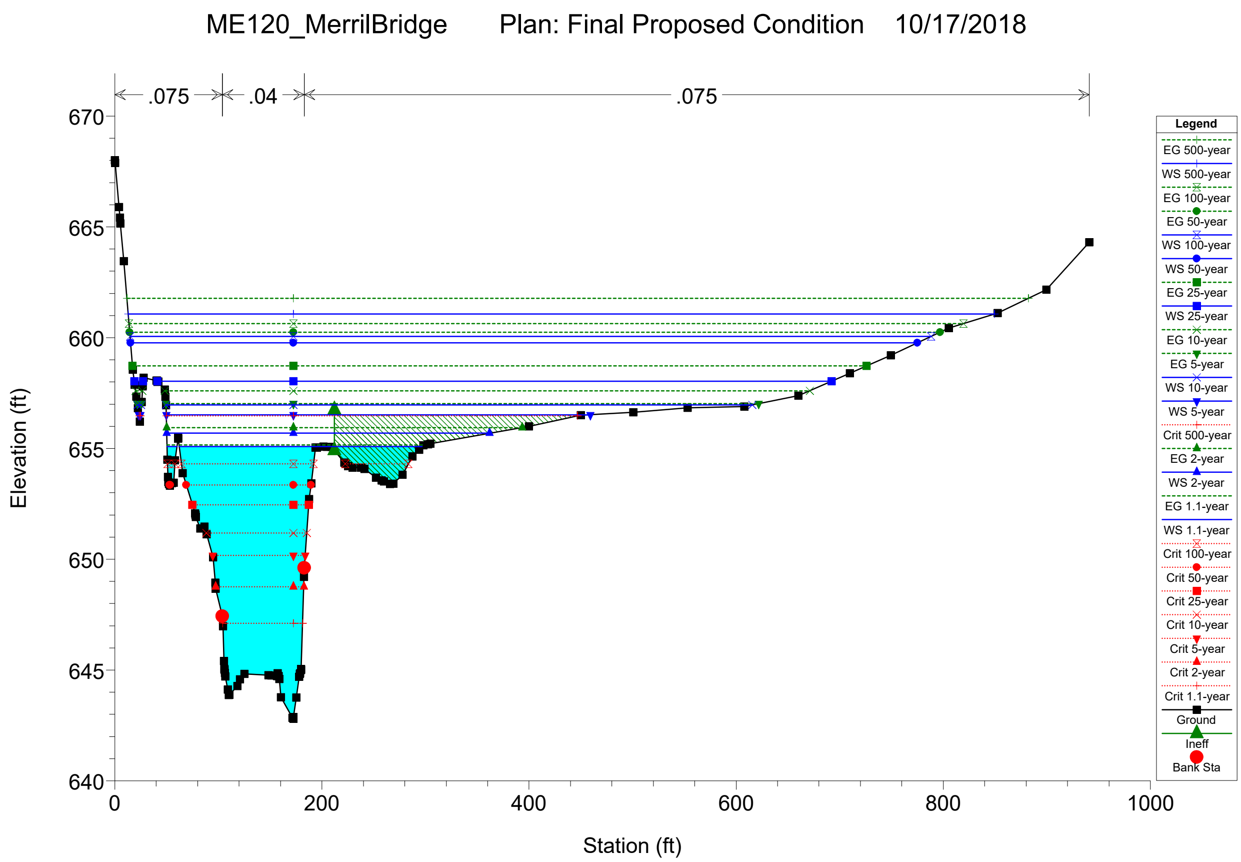


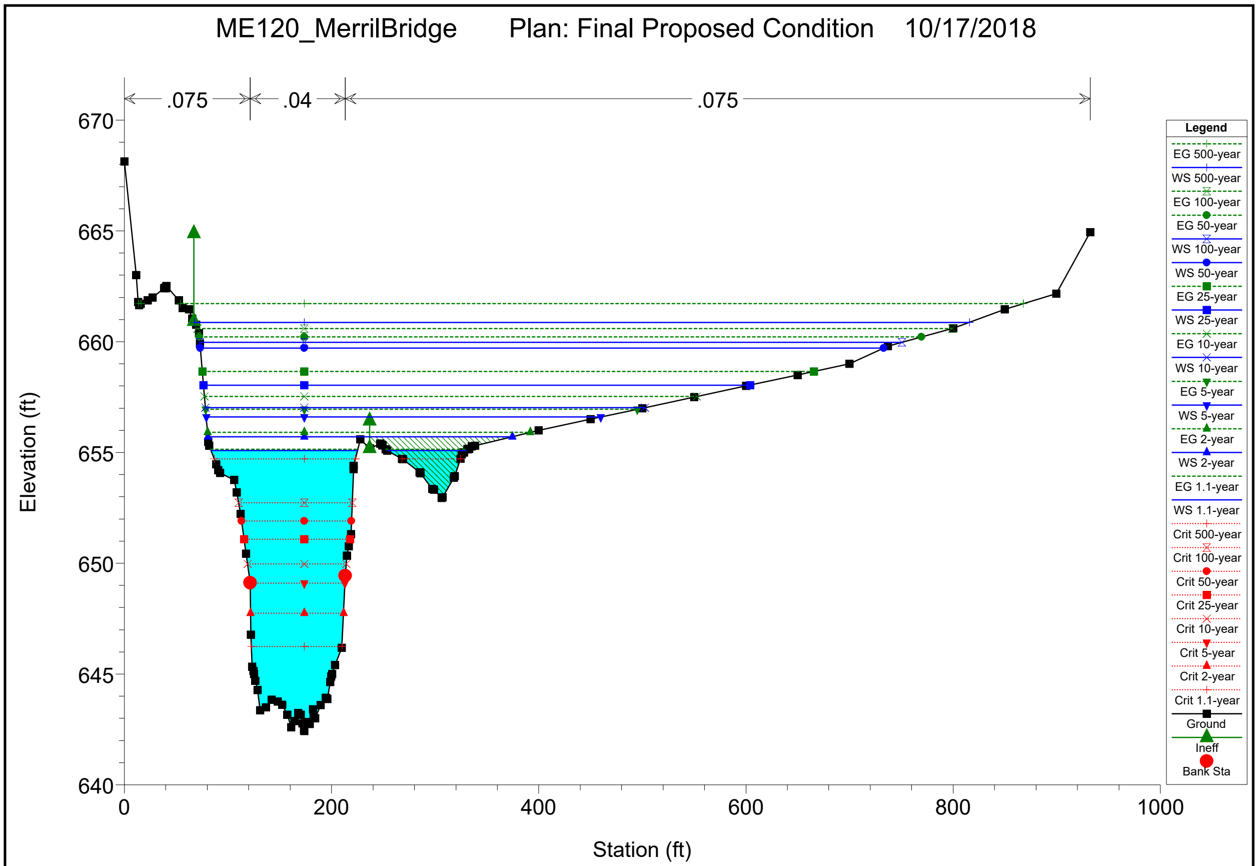
ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
Stream Reach
Elevation (ft)
Main Channel Distance (ft)
665
660
655
650
645
640
0
50
100
150
200
250
300
350
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
Crit 500-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground

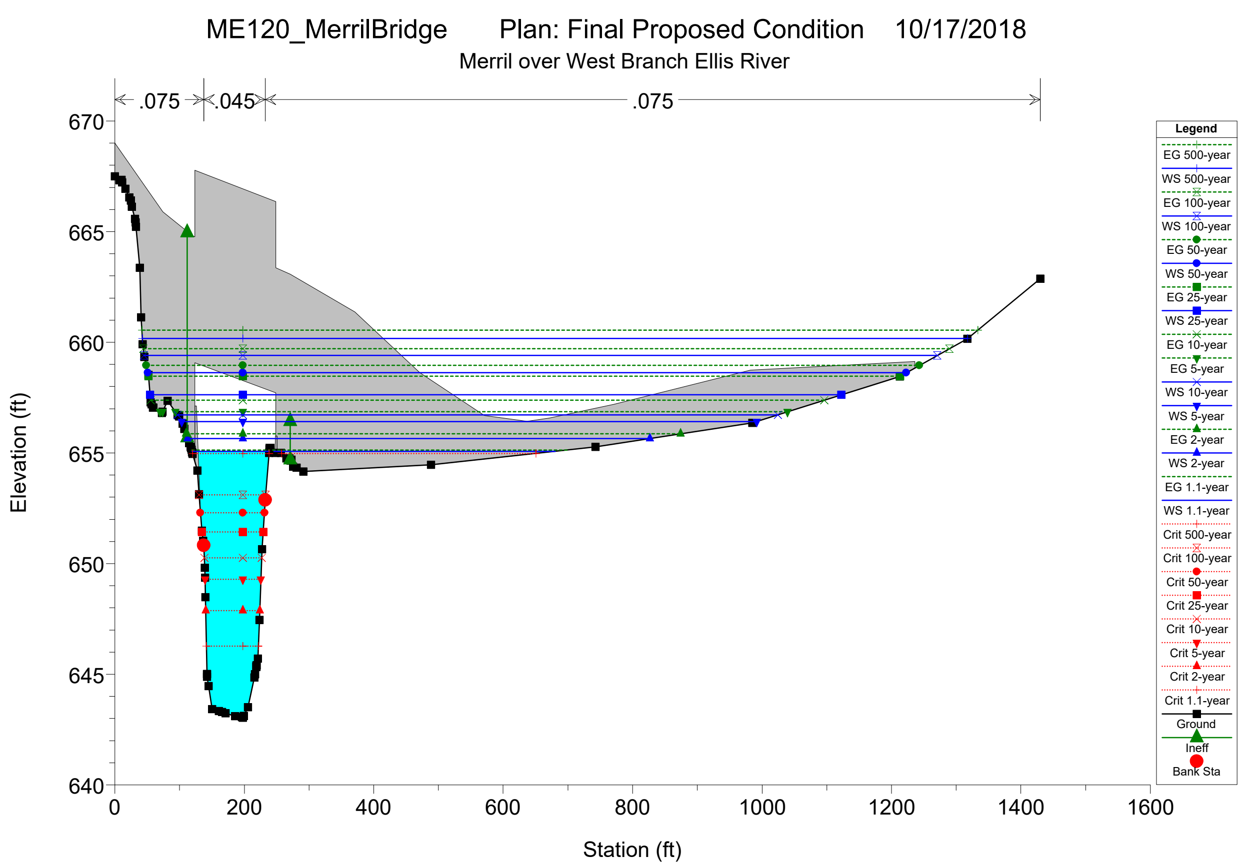
No Data for Plot

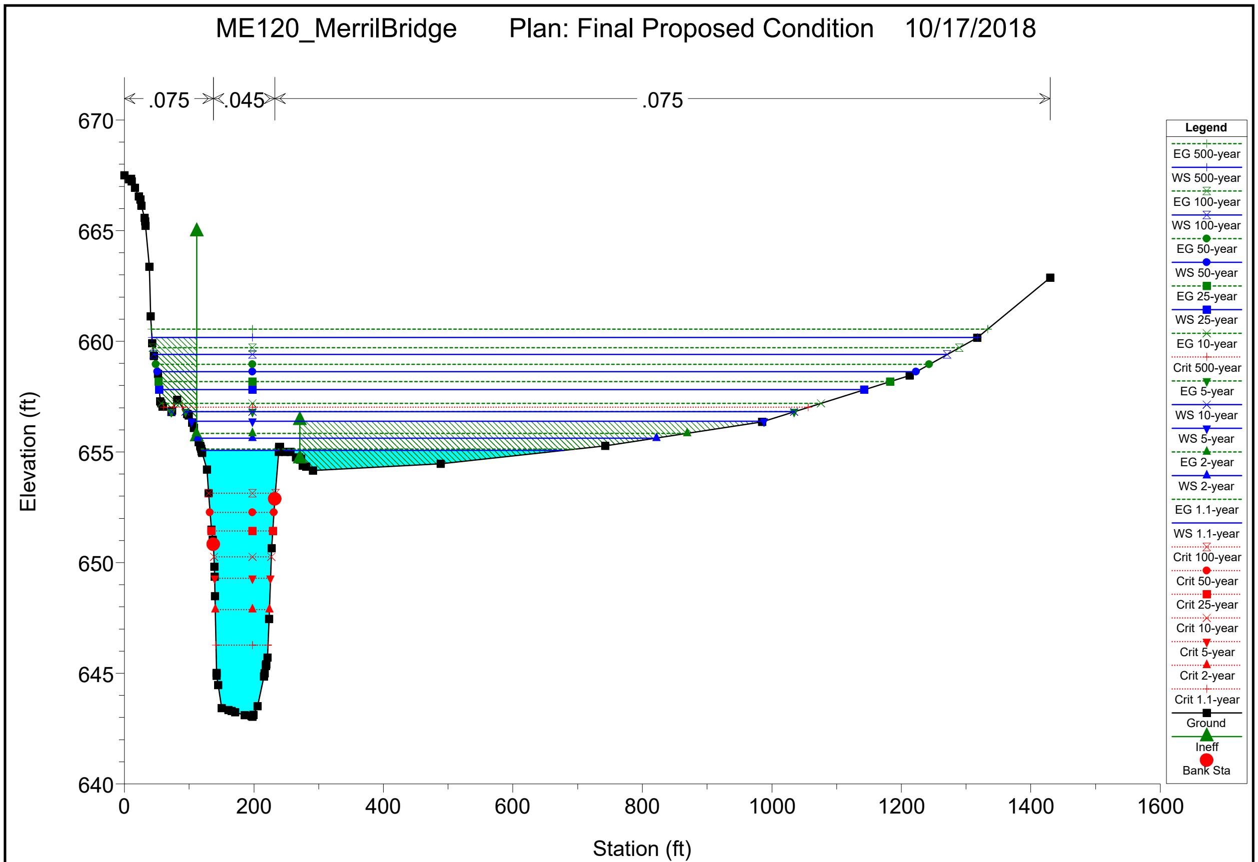



ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
.075
.04
.075
Elevation (ft)
675
670
665
660
655
650
645
640
Station (ft)
0
200
400
600
800
1000
Legend
EG 500-year
WS 500-year
EG 100-year
EG 50-year
WS 100-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
Crit 500-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta


ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
.075
.04
.075
Elevation (ft)
670
665
660
655
650
645
640
Station (ft)
0
200
400
600
800
1000
Legend
EG 500-year
WS 500-year
EG 100-year
EG 50-year
WS 100-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
Crit 500-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta


ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
EG 50-year
WS 100-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
WS 10-year
EG 5-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 500-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta


ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
Merril over West Branch Ellis River
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 500-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta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.075
.045
.075
Elevation (ft)
Station (ft)
Legend
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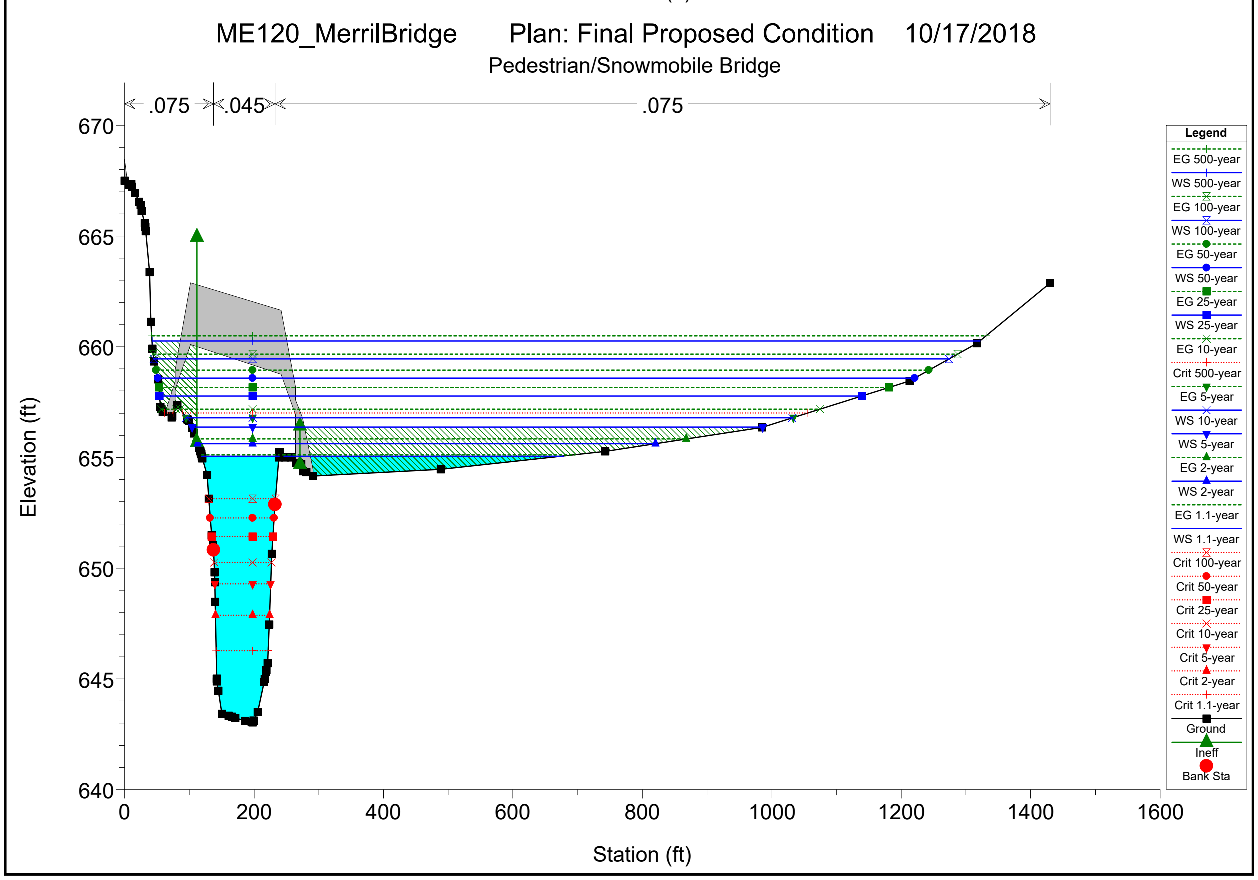
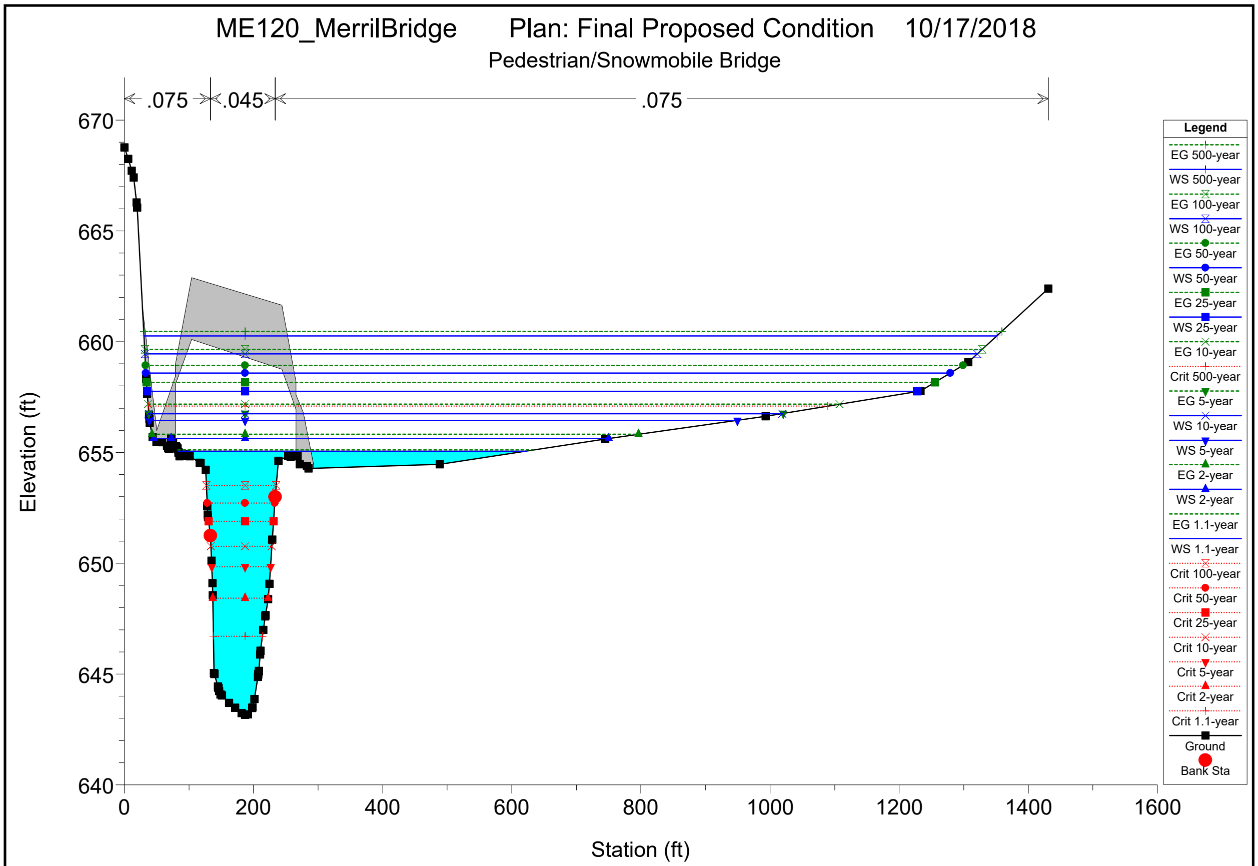
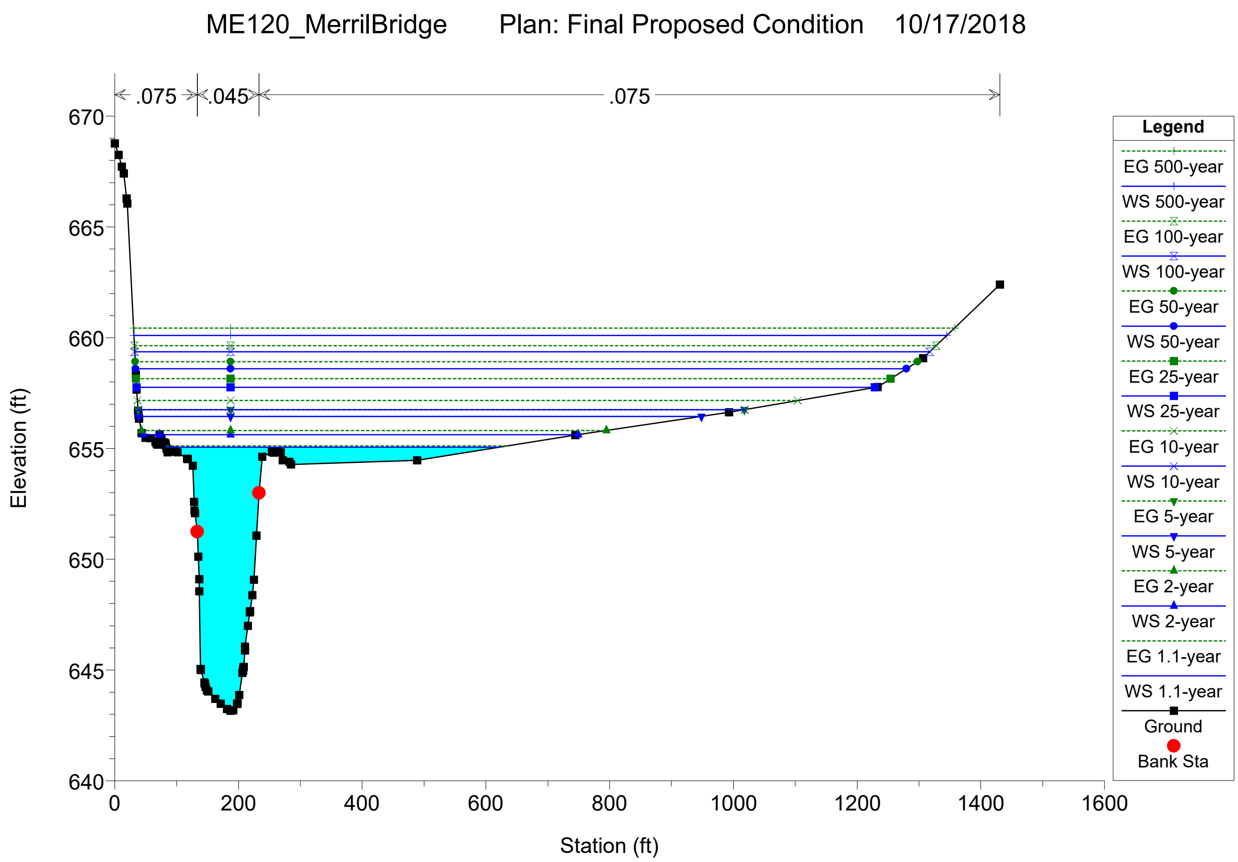
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
Crit 500-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta

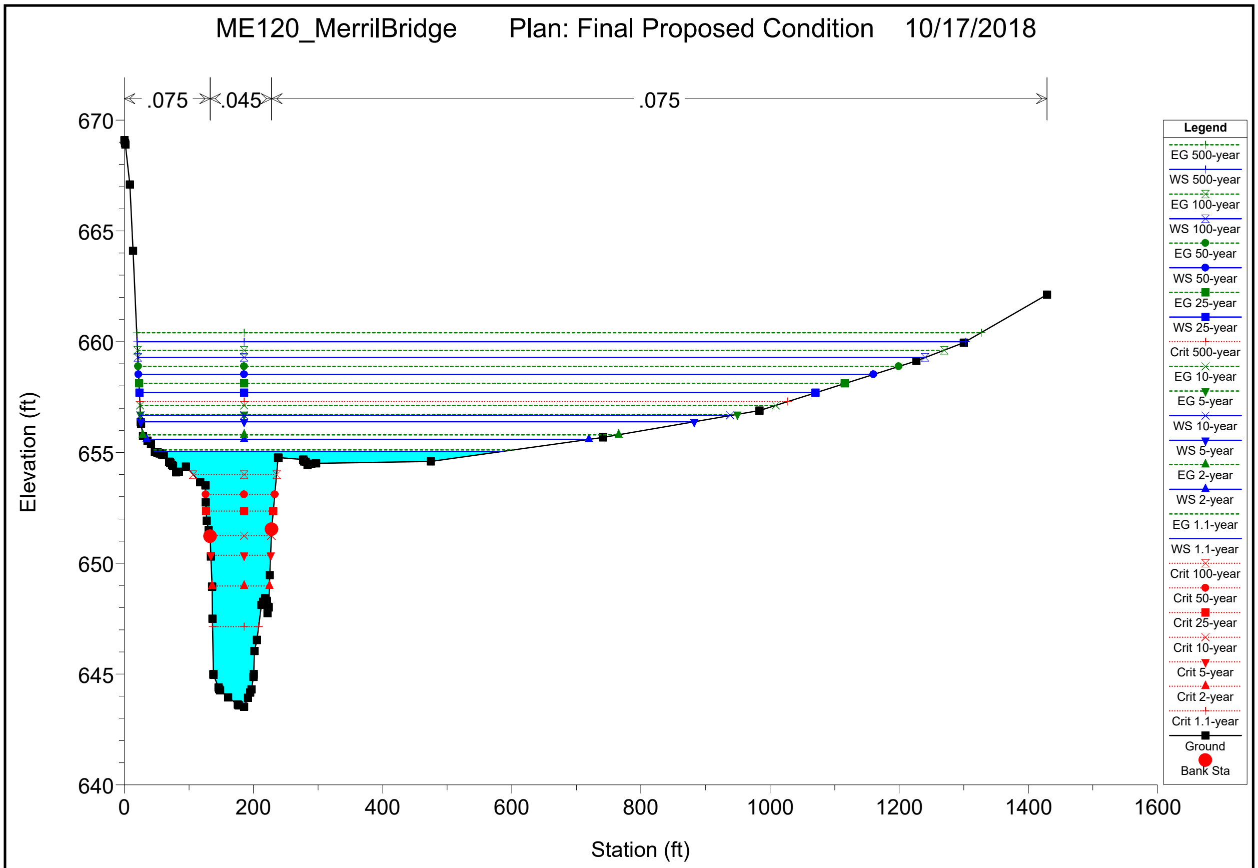

ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
Pedestrian/Snowmobile Bridge
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
Crit 500-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Ineff
Bank Sta



ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
Pedestrian/Snowmobile Bridge
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
Crit 500-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Bank Sta



ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
EG 10-year
WS 10-year
EG 5-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Ground
Bank Sta



ME120_MerrilBridge Plan: Final Proposed Condition 10/17/2018
.075
.045
.075
Elevation (ft)
Station (ft)
Legend
EG 500-year
WS 500-year
EG 100-year
WS 100-year
EG 50-year
WS 50-year
EG 25-year
WS 25-year
Crit 500-year
EG 10-year
EG 5-year
WS 10-year
WS 5-year
EG 2-year
WS 2-year
EG 1.1-year
WS 1.1-year
Crit 100-year
Crit 50-year
Crit 25-year
Crit 10-year
Crit 5-year
Crit 2-year
Crit 1.1-year
Ground
Bank Sta

