MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM

HYDROLOGIC AND HYDRAULIC REPORT

For the Replacement of:

Madawaska Bridge
Over
Little Madawaska River
In
Stockholm, Maine

Bridge #5160
WIN 19318.00
AC-BR-1931(800)X

January 29, 2016

Designed by: *Ashley Stephens, P.E., HNTB Corporation*
Checked by: *Scott Adams, P.E., HNTB Corporation*
In Charge of: *Roland Lavallee, P.E., PLS, HNTB Corporation*

Roland A. Lavallee 1/21/16
Roland Lavallee, P.E., PLS Date

STATE OF MAINE
ROLAND A. LAVALLEE
No. 6452
LICENSED
PROFESSIONAL ENGINEER

SPECIFICATIONS
DESIGN: Load and Resistance Factor Design per AASHTO LRFD Bridge Design Specifications, Seventh Edition 2014 with Interims through 2015

MaineDOT

Bridge Program
Maine DOT

Final Design

Hydrologic and Hydraulic Report

Madawaska Bridge #5160

Little Madawaska River

HNTB Corporation

For

Maine Department of Transportation

January 29, 2016

Final Design, Hydrologic and Hydraulic Report on
Little Madawaska River/Madawaska Bridge # 5160

This report details hydrologic, hydraulic and scour analyses completed for final design of Bridge #5160, Madawaska Bridge that carries Main Street over the Little Madawaska River.

1.0 Introduction

The Madawaska Bridge crosses the Little Madawaska River approximately 1.6 miles east on Lake Street from Route 161 in the town of Stockholm as shown in Figure 1.

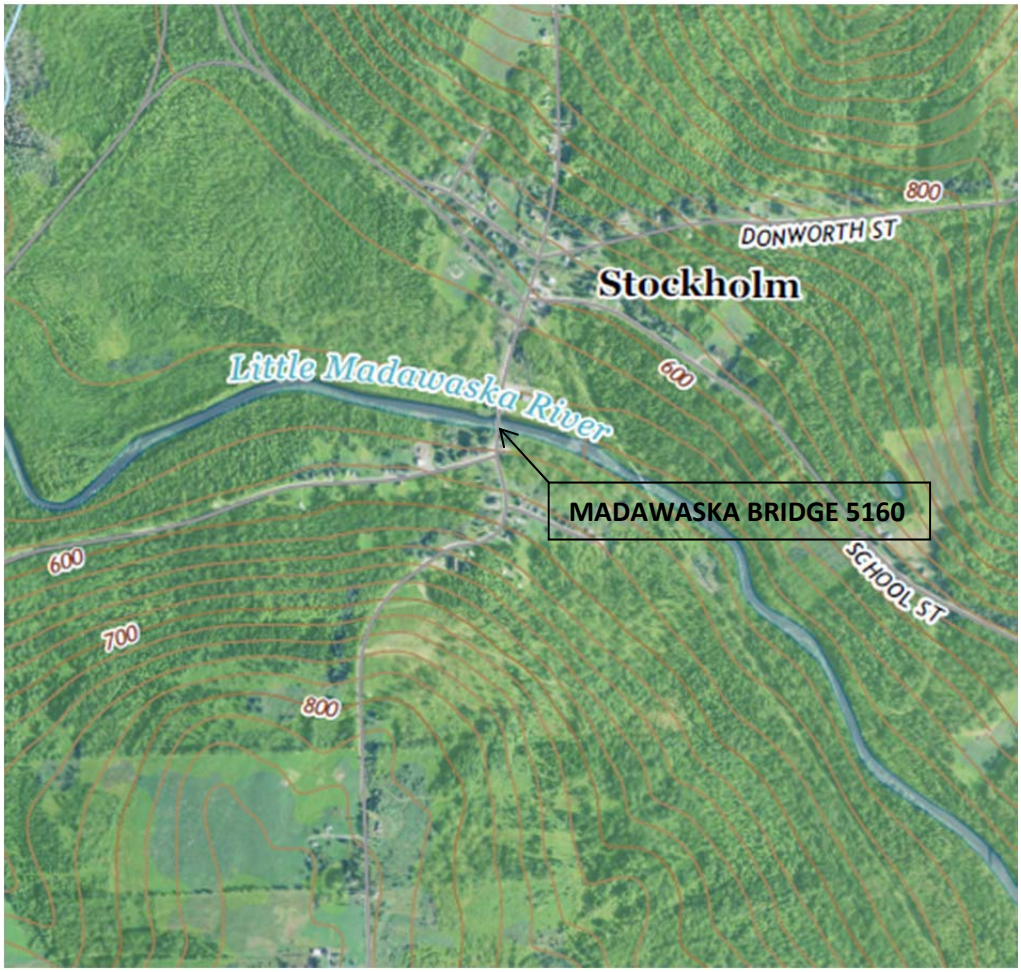

Figure 1 Madawaska Bridge 5160 on Main Street

The bridge is downstream of Little Madawaska Lake. Figure 2 shows the bridge from an aerial view point.

Figure 2 Madawaska Bridge, Main Street over Little Madawaska River

2.0 Existing Data Review

- FEMA Flood Insurance Rate Map. Town of Stockholm, ME. January 10, 1975. This map shows this area as an approximately mapped A Zone. No flood elevations were computed. Figure 3 is a copy of the Flood Insurance Rate Map for the site.

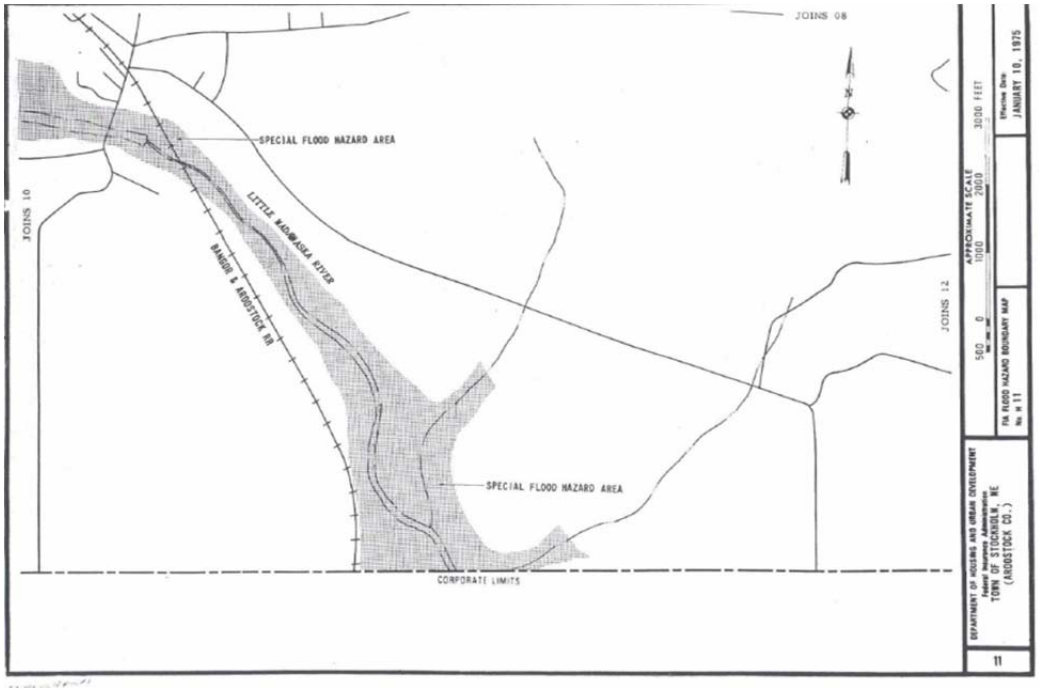

Figure 3 Flood Insurance Rate Map, Little Madawaska River at Main Street

- Historic Flood Data: Per the MaineDOT Preliminary Design Report. MaineDOT maintenance records did not have records of measured flood stages or flows. Additionally, flood information was not available from state and local planning agencies. As such the MaineDOT conducted a phone interview with a local resident and former municipal officer to determine Q2 and Q50 stage elevations relative to the existing bridge. This information was carried through final design. The phone interview record is provided in the appendix.
- Existing and proposed final project plans, site survey and site photos, including data from MaineDOT Bridge files. The existing bridge is a two-span concrete t-beam bridge. The existing abutments are cantilever vertical wall abutments and the pier is mass concrete aligned with the flow. The proposed bridge is a single span welded steel plate girder with integral abutments. The abutments meet a plain riprap slope into the river at 1.75:1. The lowest girder of the proposed and existing structures are within approximately one inch of each other. There is an existing railroad structure downstream of the bridge location, however the railroad structure has no effect on the hydraulics of Madawaska River Bridge.
- U.S. Army Corps of Engineers Ice Jam database. https://rsgisias.crrel.usace.army.mil/icejam
- Potential ice jam impacts were researched for the site. The CRREL database had a record of ice break up for Little Madawaska River in Caribou, however this was at the confluence of the Aroostook River and was located approximately 20 miles downstream. Therefore, hydraulic analyses didnot assume ice jams at this location.
- Gage information was not available for this bridge location.

3.0 Hydrology:

MaineDOT provided a measured drainage area at the project site is 115.78 square miles. The basin contains 12.07 square miles or 10.4% of wetlands and/or lakes. MaineDOT provided the following flows for this location, based on the USGS Regression Formula.

Table 1 Flow frequency data for Little Madawaska River Bridge, calculated by MaineDOT

Recurrence Interval	Flow, Cfs
1.1	1363.8
2	2525.5
5	3707.8
10	4556.3
25	5851.6
50	6492.8
100	7380.3
500	9530.7

The MaineDOT flows will be used for design purposes since gage information for the area is not available.

Table 2 Hydrologic Data Summary, Madawaska Bridge Number 5160

Drainage Area, Sq. mi.	116 square miles
Q25	5850 cfs
Design Discharge (Q50)	6490cfs
Check Discharge (Q100)	7380 cfs
Scour Check Discharge (Q500)	9530 cfs
Ordinary High Water (Q1.1)	1365 cfs

4.0 Hydraulic Analysis:

Flood elevations and flow velocities were analyzed at the bridge using U.S. Army Corps of Engineers model HECRAS. Project survey was used to plot stream cross sections. Overbank elevations were also taken from the U.S.G.S. topographic map of the project site. Figure 4 shows model cross sections. Where no project survey was available, model data is based on best judgment.

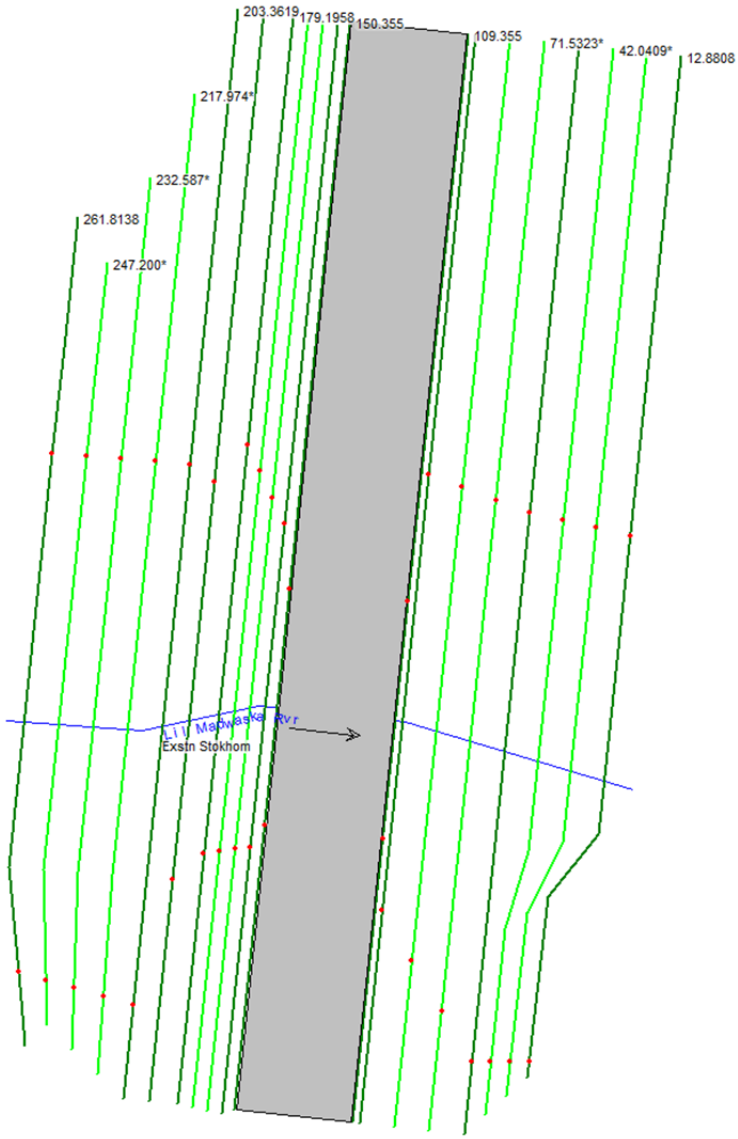

Figure 4 River cross section locations using project survey

The river bottom drops through the downstream of the bridge. Figure 5 is a plot of minimum channel elevation along the river profile showing the drop.

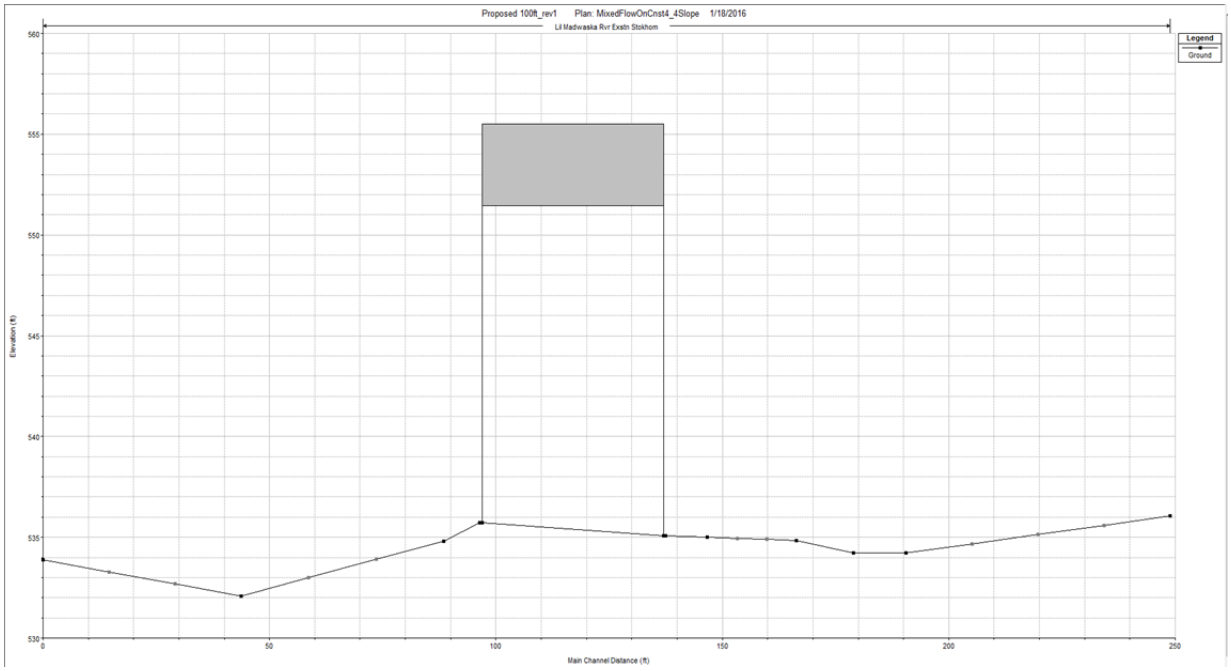

Figure 5 Stream bottom profile through Madawaska Bridge

Boundary Condition for Model: Project survey was limited to the bridge and immediate surrounding channel, as such, assumptions and trial model runs were made to assess impacts of possible water depths and channel slopes at the downstream hydraulic control section.

Hydraulic models of rivers require input of a boundary condition, in this case an assumed downstream is the boundary condition based on resident input. LIDAR data is not available for this reach of river. USGS topo maps provide the best available data with 10' contours. The only available information at the bridge is anecdotal reports from a local resident of typical high water being 7-8' below the superstructure of the bridge, a 2 year event, and approximately 3' below the superstructure for a 50 year event. Larger rocks indicate rapid flow through the bridge rather than backwater.

For the 50-year flood, the low chord elevation is 551.00' with a water elevation 2.73' below low chord. Flow is rapid and apparently passes through critical depth just below the bridge causing a possible hydraulic jump as it enters the slightly deeper area downstream.

For a proposed bridge with a low chord of 550.88', the same downstream assumptions yield slightly higher flow velocity through the bridge due to a wider section/bridge opening, but upstream elevations are essentially identical.

Clearance is reduced due to the wider bridge deck section and lower bottom girder elevation of the bridge.

Hydraulic Model: The HECRAS model was run in "mixed flow" mode, allowing calculation of water surface elevations for both sub-critical and super-critical flow.

Calculated water surface profiles (see appendix) show that flow likely enters a super-critical flow segment below or near the bridge, and passes through a hydraulic jump back to sub-critical as it passes through the bridge. The bridge section is shallow compared with much of the river channel and the bottom profile is steep through and below the bridge resulting in the flow transition. A great deal of energy is released at the site of a hydraulic jump and ongoing channel erosion can be expected where it occurs. The lower stream bed elevation at the base is typical at such a flow transition. Note that this transition is not necessarily caused by the bridge contraction, but rather by the steep natural channel at and below the bridge.

Site photos verify rapid flow during flow conditions as shown in the following photos.

Figure 6 Looking at downstream fascia

In general, the proposed condition has a lower controlling headwater elevation for each of the flow events compared to the existing condition at the first common cross section (section 159.6). This results in an increased clearance at the bridge location for the proposed condition as the lower girder elevations are similar in the existing and proposed condition. The proposed condition also has slightly higher discharge velocities compared to the existing condition, these discharge velocities were taken at the first section beyond the bridge section. These results are further summarized in Table 3 below.

Figure 7 Looking at upstream fascia

Table 3 Summary of Hydraulic Data, Final Design

Madawaska Bridge 5160: Summary of Hydraulic Data	Existing Bridge Low chord 551.00’	Proposed Bridge Low chord 550.88’
Headwater at Q25, ft, (section 159.6)	547.84	547.71
Headwater at Upstream face, Q25, ft	547.20	547.43
Headwater at Q50, ft, (section 159.6)	548.27	548.09
Headwater at Upstream face Q50, ft	547.41	547.71
Headwater at Q100, ft, (section 159.6)	548.83	548.58
Headwater at Upstream face, ft (Q100), ft	547.71	548.09
Discharge Velocity at Q25, fps	7.43	7.93
Discharge Velocity at Q50, fps	8.37	8.90
Discharge Velocity at Q100, fps	9.25	9.78
Ordinary High Water Elevation (Q1.1), ft	542.03	542.03
Discharge Velocity at Q1.1, fps	3.62	4.30
Clearance @ Q25, ft	3.16	3.17
Clearance @ Q50, ft	2.73	2.79
Clearance @ Q100, ft	2.17	2.30
Bridge Opening Area, ft^2	968	1097
Flow Area at Q50, ft^2	728.9	758.4

5.0 Scour Analysis

The Madawaska Bridge was evaluated for potential scour. No detailed scour reports were found in Maine DOT Bridge files. The only reference to scour that was found was the bridge rating for item 113 of 8, "stable above footing". Site conditions indicate the following relative to scour:

- The bridge is located in a slightly narrow segment of the river and causes a slight contraction in the channel.
- The bridge appears to be located on a high point in the bottom profile causing higher velocities.
- The bridge may have a "scour hole" downstream, but this appears to be a result of the natural stream profile rather than the bridge.
- The channel appears to have quite a bit of natural armoring with large rocks and boulders covering much of the stream bottom through the bridge.
- The slightly steeper slope below the bridge indicates the potential for a hydraulic jump and associated energy losses below the bridge.
- No field data was collected relative to scour holes, footing elevations relative to bottom elevations or other field data that may indicate local scour.
- The original bridge plans do not show bed elevations at the bridge. No data was located to evaluate long term potential for aggradation/degradation.
- The bridge segment of channel appears to be well-incised and stable with vegetated banks and no recent bank scarring observed.

No data was found relative to long term aggradation/degradation of the river bed. The bed at the bridge is higher than either-up or down-stream bed elevations, indicating an armored or bedrock base at the bridge. According to original bridge plans and surveyed bed elevations, abutment footings are still covered. For these reasons, no long term bed degradation was considered for this site.

Potential scour was computed for the new bridge. D50 and D95 were gathered from the geotechnical report for the project with the following data taken from sieve analysis of the lower portion of borings 101 and 102. Bed armoring by boulders was not considered in the scour analysis, also leading to conservative results.

Table 4 Average Soil Grain Size

	Ave. Grain Size
D50	1.55mm
D95	35mm

Abutment and contraction scour were computed. Note abutment scour calculation are conservative as they do not take scour protection into account, so. Abutments are assumed to be vertical and aligned with flow for purposes of scour computations. "Left" refers to the left side of the channel facing downstream.

Table 5 Scour Summary

Scour Calculations	Computed scour depth, ft		Approx. Scour Elevation, ft	
	100-year	500-year	100-year	500-year
Contraction Scour	4.3	4.8		
Local Scour at Left Abutment[1]	0.0	1.4		
Local Scour at Right Abutment[1]	0.0	0.8		
Bed Elevation			544.7	542.8
Top of Footing			545.5	545.5
Rock Elevation			486.9	486.9

1. Note that abutment scour is conservative, and does not account for scour protection such as riprap or natural armoring.

Borings indicate that bedrock is present at 486.9’ on abutment 1 (south) side of the bridge and elevation 489.2’ on abutment 2 (north) side of the bridge. Scour computations indicate that scour is will not reach bedrock surface at the abutments. Therefore rock scour was not considered.

6.0 Summary of Findings

- No flood insurance study elevations are available at this location.
- Research indicates no history of ice jams at this location.
- Historic data shows little to no chance of overtopping, and adequate clearance at low chord for existing bridge.
- The drainage area is 115 square miles, without a stream gage.
- The hydraulic characteristics of the bridge site indicate rapid flow through and downstream of the bridge. This slightly steeper section may cause a hydraulic jump near or slightly downstream of the bridge, resulting in rapid energy loss at that section.
- Assumed downstream existing water surface levels from local resident observations were used for final design boundary conditions to estimate water levels at the bridge.
- The existing bridge clearance above the 50-year storm is 2.73', and above the 100-year storm is 2.17'.
- For the proposed bridge, 50-year clearance is 2.79, and 100-year clearance is 2.30’ according to the hydraulic model.
- Scour calculations indicate the potential for scour is 4.3 feet at both abutment locations. Calculations do not account for natural armoring or the existing abutments providing protection. The downstream possible scour hole and potential hydraulic jump indicate potential for upstream migration of the scour hole. Scour calculations do not specifically address that issue.
- Scour protection includes leaving the base of the existing abutments in place and natural channel armoring with boulders. Plain riprap is recommended for any additional protection as channel velocities are not overly high.

7.0 References

Federal Emergency Management Agency. Flood Hazard Boundary Map

U.S. Army Corps of Engineers, Hydrologic Engineering Center. HEC-RAS River Analysis System. Version 4.1.0. January, 2010. Davis, CA

U.S. Department of Transportation. Federal Highway Administration. Evaluating Scour at Bridges, 5th edition. HEC-18. April 2012 , Publication No. FHWA-HIF-12-003

U.S. Department of Transportation. Federal Highway Administration. Bridge Scour and Stream Instability Countermeasures. HEC-23. Volume 2. September, 2009. FHWA-NHI-09-112 . DG 14, Rock Riprap at Bridge Abutments and DG 4, Riprap Revetment

Maine Dept. of Transportation. Bridge Design Manual. August 2003

U.S. Dept. of Transportation. Design of Riprap Revetment. HEC No. 11. FHWA IP-89-016, March 1989

U.S. Army Corps of Engineers. Cold Regions Research Engineering Lab, CRREL. On-line ice jam database. https://rsgisias.crrel.usaace.arum.mil/icejam/

Madawaska Bridge Bridge # 5160 Hydrology and Hydraulics

Report Final Design

Appendix

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MaineDOT Bridge Program Fax/Memo

Telephone: (207) 624-3490

Fax: (207 624-3491

Date: September 17, 2013

To: File ***Dept:*** Federal & Urban Bridge

From: Robert Bulger ***Dept:*** Federal & Urban Bridge

Subject: 19318.00, Madawaska Bridge in Stockholm, Br. #5160, Local Flood Observations

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This file letter documents local flood observations collected via telephone interviews.

On September 4, 2013, a call was made to the U.S. Post Office in Stockholm. The gentleman managing that office had only worked there for three years, but did recommend calling Mr. Michael Sandstrom, as the person who knows the town's history best. Then a call was made to Mr. David Duquette, listed as the first selectman and acting Highway Commissioner of Stockholm Maine. Mr. Duquette pointed out that our information for Stockholm Municipal Officers is out of date, but he was willing to help. He thought a Flood Study had been done for Stockholm and suggested a call to Mr. Jay Kamm of the Northern Maine Development Commission, and to Mr. Sandstrom.

After various contacts, including to the State Planning Office, it was determined to Mr. Kamm's satisfaction that there has been no Flood Study done for Stockholm. Unfortunately, the only Flood Insurance information available is the "Flood Hazard Area Map" that has been in the file for a couple months. It cannot be used to establish flood stages for any storm event.

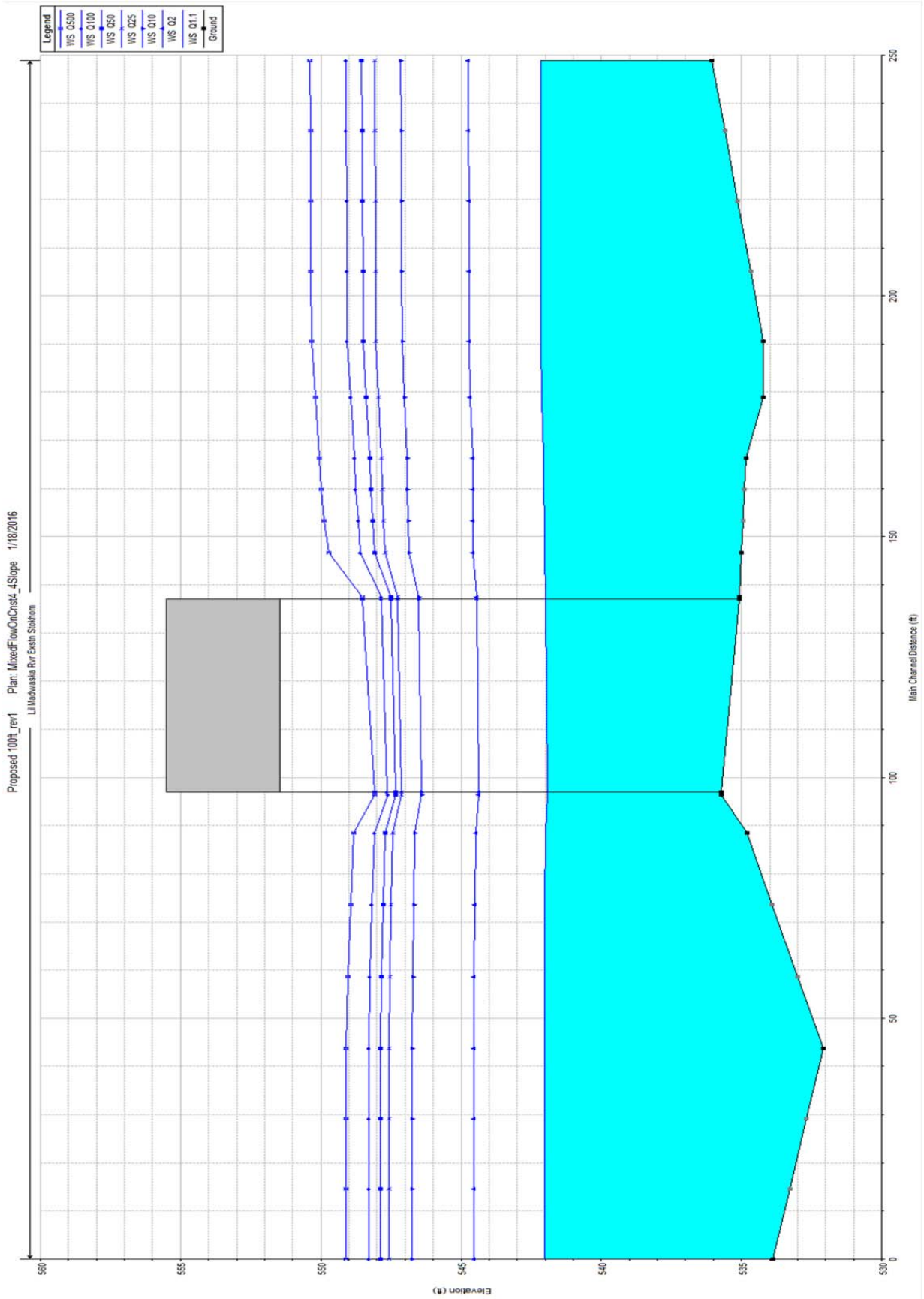
Finally, yesterday September 16, a call was made to Mr. Michael Sandstrom a former First Selectman and a resident of Stockholm for over 50 years. Mr. Sandstrom remembered the project's Preliminary Public Meeting clearly. Mr. Sandstrom also understood the request for high water information, both for a rare storm event and a common annual or biannual event.

Mr. Sandstrom suggested that his observations be correlated with Weather Service information for winters with high snow accumulation. According to his recollection, the two highest flood stages occurred after record snow accumulations in 1954 and 2008. He said those record flood stages were three to four feet below the bottom of the beams. For a more common event, he reported that the highest flood of the year is commonly six to seven feet below the bottom of the beams, the "belly of the bridge" in his words. He quickly agreed that it would be reasonable to use the first observation to limit the range of Q25 to Q50 flood stages and the second to estimate the two-year flood stage. This seems to be sound information, and appears to be the only basis for modeling the existing bridge hydraulic characteristics to determine the hydraulic boundary conditions.

Respectfully Submitted,

Robert S. Bulger

Robert S. Bulger, P.E.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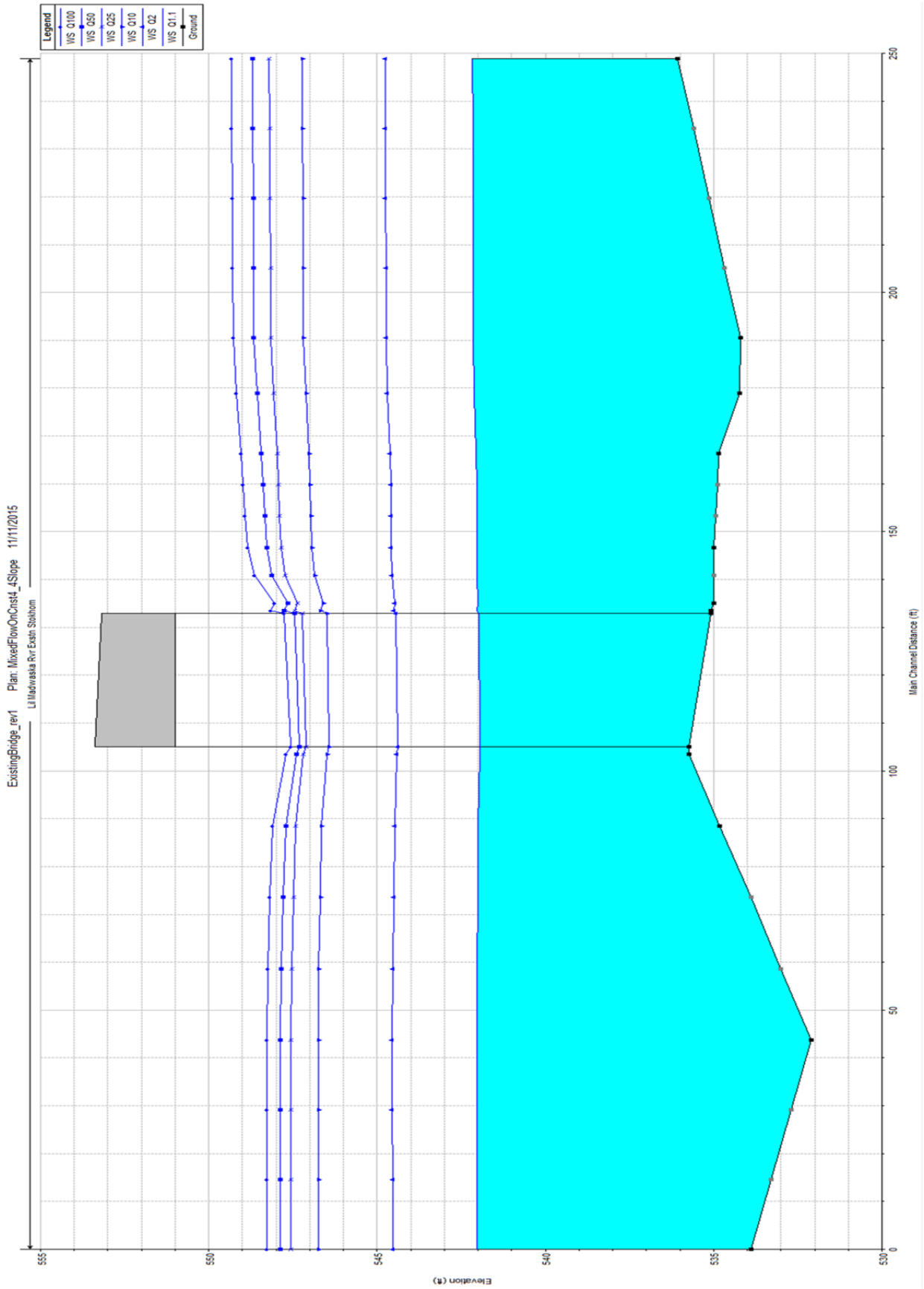
Lil Madiwaska Rvr Exstn Stoikhorn
Legend
WS Q500
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
Ground
Elevation (ft)
560
555
550
545
540
535
530
Main Channel Distance (ft)
0
50
100
150
200
250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Lit Madiwaska Rvr Exstn Stoikhorn
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
Ground
Elevation (ft)
555
550
545
540
535
530
Main Channel Distance (ft)
0
50
100
150
200
250

EXISTING

HEC-RAS Plan: MxdFlowCnstSlp River: Lil Madwaska Rvr Reach: Exstn Stokhom

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)	
Exstn Stokhom	261.8138	Q1.1	1365.00	536.06	542.17	539.08	542.32	0.000636	3.13	436.72	143.16	0.32
Exstn Stokhom	261.8138	Q2	2525.00	536.06	544.77	540.41	544.90	0.000305	2.91	866.87	182.22	0.24
Exstn Stokhom	261.8138	Q10	4560.00	536.06	547.23	542.29	547.40	0.000283	3.35	1361.43	222.08	0.24
Exstn Stokhom	261.8138	Q25	5650.00	536.06	548.21	542.84	548.40	0.000266	3.58	1588.42	241.32	0.24
Exstn Stokhom	261.8138	Q50	6490.00	536.06	548.71	543.18	548.94	0.000279	3.84	1712.12	251.19	0.24
Exstn Stokhom	261.8138	Q100	7380.00	536.06	549.33	543.55	549.58	0.000278	4.03	1870.86	263.20	0.25
Exstn Stokhom	247.200*	Q1.1	1365.00	535.60	542.15		542.31	0.000581	3.15	432.67	130.89	0.31
Exstn Stokhom	247.200*	Q2	2525.00	535.60	544.75		544.89	0.000330	2.99	844.05	181.44	0.24
Exstn Stokhom	247.200*	Q10	4560.00	535.60	547.21		547.40	0.000298	3.41	1336.52	218.51	0.24
Exstn Stokhom	247.200*	Q25	5650.00	535.60	548.19		548.40	0.000282	3.64	1560.87	240.21	0.24
Exstn Stokhom	247.200*	Q50	6490.00	535.60	548.70		548.93	0.000295	3.89	1684.07	250.69	0.25
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Exstn Stokhom	232.587*	Q1.1	1365.00	535.14	542.15		542.30	0.000513	3.10	440.31	124.54	0.29
Exstn Stokhom	232.587*	Q2	2525.00	535.14	544.74		544.89	0.000339	3.05	827.93	176.44	0.25
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Exstn Stokhom	232.587*	Q50	6490.00	535.14	548.68		548.93	0.000313	3.95	1655.96	249.32	0.26
Exstn Stokhom	232.587*	Q100	7380.00	535.14	549.30		549.57	0.000308	4.13	1813.51	261.99	0.26
Exstn Stokhom	217.974*	Q1.1	1365.00	534.67	542.15		542.29	0.000466	3.02	451.93	123.41	0.28
Exstn Stokhom	217.974*	Q2	2525.00	534.67	544.74		544.88	0.000310	3.05	828.58	164.66	0.24
Exstn Stokhom	217.974*	Q10	4560.00	534.67	547.19		547.39	0.000318	3.52	1295.66	211.54	0.25
Exstn Stokhom	217.974*	Q25	5650.00	534.67	548.17		548.39	0.000315	3.75	1508.41	224.26	0.25
Exstn Stokhom	217.974*	Q50	6490.00	534.67	548.67		548.92	0.000333	4.00	1627.09	248.77	0.26
Exstn Stokhom	217.974*	Q100	7380.00	534.67	549.29		549.56	0.000326	4.18	1784.71	261.00	0.26
Exstn Stokhom	203.3619	Q1.1	1365.00	534.21	542.15		542.28	0.000423	2.93	465.30	122.77	0.27
Exstn Stokhom	203.3619	Q2	2525.00	534.21	544.74		544.88	0.000295	3.01	839.79	163.25	0.23
Exstn Stokhom	203.3619	Q10	4560.00	534.21	547.18		547.38	0.000309	3.55	1285.36	202.07	0.25
Exstn Stokhom	203.3619	Q25	5650.00	534.21	548.16		548.38	0.000320	3.79	1490.61	218.06	0.26
Exstn Stokhom	203.3619	Q50	6490.00	534.21	548.66		548.92	0.000342	4.06	1600.73	225.25	0.27
Exstn Stokhom	203.3619	Q100	7380.00	534.21	549.28		549.56	0.000346	4.24	1754.94	260.88	0.27
Exstn Stokhom	191.8042	Q1.1	1365.00	534.22	542.12		542.27	0.000463	3.19	428.07	103.06	0.28
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Exstn Stokhom	191.8042	Q50	6490.00	534.22	548.57		548.90	0.000397	4.68	1459.73	250.18	0.29
Exstn Stokhom	191.8042	Q100	7380.00	534.22	549.17		549.54	0.000398	4.91	1619.46	275.78	0.29
Exstn Stokhom	179.1958	Q1.1	1365.00	534.84	542.07		542.26	0.000510	3.56	383.44	85.57	0.30
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Exstn Stokhom	179.1958	Q100	7380.00	534.84	549.05		549.53	0.000601	5.55	1383.96	266.24	0.35
Exstn Stokhom	172.663*	Q1.1	1365.00	534.89	542.04		542.26	0.000563	3.73	366.43	82.71	0.31
Exstn Stokhom	172.663*	Q2	2525.00	534.89	544.60		544.85	0.000575	4.05	623.91	126.97	0.32
Exstn Stokhom	172.663*	Q10	4560.00	534.89	546.99		547.35	0.000556	4.79	952.73	146.81	0.33
Exstn Stokhom	172.663*	Q25	5650.00	534.89	547.94		548.35	0.000590	5.15	1096.70	158.29	0.34
Exstn Stokhom	172.663*	Q50	6490.00	534.89	548.40		548.88	0.000639	5.54	1173.95	187.64	0.36
Exstn Stokhom	172.663*	Q100	7380.00	534.89	548.99		549.52	0.000633	5.81	1302.75	235.51	0.36
Exstn Stokhom	166.131*	Q1.1	1365.00	534.95	542.02		542.25	0.000616	3.84	355.20	81.80	0.32
Exstn Stokhom	166.131*	Q2	2525.00	534.95	544.60		544.85	0.000513	4.03	627.09	117.76	0.31
Exstn Stokhom	166.131*	Q10	4560.00	534.95	546.97		547.34	0.000550	4.93	924.94	134.72	0.33
Exstn Stokhom	166.131*	Q25	5650.00	534.95	547.90		548.34	0.000585	5.37	1052.25	140.88	0.35
Exstn Stokhom	166.131*	Q50	6490.00	534.95	548.35		548.87	0.000665	5.81	1116.52	146.02	0.37
Exstn Stokhom	166.131*	Q100	7380.00	534.95	548.92		549.51	0.000687	6.14	1214.37	210.46	0.38
Exstn Stokhom	159.6	Q1.1	1365.00	535.00	542.03		542.25	0.000669	3.75	364.36	92.47	0.33
Exstn Stokhom	159.6	Q2	2525.00	535.00	544.59		544.84	0.000476	4.07	620.52	107.28	0.30
Exstn Stokhom	159.6	Q10	4560.00	535.00	546.93		547.34	0.000566	5.14	887.56	122.95	0.34
Exstn Stokhom	159.6	Q25	5650.00	535.00	547.84		548.34	0.000602	5.64	1001.33	125.62	0.35
Exstn Stokhom	159.6	Q50	6490.00	535.00	548.27		548.86	0.000689	6.15	1055.95	128.83	0.38
Exstn Stokhom	159.6	Q100	7380.00	535.00	548.83		549.49	0.000756	6.53	1129.51	134.64	0.40
Exstn Stokhom	153.75*	Q1.1	1365.00	535.00	542.02		542.24	0.000596	3.74	364.52	85.72	0.32
Exstn Stokhom	153.75*	Q2	2525.00	535.00	544.56		544.84	0.000477	4.23	597.61	97.68	0.30
Exstn Stokhom	153.75*	Q10	4560.00	535.00	546.86		547.33	0.000573	5.49	830.38	102.52	0.34
Exstn Stokhom	153.75*	Q25	5650.00	535.00	547.74		548.32	0.000637	6.14	920.73	103.19	0.36
Exstn Stokhom	153.75*	Q50	6490.00	535.00	548.14		548.84	0.000735	6.75	961.73	103.46	0.39
Exstn Stokhom	153.75*	Q100	7380.00	535.00	548.65		549.47	0.000803	7.27	1015.36	103.82	0.41
Exstn Stokhom	147.9	Q1.1	1365.00	535.00	542.00		542.24	0.000562	3.91	349.49	71.38	0.31
Exstn Stokhom	147.9	Q2	2525.00	535.00	544.47		544.83	0.000533	4.79	526.82	72.08	0.31
Exstn Stokhom	147.9	Q10	4560.00	535.00	546.61		547.30	0.000790	6.69	681.30	72.69	0.39
Exstn Stokhom	147.9	Q25	5650.00	535.00	547.37		548.29	0.000956	7.66	737.18	72.91	0.42