APPENDIX G

Scour Analysis

Proj. Merrill Bridge	Job No. 63738	Sheet No. 1 OF 4
Made by KAR	Checked by SPA	Backchecked by CMV
Date 9/8/2017	Date	Date

HNTB

Scour Analysis: 100-year storm U/S face of Merrill Bridge

Aggradation/Degradation | | ***ft***

Live Bed Vs. Clear Water

Depth of flow, y1	15.56	ft
Particle size in a mix of which 50% are smaller, D50 (m)	0.00230	m
Particle size in a mix of which 50% are smaller, D50 (ft)	0.00754	ft
Velocity of main Channel, V	7.3	ft/s
Critical Velocity, Vc	3.46	ft/s

$$V_c = K_u y^{1/6} D^{1/3}$$

Ku = 11.17

(HEC-18, 5th Edition, April 2012, Equation 6.1)

Live Bed vs. Clear Water Live Bed ←Type of Contraction Scour Analysis to be completed

Live Bed Scour

Avg depth in U/S main channel, y1	15.56	ft
Ex depth in the contracted section before scour, yo	17.54	ft
Flow in the U/S channel transporting sediment Q1	9004.11	ft^3/s
Flow in the contracted channel, Q2	10013.38	ft^3/s
Top width of U/S main channel, W1	79.27	ft
Top width of the main channel in the contracted section, W2	125	ft
Fall Velocity, ω	0.69	ft/s
Slope of energy grade line of main channel, S1	0.001069	ft/ft
Shear Velocity, Vα	0.73	
Vα/ω	1.06	
Exponent, k1	0.64	
Avg depth in contracted section, y2	12.73	
****Scour depth, ys***	-4.81	***ft***

$$V_\alpha = (g y_1 S_1)^{1/2}$$

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{\frac{6}{7}} \left(\frac{W_1}{W_2}\right)^{k_1}$$

$$y_s = y_2 - y_0$$

(HEC-18, 5th Edition, April 2012, Equations 6.2 and 6.3)

Clear Water Scour

Discharge through the bridge, Q	10013.38	
Median diameter of bed material, D50	0.00754	ft
Diameter of smallest nontrasportable particle, Dm	0.00943	
Bottom width of the contracted section, W	125.00	
Existing depth in the contracted Section, yo	17.54	
Avg depth in the contracted section after contraction scour, y2	20.17	
****Scour depth, ys***	2.63	***ft***

$$y_2 = \left[\frac{K_u Q^2}{{D_m}^{2/3} W^2}\right]^{3/7}$$

$$y_s = y_2 - y_0$$

(HEC-18, 5th Edition, April 2012, Equation 6.4)

**** If calculated y_s returns negative answer, the scour depth equals zero***

Proj. Merril Bridge	Job No. 63738	Sheet No. 2 OF 4
Made by KAR	Checked by SPA	Backchecked by CMV
Date 9/8/2017	Date	Date

HNTB

Scour Analysis: 100-year storm U/S face of Merrill Bridge

Local Scour at Abutments
Near Abutment

Coefficient for Abutment Shape, K1	0.55	
Coefficient for angle of embankment to flow, K2	1.00	
Length of active flow obstructed by embankment, L'	537.33	ft
Average depth of flow on embankment, ya	3.24	ft
Velocity on embankment, Ve	1.34	ft/s
Froude Number of approach flow = $V_e/(gy_a)^{1/2}$	**0.131**	
Length of embankment projected to normal flow, L	680.00	ft

$$\frac{y_s}{y_a} = 2.27K_1K_2\left(\frac{L'}{y_a}\right)^{0.43}(Fr)^{0.61} + 1$$

Near Abutment Scour Depth, ys **13.79** ***ft***

(HEC-18, 5th Edition, April 2012, Equation 8.1)

Far Abutment

Coefficient for Abutment Shape, K1	0.55	
Coefficient for angle of embankment to flow, K2	1.00	
Length of active flow obstructed by embankment, L'	48.55	ft
Average depth of flow on embankment, ya	5.96	ft
Velocity on embankment, Ve	1.97	ft/s
Froude Number of approach flow = $V_e/(gy_a)^{1/2}$	**0.142**	
Length of embankment projected to normal flow, L	110.00	ft

$$\frac{y_s}{y_a} = 2.27K_1K_2\left(\frac{L'}{y_a}\right)^{0.43}(Fr)^{0.61} + 1$$

Far Abutment Scour Depth, ys **11.54** ***ft***

(HEC-18, 5th Edition, April 2012, Equation 8.1)

Scour Analysis: 500-year storm U/S face of Merrill Bridge

Aggradation/Degradation | | ***ft***

Live Bed Vs. Clear Water

Depth of flow, y1	16.56	ft
Particle size in a mix of which 50% are smaller, D50 (m)	0.00230	m
Particle size in a mix of which 50% are smaller, D50 (ft)	0.00754	ft
Velocity of main Channel, V	8.45	ft/s
Critical Velocity, Vc	3.50	ft/s

$$V_c = K_u y^{1/6} D^{1/3}$$

Ku = 11.17

(HEC-18, 5th Edition, April 2012, Equation 6.1)

Live Bed vs. Clear Water Live Bed ←Type of Contraction Scour Analysis to be completed

Live Bed Scour

Avg depth in U/S main channel, y1	16.56	ft
Ex depth in the contracted section before scour, yo	18.44	ft
Flow in the U/S channel transporting sediment Q1	11090.8	ft^3/s
Flow in the contracted channel, Q2	11436.88	ft^3/s
Top width of U/S main channel, W1	79.27	ft
Top width of the main channel in the contracted section, W2	125	ft
Fall Velocity, ω	0.69	ft/s
Slope of energy grade line of main channel, S1	0.001317	ft/ft
Shear Velocity, Vα	0.84	
Vα/ω	1.21	
Exponent, k1	0.64	
Avg depth in contracted section, y2	12.70	
****Scour depth, ys***	-5.74	***ft***

$$V_\alpha = (g y_1 S_1)^{1/2}$$

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{\frac{6}{7}} \left(\frac{W_1}{W_2}\right)^{k_1}$$

$$y_s = y_2 - y_0$$

(HEC-18, 5th Edition, April 2012, Equations 6.2 and 6.3)

Clear Water Scour

Discharge through the bridge, Q	11436.88	
Median diameter of bed material, D50	0.00754	ft
Diameter of smallest nontrasportable particle, Dm	0.00943	
Bottom width of the contracted section, W	125.00	
Existing depth in the contracted Section, yo	18.44	
Avg depth in the contracted section after contraction scour, y2	22.60	
****Scour depth, ys***	4.16	***ft***

$$y_2 = \left[\frac{K_u Q^2}{D_m^{2/3} W^2}\right]^{3/7}$$

$$y_s = y_2 - y_0$$

(HEC-18, 5th Edition, April 2012, Equation 6.4)

**** If calculated y_s returns negative answer, the scour depth equals zero***

Scour Analysis: 500-year storm U/S face of Merrill Bridge

Local Scour at Abutments
Near Abutment

Coefficient for Abutment Shape, K1	0.55	
Coefficient for angle of embankment to flow, K2	1.00	
Length of active flow obstructed by embankment, L'	602.41	ft
Average depth of flow on embankment, ya	3.74	ft
Velocity on embankment, Ve	1.71	ft/s
Froude Number of approach flow = $V_e/(gy_a)^{1/2}$	0.156	
Length of embankment projected to normal flow, L	680.00	ft

$$\frac{y_s}{y_a} = 2.27K_1K_2\left(\frac{L'}{y_a}\right)^{0.43}(Fr)^{0.61} + 1$$

Near Abutment Scour Depth, ys **17.10** ***ft***

Far Abutment

Coefficient for Abutment Shape, K1	0.55	
Coefficient for angle of embankment to flow, K2	1.00	
Length of active flow obstructed by embankment, L'	53.69	ft
Average depth of flow on embankment, ya	6.23	ft
Velocity on embankment, Ve	2.35	ft/s
Froude Number of approach flow = $V_e/(gy_a)^{1/2}$	0.166	
Length of embankment projected to normal flow, L	110.00	ft

$$\frac{y_s}{y_a} = 2.27K_1K_2\left(\frac{L'}{y_a}\right)^{0.43}(Fr)^{0.61} + 1$$

Far Abutment Scour Depth, ys **12.80** ***ft***

Proj. Merrill Bridge	Job No. 63738	Sheet No.
Made by SPA	Checked by CMV	Backchecked by
Date 12/7/2017	Date	Date

HNTB

Scour Summary

	100 - year storm	
	Near Abutment	Far Abutment
Aggradation/ Degradation (ft)	0.00	0.00
Contraction/Expansion Scour (ft) *	0.00	0.00
Local Scour (ft)	13.79	11.54
Pressure Flow Scour (ft)	---	---
TOTAL SCOUR (ft)	***13.79***	***11.54***

	500-year storm	
	Near Abutment	Far Abutment
Aggradation/ Degradation (ft)	0.00	0.00
Contraction/Expansion Scour (ft) *	0.00	0.00
Local Scour (ft)	17.10	12.80
Pressure Flow Scour (ft)	---	---
TOTAL SCOUR (ft)	***17.10***	***12.80***

** If calculated y_s returns negative answer, the scour depth equals zero*

Plan: Final Proposed Condition   Stream   Reach RS: 249.1838   Profile: 100-year

E.G. Elev (ft)	660.64	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.57	Wt. n-Val.	0.075	0.040	0.075
W.S. Elev (ft)	660.06	Reach Len. (ft)	47.96	40.07	27.28
Crit W.S. (ft)	654.31	Flow Area (sq ft)	510.63	1233.67	2185.78
E.G. Slope (ft/ft)	0.001069	Area (sq ft)	510.63	1233.67	2185.78
Q Total (cfs)	13350.00	Flow (cfs)	1019.55	9004.11	3326.35
Top Width (ft)	773.77	Top Width (ft)	89.13	79.27	605.37
Vel Total (ft/s)	3.40	Avg. Vel. (ft/s)	2.00	7.30	1.52
Max Chl Dpth (ft)	17.26	Hydr. Depth (ft)	5.73	15.56	3.61
Conv. Total (cfs)	408368.1	Conv. (cfs)	31187.4	275429.9	101750.8
Length Wtd. (ft)	37.83	Wetted Per. (ft)	94.34	83.73	606.89
Min Ch El (ft)	642.80	Shear (lb/sq ft)	0.36	0.98	0.24
Alpha	3.19	Stream Power (lb/ft s)	0.72	7.17	0.37
Frctn Loss (ft)	0.04	Cum Volume (acre-ft)	1.57	6.51	9.80
C & E Loss (ft)	0.00	Cum SA (acres)	0.26	0.26	3.39

UNCONTRACTED SECTIONS

Plan: Final Proposed Condition   Stream   Reach RS: 249.1838   Profile: 500-year

E.G. Elev (ft)	661.78	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.71	Wt. n-Val.	0.075	0.040	0.075
W.S. Elev (ft)	661.06	Reach Len. (ft)	47.96	40.07	27.28
Crit W.S. (ft)	656.47	Flow Area (sq ft)	600.81	1313.07	2819.98
E.G. Slope (ft/ft)	0.001317	Area (sq ft)	600.81	1313.07	2819.98
Q Total (cfs)	17850.00	Flow (cfs)	1463.04	11090.80	5296.16
Top Width (ft)	836.67	Top Width (ft)	90.92	79.27	666.48
Vel Total (ft/s)	3.77	Avg. Vel. (ft/s)	2.44	8.45	1.88
Max Chl Dpth (ft)	18.26	Hydr. Depth (ft)	6.61	16.56	4.23
Conv. Total (cfs)	491852.5	Conv. (cfs)	40313.7	305604.3	145934.5
Length Wtd. (ft)	37.29	Wetted Per. (ft)	96.40	83.73	668.01
Min Ch El (ft)	642.80	Shear (lb/sq ft)	0.51	1.29	0.35
Alpha	3.23	Stream Power (lb/ft s)	1.25	10.89	0.65
Frctn Loss (ft)	0.05	Cum Volume (acre-ft)	1.79	6.72	12.68
C & E Loss (ft)	0.01	Cum SA (acres)	0.25	0.24	3.70

Plan: Final Proposed Condition   Stream   Reach RS: 209.1155   Profile: 100-year

E.G. Elev (ft)	660.59	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.62	Wt. n-Val.	0.075	0.040	0.075
W.S. Elev (ft)	659.97	Reach Len. (ft)	53.30	53.30	53.30
Crit W.S. (ft)	652.73	Flow Area (sq ft)	289.57	1473.74	1739.00
E.G. Slope (ft/ft)	0.000962	Area (sq ft)	289.57	1473.74	1739.00
Q Total (cfs)	13350.00	Flow (cfs)	570.20	10447.53	2332.26
Top Width (ft)	677.83	Top Width (ft)	48.55	91.95	537.33
Vel Total (ft/s)	3.81	Avg. Vel. (ft/s)	1.97	7.09	1.34
Max Chl Dpth (ft)	17.54	Hydr. Depth (ft)	5.96	16.03	3.24
Conv. Total (cfs)	430367.7	Conv. (cfs)	18381.8	336800.0	75185.8
Length Wtd. (ft)	53.30	Wetted Per. (ft)	50.49	96.58	539.44
Min Ch El (ft)	642.43	Shear (lb/sq ft)	0.34	0.92	0.19
Alpha	2.74	Stream Power (lb/ft s)	0.68	6.50	0.26
Frctn Loss (ft)		Cum Volume (acre-ft)	1.13	5.27	8.57
C & E Loss (ft)		Cum SA (acres)	0.18	0.18	3.04

SECTIONS UPSTREAM OF BRIDGE

Plan: Final Proposed Condition   Stream   Reach RS: 209.1155   Profile: 500-year

E.G. Elev (ft)	661.72	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.84	Wt. n-Val.	0.075	0.040	0.075
W.S. Elev (ft)	660.87	Reach Len. (ft)	53.30	53.30	53.30
Crit W.S. (ft)	654.71	Flow Area (sq ft)	334.70	1556.39	2252.96
E.G. Slope (ft/ft)	0.001284	Area (sq ft)	334.70	1556.39	2252.96
Q Total (cfs)	17850.00	Flow (cfs)	784.90	13219.75	3845.35
Top Width (ft)	748.05	Top Width (ft)	53.69	91.95	602.41
Vel Total (ft/s)	4.31	Avg. Vel. (ft/s)	2.35	8.49	1.71
Max Chl Dpth (ft)	18.44	Hydr. Depth (ft)	6.23	16.93	3.74
Conv. Total (cfs)	498058.9	Conv. (cfs)	21900.5	368863.5	107294.8
Length Wtd. (ft)	53.30	Wetted Per. (ft)	55.76	96.58	604.53
Min Ch El (ft)	642.43	Shear (lb/sq ft)	0.48	1.29	0.30
Alpha	2.93	Stream Power (lb/ft s)	1.13	10.98	0.51
Frctn Loss (ft)		Cum Volume (acre-ft)	1.27	5.40	11.09
C & E Loss (ft)		Cum SA (acres)	0.17	0.17	3.30