HEC-RAS Plan: MxdFlowCnstSlp River: Lil Madwaska Rvr Reach: Exstn Stokhom (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)	
Exstn Stokhom	147.9	Q50	6490.00	535.00	547.65		548.79	0.001161	8.57	757.63	72.99	0.47
Exstn Stokhom	147.9	Q100	7380.00	535.00	548.04		549.41	0.001344	9.39	786.00	73.10	0.50
Exstn Stokhom	146.3550	Q1.1	1365.00	535.08	542.04	538.72	542.22	0.000389	3.42	398.94	72.24	0.26
Exstn Stokhom	146.3550	Q2	2525.00	535.08	544.51	539.86	544.81	0.000418	4.37	578.35	72.68	0.27
Exstn Stokhom	146.3550	Q10	4560.00	535.08	546.67	541.49	547.27	0.000653	6.20	735.79	73.06	0.34
Exstn Stokhom	146.3550	Q25	5650.00	535.08	547.46	542.26	548.25	0.000799	7.12	793.18	73.20	0.38
Exstn Stokhom	146.3550	Q50	6490.00	535.08	547.76	542.82	548.75	0.000970	7.96	815.29	73.25	0.42
Exstn Stokhom	146.3550	Q100	7380.00	535.08	548.17	543.39	549.35	0.001126	8.73	845.26	73.32	0.45
Exstn Stokhom	129.355		Bridge									
Exstn Stokhom	116.3550	Q1.1	1365.00	535.73	541.96		542.16	0.000477	3.62	377.27	72.82	0.28
Exstn Stokhom	116.3550	Q2	2525.00	535.73	544.41		544.73	0.000484	4.54	556.38	73.13	0.29
Exstn Stokhom	116.3550	Q10	4560.00	535.73	546.48		547.13	0.000753	6.44	707.76	73.39	0.37
Exstn Stokhom	116.3550	Q25	5650.00	535.73	547.20		548.05	0.000931	7.43	760.26	73.47	0.41
Exstn Stokhom	116.3550	Q50	6490.00	535.73	547.41		548.49	0.001156	8.37	775.61	73.50	0.45
Exstn Stokhom	116.3550	Q100	7380.00	535.73	547.71		549.04	0.001372	9.25	797.78	73.53	0.49
Exstn Stokhom	101.3550	Q1.1	1365.00	534.81	542.00		542.12	0.000279	2.77	492.39	103.61	0.22
Exstn Stokhom	101.3550	Q2	2525.00	534.81	544.49		544.65	0.000251	3.28	768.68	113.44	0.22
Exstn Stokhom	101.3550	Q10	4560.00	534.81	546.65		546.94	0.000405	4.34	1051.28	144.29	0.28
Exstn Stokhom	101.3550	Q25	5650.00	534.81	547.43		547.80	0.000457	4.85	1165.37	147.41	0.30
Exstn Stokhom	101.3550	Q50	6490.00	534.81	547.71		548.16	0.000544	5.38	1206.73	148.69	0.33
Exstn Stokhom	101.3550	Q100	7380.00	534.81	548.09		548.62	0.000612	5.84	1263.53	150.26	0.35
Exstn Stokhom	86.4436*	Q1.1	1365.00	533.90	542.01		542.10	0.000202	2.40	569.47	117.15	0.19
Exstn Stokhom	86.4436*	Q2	2525.00	533.90	544.51		544.64	0.000219	2.85	884.89	147.23	0.21
Exstn Stokhom	86.4436*	Q10	4560.00	533.90	546.70		546.91	0.000275	3.73	1223.53	160.49	0.24
Exstn Stokhom	86.4436*	Q25	5650.00	533.90	547.49		547.76	0.000315	4.18	1352.92	165.89	0.26
Exstn Stokhom	86.4436*	Q50	6490.00	533.90	547.79		548.12	0.000378	4.63	1402.06	168.70	0.28
Exstn Stokhom	86.4436*	Q100	7380.00	533.90	548.18		548.57	0.000430	5.02	1469.28	172.43	0.30
Exstn Stokhom	71.5323*	Q1.1	1365.00	533.00	542.03		542.09	0.000139	2.08	655.99	126.07	0.16
Exstn Stokhom	71.5323*	Q2	2525.00	533.00	544.53		544.63	0.000155	2.46	1026.10	166.04	0.17
Exstn Stokhom	71.5323*	Q10	4560.00	533.00	546.73		546.89	0.000201	3.24	1406.11	182.19	0.21
Exstn Stokhom	71.5323*	Q25	5650.00	533.00	547.53		547.74	0.000233	3.63	1555.72	189.89	0.22
Exstn Stokhom	71.5323*	Q50	6490.00	533.00	547.84		548.09	0.000279	4.02	1613.95	193.59	0.25
Exstn Stokhom	71.5323*	Q100	7380.00	533.00	548.24		548.54	0.000318	4.36	1693.21	198.74	0.26
Exstn Stokhom	56.6210	Q1.1	1365.00	532.09	542.04		542.09	0.000100	1.80	756.61	140.01	0.14
Exstn Stokhom	56.6210	Q2	2525.00	532.09	544.54		544.62	0.000113	2.15	1174.74	183.71	0.15
Exstn Stokhom	56.6210	Q10	4560.00	532.09	546.75		546.88	0.000153	2.84	1606.73	207.82	0.18
Exstn Stokhom	56.6210	Q25	5650.00	532.09	547.57		547.72	0.000177	3.17	1779.62	216.65	0.20
Exstn Stokhom	56.6210	Q50	6490.00	532.09	547.88		548.07	0.000208	3.51	1847.25	218.17	0.21
Exstn Stokhom	56.6210	Q100	7380.00	532.09	548.29		548.51	0.000232	3.81	1937.26	220.18	0.23
Exstn Stokhom	42.0409*	Q1.1	1365.00	532.69	542.03		542.09	0.000106	1.82	750.47	144.42	0.14
Exstn Stokhom	42.0409*	Q2	2525.00	532.69	544.54		544.61	0.000114	2.15	1176.66	186.35	0.15
Exstn Stokhom	42.0409*	Q10	4560.00	532.69	546.75		546.88	0.000150	2.83	1612.21	207.77	0.18
Exstn Stokhom	42.0409*	Q25	5650.00	532.69	547.56		547.72	0.000175	3.17	1784.56	217.49	0.19
Exstn Stokhom	42.0409*	Q50	6490.00	532.69	547.87		548.06	0.000207	3.50	1852.62	220.17	0.21
Exstn Stokhom	42.0409*	Q100	7380.00	532.69	548.28		548.51	0.000232	3.80	1943.46	222.39	0.23
Exstn Stokhom	27.4608*	Q1.1	1365.00	533.28	542.03		542.08	0.000111	1.83	744.97	147.42	0.14
Exstn Stokhom	27.4608*	Q2	2525.00	533.28	544.54		544.61	0.000115	2.14	1178.08	189.06	0.15
Exstn Stokhom	27.4608*	Q10	4560.00	533.28	546.75		546.88	0.000150	2.82	1617.71	208.99	0.18
Exstn Stokhom	27.4608*	Q25	5650.00	533.28	547.56		547.72	0.000172	3.16	1790.28	217.12	0.19
Exstn Stokhom	27.4608*	Q50	6490.00	533.28	547.87		548.06	0.000205	3.49	1858.14	220.28	0.21
Exstn Stokhom	27.4608*	Q100	7380.00	533.28	548.28		548.51	0.000231	3.79	1949.31	224.00	0.23
Exstn Stokhom	12.8808	Q1.1	1365.00	533.88	542.03	536.88	542.08	0.000113	1.84	740.48	146.79	0.14
Exstn Stokhom	12.8808	Q2	2525.00	533.88	544.54	537.95	544.61	0.000117	2.14	1179.37	191.78	0.15
Exstn Stokhom	12.8808	Q10	4560.00	533.88	546.75	539.29	546.87	0.000149	2.81	1623.29	210.48	0.18
Exstn Stokhom	12.8808	Q25	5650.00	533.88	547.56	539.90	547.71	0.000171	3.14	1796.73	217.78	0.19
Exstn Stokhom	12.8808	Q50	6490.00	533.88	547.87	540.34	548.06	0.000203	3.48	1864.68	220.58	0.21
Exstn Stokhom	12.8808	Q100	7380.00	533.88	548.28	540.80	548.50	0.000229	3.77	1955.88	224.28	0.23

Plan: MxdFlowCnstSlp Lil Madwaska Rvr Exstn Stokhom RS: 129.355 Profile: Q50

E.G. US. (ft)	548.75	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	547.76	E.G. Elev (ft)	548.67	548.60
Q Total (cfs)	6490.00	W.S. Elev (ft)	547.44	547.30
Q Bridge (cfs)	6490.00	Crit W.S. (ft)	543.24	543.42
Q Weir (cfs)		Max Chl Dpth (ft)	12.36	11.57
Weir Sta Lft (ft)		Vel Total (ft/s)	8.90	9.14
Weir Sta Rgt (ft)		Flow Area (sq ft)	728.91	709.89
Weir Submerg		Froude # Chl	0.48	0.50
Weir Max Depth (ft)		Specif Force (cu ft)	5766.77	5582.86
Min El Weir Flow (ft)	553.40	Hydr Depth (ft)	10.63	10.31
Min El Prs (ft)	551.00	W.P. Total (ft)	106.48	106.03
Delta EG (ft)	0.25	Conv. Total (cfs)	156191.3	149885.3
Delta WS (ft)	0.36	Top Width (ft)	68.57	68.84
BR Open Area (sq ft)	967.80	Frctn Loss (ft)	0.05	0.00
BR Open Vel (ft/s)	9.14	C & E Loss (ft)	0.02	0.11
Coef of Q		Shear Total (lb/sq ft)	0.74	0.78
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

PROPOSED

HEC-RAS Plan: MxdFlowCnstSlp River: Lil Madwaska Rvr Reach: Exstn Stokhom

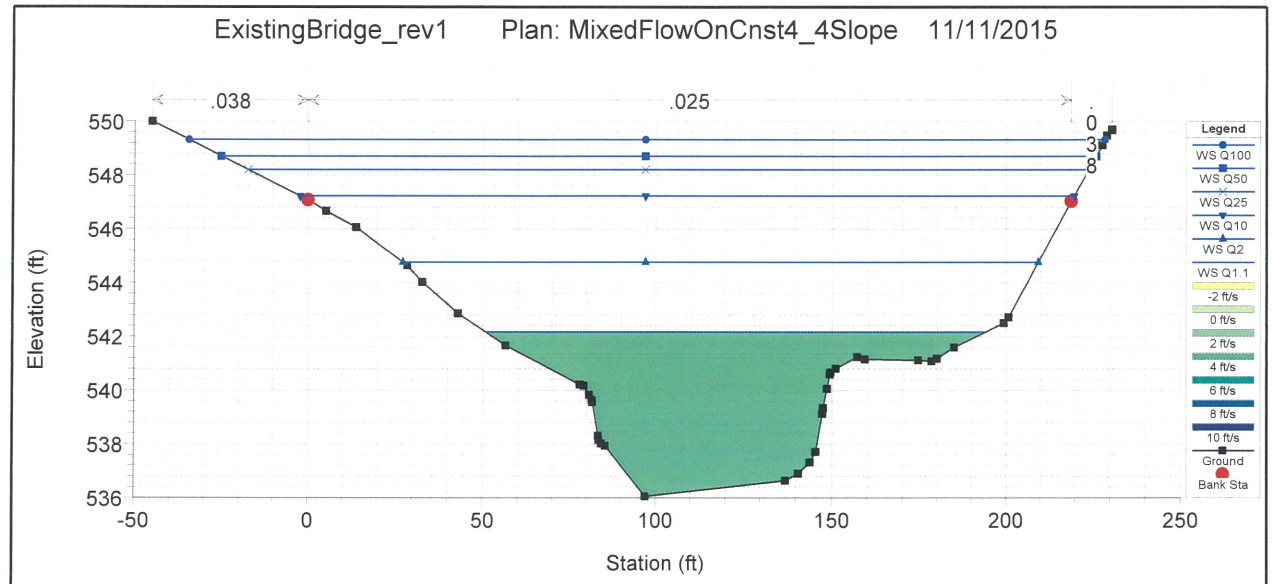
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Exstn Stokhom	261.8138	Q1.1	1365.00	536.06	542.17	539.08	542.32	0.000634	3.12	437.20	143.25	0.31
Exstn Stokhom	261.8138	Q2	2525.00	536.06	544.75	540.41	544.88	0.000308	2.92	864.11	182.00	0.24
Exstn Stokhom	261.8138	Q10	4560.00	536.06	547.15	542.29	547.33	0.000294	3.39	1344.97	220.62	0.24
Exstn Stokhom	261.8138	Q25	5650.00	536.06	548.09	542.83	548.29	0.000281	3.64	1559.91	238.99	0.24
Exstn Stokhom	261.8138	Q50	6490.00	536.06	548.55	543.20	548.78	0.000300	3.93	1671.58	248.00	0.25
Exstn Stokhom	261.8138	Q100	7380.00	536.06	549.11	543.56	549.37	0.000304	4.15	1814.43	259.07	0.26
Exstn Stokhom	261.8138	Q500	9530.00	536.06	550.39	544.34	550.71	0.000307	4.59	2164.01	292.11	0.26
Exstn Stokhom	247.200*	Q1.1	1365.00	535.60	542.16		542.31	0.000579	3.15	433.11	130.96	0.31
Exstn Stokhom	247.200*	Q2	2525.00	535.60	544.74		544.88	0.000334	3.00	841.27	181.20	0.25
Exstn Stokhom	247.200*	Q10	4560.00	535.60	547.14		547.33	0.000309	3.45	1320.23	217.52	0.25
Exstn Stokhom	247.200*	Q25	5650.00	535.60	548.08		548.29	0.000299	3.70	1532.34	237.75	0.25
Exstn Stokhom	247.200*	Q50	6490.00	535.60	548.53		548.78	0.000318	3.98	1643.40	247.37	0.26
Exstn Stokhom	247.200*	Q100	7380.00	535.60	549.10		549.37	0.000320	4.20	1786.16	260.76	0.26
Exstn Stokhom	247.200*	Q500	9530.00	535.60	550.38		550.71	0.000319	4.63	2149.02	300.02	0.27
Exstn Stokhom	232.587*	Q1.1	1365.00	535.14	542.15		542.30	0.000512	3.10	440.73	124.62	0.29
Exstn Stokhom	232.587*	Q2	2525.00	535.14	544.73		544.87	0.000342	3.06	825.21	176.16	0.25
Exstn Stokhom	232.587*	Q10	4560.00	535.14	547.13		547.32	0.000321	3.51	1298.06	214.48	0.25
Exstn Stokhom	232.587*	Q25	5650.00	535.14	548.06		548.28	0.000319	3.76	1504.84	236.83	0.26
Exstn Stokhom	232.587*	Q50	6490.00	535.14	548.52		548.77	0.000338	4.04	1615.23	246.48	0.27
Exstn Stokhom	232.587*	Q100	7380.00	535.14	549.08		549.36	0.000338	4.25	1756.79	256.89	0.27
Exstn Stokhom	232.587*	Q500	9530.00	535.14	550.36		550.70	0.000336	4.69	2108.28	308.96	0.28
Exstn Stokhom	217.974*	Q1.1	1365.00	534.67	542.15		542.29	0.000465	3.02	452.35	123.49	0.28
Exstn Stokhom	217.974*	Q2	2525.00	534.67	544.72		544.87	0.000313	3.06	826.04	164.54	0.24
Exstn Stokhom	217.974*	Q10	4560.00	534.67	547.12		547.31	0.000329	3.56	1279.74	210.59	0.25
Exstn Stokhom	217.974*	Q25	5650.00	534.67	548.05		548.28	0.000332	3.81	1481.48	222.05	0.26
Exstn Stokhom	217.974*	Q50	6490.00	534.67	548.51		548.77	0.000360	4.10	1586.27	245.11	0.27
Exstn Stokhom	217.974*	Q100	7380.00	534.67	549.07		549.36	0.000359	4.31	1727.72	257.25	0.28
Exstn Stokhom	217.974*	Q500	9530.00	534.67	550.35		550.70	0.000352	4.73	2071.84	282.32	0.28
Exstn Stokhom	203.3619	Q1.1	1365.00	534.21	542.15		542.28	0.000422	2.93	465.71	122.84	0.27
Exstn Stokhom	203.3619	Q2	2525.00	534.21	544.72		544.86	0.000297	3.02	837.28	163.10	0.23
Exstn Stokhom	203.3619	Q10	4560.00	534.21	547.11		547.31	0.000319	3.59	1270.17	200.81	0.25
Exstn Stokhom	203.3619	Q25	5650.00	534.21	548.04		548.27	0.000335	3.86	1464.36	215.90	0.26
Exstn Stokhom	203.3619	Q50	6490.00	534.21	548.49		548.76	0.000365	4.15	1563.64	222.02	0.27
Exstn Stokhom	203.3619	Q100	7380.00	534.21	549.06		549.35	0.000382	4.37	1697.73	255.98	0.28
Exstn Stokhom	203.3619	Q500	9530.00	534.21	550.34		550.69	0.000370	4.78	2041.92	280.18	0.29
Exstn Stokhom	191.8042	Q1.1	1365.00	534.22	542.12		542.28	0.000462	3.19	428.43	103.10	0.28
Exstn Stokhom	191.8042	Q2	2525.00	534.22	544.67		544.85	0.000398	3.45	732.50	141.69	0.27
Exstn Stokhom	191.8042	Q10	4560.00	534.22	547.04		547.30	0.000399	4.09	1122.40	191.45	0.28
Exstn Stokhom	191.8042	Q25	5650.00	534.22	547.96		548.26	0.000394	4.43	1315.97	223.81	0.28
Exstn Stokhom	191.8042	Q50	6490.00	534.22	548.40		548.75	0.000428	4.79	1417.66	242.24	0.30
Exstn Stokhom	191.8042	Q100	7380.00	534.22	548.95		549.34	0.000437	5.06	1557.46	266.11	0.31
Exstn Stokhom	191.8042	Q500	9530.00	534.22	550.21		550.67	0.000441	5.57	1921.97	307.52	0.31
Exstn Stokhom	179.1958	Q1.1	1365.00	534.84	542.07		542.27	0.000509	3.56	383.73	85.59	0.30
Exstn Stokhom	179.1958	Q2	2525.00	534.84	544.58		544.84	0.000449	4.07	620.77	103.08	0.29
Exstn Stokhom	179.1958	Q10	4560.00	534.84	546.93		547.28	0.000619	4.76	958.75	161.69	0.34
Exstn Stokhom	179.1958	Q25	5650.00	534.84	547.84		548.24	0.000633	5.08	1113.10	181.95	0.35
Exstn Stokhom	179.1958	Q50	6490.00	534.84	548.27		548.73	0.000675	5.47	1196.48	222.15	0.37
Exstn Stokhom	179.1958	Q100	7380.00	534.84	548.81		549.32	0.000672	5.75	1322.43	244.95	0.37
Exstn Stokhom	179.1958	Q500	9530.00	534.84	550.07		550.65	0.000638	6.22	1681.56	309.83	0.37
Exstn Stokhom	172.663*	Q1.1	1365.00	534.89	542.05		542.26	0.000562	3.72	366.72	82.73	0.31
Exstn Stokhom	172.663*	Q2	2525.00	534.89	544.58		544.84	0.000581	4.06	621.85	126.87	0.32
Exstn Stokhom	172.663*	Q10	4560.00	534.89	546.91		547.28	0.000576	4.85	940.97	146.18	0.34
Exstn Stokhom	172.663*	Q25	5650.00	534.89	547.81		548.24	0.000620	5.25	1076.14	156.71	0.35
Exstn Stokhom	172.663*	Q50	6490.00	534.89	548.22		548.72	0.000695	5.69	1142.15	169.09	0.38
Exstn Stokhom	172.663*	Q100	7380.00	534.89	548.75		549.31	0.000706	6.01	1246.89	221.68	0.38
Exstn Stokhom	172.663*	Q500	9530.00	534.89	549.98		550.64	0.000693	6.58	1564.64	289.12	0.39
Exstn Stokhom	166.131*	Q1.1	1365.00	534.95	542.03		542.26	0.000615	3.84	355.49	81.86	0.32
Exstn Stokhom	166.131*	Q2	2525.00	534.95	544.58		544.83	0.000518	4.04	625.19	117.65	0.31
Exstn Stokhom	166.131*	Q10	4560.00	534.95	546.89		547.27	0.000569	4.99	914.12	134.29	0.34
Exstn Stokhom	166.131*	Q25	5650.00	534.95	547.77		548.23	0.000611	5.46	1033.93	139.31	0.35
Exstn Stokhom	166.131*	Q50	6490.00	534.95	548.16		548.71	0.000706	5.95	1090.10	143.96	0.38
Exstn Stokhom	166.131*	Q100	7380.00	534.95	548.68		549.30	0.000762	6.33	1166.38	163.72	0.40
Exstn Stokhom	166.131*	Q500	9530.00	534.95	549.87		550.63	0.000776	7.02	1442.79	265.71	0.41
Exstn Stokhom	159.6	Q1.1	1365.00	535.00	542.03		542.25	0.000667	3.74	364.70	92.50	0.33
Exstn Stokhom	159.6	Q2	2525.00	535.00	544.57		544.83	0.000480	4.08	618.79	107.19	0.30
Exstn Stokhom	159.6	Q10	4560.00	535.00	546.85		547.27	0.000583	5.20	877.65	122.22	0.34
Exstn Stokhom	159.6	Q25	5650.00	535.00	547.71		548.22	0.000634	5.74	984.80	125.30	0.36
Exstn Stokhom	159.6	Q50	6490.00	535.00	548.09		548.70	0.000728	6.29	1032.43	126.92	0.39
Exstn Stokhom	159.6	Q100	7380.00	535.00	548.58		549.29	0.000813	6.73	1096.22	132.04	0.41
Exstn Stokhom	159.6	Q500	9530.00	535.00	549.72		550.61	0.000902	7.58	1314.22	248.48	0.44
Exstn Stokhom	150.355	Q1.1	1365.00	535.08	541.98	538.94	542.24	0.000580	4.07	335.72	66.91	0.32

HEC-RAS Plan: MxdFlowCnstSlp River: Lil Madwaska Rvr Reach: Exstn Stokhom (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)	
Exstn Stokhom	150.355	Q2	2525.00	535.08	544.43	540.32	544.81	0.000587	4.95	510.13	75.48	0.34
Exstn Stokhom	150.355	Q10	4560.00	535.08	546.52	542.20	547.23	0.000857	6.75	675.64	82.81	0.42
Exstn Stokhom	150.355	Q25	5650.00	535.08	547.26	543.07	548.17	0.001026	7.66	737.82	85.39	0.46
Exstn Stokhom	150.355	Q50	6490.00	535.08	547.50	543.69	548.64	0.001252	8.56	758.45	86.24	0.51
Exstn Stokhom	150.355	Q100	7380.00	535.08	547.85	544.30	549.21	0.001452	9.36	788.30	87.44	0.55
Exstn Stokhom	150.355	Q500	9530.00	535.08	548.54	545.69	550.49	0.001963	11.22	849.47	89.85	0.64
Exstn Stokhom	129.355		Bridge									
Exstn Stokhom	109.355	Q1.1	1365.00	535.73	541.92		542.20	0.000698	4.30	317.15	66.68	0.35
Exstn Stokhom	109.355	Q2	2525.00	535.73	544.37		544.78	0.000663	5.14	491.11	75.26	0.35
Exstn Stokhom	109.355	Q10	4560.00	535.73	546.42		547.18	0.000954	6.98	653.11	82.45	0.44
Exstn Stokhom	109.355	Q25	5650.00	535.73	547.13		548.11	0.001143	7.93	712.65	84.94	0.48
Exstn Stokhom	109.355	Q50	6490.00	535.73	547.33		548.56	0.001413	8.90	729.26	85.62	0.54
Exstn Stokhom	109.355	Q100	7380.00	535.73	547.62		549.11	0.001659	9.78	754.53	86.65	0.58
Exstn Stokhom	109.355	Q500	9530.00	535.73	548.09		550.32	0.002384	11.98	795.36	88.28	0.70
Exstn Stokhom	101.3550	Q1.1	1365.00	534.81	542.00		542.12	0.000279	2.77	492.39	103.61	0.22
Exstn Stokhom	101.3550	Q2	2525.00	534.81	544.49		544.65	0.000251	3.28	768.68	113.44	0.22
Exstn Stokhom	101.3550	Q10	4560.00	534.81	546.65		546.94	0.000405	4.34	1051.28	144.29	0.28
Exstn Stokhom	101.3550	Q25	5650.00	534.81	547.43		547.80	0.000457	4.85	1165.37	147.41	0.30
Exstn Stokhom	101.3550	Q50	6490.00	534.81	547.71		548.16	0.000544	5.38	1206.73	148.69	0.33
Exstn Stokhom	101.3550	Q100	7380.00	534.81	548.09		548.62	0.000612	5.84	1263.53	150.26	0.35
Exstn Stokhom	101.3550	Q500	9530.00	534.81	548.82		549.57	0.000805	6.93	1374.21	155.08	0.41
Exstn Stokhom	86.4436*	Q1.1	1365.00	533.90	542.01		542.10	0.000202	2.40	569.47	117.15	0.19
Exstn Stokhom	86.4436*	Q2	2525.00	533.90	544.51		544.64	0.000219	2.85	884.89	147.23	0.21
Exstn Stokhom	86.4436*	Q10	4560.00	533.90	546.70		546.91	0.000275	3.73	1223.53	160.49	0.24
Exstn Stokhom	86.4436*	Q25	5650.00	533.90	547.49		547.76	0.000315	4.18	1352.92	165.89	0.26
Exstn Stokhom	86.4436*	Q50	6490.00	533.90	547.79		548.12	0.000378	4.63	1402.06	168.70	0.28
Exstn Stokhom	86.4436*	Q100	7380.00	533.90	548.18		548.57	0.000430	5.02	1469.28	172.43	0.30
Exstn Stokhom	86.4436*	Q500	9530.00	533.90	548.95		549.50	0.000566	5.94	1604.39	179.99	0.35
Exstn Stokhom	71.5323*	Q1.1	1365.00	533.00	542.03		542.09	0.000139	2.08	655.99	126.07	0.16
Exstn Stokhom	71.5323*	Q2	2525.00	533.00	544.53		544.63	0.000155	2.46	1026.10	166.04	0.17
Exstn Stokhom	71.5323*	Q10	4560.00	533.00	546.73		546.89	0.000201	3.24	1406.11	182.19	0.21
Exstn Stokhom	71.5323*	Q25	5650.00	533.00	547.53		547.74	0.000233	3.63	1555.72	189.89	0.22
Exstn Stokhom	71.5323*	Q50	6490.00	533.00	547.84		548.09	0.000279	4.02	1613.95	193.59	0.25
Exstn Stokhom	71.5323*	Q100	7380.00	533.00	548.24		548.54	0.000318	4.36	1693.21	198.74	0.26
Exstn Stokhom	71.5323*	Q500	9530.00	533.00	549.04		549.45	0.000408	5.14	1853.78	204.50	0.30
Exstn Stokhom	56.6210	Q1.1	1365.00	532.09	542.04		542.09	0.000100	1.80	756.61	140.01	0.14
Exstn Stokhom	56.6210	Q2	2525.00	532.09	544.54		544.62	0.000113	2.15	1174.74	183.71	0.15
Exstn Stokhom	56.6210	Q10	4560.00	532.09	546.75		546.88	0.000153	2.84	1606.73	207.82	0.18
Exstn Stokhom	56.6210	Q25	5650.00	532.09	547.57		547.72	0.000177	3.17	1779.62	216.65	0.20
Exstn Stokhom	56.6210	Q50	6490.00	532.09	547.88		548.07	0.000208	3.51	1847.25	218.17	0.21
Exstn Stokhom	56.6210	Q100	7380.00	532.09	548.29		548.51	0.000232	3.81	1937.26	220.18	0.23
Exstn Stokhom	56.6210	Q500	9530.00	532.09	549.10		549.41	0.000295	4.50	2117.45	224.14	0.26
Exstn Stokhom	42.0409*	Q1.1	1365.00	532.69	542.03		542.09	0.000106	1.82	750.47	144.42	0.14
Exstn Stokhom	42.0409*	Q2	2525.00	532.69	544.54		544.61	0.000114	2.15	1176.66	186.35	0.15
Exstn Stokhom	42.0409*	Q10	4560.00	532.69	546.75		546.88	0.000150	2.83	1612.21	207.77	0.18
Exstn Stokhom	42.0409*	Q25	5650.00	532.69	547.56		547.72	0.000175	3.17	1784.56	217.49	0.19
Exstn Stokhom	42.0409*	Q50	6490.00	532.69	547.87		548.06	0.000207	3.50	1852.62	220.17	0.21
Exstn Stokhom	42.0409*	Q100	7380.00	532.69	548.28		548.51	0.000232	3.80	1943.46	222.39	0.23
Exstn Stokhom	42.0409*	Q500	9530.00	532.69	549.10		549.41	0.000295	4.48	2125.57	226.78	0.26
Exstn Stokhom	27.4608*	Q1.1	1365.00	533.28	542.03		542.08	0.000111	1.83	744.97	147.42	0.14
Exstn Stokhom	27.4608*	Q2	2525.00	533.28	544.54		544.61	0.000115	2.14	1178.08	189.06	0.15
Exstn Stokhom	27.4608*	Q10	4560.00	533.28	546.75		546.88	0.000150	2.82	1617.71	208.99	0.18
Exstn Stokhom	27.4608*	Q25	5650.00	533.28	547.56		547.72	0.000172	3.16	1790.28	217.12	0.19
Exstn Stokhom	27.4608*	Q50	6490.00	533.28	547.87		548.06	0.000205	3.49	1858.14	220.28	0.21
Exstn Stokhom	27.4608*	Q100	7380.00	533.28	548.28		548.51	0.000231	3.79	1949.31	224.00	0.23
Exstn Stokhom	27.4608*	Q500	9530.00	533.28	549.09		549.40	0.000295	4.47	2132.94	229.24	0.26
Exstn Stokhom	12.8808	Q1.1	1365.00	533.88	542.03	536.88	542.08	0.000113	1.84	740.48	146.79	0.14
Exstn Stokhom	12.8808	Q2	2525.00	533.88	544.54	537.95	544.61	0.000117	2.14	1179.37	191.78	0.15
Exstn Stokhom	12.8808	Q10	4560.00	533.88	546.75	539.29	546.87	0.000149	2.81	1623.29	210.48	0.18
Exstn Stokhom	12.8808	Q25	5650.00	533.88	547.56	539.90	547.71	0.000171	3.14	1796.73	217.78	0.19
Exstn Stokhom	12.8808	Q50	6490.00	533.88	547.87	540.34	548.06	0.000203	3.48	1864.68	220.58	0.21
Exstn Stokhom	12.8808	Q100	7380.00	533.88	548.28	540.80	548.50	0.000229	3.77	1955.88	224.28	0.23
Exstn Stokhom	12.8808	Q500	9530.00	533.88	549.09	542.13	549.40	0.000294	4.45	2140.15	230.59	0.26