BRIDGE SECTIONS

Plan: Final Proposed Condition   Stream   Reach RS: 180   Profile: 100-year

E.G. US. (ft)	660.59	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	659.97	E.G. Elev (ft)	660.59	659.71
Q Total (cfs)	13350.00	W.S. Elev (ft)	659.97	659.40
Q Bridge (cfs)	10013.38	Crit W.S. (ft)	652.87	653.11
Q Weir (cfs)	3336.62	Max Chl Dpth (ft)	17.54	16.36
Weir Sta Lft (ft)	356.88	Vel Total (ft/s)	6.38	5.16
Weir Sta Rgt (ft)	799.34	Flow Area (sq ft)	2093.18	2587.73
Weir Submerg	0.50	Froude # Chl	0.34	0.34
Weir Max Depth (ft)	3.51	Specif Force (cu ft)	16393.38	15257.51
Min El Weir Flow (ft)	657.09	Hydr Depth (ft)	5.64	3.13
Min El Prs (ft)	659.08	W.P. Total (ft)	634.09	1090.32
Delta EG (ft)	0.88	Conv. Total (cfs)		
Delta WS (ft)	0.57	Top Width (ft)	371.28	827.95
BR Open Area (sq ft)	1434.17	Frctn Loss (ft)		
BR Open Vel (ft/s)	6.98	C & E Loss (ft)		
BR Sluice Coef		Shear Total (lb/sq ft)		
BR Sel Method	Press/Weir	Power Total (lb/ft s)		

Plan: Final Proposed Condition   Stream   Reach RS: 180   Profile: 500-year

E.G. US. (ft)	661.72	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	660.87	E.G. Elev (ft)	661.72	660.55
Q Total (cfs)	17850.00	W.S. Elev (ft)	660.87	660.17
Q Bridge (cfs)	11436.88	Crit W.S. (ft)	654.71	654.98
Q Weir (cfs)	6413.12	Max Chl Dpth (ft)	18.44	17.13
Weir Sta Lft (ft)	314.89	Vel Total (ft/s)	7.22	5.49
Weir Sta Rgt (ft)	867.71	Flow Area (sq ft)	2472.60	3250.92
Weir Submerg	0.49	Froude # Chl	0.40	0.36
Weir Max Depth (ft)	4.63	Specif Force (cu ft)	20326.26	18756.58
Min El Weir Flow (ft)	657.09	Hydr Depth (ft)	5.27	3.60
Min El Prs (ft)	659.08	W.P. Total (ft)	731.90	1165.25
Delta EG (ft)	1.17	Conv. Total (cfs)		
Delta WS (ft)	0.70	Top Width (ft)	469.07	902.86
BR Open Area (sq ft)	1434.17	Frctn Loss (ft)		
BR Open Vel (ft/s)	7.97	C & E Loss (ft)		
BR Sluice Coef		Shear Total (lb/sq ft)		
BR Sel Method	Press/Weir	Power Total (lb/ft s)		

7.5 Frost Protection

Pile-supported integral abutments shall be embedded a minimum of 4.0 feet for frost protection per MaineDOT BDG Figure 5-2.

Foundations placed on the native soils should be designed with an appropriate embedment for frost protection. According to MaineDOT BDG Figure 5-1, Maine Design Freezing Index Map, Andover has a design freezing index (DFI) of approximately 1800 F-degree days. The anticipated coarse-grained fill material was assigned a water content of 10%. These components correlate to a frost depth of 7.5 feet. A similar analysis was performed using Modberg software by the US Army Cold Regions Research and Engineering Laboratory (CRREL). For the Modberg analysis, Farmington, Maine has a DFI from the Modberg database of approximately 2023 F-degree days. Farmington was selected because it lies along the same isoline as Andover and Andover is not available in the Modberg database. A water content of 10% was used. These components correlate to a frost depth of approximately 7.7 feet.

Based on the MaineDOT BDG methodology it is recommended that foundations bearing on coarse-grained soils be designed with an embedment of approximately 7.5 feet for frost protection. See Appendix C – Calculations for supporting calculations.

Riprap is not to be considered as contributing to the overall thickness of soils required for frost protection.

7.6 Scour and Riprap

The fine, sandy alluvial deposit encountered at the Merrill Bridge site is very erodible. The condition of the existing bridge channel protection is rated a '5' corresponding to "Bank eroded; major damage." Scour countermeasures have been installed to correct scour problems, according to the 2015 MaineDOT Bridge Inspection Report.

Grain size analyses were performed on samples from the stream alluvium deposit to generate grain size curves for determining parameters to be used in scour analyses. Three soil samples were judged to be similar in nature to the soils likely to be exposed to scour conditions. The recommended streambed grain size parameter was derived from the average D_{50} of these samples and is presented in Table 7, below.

Sample	Sample Depth (ft)	D_{50} (mm)
BB-AWBER-101 3D	10-12	5.1
BB-AWBER-102 4D	15-17	1.8
BB-AWBER-102 5D	20-20.6	.07
	Average	2.3

Table 7 – Average D_{50} of Representative Samples for Scour

The grain size curves are included in Appendix B – Laboratory Test Results.

The consequences of changes in foundation conditions resulting from the design (Q_{100}) and check (Q_{500}) floods for scour shall be considered at the strength and extreme limit states, respectively. Design at the strength limit state should consider loss of lateral and vertical support due to scour. Design at the extreme limit state should check that the nominal foundation resistance due to the check flood (Q_{500}) event is no less than the extreme limit state loads. At the service limit state, the design shall limit movements and ensure overall stability considering scour at the design load.

For scour protection of the pile supported abutments, the PDR indicates the bridge approach slopes and the abutment slopes will be armored with a layer of plain riprap. Refer to MaineDOT BDG Section 2.3.11.3 for information regarding scour design. Typically, the top of the riprap is located at, or above, the Q_{50} elevation.

Plain riprap shall conform to MaineDOT Standard Specification 703.26 – Plain and Hand Laid Riprap. The toe of the riprap section shall be constructed at least 1 foot below the streambed elevation. The riprap section shall be underlain by a 1 foot thick layer of bedding material conforming to MaineDOT Standard Specification 703.19 and Class 1 nonwoven erosion control geotextile per MaineDOT Standard Details 610(02) and 610(03).

7.7 Seismic Design Considerations

The United States Geological Survey Seismic Design CD (Version 2.1) provided with the LRFD Manual, and LRFD Articles 3.10.3.1 and 3.10.6 were used to develop parameters for seismic design. Based on site coordinates, the software provided the recommended AASHTO Response Spectra for a 7 percent probability of exceedance in 75 years. These results are summarized in Table 8.