Plan: MxdFlowCnstSlp Lil Madwaska Rvr Exstn Stokhom RS: 129.355 Profile: Q50

E.G. US. (ft)	548.64	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	547.50	E.G. Elev (ft)	548.64	548.56
Q Total (cfs)	6490.00	W.S. Elev (ft)	547.50	547.33
Q Bridge (cfs)	6490.00	Crit W.S. (ft)	543.71	543.93
Q Weir (cfs)		Max Chl Dpth (ft)	12.42	11.60
Weir Sta Lft (ft)		Vel Total (ft/s)	8.56	8.90
Weir Sta Rgt (ft)		Flow Area (sq ft)	758.38	729.33
Weir Submerg		Froude # Chl	0.51	0.54
Weir Max Depth (ft)		Specif Force (cu ft)	5635.28	5417.35
Min El Weir Flow (ft)	555.53	Hydr Depth (ft)	8.79	8.52
Min El Prs (ft)	551.45	W.P. Total (ft)	92.42	91.73
Delta EG (ft)	0.08	Conv. Total (cfs)	183384.4	172686.3
Delta WS (ft)	0.18	Top Width (ft)	86.23	85.63
BR Open Area (sq ft)	1096.94	Frctn Loss (ft)	0.05	0.00
BR Open Vel (ft/s)	8.90	C & E Loss (ft)	0.03	0.00
Coef of Q		Shear Total (lb/sq ft)	0.64	0.70
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00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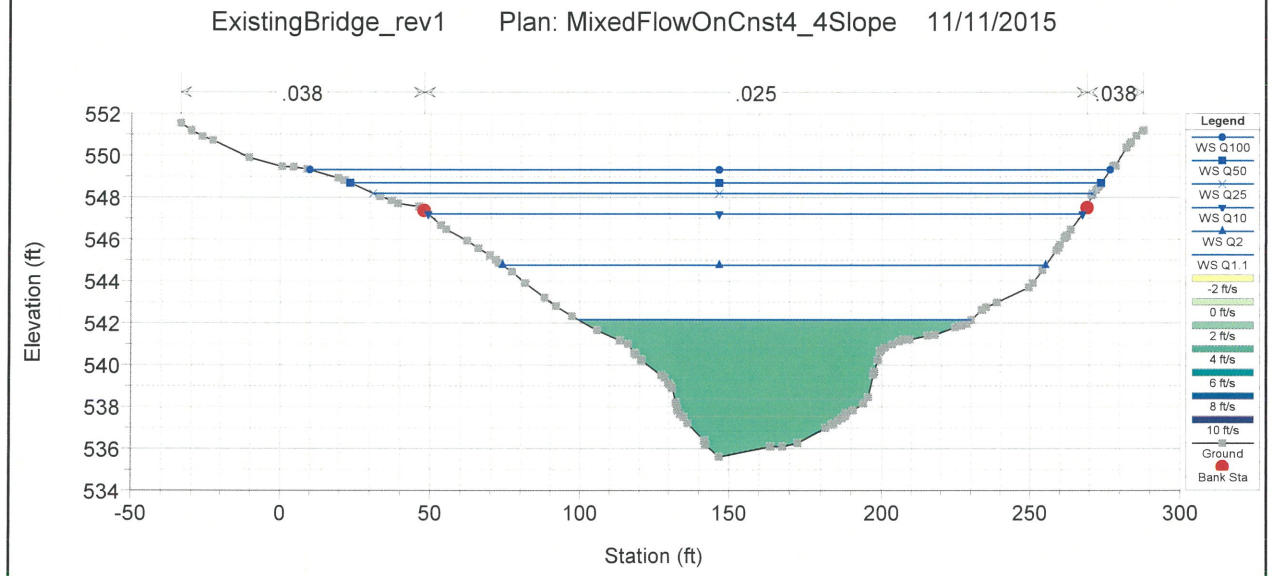
.038
.025
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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.025
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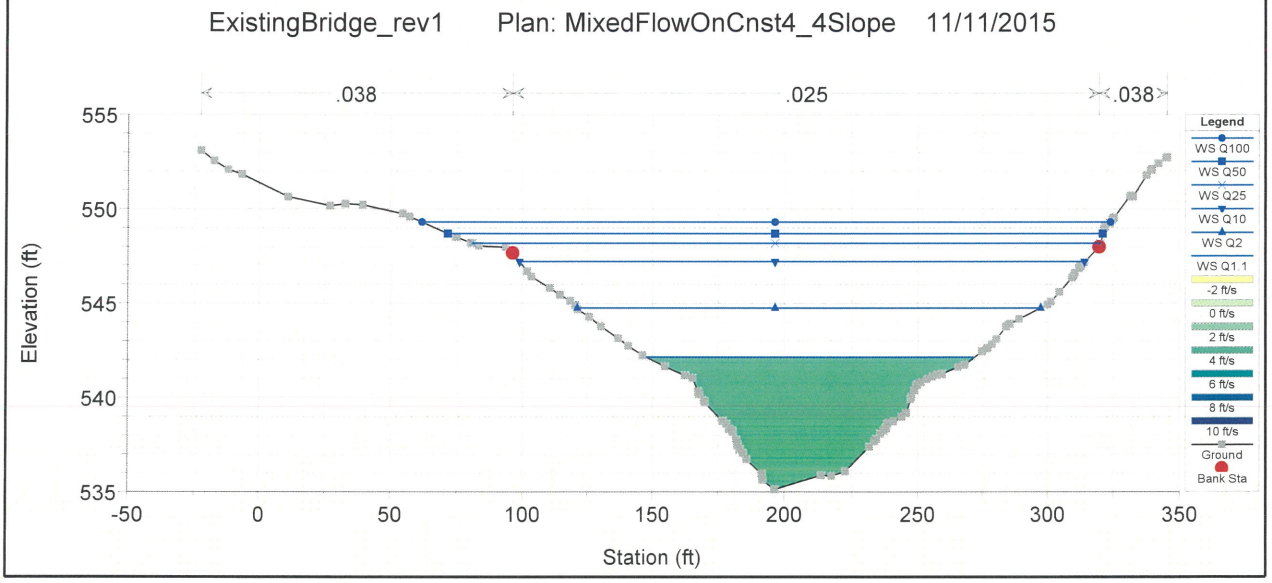
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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.025
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Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
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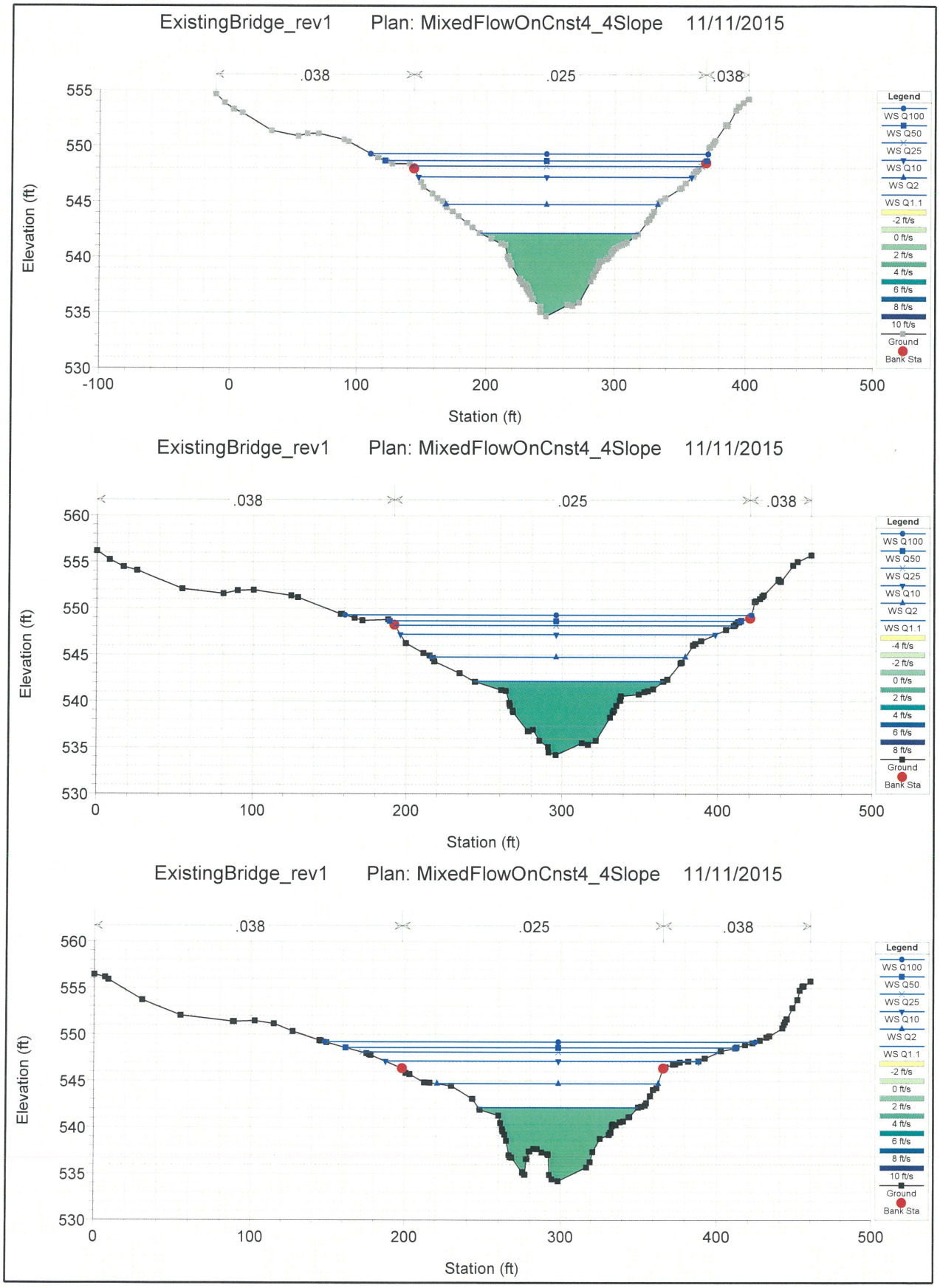
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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.025
.038
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta
ExistingBridge_rev1 Plan: MixedFlowOnCnst4_4Slope 11/11/2015
.038
.025
.038
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-4 ft/s
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Bank Sta
ExistingBridge_rev1 Plan: MixedFlowOnCnst4_4Slope 11/11/2015
.038
.025
.038
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
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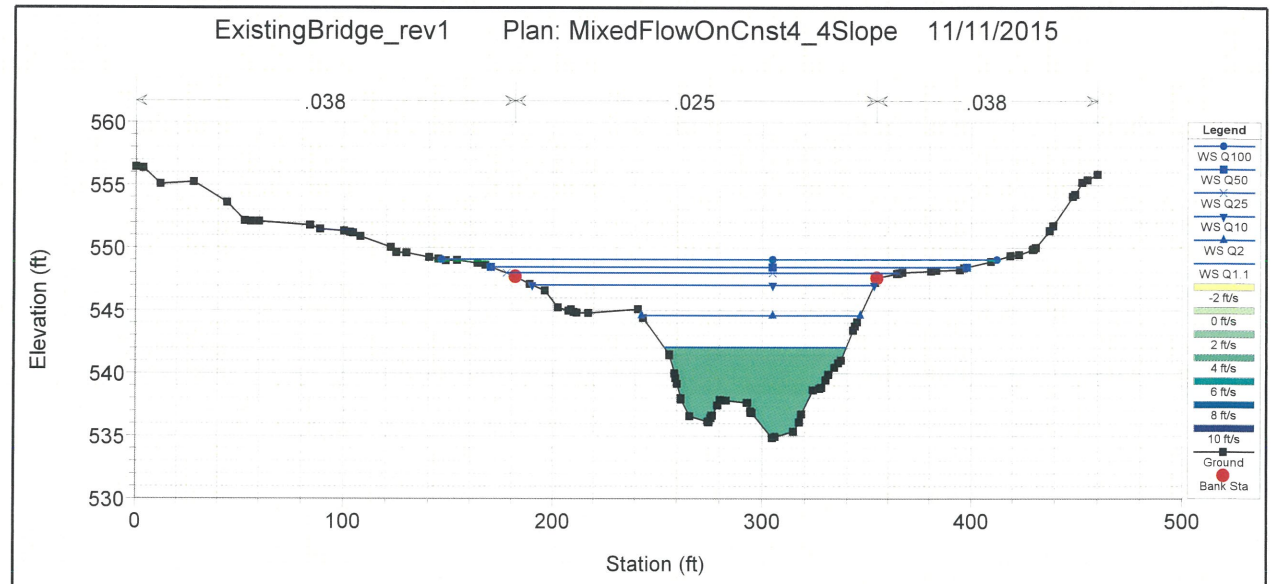
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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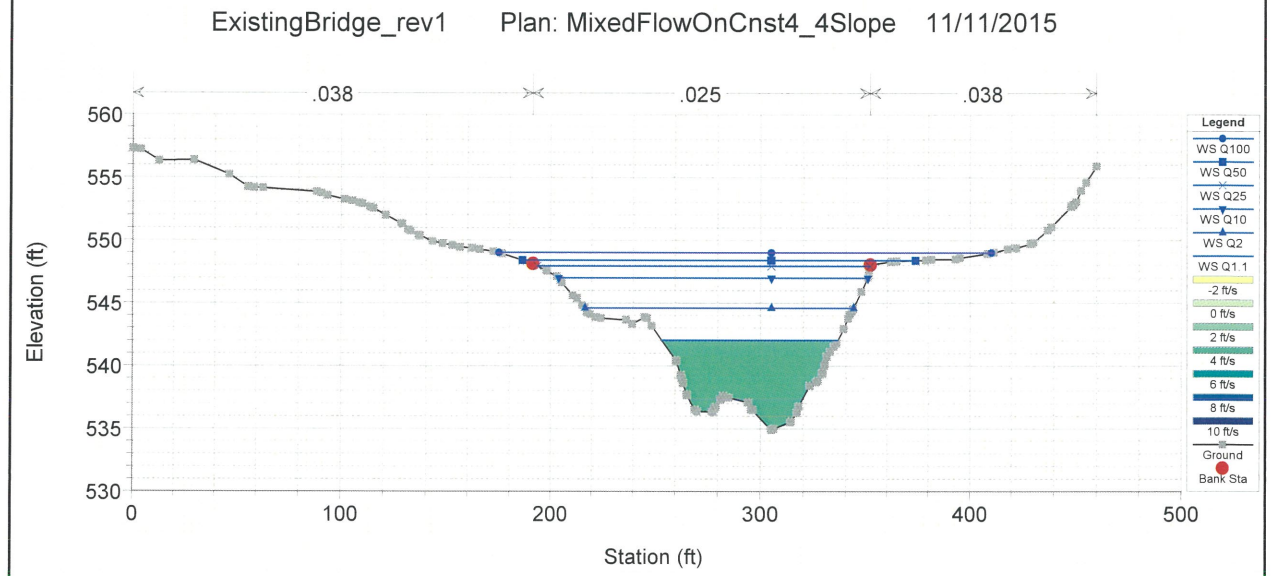
.025
.038
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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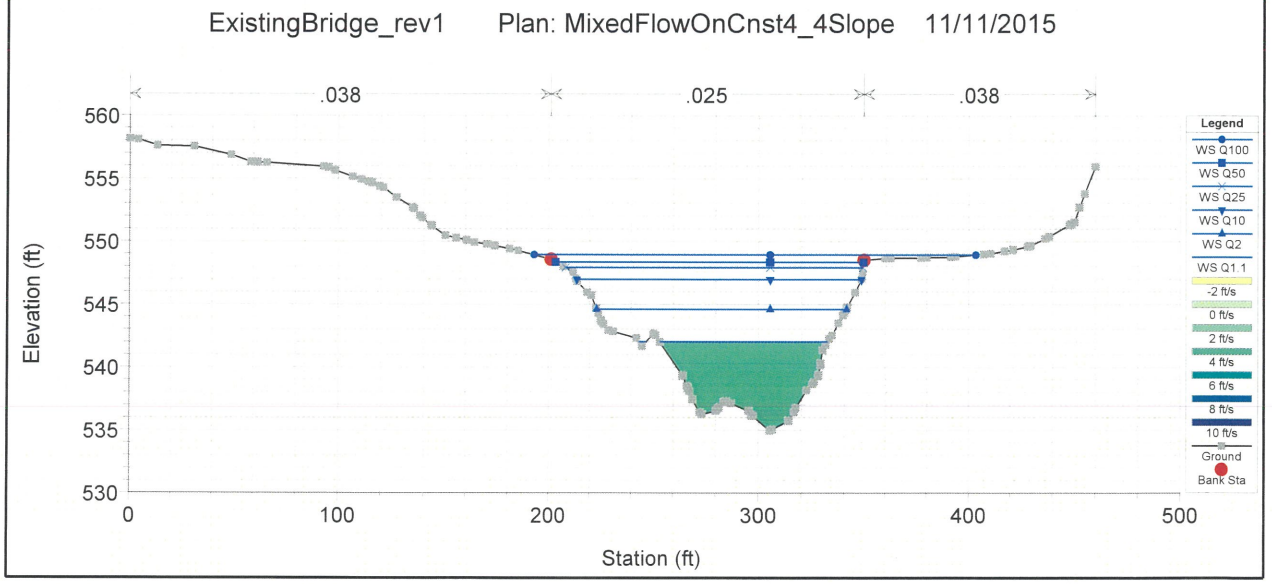
.025
.038
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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.025
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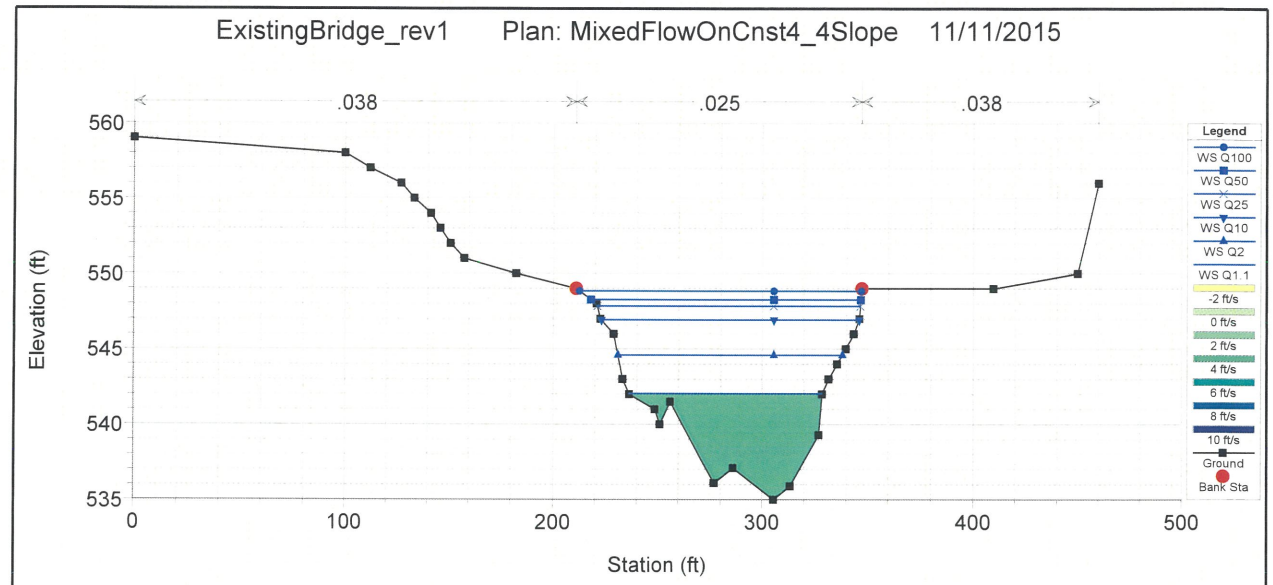
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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.025
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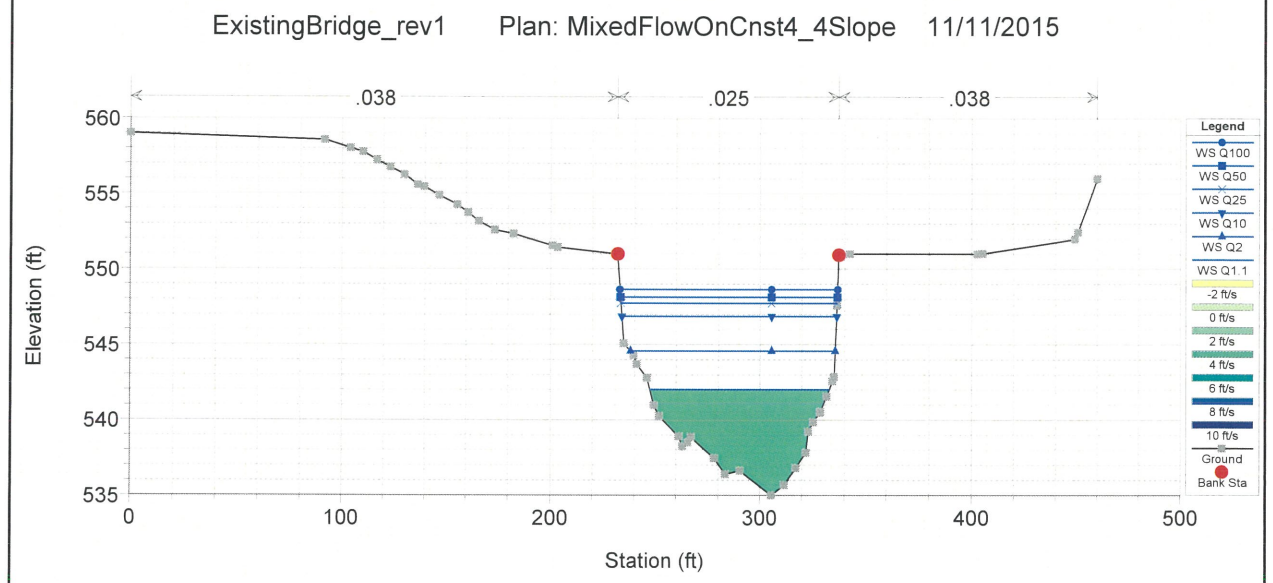
Elevation (ft)
Station (ft)
Legend
WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta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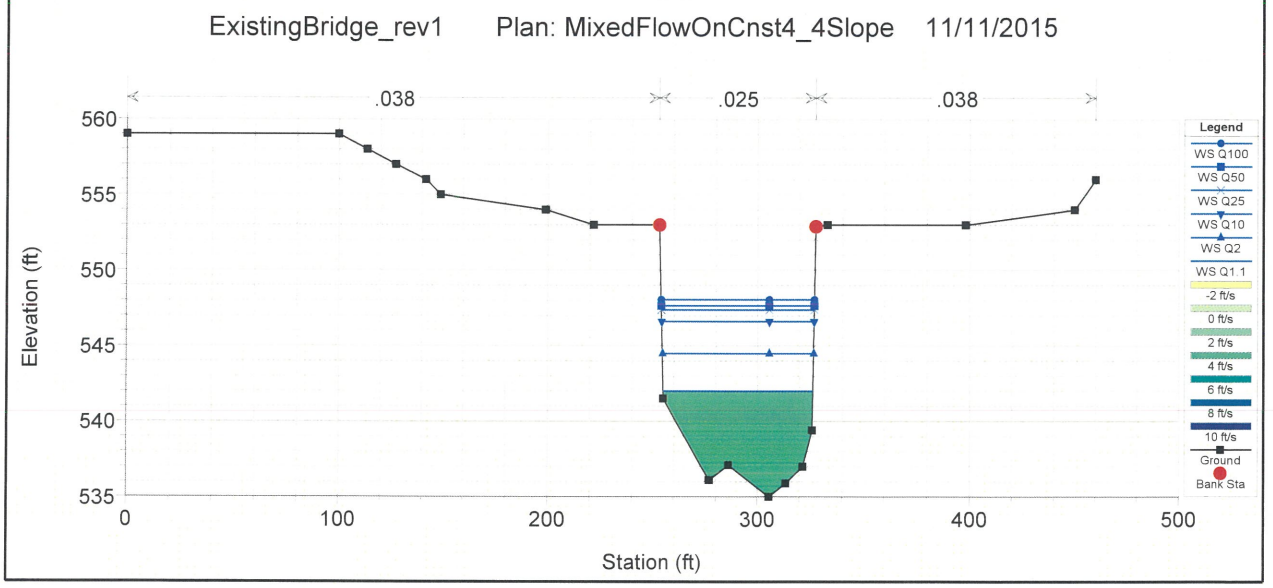
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Elevation (ft)
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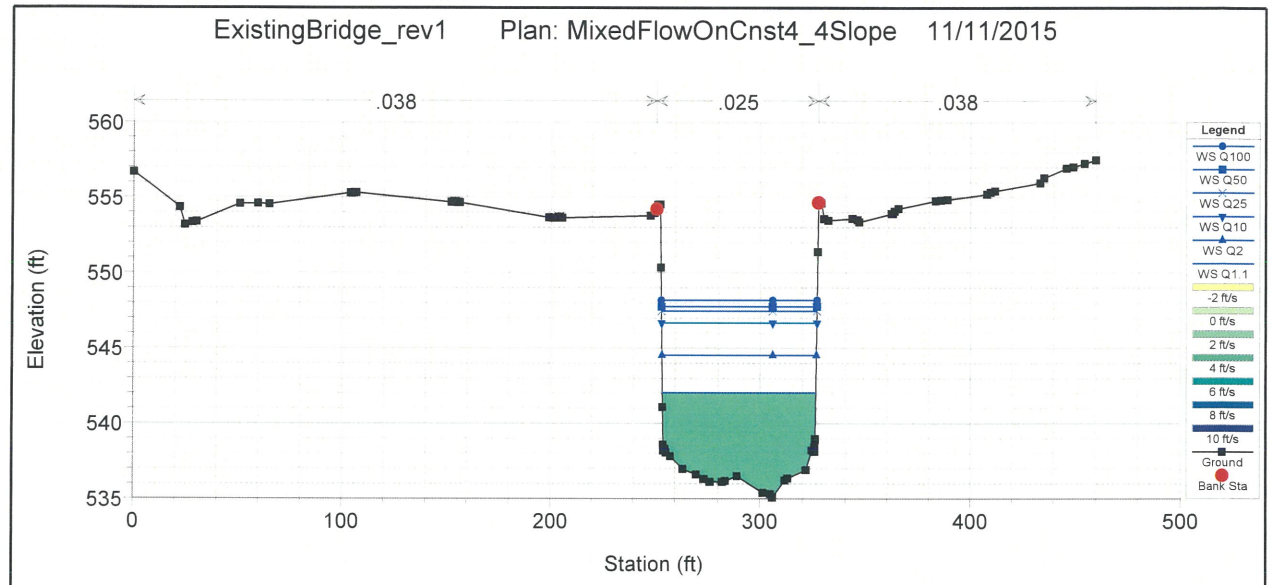
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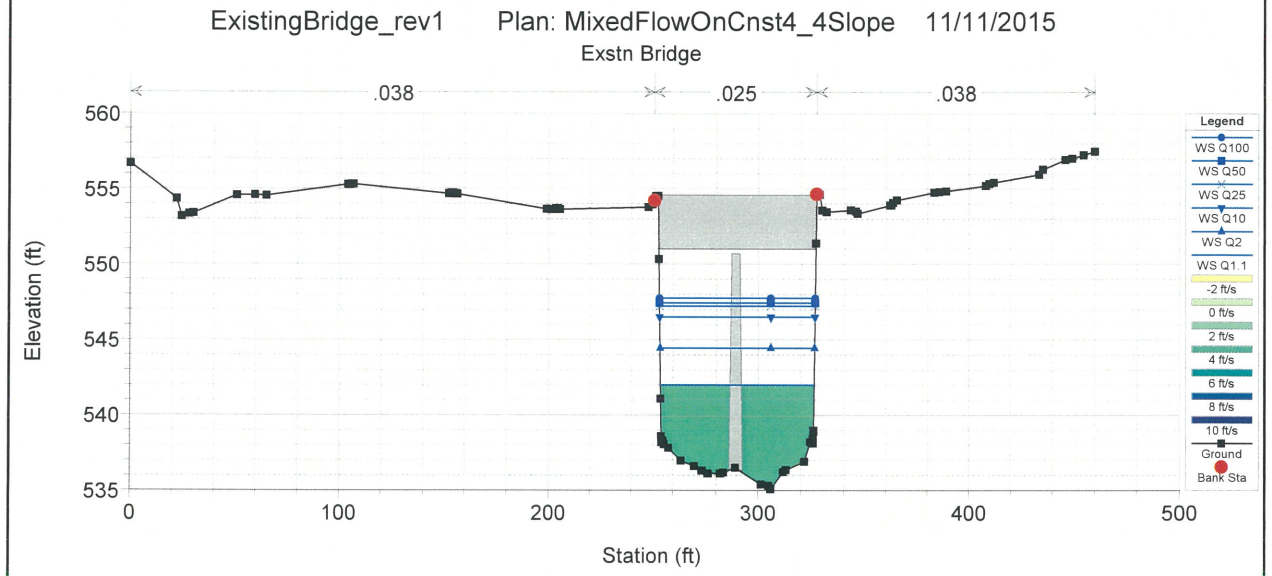
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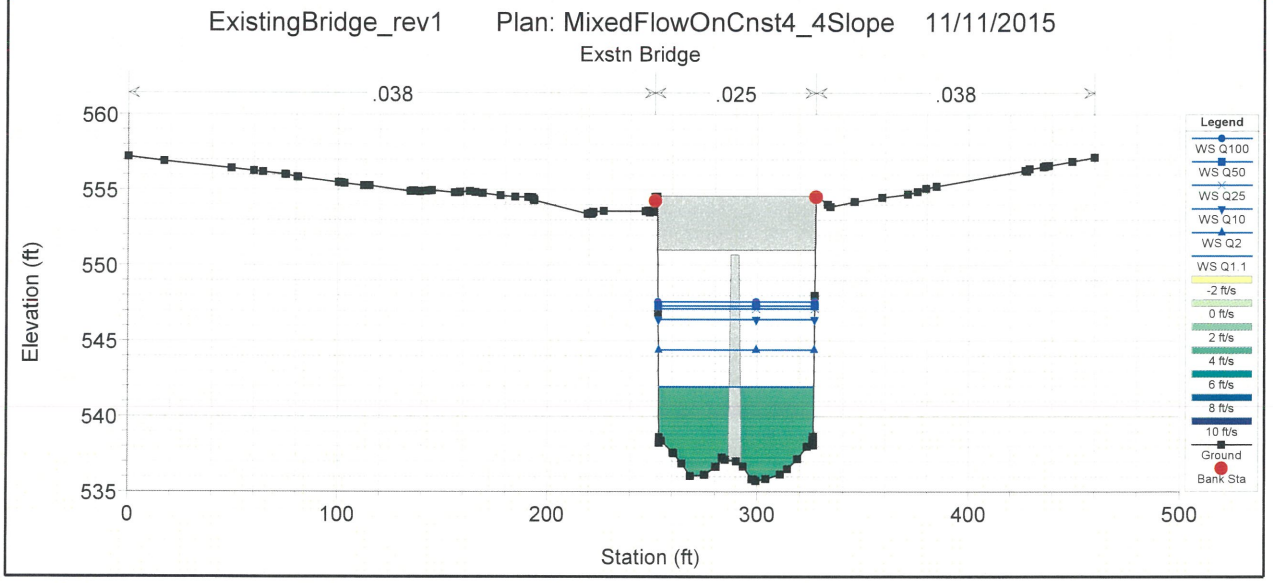
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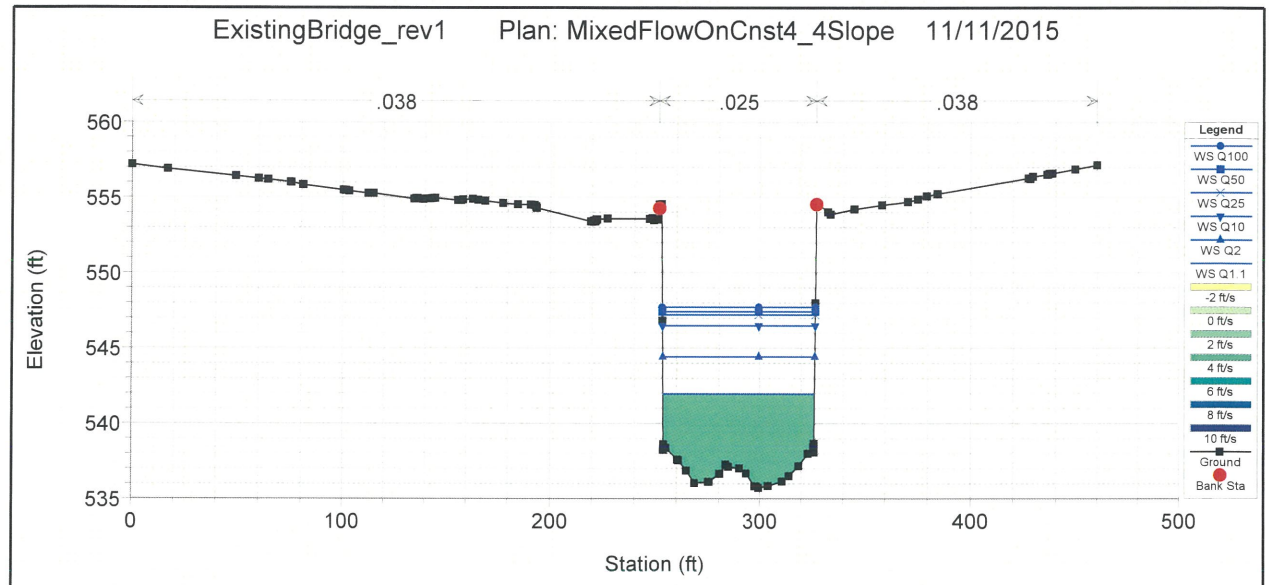
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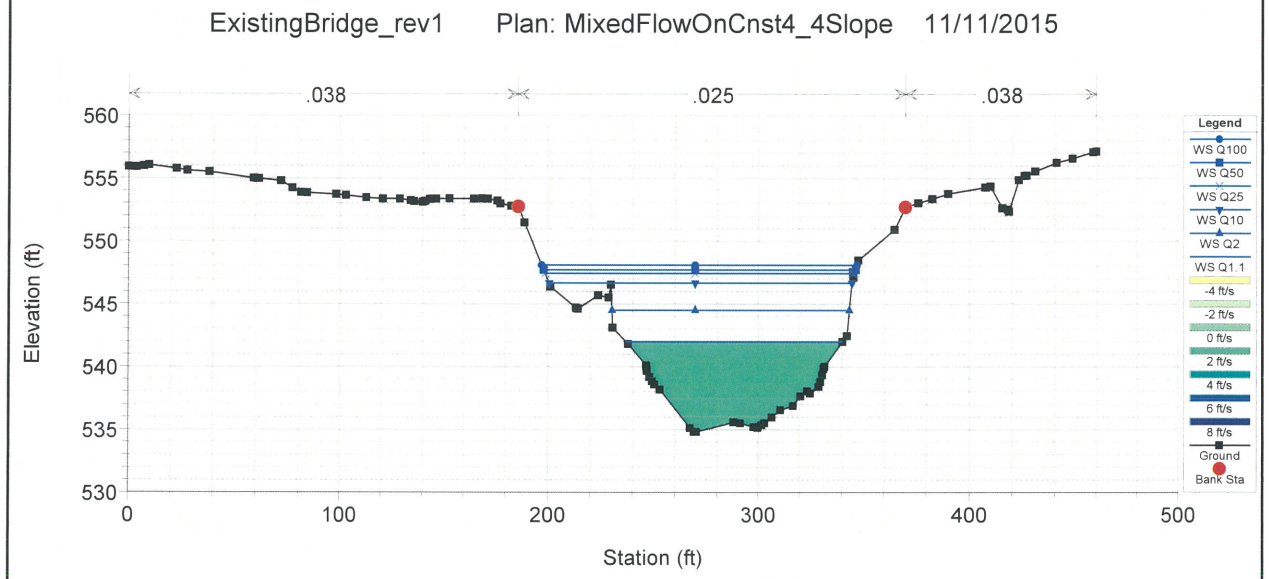
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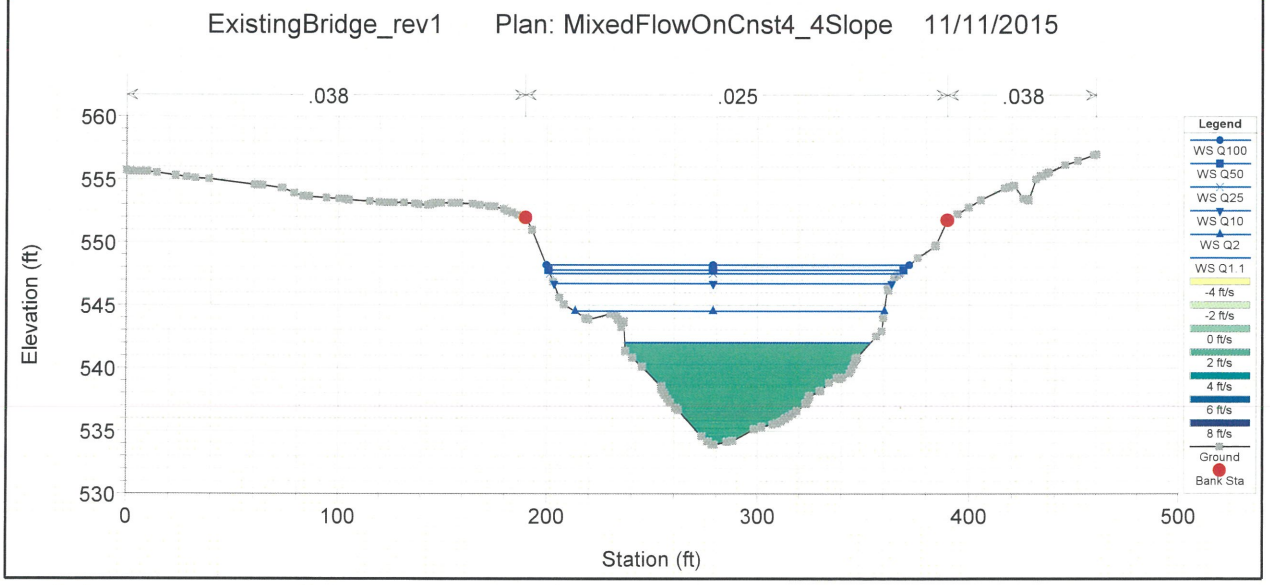
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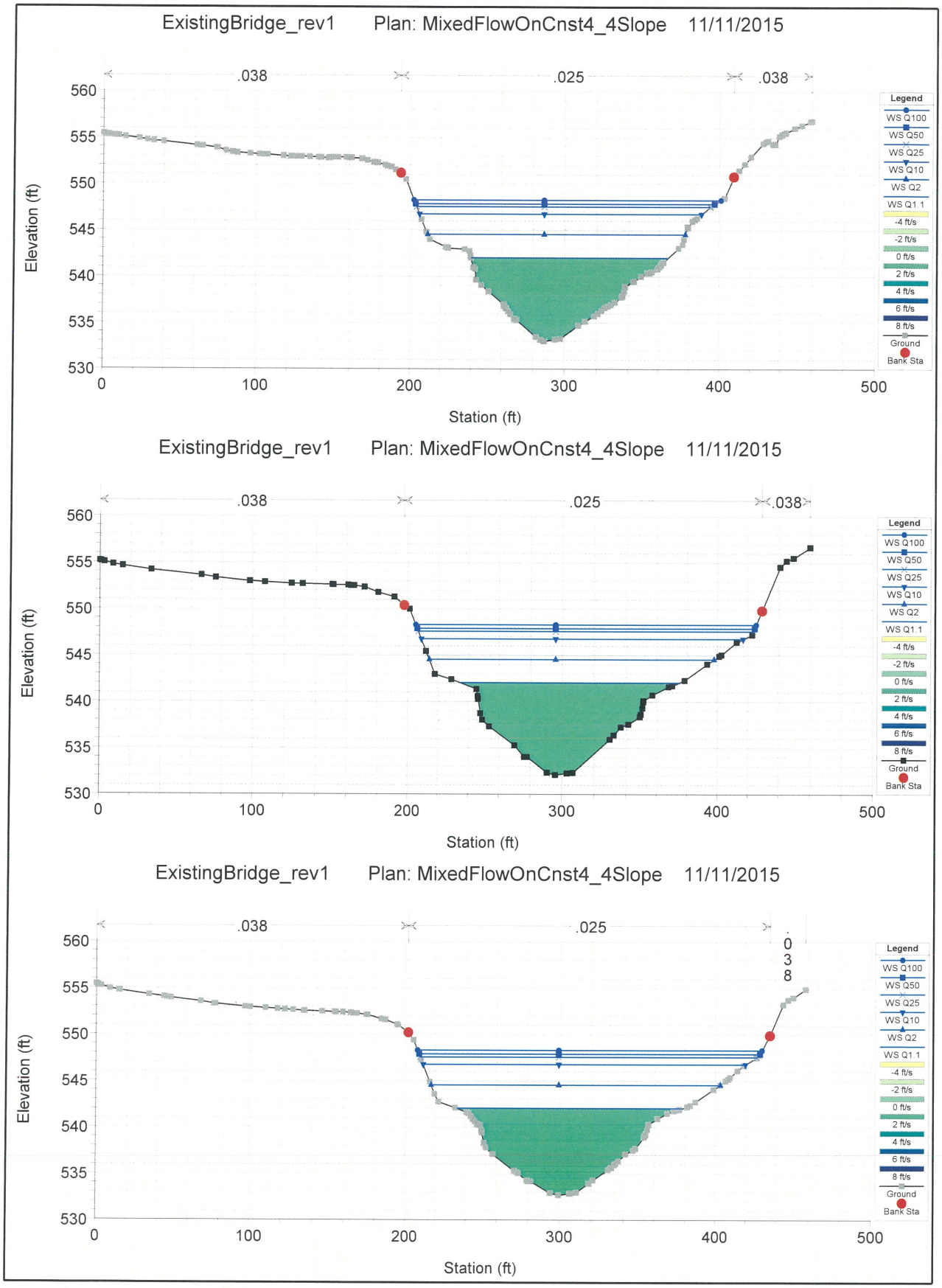
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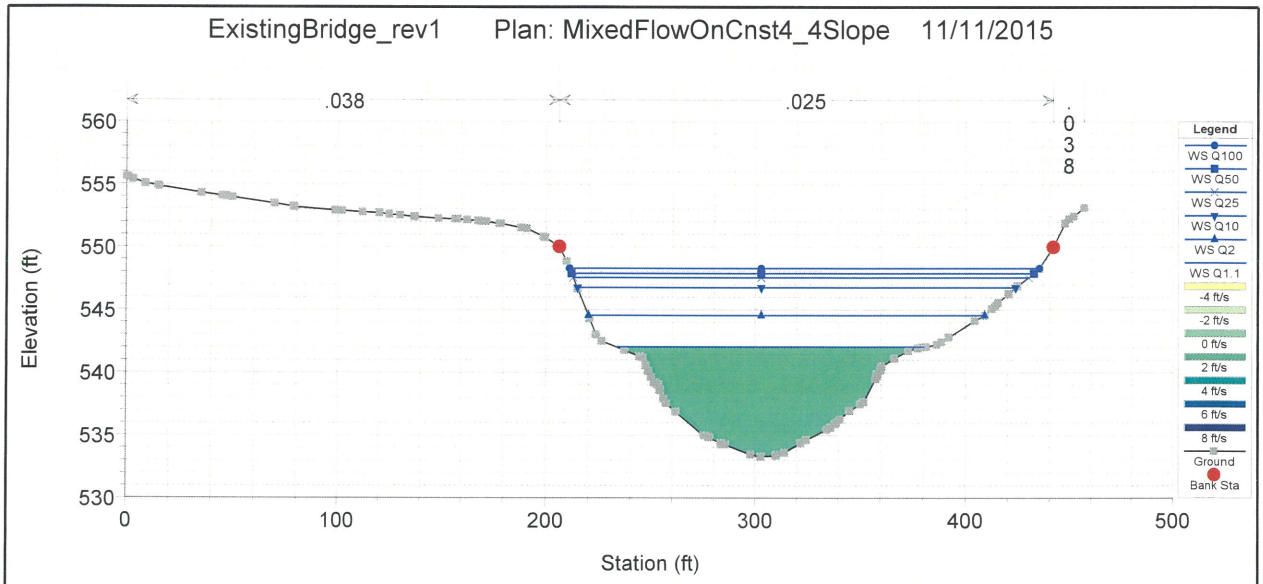
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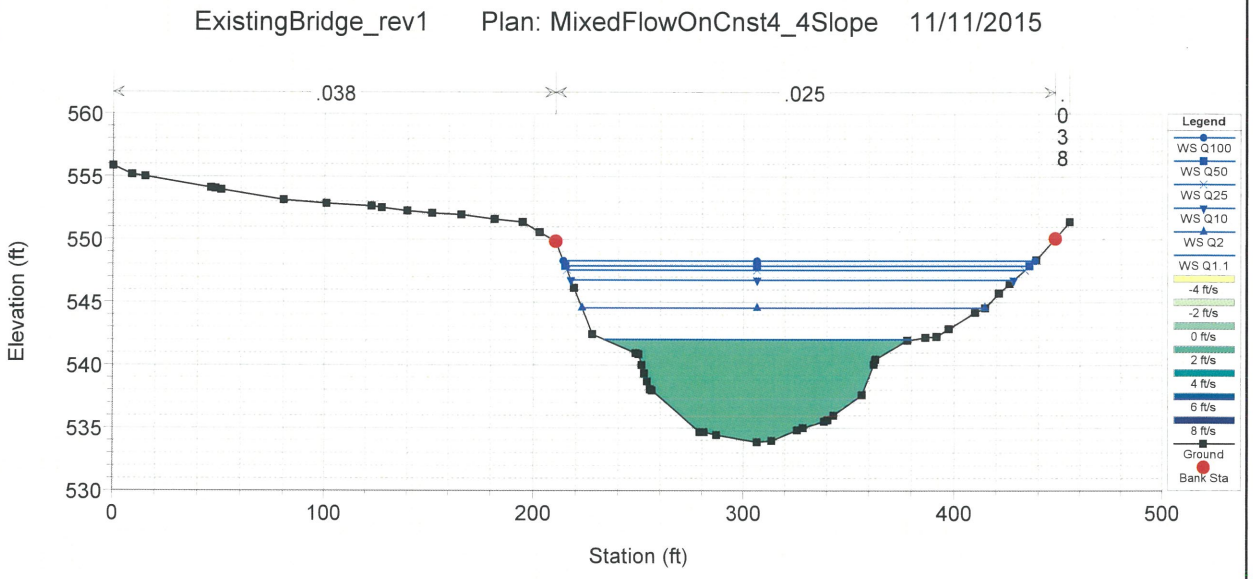
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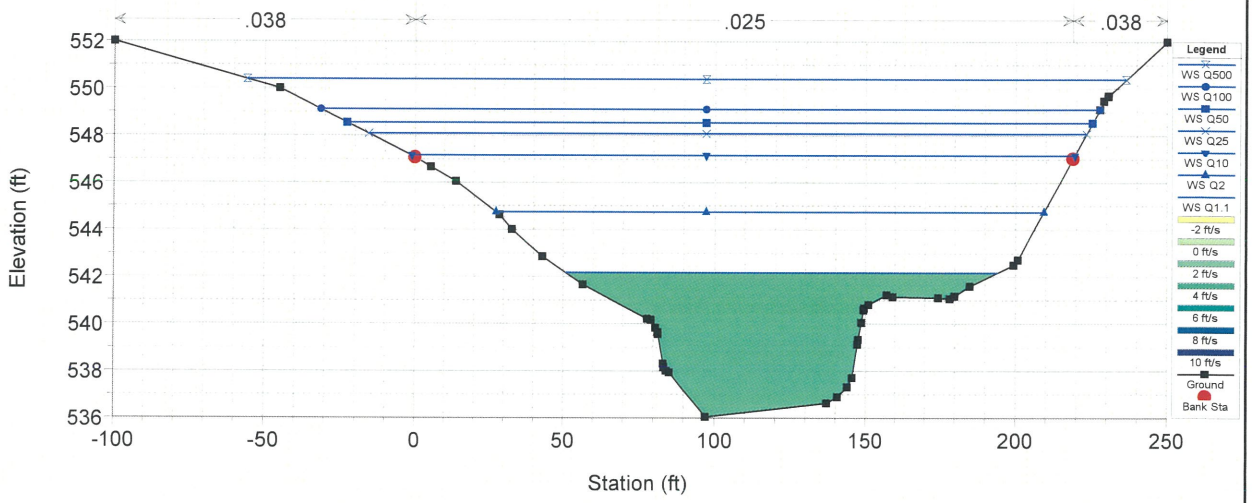
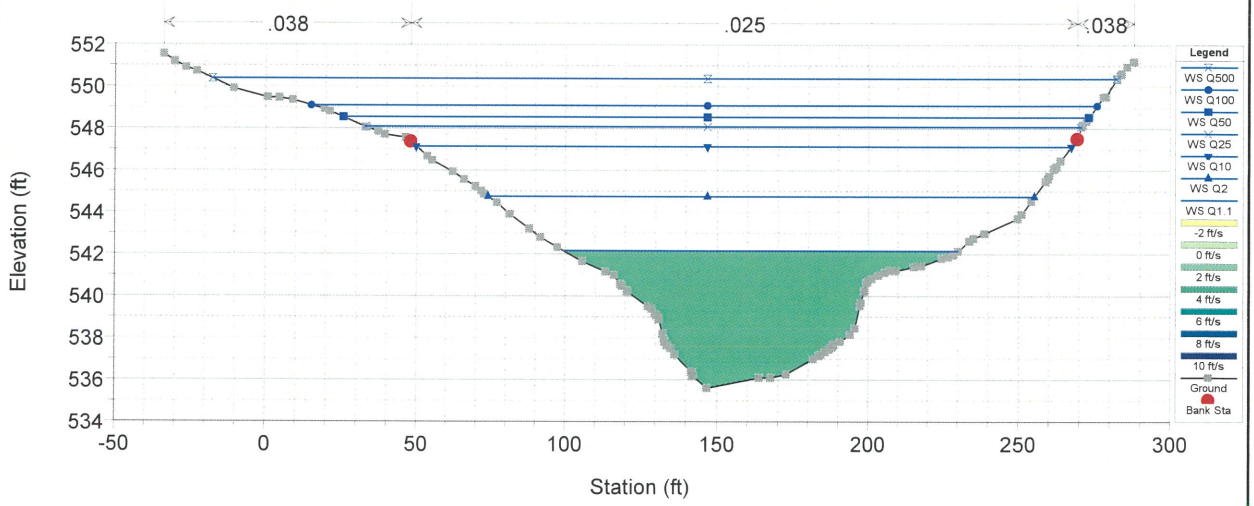
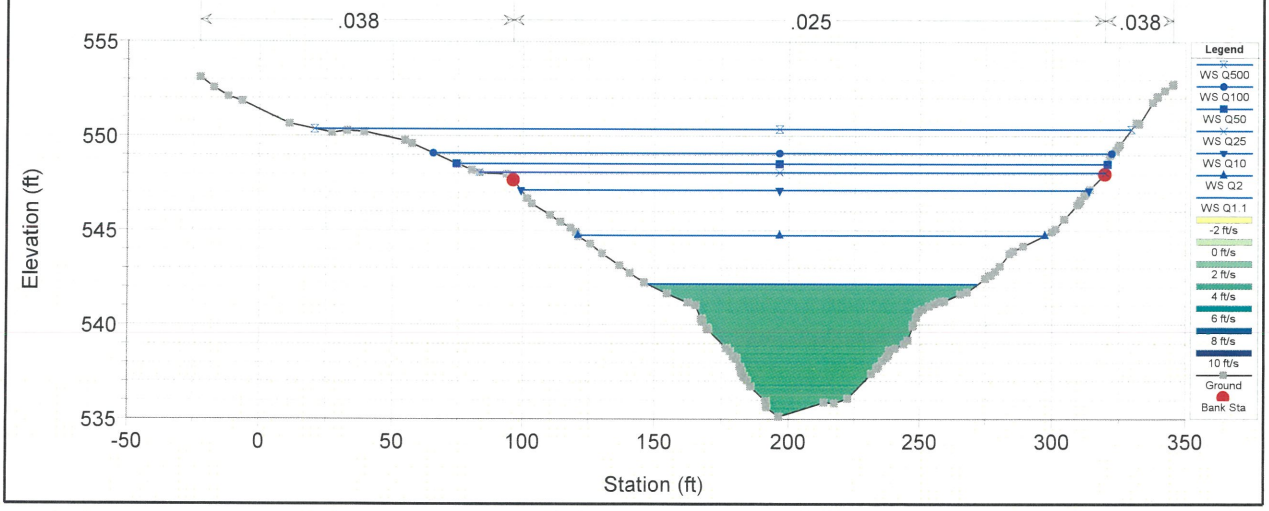
Proposed 100ft_rev1 Plan: MixedFlowOnCnst4_4Slope 1/18/2016