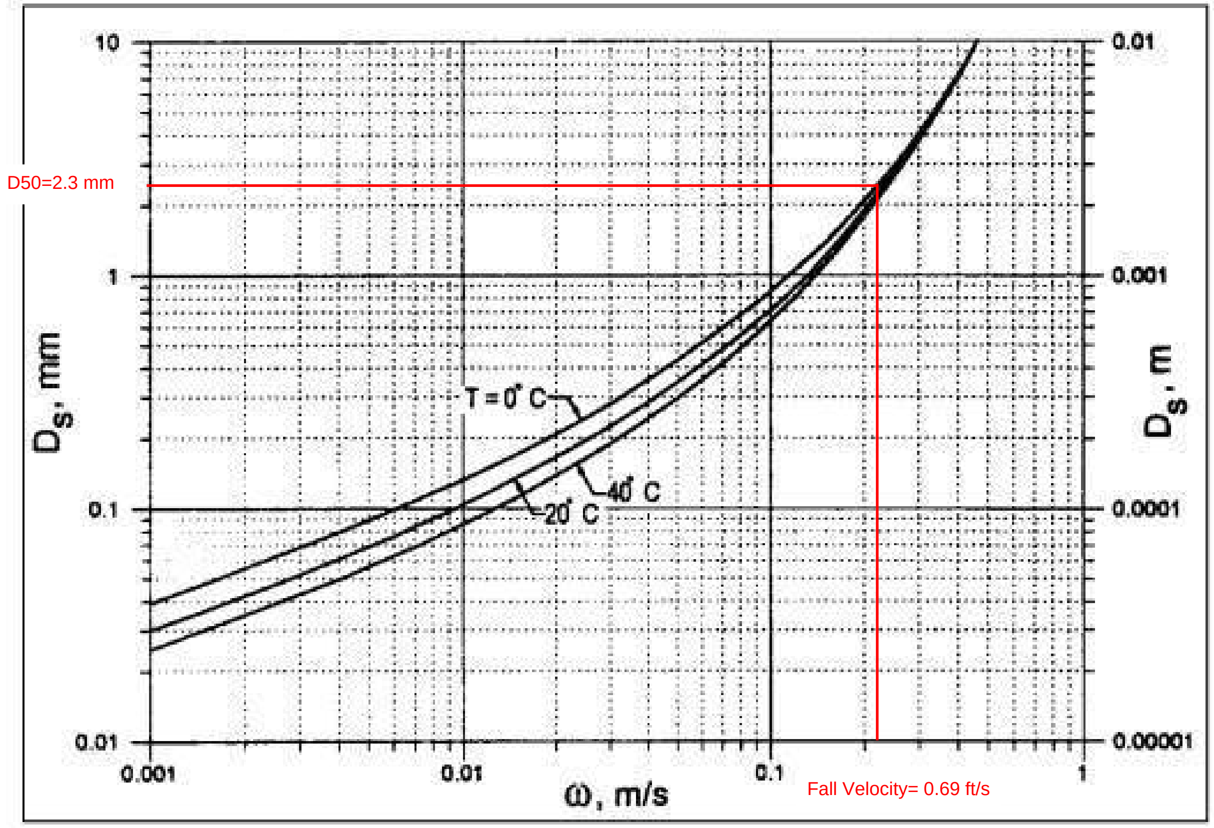
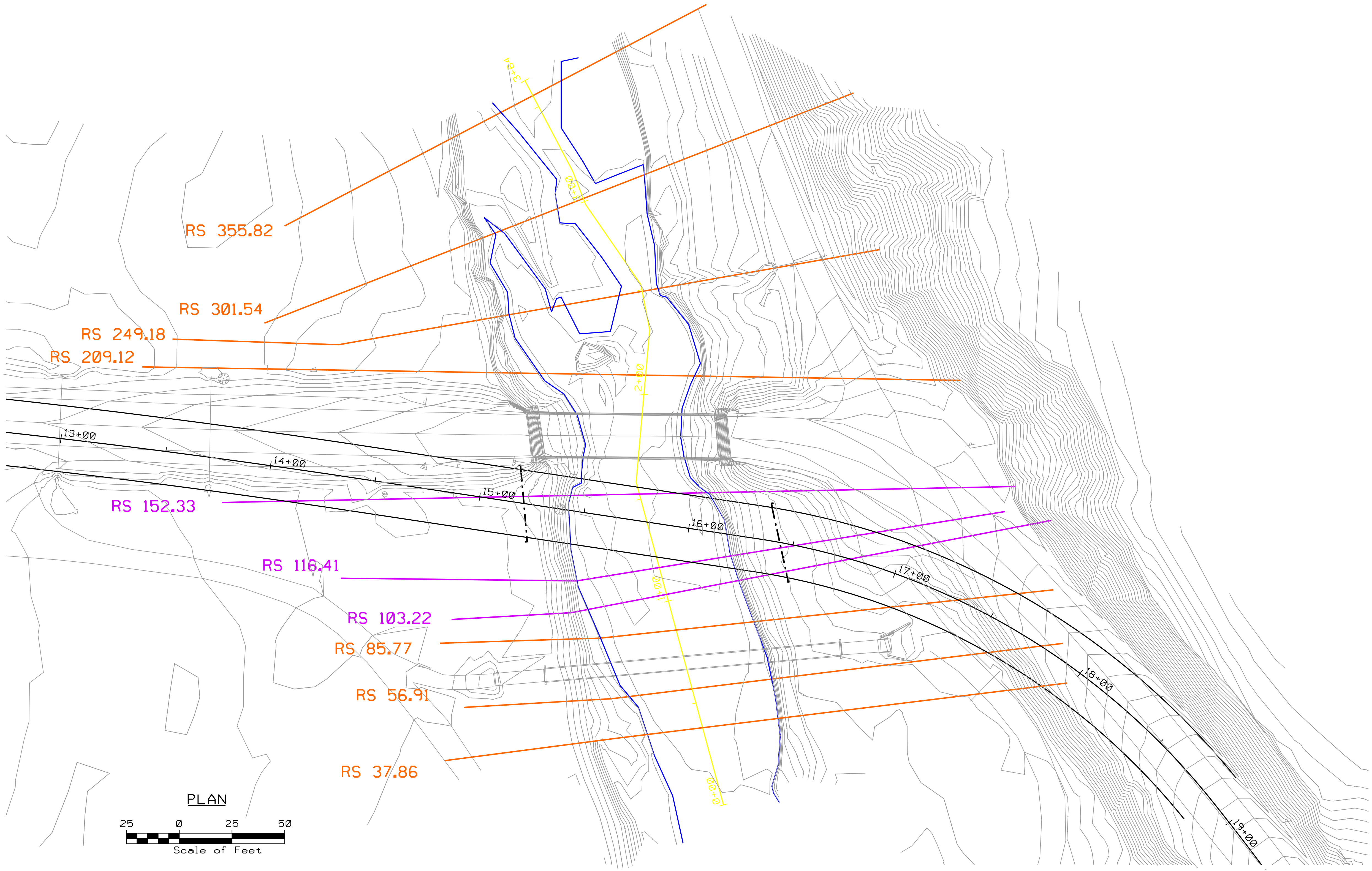


Figure 6.8. Fall velocity of sand-sized particles with specific gravity of 2.65 in metric units.

APPENDIX H

Drawings



LEGEND

RS 1168.56	EXISTING/PROPOSED CROSS SECTIONS
RS 1168.56	EXISTING ONLY CROSS SECTIONS
	STREAM ALIGNMENT

STATE OF MAINE
DEPT. OF TRANSPORTATION

63738

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21658.00

H&H PLANS

3215

MERRILL BRIDGE
WEST BRANCH ELLIS RIVER
ANDOVER OXFORD

HEC-RAS GENERAL PLAN