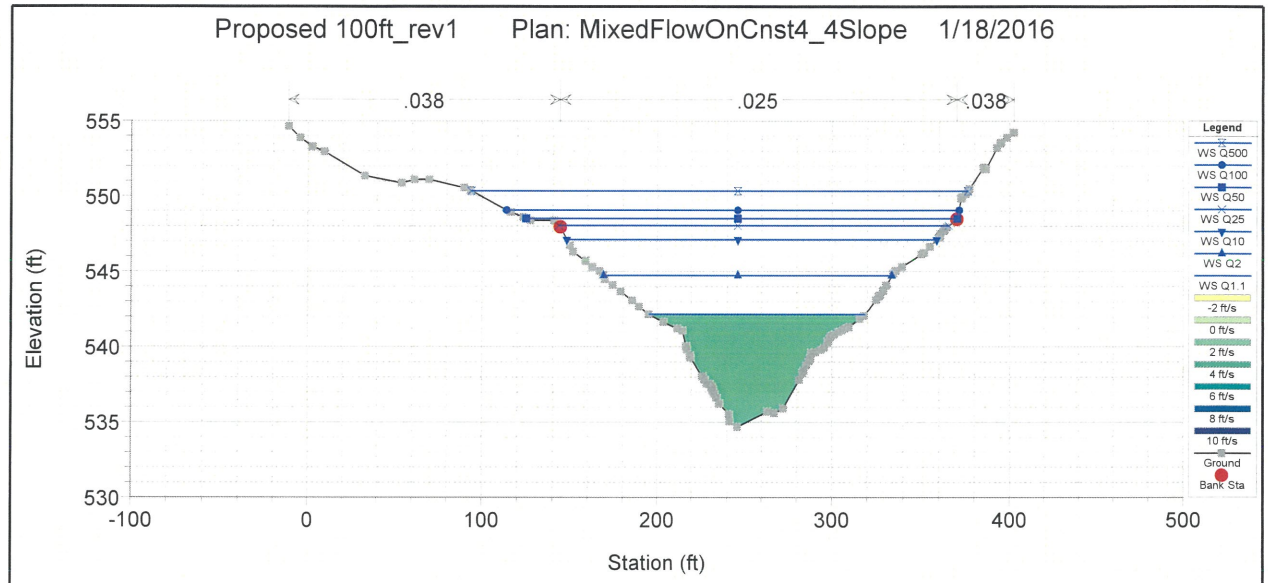


Proposed 100ft_rev1 Plan: MixedFlowOnCnst4_4Slope 1/18/2016



Proposed 100ft_rev1 Plan: MixedFlowOnCnst4_4Slope 1/18/2016

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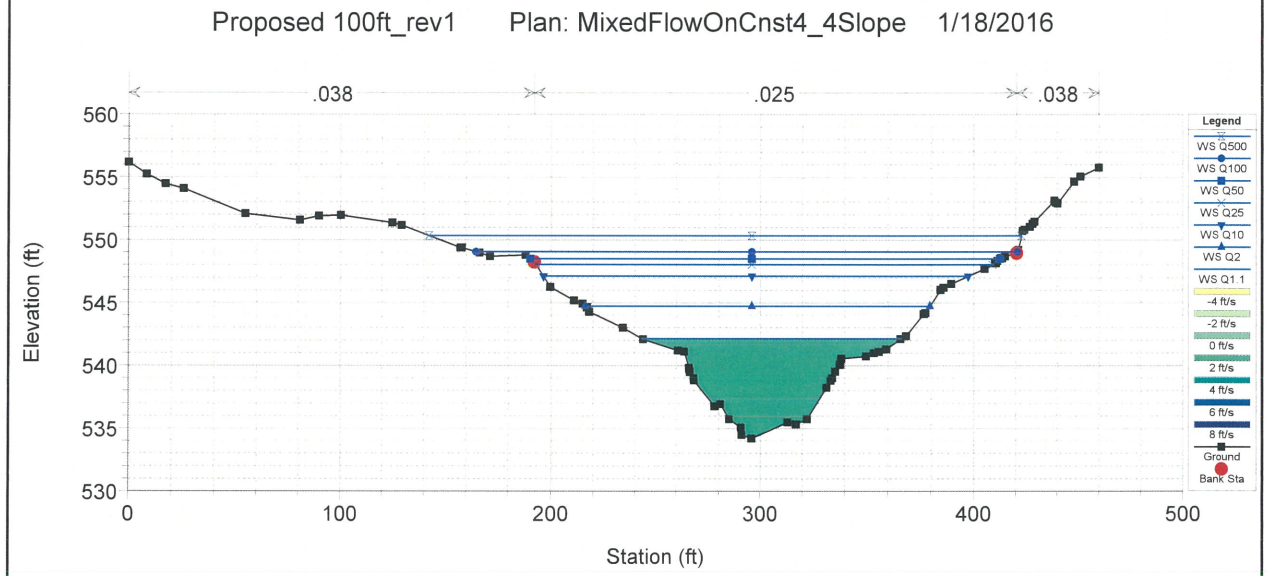
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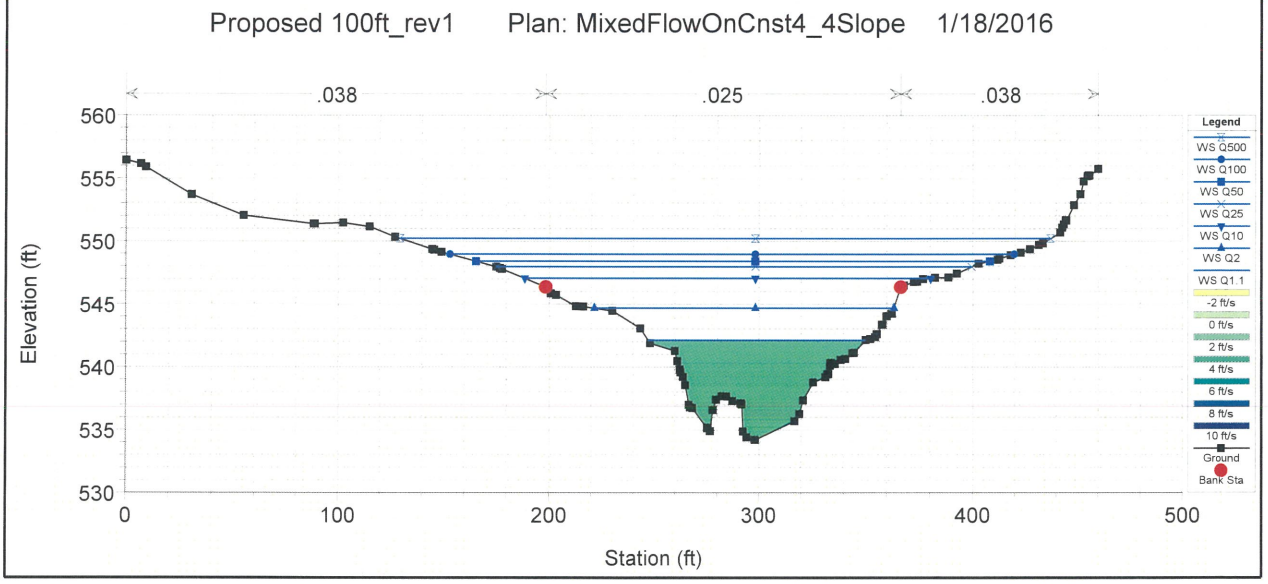
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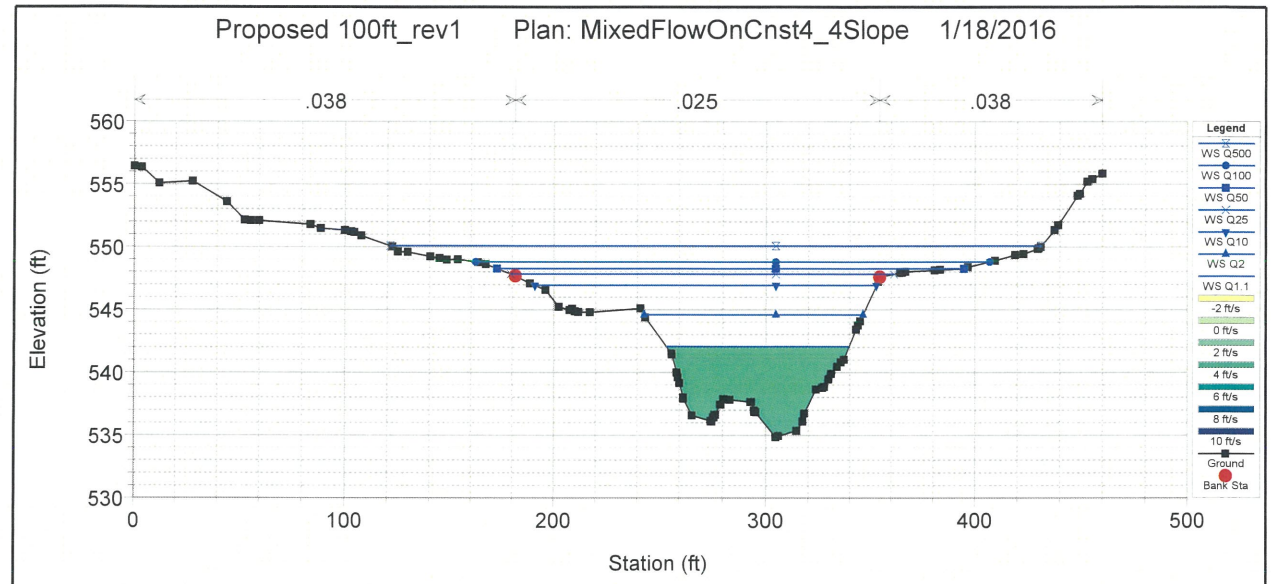
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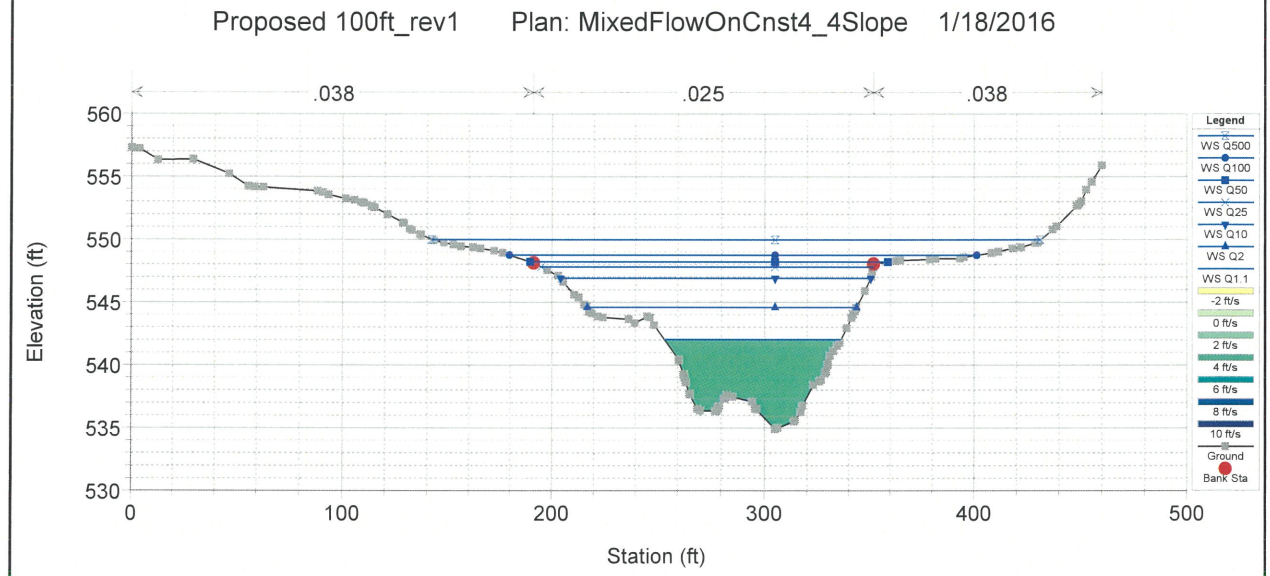
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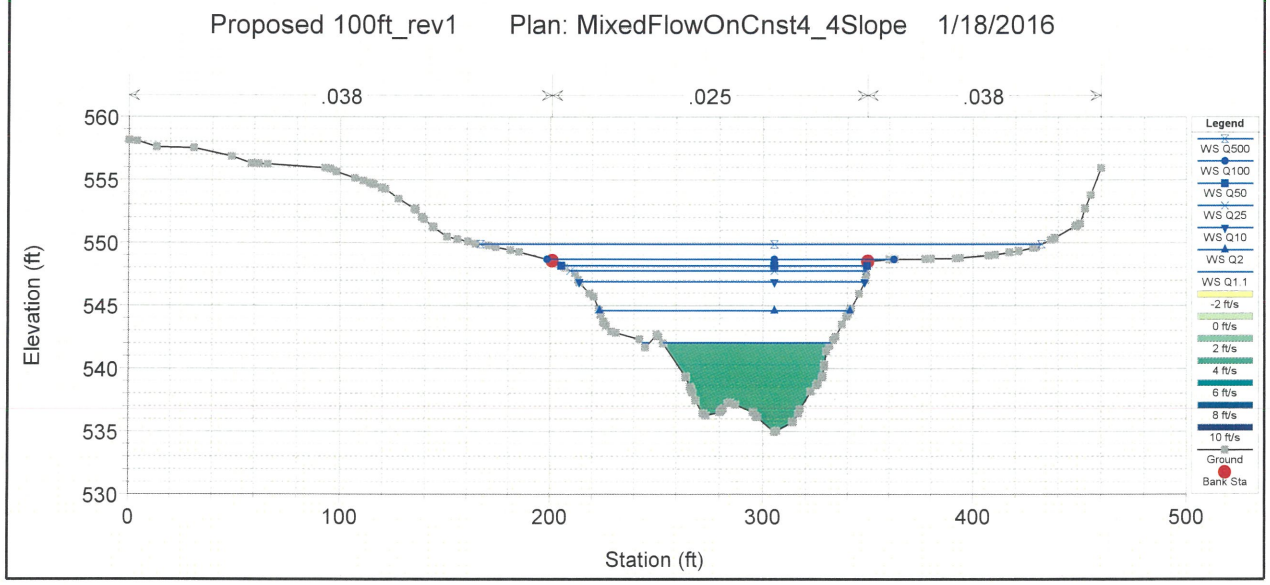
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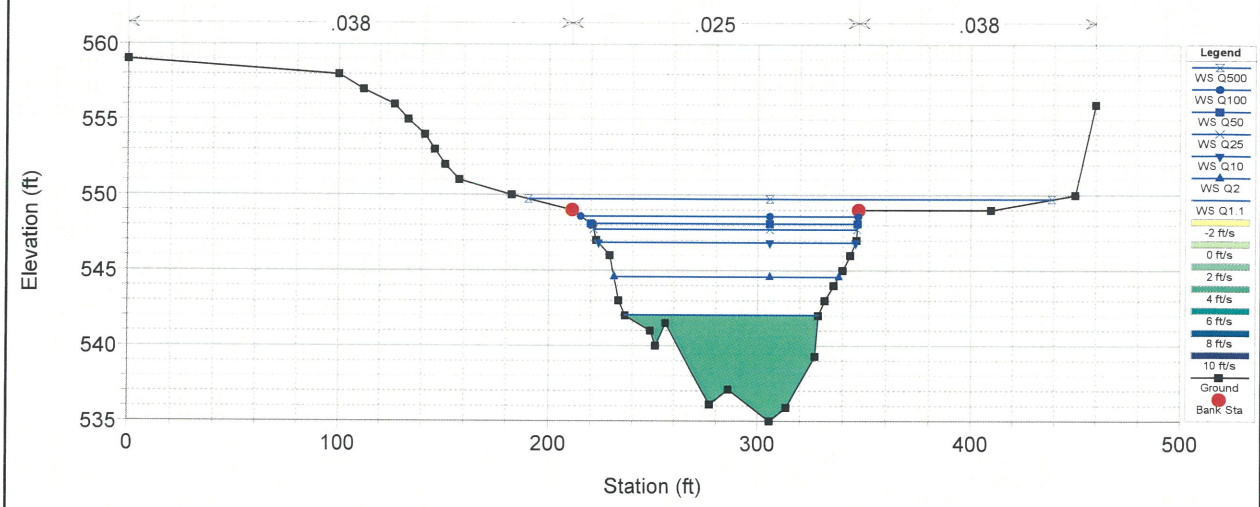
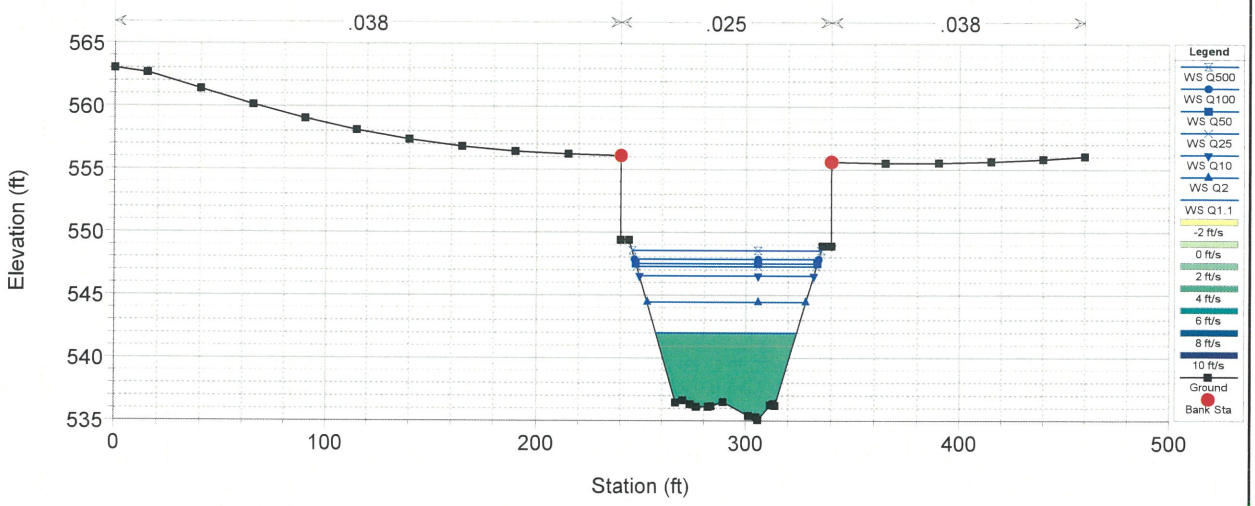
Proposed 100ft_rev1 Plan: MixedFlowOnCnst4_4Slope 1/18/2016



Proposed 100ft_rev1 Plan: MixedFlowOnCnst4_4Slope 1/18/2016



Proposed 100ft_rev1 Plan: MixedFlowOnCnst4_4Slope 1/18/2016

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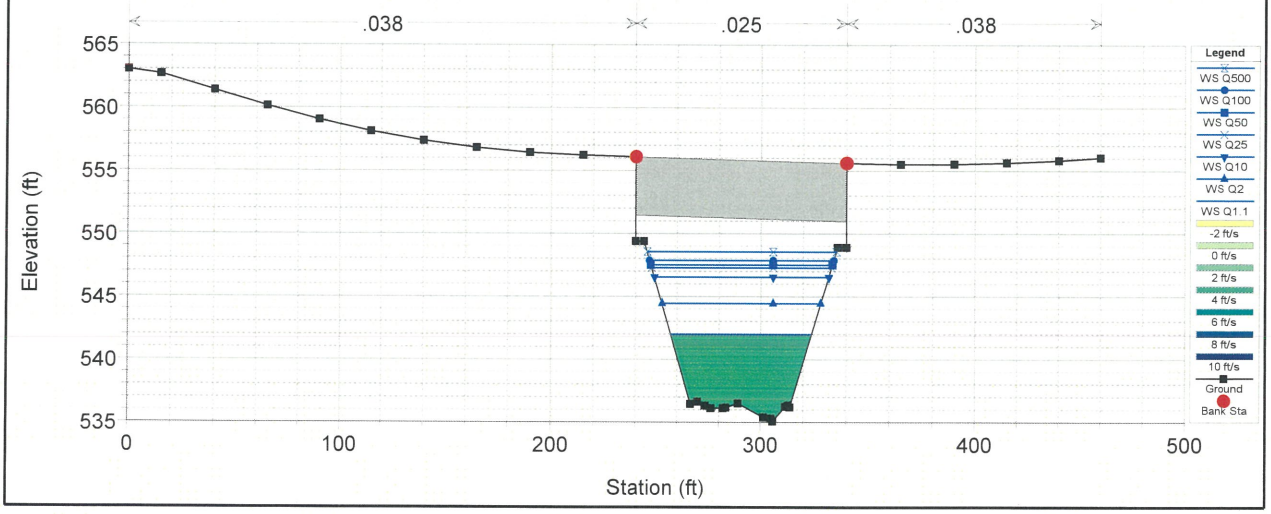

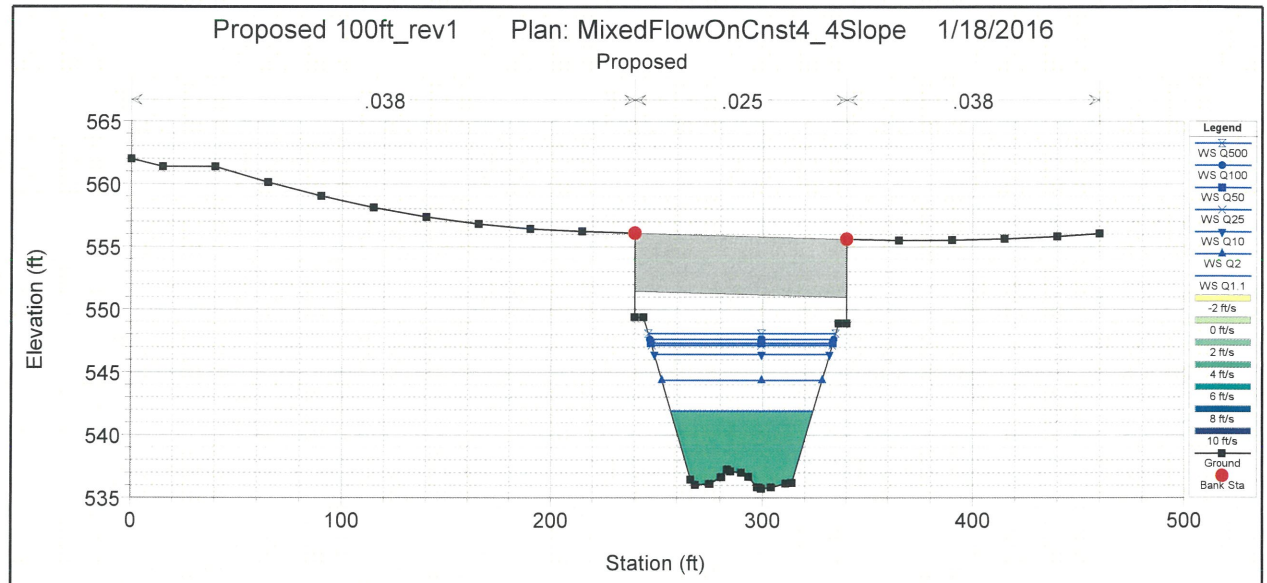
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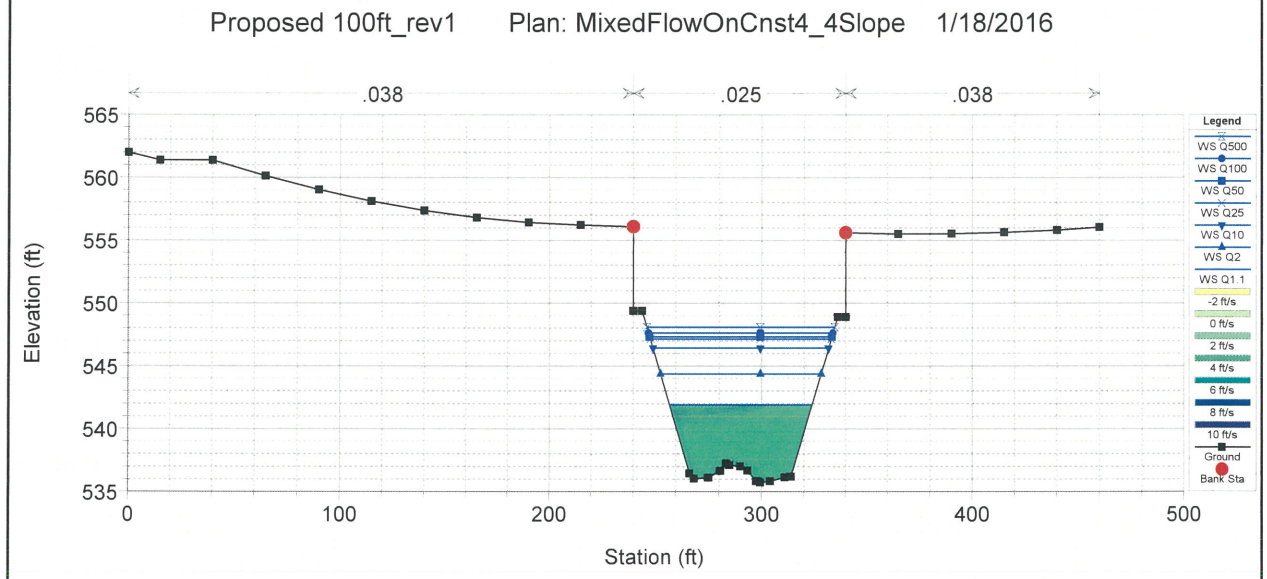
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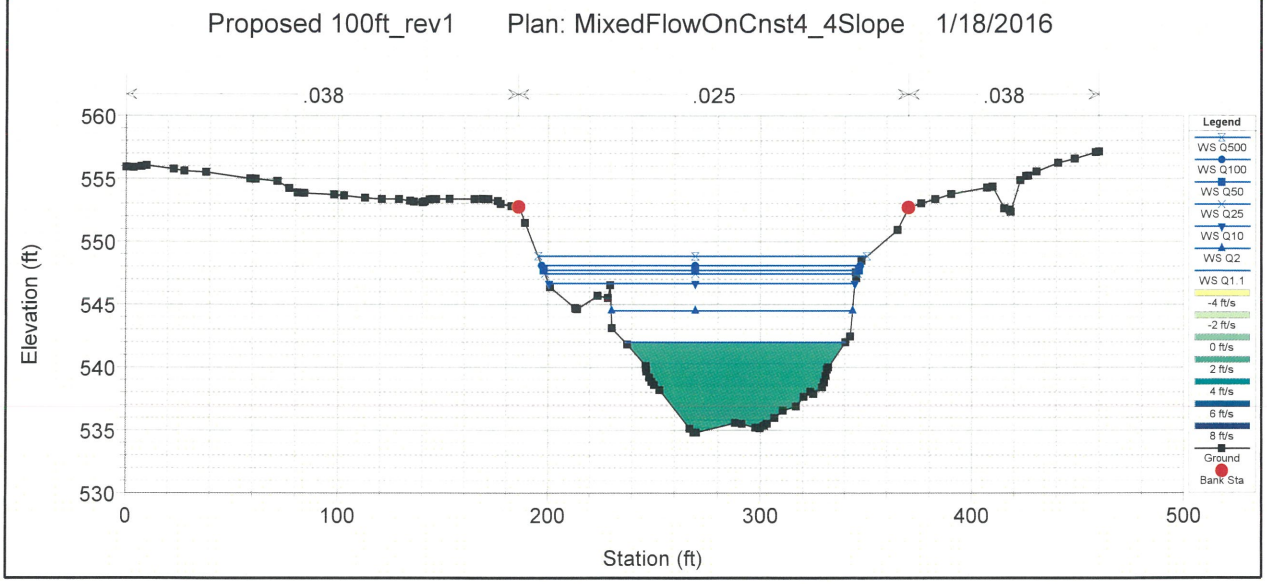
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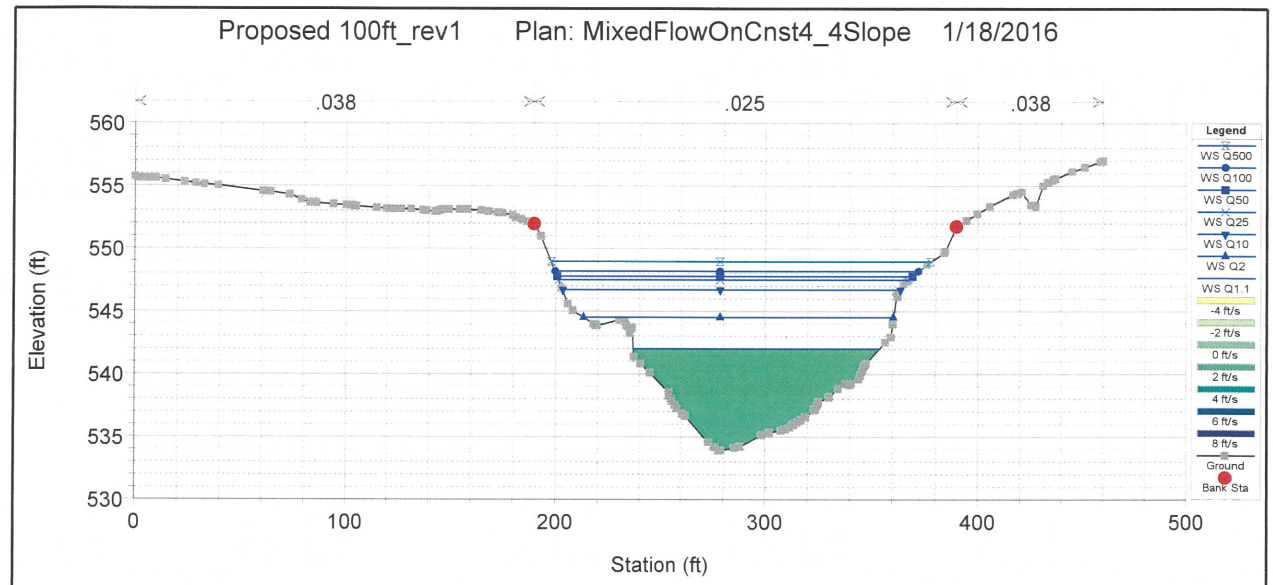
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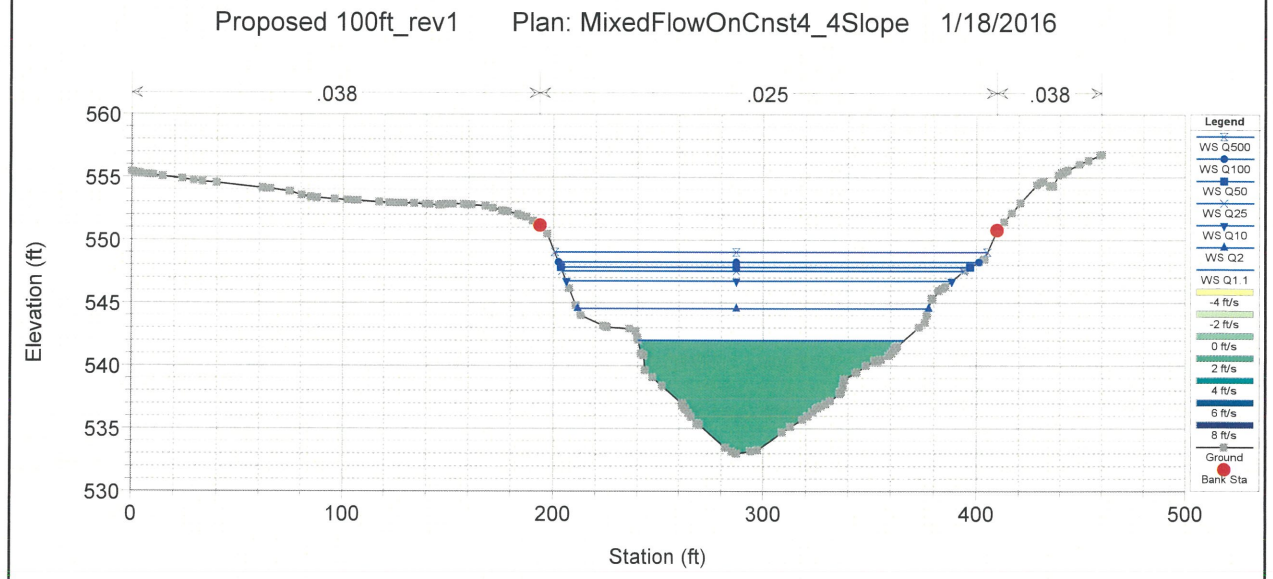
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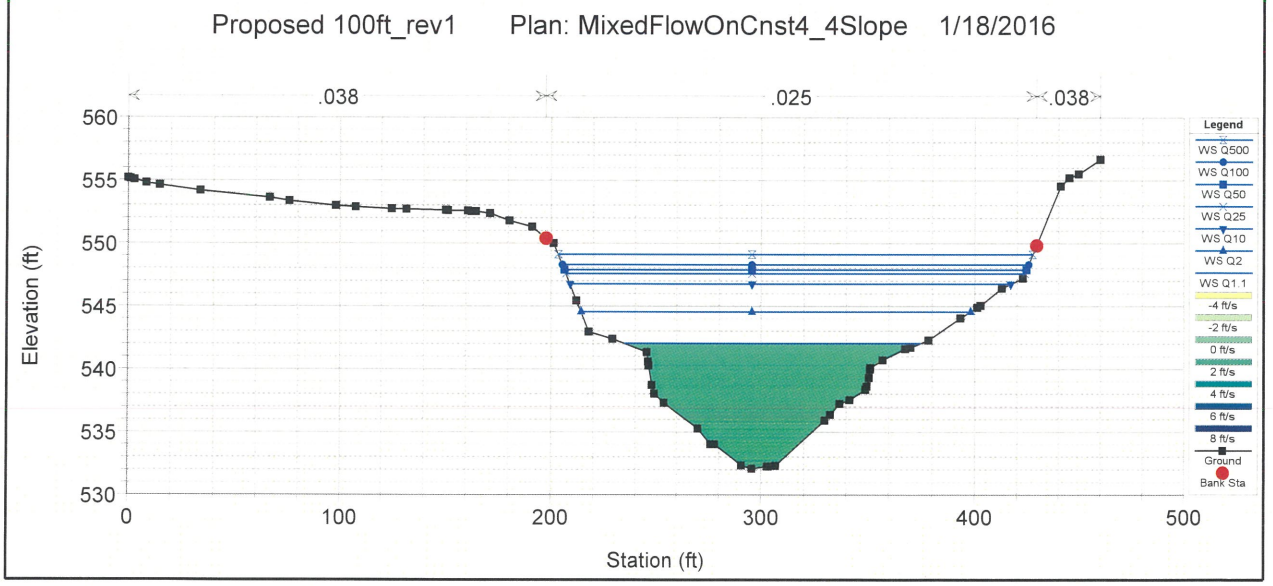
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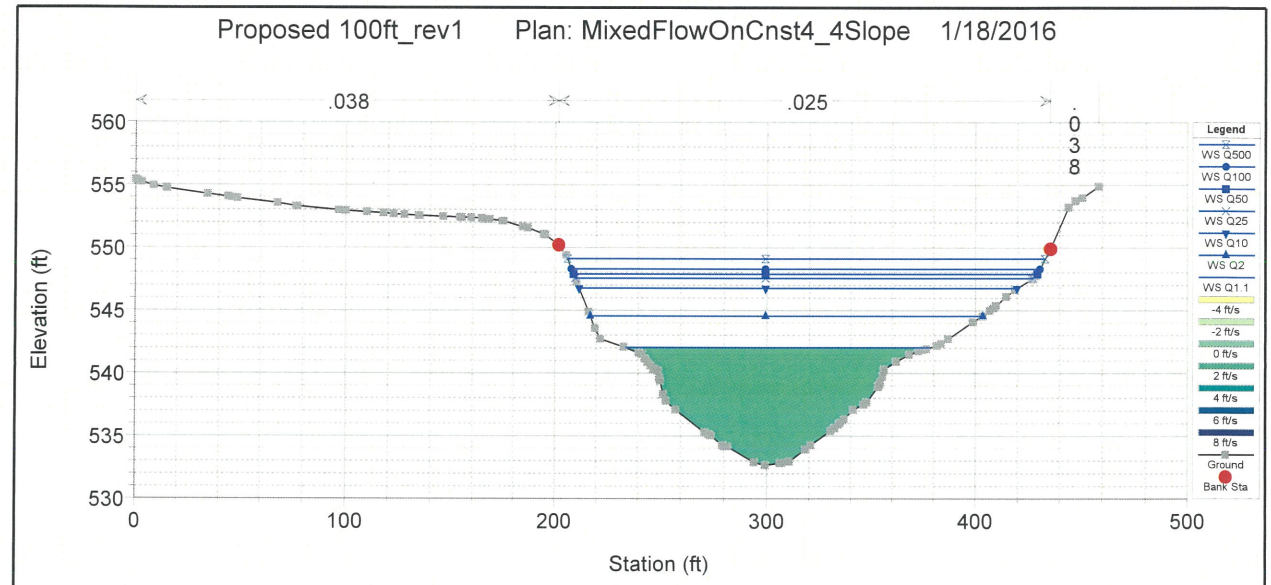
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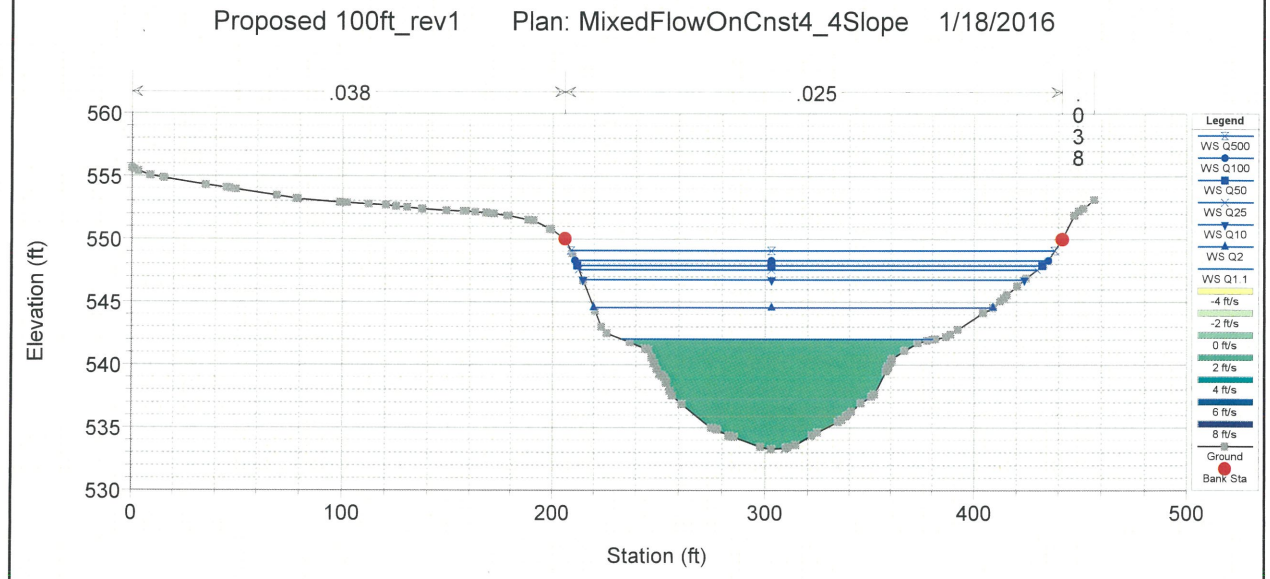
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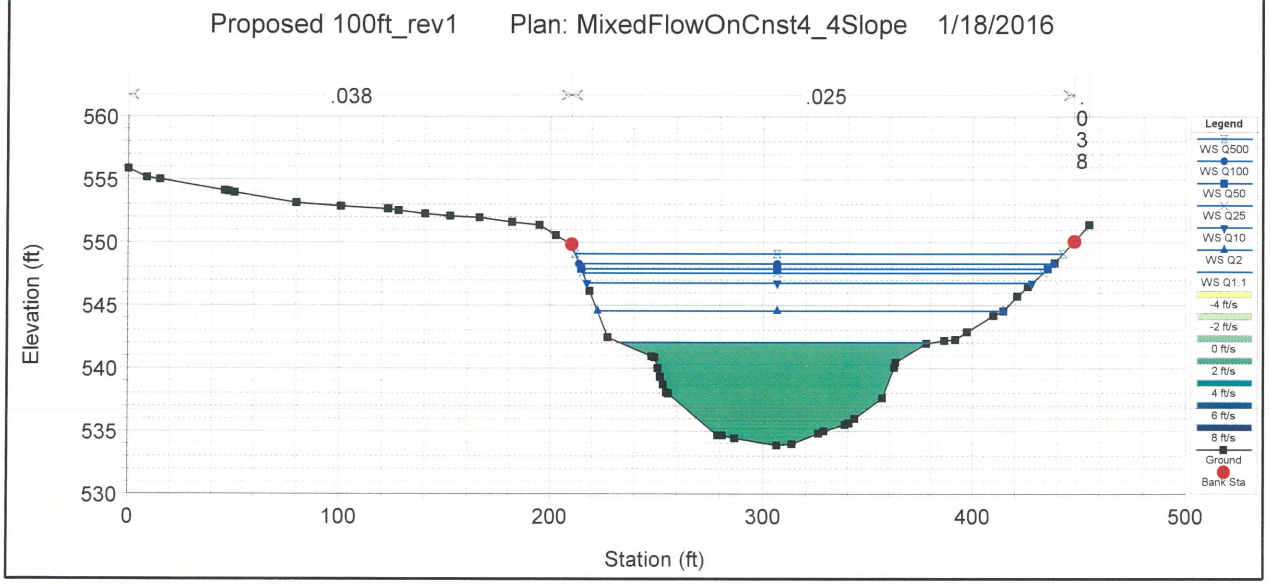
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WS Q100
WS Q50
WS Q25
WS Q10
WS Q2
WS Q1.1
-4 ft/s
-2 ft/s
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
Ground
Bank Sta

SCOUR EVALUATION

Purpose:

Calculation of abutment scour depths at integral abutment locations.

References:

- AASHTO LRFD Bridge Design Specifications, 7th edition, 2014
- HEC-18 Evaluation Scour at Bridges, Fifth Edition

Notes & Assumptions:

- Calculation for scour for Design Scour Q100 and check scour Q500 event.

Q100 DESIGN SCOUR EVENT:

CONTRACTION SCOUR

Determine Type of Scour:

Average Depth of Flow Upstream: $y := 8.3ft$ From x-section 159.6

Particle Size for Vc: $D_{50} := 1.55mm$ From geotechnical report

Unit Factor: $K_u := 11.17$ For English units

Critical Velocity: $V_c := K_u \cdot \left(\frac{y}{ft}\right)^{\frac{1}{6}} \cdot \left(\frac{D_{50}}{ft}\right)^{\frac{1}{3}} \cdot \frac{ft}{sec} = 2.73 \cdot \frac{ft}{sec}$

Design Flow Velocity: $V := 6.73 \frac{ft}{sec}$

Scour Evaluation Type: $Scour_{type} := \begin{cases} \text{"Clear-water"} & \text{if } V_c > V \\ \text{"Live-bed"} & \text{if } V > V_c \end{cases} = \text{"Live-bed"}$

Live-Bed Contraction Scour:

Flow in Channel Upstream: $Q_1 := 7380 \frac{ft^3}{sec}$

Flow in Contracted Channel: $Q_2 := 7380 \frac{ft^3}{sec}$

Bottom Width of Channel Upstream: $W_1 := 327.0ft - 236.30ft = 90.7 \cdot ft$

Bottom Width of Channel Upstream: $W_2 := 313.75ft - 266.65ft = 47.1 \cdot ft$

Slope of the Energy Grade Line: $S_1 := 0.000813$

Shear Velocity: $V_s := \left(\frac{g}{\frac{ft}{sec^2}} \cdot \frac{y}{ft} \cdot S_1 \right)^{0.5} \cdot \frac{ft}{sec}$ $\quad V_s = 0.47 \cdot \frac{ft}{sec}$

Fall Velocity: $T := 0.15 \frac{m}{sec} = 0.49 \cdot \frac{ft}{sec}$ From Figure 6.8

Exponent k1:

$$k_1 := \begin{cases} 0.59 & \text{if } \frac{V_s}{T} < 0.50 = 0.64 \\ 0.69 & \text{if } \frac{V_s}{T} > 2.0 \\ 0.64 & \text{otherwise} \end{cases}$$

Average Depth in Contracted Section: $y_2 := \left(\frac{Q_2}{Q_1} \right)^{\frac{6}{7}} \cdot \left(\frac{W_1}{W_2} \right)^{k_1} \cdot y = 12.62 \cdot ft$

Contraction Scour Depth: $y_{sc100} := y_2 - y = 4.32 \cdot ft$ Conservatively take upstream depth

LOCAL SCOUR AT ABUTMENT 1 AND 2

Local scour is not present for Q100 at abutment 1 and 2 due to no flow in the overbanks.

TOTAL SCOUR AT ABUTMENT 1 AND 2

Since local scour is not present at Q100, total scour is the contraction scour.

Q500 SCOUR EVENT:

CONTRACTION SCOUR

Determine Type of Scour:

Average Depth of Flow Upstream: $y := 9.17ft$ From x-section 159.6

Particle Size for Vc: $D_{50} := 1.55mm$ From geotechnical report

Unit Factor: $K_u := 11.17$ For English units

Critical Velocity: $V_c := K_u \cdot \left(\frac{y}{ft}\right)^{\frac{1}{6}} \cdot \left(\frac{D_{50}}{ft}\right)^{\frac{1}{3}} \cdot \frac{ft}{sec} = 2.78 \cdot \frac{ft}{sec}$

Design Flow Velocity: $V := 7.58 \frac{ft}{sec}$

Scour Evaluation Type: $Scour_{type} := \begin{cases} \text{"Clear-water"} & \text{if } V_c > V \\ \text{"Live-bed"} & \text{if } V > V_c \end{cases} = \text{"Live-bed"}$

Live-Bed Contraction Scour:

Flow in Channel Upstream: $Q_1 := 9478.65 \frac{ft^3}{sec}$

Flow in Contracted Channel: $Q_2 := 9530 \frac{ft^3}{sec}$

Bottom Width of Channel Upstream: $W_1 := 327.0ft - 236.30ft = 90.7 \cdot ft$

Bottom Width of Channel Upstream: $W_2 := 313.75ft - 266.65ft = 47.1 \cdot ft$

Slope of the Energy Grade Line: $S_1 := 0.000902$

Shear Velocity: $V_s := \left(\frac{g}{\frac{ft}{sec^2}} \cdot \frac{y}{ft} \cdot S_1\right)^{0.5} \cdot \frac{ft}{sec}$ $V_s = 0.52 \cdot \frac{ft}{sec}$

Fall Velocity: $T := 0.15 \frac{m}{sec} = 0.49 \cdot \frac{ft}{sec}$ From Figure 6.8

Exponent k1:

$$k_1 := \begin{cases} 0.59 & \text{if } \frac{V_s}{T} < 0.50 = 0.64 \\ 0.69 & \text{if } \frac{V_s}{T} > 2.0 \\ 0.64 & \text{otherwise} \end{cases}$$

Average Depth in Contracted Section:

$$y_2 := \left(\frac{Q_2}{Q_1}\right)^{\frac{6}{7}} \cdot \left(\frac{W_1}{W_2}\right)^{k_1} \cdot y = 14.01 \cdot ft$$

Contraction Scour Depth:

$y_{sc500} := y_2 - y = 4.84 \cdot ft$ Conservatively take upstream depth

LOCAL SCOUR AT ABUTMENT 1

Froehlich's Live-Bed Abutment Scour *HEC-18: 8.6.1*

Abutment Shape Factor: $K_1 := 0.55$ Spill through

Abutment Angle to Flow: $\theta := 90$

Angle of Embankment to Flow Factor: $K_2 := \left(\frac{\theta}{90}\right)^{0.13} = 1.00$

Length of Active Flow Obstruction: $L_i := 91.60 ft$ from x-section 159.6

Flow Area of Embankment: $A_e := 55.68 ft^2$ from x-section 159.6

Flow Obstructed by Embankment: $Q_e := 46.93 \frac{ft^3}{sec}$ from x-section 159.6

Velocity at Obstructed Flow: $V_e := 0.84 \frac{ft}{sec}$ from x-section 159.6

Length of Embankment normal to flow: $L := 91.60 ft$

Average Flow Depth in Floodplain: $y_a := \frac{A_e}{L} = 0.61 \cdot ft$

Froude Number: $Fr := \frac{V_e}{(g \cdot y_a)^{0.5}} = 0.19$

Gravity: $g = 32.2 \cdot \frac{ft}{sec^2}$

Scour Depth: $y_{s_FR} := \left[2.27 \cdot K_1 \cdot K_2 \cdot \left(\frac{L_i}{y_a}\right)^{0.43} \cdot Fr^{0.61} + 1\right] \cdot y_a = 2.99 \cdot ft$

HIRE Live-Bed Abutment Scour

HEC-18: 8.6.2

Abutment Shape Factor: $K_1 = 0.55$ Spill through

Angle of Embankment to Flow Factor: $K_2 = 1.00$

Length of Embankment normal to flow: $L = 92 \cdot ft$

Average Flow Depth in Floodplain: $y_1 := 0.61ft$ from HEC-RAS x-section 159.6

Froude Number: $Fr := \frac{V_e}{(g \cdot y_1)^{0.5}} = 0.19$

Gravity: $g = 32.2 \cdot \frac{ft}{sec^2}$

Scour Depth: $\boxed{y_{s_HIRE} := \left(4 \cdot Fr^{0.33} \cdot \frac{K_1}{0.55} \cdot K_2\right) \cdot y_1 = 1.41 \cdot ft}$

Abutment Scour

Determine Equation:

$$y_{sL5001} := \begin{cases} y_{s_FR} & \text{if } \frac{L}{y_a} \le 25 \\ y_{s_HIRE} & \text{otherwise} \end{cases} = 1.41 \cdot ft$$

LOCAL SCOUR AT ABUTMENT 2

Froehlich's Live-Bed Abutment Scour *HEC-18: 8.6.1*

Abutment Shape Factor: $K_1 := 0.55$ Spill through

Abutment Angle to Flow: $\theta := 90$

Angle of Embankment to Flow Factor: $K_2 := \left(\frac{\theta}{90}\right)^{0.13} = 1.00$

Length of Active Flow Obstruction: $L_i := 20.48\,ft$ from x-section 159.6

Flow Area of Embankment: $A_e := 7.41\,ft^2$ from x-section 159.6

Flow Obstructed by Embankment: $Q_e := 4.42\,\frac{ft^3}{sec}$ from x-section 159.6

Velocity at Obstructed Flow: $V_e := 0.60\,\frac{ft}{sec}$ from x-section 159.6

Length of Embankment normal to flow: $L := 20.48\,ft$

Average Flow Depth in Floodplain: $y_a := \frac{A_e}{L} = 0.36 \cdot ft$

Froude Number: $Fr := \frac{V_e}{(g \cdot y_a)^{0.5}} = 0.18$

Gravity: $g = 32.2 \cdot \frac{ft}{sec^2}$

Scour Depth: $$\boxed{y_{s_FR} := \left[2.27 \cdot K_1 \cdot K_2 \cdot \left(\frac{L_i}{y_a}\right)^{0.43} \cdot Fr^{0.61} + 1\right] \cdot y_a = 1.25 \cdot ft}$$

HIRE Live-Bed Abutment Scour *HEC-18: 8.6.2*

Abutment Shape Factor: $K_1 = 0.55$ Spill through

Angle of Embankment to Flow Factor: $K_2 = 1.00$

Length of Embankment normal to flow: $L = 20.48 \cdot ft$

Average Flow Depth in Floodplain: $y_1 := 0.36ft$ from HEC-RAS x-section 159.6

Froude Number: $Fr := \frac{V_e}{(g \cdot y_1)^{0.5}} = 0.18$

Gravity: $g = 32.2 \cdot \frac{ft}{sec^2}$

Scour Depth: $\boxed{y_{s_HIRE} := \left(4 \cdot Fr^{0.33} \cdot \frac{K_1}{0.55} \cdot K_2\right) \cdot y_1 = 0.81 \cdot ft}$

Abutment Scour

Determine Equation:

$$y_{sL5002} := \begin{cases} y_{s_FR} & \text{if } \frac{L}{y_a} \le 25 \\ y_{s_HIRE} & \text{otherwise} \end{cases} = 0.81 \cdot ft$$

TOTAL SCOUR AT ABUTMENT 1 AND 2

Abutment 1: $y_{s1} := y_{sc500} + y_{sL5001} = 6.25 \cdot ft$

Abutment 2: $y_{s2} := y_{sc500} + y_{sL5002} = 5.65 \cdot ft$

Plan: MxdFlowCnstSlp Lil Madwaska Rvr Exstn Stokhom RS: 159.6 Profile: Q100

E.G. Elev (ft)	549.29	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.70	Wt. n-Val.		0.025	
W.S. Elev (ft)	548.58	Reach Len. (ft)	9.25	9.25	9.25
Crit W.S. (ft)		Flow Area (sq ft)		1096.22	
E.G. Slope (ft/ft)	0.000813	Area (sq ft)		1096.22	
Q Total (cfs)	7380.00	Flow (cfs)		7380.00	
Top Width (ft)	132.04	Top Width (ft)		132.04	
Vel Total (ft/s)	6.73	Avg. Vel. (ft/s)		6.73	
Max Chl Dpth (ft)	13.58	Hydr. Depth (ft)		8.30	
Conv. Total (cfs)	258762.1	Conv. (cfs)		258762.1	
Length Wtd. (ft)	9.25	Wetted Per. (ft)		138.51	
Min Ch El (ft)	535.00	Shear (lb/sq ft)		0.40	
Alpha	1.00	Stream Power (lb/ft s)	460.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)		4.70	
C & E Loss (ft)	0.07	Cum SA (acres)		0.54	

Plan: MxdFlowCnstSlp Lil Madwaska Rvr Exstn Stokhom RS: 159.6 Profile: Q500

E.G. Elev (ft)	550.61	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.89	Wt. n-Val.	0.038	0.025	0.038
W.S. Elev (ft)	549.72	Reach Len. (ft)	9.25	9.25	9.25
Crit W.S. (ft)		Flow Area (sq ft)	7.41	1251.13	55.68
E.G. Slope (ft/ft)	0.000902	Area (sq ft)	7.41	1251.13	55.68
Q Total (cfs)	9530.00	Flow (cfs)	4.42	9478.65	46.93
Top Width (ft)	248.48	Top Width (ft)	20.48	136.40	91.60
Vel Total (ft/s)	7.25	Avg. Vel. (ft/s)	0.60	7.58	0.84
Max Chl Dpth (ft)	14.72	Hydr. Depth (ft)	0.36	9.17	0.61
Conv. Total (cfs)	317241.8	Conv. (cfs)	147.0	315532.5	1562.2
Length Wtd. (ft)	9.25	Wetted Per. (ft)	20.49	143.14	91.61
Min Ch El (ft)	535.00	Shear (lb/sq ft)	0.02	0.49	0.03
Alpha	1.09	Stream Power (lb/ft s)	460.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	5.12	0.01
C & E Loss (ft)	0.11	Cum SA (acres)	0.00	0.56	0.01

Plan: MxdFlowCnstSlp Lil Madwaska Rvr Exstn Stokhom RS: 129.355 Profile: Q100

E.G. US. (ft)	549.21	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	547.85	E.G. Elev (ft)	549.21	549.11
Q Total (cfs)	7380.00	W.S. Elev (ft)	547.85	547.62
Q Bridge (cfs)	7380.00	Crit W.S. (ft)	544.34	544.56
Q Weir (cfs)		Max Chl Dpth (ft)	12.77	11.89
Weir Sta Lft (ft)		Vel Total (ft/s)	9.36	9.78
Weir Sta Rgt (ft)		Flow Area (sq ft)	788.21	754.62
Weir Submerg		Froude # Chl	0.55	0.58
Weir Max Depth (ft)		Specif Force (cu ft)	6322.04	6083.06
Min El Weir Flow (ft)	555.53	Hydr Depth (ft)	9.01	8.71
Min El Prs (ft)	551.45	W.P. Total (ft)	93.80	92.91
Delta EG (ft)	0.10	Conv. Total (cfs)	193634.6	181223.1
Delta WS (ft)	0.23	Top Width (ft)	87.43	86.65
BR Open Area (sq ft)	1096.94	Frctn Loss (ft)	0.06	0.00
BR Open Vel (ft/s)	9.78	C & E Loss (ft)	0.04	0.00
Coef of Q		Shear Total (lb/sq ft)	0.76	0.84
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

Plan: MxdFlowCnstSlp Lil Madwaska Rvr Exstn Stokhom RS: 129.355 Profile: Q500

E.G. US. (ft)	550.49	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	548.54	E.G. Elev (ft)	550.49	550.32
Q Total (cfs)	9530.00	W.S. Elev (ft)	548.54	548.09
Q Bridge (cfs)	9530.00	Crit W.S. (ft)	545.71	545.90
Q Weir (cfs)		Max Chl Dpth (ft)	13.46	12.36
Weir Sta Lft (ft)		Vel Total (ft/s)	11.22	11.98
Weir Sta Rgt (ft)		Flow Area (sq ft)	849.34	795.50
Weir Submerg		Froude # Chl	0.64	0.70
Weir Max Depth (ft)		Specif Force (cu ft)	8061.48	7749.44
Min El Weir Flow (ft)	555.53	Hydr Depth (ft)	9.45	9.01
Min El Prs (ft)	551.45	W.P. Total (ft)	96.58	94.80
Delta EG (ft)	0.17	Conv. Total (cfs)	215074.0	195249.8
Delta WS (ft)	0.45	Top Width (ft)	89.85	88.29
BR Open Area (sq ft)	1096.94	Frctn Loss (ft)	0.09	0.00
BR Open Vel (ft/s)	11.98	C & E Loss (ft)	0.08	0.00
Coef of Q		Shear Total (lb/sq ft)	1.08	1.25
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

7.6 Scour and Riprap

Grain size analyses were performed on samples taken at the approximate streambed elevation to generate grain size curves for determining parameters to be used in scour analyses. The sample was assumed to be similar in nature to the soils likely to be exposed to scour conditions. The following streambed grain size parameters can be used in scour analyses:

- Average diameter of particle at 50 percent passing, D_{50} = 1.55 mm (medium sand)
- Average diameter of particle at 95 percent passing, D_{95} = 35 mm (coarse gravel)
- Soil Classification AASHTO Soil Type A-2-4.

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 that 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 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 1 foot below the streambed elevation. The riprap section shall be underlain by a 1 foot thick layer of bedding material conforming 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: