

PRELIMINARY  
HYDRAULIC ANALYSIS  
REPORT

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December 2022  
Revised September 2024

COBBOSSEE ROAD OVER  
MUD MILLS STREAM

FEDERAL PROJECT NUMBER  
WIN 026156.00

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Town of Monmouth  
Kennebec County  
Maine

PREPARED FOR  
**Maine Department of  
Transportation**  
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## 1.0 Background Information

The following is a preliminary hydraulic analysis report for Bridge No. 3671, Cobbossee Road over Mud Mills Stream, in the Town of Monmouth.

Bridge No. 3671 consists of three (3) riveted corrugated steel pipe culverts. Each culvert barrel is approximately 77 feet long and has a 6-foot diameter. The culverts were originally constructed in 1970 at an approximate 30-degree skew with Cobbossee Road. Cobbossee Road through the project area has two 11-foot travel lanes of with an approximate width of 32 feet.

The proposed construction alternative is to replace the existing culverts with a single 16-foot wide by 8-foot high precast concrete box culvert. The culvert will be partially buried with the bottom 2 feet filled with special fill. The riprap will extend through the proposed culvert and past the upstream and downstream wingwalls. Additionally, the proposed culvert will be located approximately 14 feet south of the existing culverts. Mud Mills Stream will be realigned to account for the shift. The proposed culvert will mimic the skew of the existing culverts. The proposed roadway profile will be slightly raised to facilitate construction of the larger structure.

## 1.1. Existing Data Review

- There is no USGS stream gage located within the vicinity of the project site.
- FEMA data is not available for the bridge.
- Mud Mills Stream peak flows were calculated utilizing SIR 2015-4059 by MaineDOT. These values were used in the analysis and can be found in Table 1.

## 2.0 Hydrology

At Bridge No. 3671, Mud Mills Stream has an approximate watershed area of 3.3 square miles, as calculated by the USGS StreamStats program. The watershed is bounded by a series of peaks and ridges to the east and south. State Route 132 roadway corridor provides the watershed its western barrier. Aerial photography of the watershed shows that it mostly consists of forests with some pasteurized farmland. According to the USGS StreamStats website, the watershed contains approximately 14 percent storage area (combined waterbodies and wetland areas).

Mud Mills Stream begins at the outfall of an unnamed swamp, located approximately 3 miles upstream of the Bridge No, 3671. From the outfall, the stream travels north, at an average streambed slope of 58.5 feet per mile, before reaching the subject bridge. Between the swamp outfall and the subject bridge, Mud Mills Stream crosses underneath two roadway crossings; Ridge Road and Gilman Road.

After Mud Mills Stream passes through Bridge No. 3671, the stream continues to travel approximately 2.6 miles north before merging with Wilson Stream and ultimately emptying into Annabessacook Lake.

FEMA has not performed a detailed study for Mud Mills Stream but Bridge No. 3671 is located in a FEMA A zone.

The recommended peak flows for the existing and proposed HEC-RAS analysis were provided by MaineDOT. These peak flows were developed using the USGS regression equations in the StreamStats Program. The regression analysis calculates peak flows for small ungaged streams and compares map-based to field-based variables (SIR 20154059 and SIR 20205092). The USGS regression equations use the watershed area and storage capacity as variables for calculating the peak flows. The MaineDOT hydrology calculations can be found in Appendix B. Table 1 lists the peak flows determined by MaineDOT.

**Table 1: Peak Discharges at Bridge No. 3671 over  
Mud Mills Stream**

Drainage Area	3.31 (sq. miles)
Storm Event (Years)	Peak Discharge (cfs)
1.1	55
10	220
25	285
50	335
100	390
200	450
500	530

### 3.0 Hydraulic Analysis

Hydraulic calculations for the project were performed using the U.S. Army Corps of Engineers HEC-RAS 5.0.7 computer program.

To develop a hydraulic model of Mud Mills Stream, a series of field cross-sections were taken between 580 feet upstream and 420 feet downstream of the existing bridge, which equates to approximately three times the floodplain width, exceeding FHWA's recommended guidance of a minimum of two times the floodplain width. Where available, project specific field survey information was used. Outside of surveyed limits, available Light Detection and Ranging (LIDAR) data available from NOAA was used. All elevation data is in the NAVD 1988 vertical datum.

Within the extents of the hydraulic model, Mud Mills Stream is a meandering watercourse, with shallow pools and emergent weeds scattered throughout the main channel. A Manning's Roughness Coefficient of 0.047 was used to represent the channel due to the calibration and sensitivity analysis discussed in Section 3.2. Outside of the main channel's banks, a Manning's Roughness Coefficient of 0.030 was used to represent undeveloped, grassed areas, and 0.100 was used for undeveloped, wooded areas. Elsewhere, a Manning's Roughness Coefficient of 0.023 was used to represent gravel roads.

Values of 0.1 and 0.3 are used for contraction and expansion dynamic head losses, except at the bridge. At the bridge, where the flow area changes more suddenly, values of 0.3 and 0.5 are used.

All profiles were run utilizing a mixed flow regime, with normal depth selected as both the upstream and downstream boundary conditions. The hydraulic analysis procedure used by the HEC-RAS program is based on the solution of the one-dimensional energy equation. The head loss in the energy equation is comprised of friction losses (utilizing Manning's equation) and contraction/expansion losses (coefficient multiplied by the change in velocity head).

### **3.1. Existing Conditions**

An existing conditions model was developed for the three riveted, corrugated steel pipe culverts. Each culvert was modeled with a Manning's Roughness Coefficient of 0.026. A slightly higher Manning's was used to depict the obstructions caused by the lateral bracing within the culvert. The culverts each have a 6-foot diameter and provide a hydraulic opening of approximately 85 square feet in total.

The existing culverts have varying inverts on both the upstream and downstream ends. Along the crossing's upstream side, the northernmost pipe has the lowest invert, at elevation 184.34 feet, and the southernmost pipe has the highest invert of 184.74 feet. Cobbossee Road's overtopping elevation is at 195.42 feet. Along the upstream side, Cobbossee Road has a minimum edge of pavement elevation of 193.81 feet.

The existing conditions model was run for all seven studied storm events. Only the 500-year storm events were shown to inundate all three culverts. None of the profiles were resulted in an overtopping of the roadway.

According to the MaineDOT Bridge Design Guide, culverts are required to have a headwater depth versus structure depth ratio (HW/D) of less than 0.9 for the 50-year storm event. During the 50-year storm event, the existing headwater water surface elevation (WSEL) is at 190.25 feet. Based on the Bridge Design Guide, all three culverts fail to provide the required HW/D ratio. From the northernmost pipe, the existing culvert's HW/D ratios are 0.98, 0.93 and 0.92.

The Bridge Design Guide also recommends that crossings should provide a minimum of 1-foot of clearance between the 100-year headwater WSEL and the edge of the pavement. At Section 515, the Upstream Bridge Face Section, the existing 100-year WSEL is at 190.63 feet. The culverts provide 3.18 feet of clearance, meeting the recommendation.

The existing conditions' hydraulic parameter summary can be found in Table 4. Output for all studied storm events, including cross-sections, water surface profiles and profile output tables is located in Appendix C.

### **3.2. Calibration and Sensitivity**

The downstream slope was determined by calculating the difference in the stream bed elevation at the center of the channel between upstream and downstream cross sections and dividing it by the channel length. Survey data was utilized where applicable between the furthest reaches of the cross sections. Certain downstream cross sections near the bridge reported higher channel bed elevations than upstream sections and were

disregarded for this calculation as they would provide a slope that was flatter than expected due to these local observations.

As noted in the report, hydrologic information on Mud Mills Stream is limited. The FEMA FIS Report for Kennebec County provides water surface elevations of Annabessacook Lake, located upstream of the bridge, for the 10-, 50-, 100-, and 500-year storm events. Table 2 below, provides these elevations and the remaining storm event elevations, that were calculated by linear regression, discussed in this report in order to compare the existing and proposed model elevations. However, these water surface elevations are notably lower than the elevations calculated at the downstream limits of the model. Calibration of the tailwater conditions off these elevations are impractical for the analysis. Additionally, there are no stream gages located along Mud Mills Stream or Wilson Stream to properly calibrate the channel's Manning roughness numbers or tailwater conditions.

A surveyed wetland delineation was utilized to estimate the maximum and average high-water elevation for Q1.1 at several upstream and downstream cross sections that intersected the wetland delineation line as the basis of the model calibration. A maximum and average high-water elevation were compared due to discrepancies between observed water surface elevation and the wetland delineation survey. Based on field visits, upstream of the bridge is anticipated to have a water surface elevation of 188.00 ft NAVD88, so all upstream cross section from 515 to 570 were modified. The new elevations for Q1.1 were compared against those calculated from the existing model. For the average high-water elevation, the Manning's n-value for the channel was lowered to 0.027 at all cross sections to determine a best fit curve of the wetland and Q1.1 elevation data. For the maximum high-water elevation, the Manning's n-value was raised to 0.047 at all cross sections for the existing and proposed conditions resulting in a best fit curve of the wetland and Q1.1 elevation data. The elevations for Q1.1 based on the maximum and average high-water elevations from the wetland delineation are provided in Table 3 below.

For the average high-water elevation, the calibrated Q1.1 elevation at Section 515 is 186.75, as noted in Table 3, which is closer to the uncalibrated Q1.1 value for both proposed condition values than for the elevations for Q1.1 at Annabessacook Lake provided in Table 2. For the maximum high-water elevation, the calibrated Q1.1 elevation at Section 515 is 188.00, as noted in Table 3, which is closer to the uncalibrated Q1.1 value for both proposed condition values than Q1.1 for the average high-water elevation and the elevation at Annabessacook Lake provided in Table 2. Therefore, the maximum high-water elevations were used to calibrate the model.

**Table 2: Annabessacook Lake Water Surface Elevations (ft, NAVD88)**

Storm Event (Years)	Elevation
1.1	170.6
10	171.5
25	171.9
50	172.1
100	172.4
200	172.7
500	173.0

**Table 3: Surveyed Wetland Delineation Elevations for Q1.1 (ft, NAVD88)**

Cross Sections	Average Elevation	Maximum Elevation
245	186.75	186.75
320	187.00	187.00
370	188.00	188.00
410	187.50	187.50
515	186.75	188.00
540	186.50	188.00
570	186.50	188.00

### 3.3. Proposed Conditions

#### 22-foot Wide by 8-foot High Box Culvert Option

The proposed conditions model replaces the existing culverts with a 22-foot wide by 8-foot-high precast concrete box culvert. The culvert will be partially buried with the bottom 2 feet filled with riprap. The riprap will extend through the proposed culvert and extend past the upstream and downstream wingwalls. To accommodate this change and for calibration, the Manning's Roughness Coefficient was modified to 0.047 within the main channel.

Compared to existing, the proposed culvert has a higher low chord, at elevation 191.00 feet, and a larger hydraulic opening, 132 square feet. The proposed roadway profile is also slightly raised. The proposed culvert will be located approximately 14 feet south of the existing crossing. The reach lengths within the proposed model were modified accordingly.

The proposed culvert will meet the MaineDOT Bridge Design Guide headwater depth requirements. During the 50-year storm event, the proposed model has a WSEL of 189.59 feet at Section 515. The proposed culvert provides a HW/D ratio of 0.75, which is below the maximum 0.9 threshold. Additionally, the proposed culvert also meets the MaineDOT clearance guidelines of a minimum of 1 foot of vertical clearance between the 100-year storm event WSEL and low chord for minor riverine bridges by providing 1.20 feet of clearance.

The 100-year proposed WSELs were compared to the existing WSELs to evaluate the proposed culvert's impact to the Mud Mills Stream's floodplain. Upstream of the culvert, the proposed model reduces 100-year WSELs between 0.05 to 0.83 feet at every section. At the approach section, Section 540, the proposed elevation is 0.90 feet lower than existing. At the upstream bridge face, Section 515, the proposed elevation is 0.77 feet lower than existing. Downstream of the bridge, the proposed model is within 0.03 feet of existing.

#### 16-foot Wide by 8-foot High Box Culvert Option

The proposed conditions model replaces the existing culverts with a 16-foot wide by 8-foot-high precast concrete box culvert. The culvert will be partially buried with the bottom 2 feet filled with riprap. The riprap will extend through the proposed culvert and extend past the upstream and downstream wingwalls. To accommodate this change and address calibration, the Manning's Roughness Coefficient was modified to 0.047 within the main channel.

Compared to existing, the proposed culvert has a higher low chord, at elevation 191.00 feet, and a larger hydraulic opening, 96 square feet. The proposed roadway profile is also slightly raised. The proposed culvert will be located approximately 14 feet south of the existing crossing. The reach lengths within the proposed model were modified accordingly. The proposed culvert will meet the MaineDOT Bridge Design Guide headwater depth requirements. During the 50-year storm event, the proposed model has a WSEL of 189.76 feet at Section 515. The proposed culvert provides a HW/D ratio of 0.78 which is below the maximum 0.9 threshold. Additionally, the proposed culvert also meets the MaineDOT clearance guidelines of a minimum of 1 foot of vertical clearance between the 100-year storm event WSEL and low chord for minor riverine bridges by providing 1.24 feet of clearance.

The 100-year proposed WSELs were compared to the existing WSELs to evaluate the proposed culvert's impact to the Mud Mills Stream's floodplain. Upstream of the culvert, the proposed model reduces 100-year WSELs between 0.05 to 0.61 feet at every section. At the approach section, Section 540, the proposed elevation is 0.64 feet lower than existing. At the upstream bridge face, Section 515, the proposed elevation is 0.55 feet lower than existing. Downstream of the bridge, the proposed model is within 0.03 feet of existing.

The proposed conditions' hydraulic parameters are summarized in Table 4. Output for all studied storm events, including cross-sections, water surface profiles and profile output tables is located in Appendix D.

**Table 4: Hydraulic Analysis Summary**

Summary of Hydraulic Data	Existing Conditions	Proposed Conditions 22' Span	Proposed Conditions 16' Span
Low Chord Elevation (ft NAVD 88)	190.74	191.00	191.00
Clear Span (ft)	18 (Total)	22	16
Bridge Opening Area (sq. ft)	84.8 (Total)	132	96
Ordinary High-Water Elevation (Q1.1) at US Bridge Face (ft NAVD 88) <sup>1</sup>	187.67	187.61	187.62
Q10 Headwater Elevation (ft NAVD 88) <sup>1</sup>	189.45	189.10	189.18
Q50 Headwater Elevation (ft NAVD 88) <sup>1</sup>	190.25	189.59	189.76
Q100 Headwater Elevation (ft NAVD 88) <sup>1</sup>	190.63	189.80	190.02
Q200 Headwater Elevation (ft NAVD 88) <sup>1</sup>	191.06	189.99	190.27
Q500 Headwater Elevation (ft NAVD 88) <sup>1</sup>	191.65	190.19	190.57
Ordinary High-Water Velocity (Q1.1) at DS Bridge Face (ft/s) <sup>2</sup>	0.75	0.69	0.69
Q10 Discharge Velocity (fps) <sup>2</sup>	1.90	1.76	1.76
Q50 Discharge Velocity (fps) <sup>2</sup>	2.59	2.41	2.41
Q100 Discharge Velocity (fps) <sup>2</sup>	2.90	2.70	2.70
Q200 Discharge Velocity (fps) <sup>2</sup>	3.23	3.01	3.01
Q500 Discharge Velocity (fps) <sup>2</sup>	3.68	3.43	3.43
Q50 Clearance (ft) <sup>3</sup>	0.49	1.41	1.24
Q100 Clearance (ft) <sup>3</sup>	0.11	1.20	0.98
HW/D Ratio	0.98, 0.93, and 0.92	0.75	0.78

Note: 1. Headwater Elevation is taken at Section 515.

2. Discharge Velocity is taken at Section 410.

3. Negative Clearances indicate that the low chord of the bridge is submerged.

### Recommended Solution

MaineDOT identified the bankfull width of 16-feet to 21-feet upstream and downstream of the existing culverts at Cobbossee Road over Mud Mills Stream. A 22-foot wide by 8-foot-high precast concrete box culvert was originally proposed as it met the 1.2 times bankfull width design standard. A 16-foot wide by 8-foot-high precast concrete box culvert was analyzed as it was the minimum width acceptable that meets the bankfull width range. The HW/D ratio for 16-foot wide by 8-foot-high culvert was less than the maximum ratio of 0.9 for the 50-year storm event. Therefore, the 16-foot wide by 8-foot-high precast concrete box culvert was selected as the recommended solution.

#### **4.0 Scour Countermeasure Analysis**

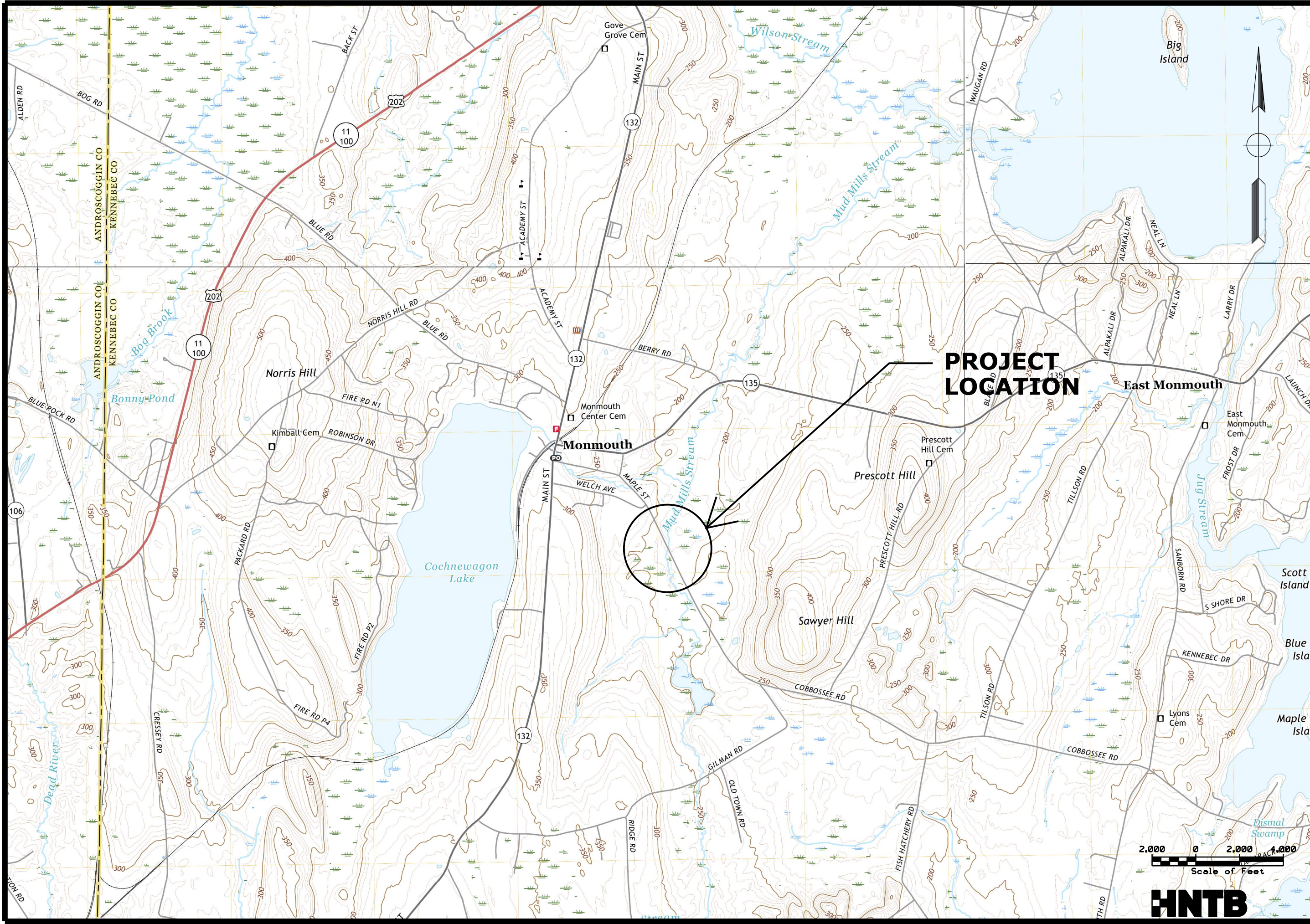
As part of the proposed alternative, the channel will be lined with riprap through the culvert and at the faces of the culvert. The sizing analysis was performed based on equations from FHWA publication HEC-23 (Third Edition), Design Guideline 4. Design Guideline 14 was also used to confirm riprap sizing. The 100- and 200-year storm events were used to riprap sizing calculations. Based on the calculations, riprap with a minimum  $D_{50}$  of 6 inches will provide the acceptable channel protection from scour and erosion. The scour countermeasure calculations can be found in Appendix E.

#### **5.0 Summary**

The project proposes to replace the existing culverts that carries Cobbossee Road over Mud Mills Stream in the Town of Monmouth, Kennebec County with a precast concrete box culvert. The proposed culvert will meet or exceed the MaineDOT Bridge Design Guide headwater depth and clearance requirements. Replacing the existing culverts will reduce upstream water surface elevations for all studied storm events, without adversely impacting the floodplain or increasing flooding risks to adjacent properties. No overtopping was shown during any of the storm events.

# APPENDIX A

Project Location Maps



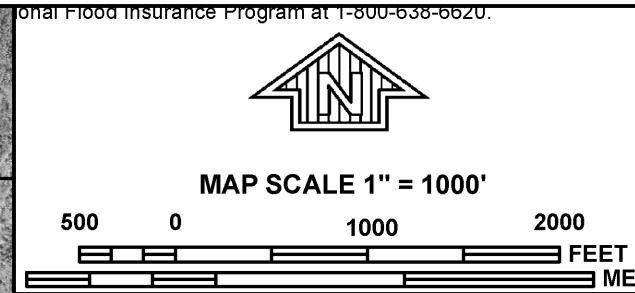
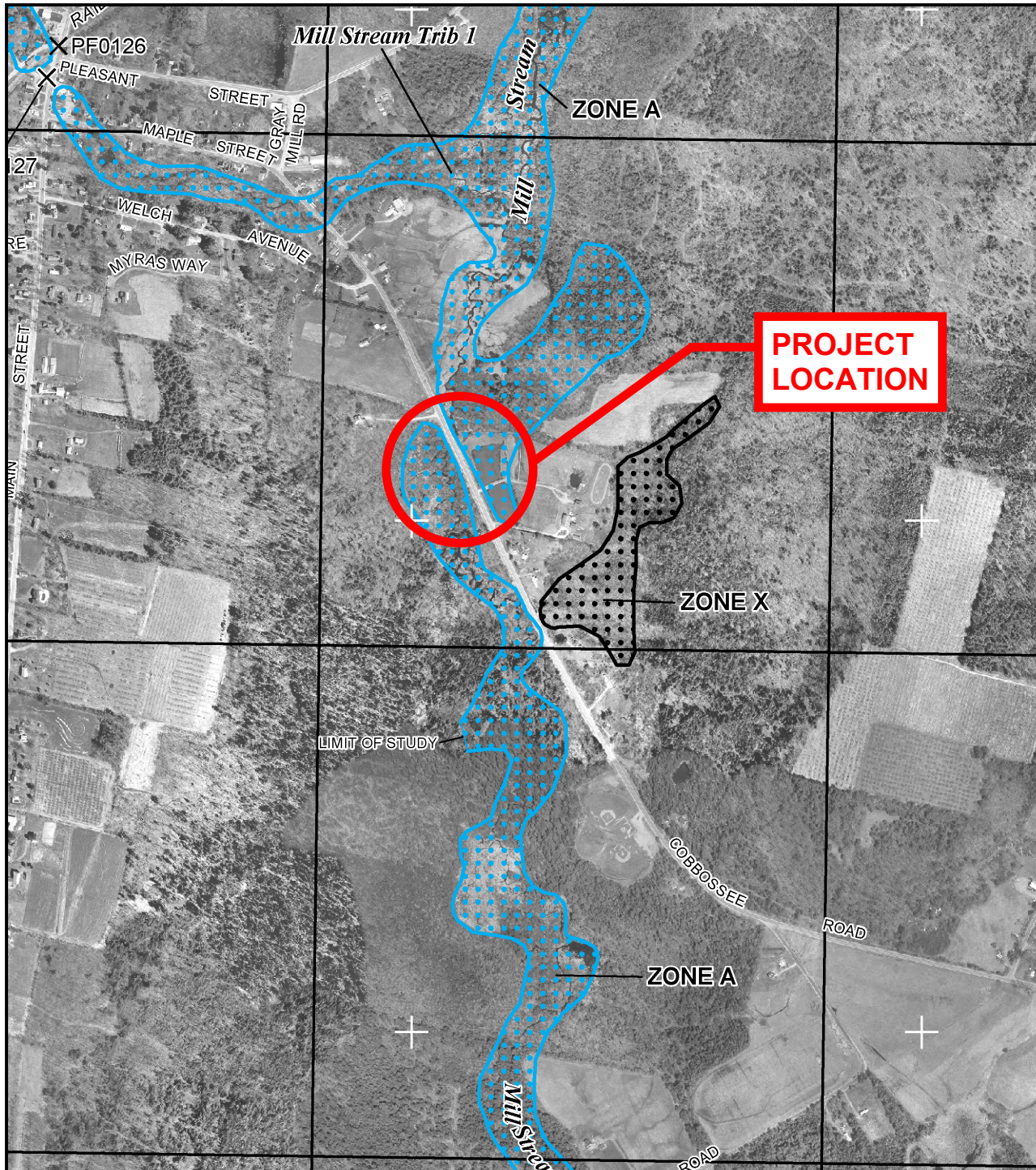
**PROJECT LOCATION**



**HNTB**



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<b>DEPARTMENT OF TRANSPORTATION</b>																																																					
<b>BRIDGE NO. 3671</b>																																																					
<b>WIN</b>																																																					
<b>COBBOSSECONTEE ROAD OVER MUD MILLS STREAM</b>	<b>LOCATION MAP</b>																																																				
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NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0610D

**FIRM**  
**FLOOD INSURANCE RATE MAP**  
**KENNEBEC COUNTY,**  
**MAINE**  
**(ALL JURISDICTIONS)**

PANEL 610 OF 775  
 (SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MONMOUTH, TOWN OF	230240	0610	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**  
**23011C0610D**  
**EFFECTIVE DATE**  
**JUNE 16, 2011**

Federal Emergency Management Agency

This is an official FIRMette showing a portion of the above-referenced flood map created from the MSC FIRMette Web tool. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For additional information about how to make sure the map is current, please see the Flood Hazard Mapping Updates Overview Fact Sheet available on the FEMA Flood Map Service Center home page at <https://msc.fema.gov>.

# APPENDIX B

MaineDOT Hydrology Report

WIN:	26156.00	
Town:	Monmouth	
Route No.:	Cobbossee Rd	
Asset ID:	3671	
Lat:	44.23210	Long: -70.02590

Project Name:	
Stream Name:	Mud Mills Stream
Bridge Name:	Bailey Flat
Analysis by:	csh
Date:	9/8/2022

### Peak Flow Calculations by USGS Regression Equations (Lombard/Hodgkins, 2021; Hodgkins, 1999 & Lombard/Hodgkins, 2015)

*Enter data in blue cells only!*

*ver. 2021 Jan 01*

	km <sup>2</sup>	mi <sup>2</sup>	ac
A	8.57	3.31	2118.4
W	1.20	0.5	297.2
P <sub>c</sub>	417666	4895691	
County	Kennebec		

*Enter data in [mi<sup>2</sup>]*  
 Watershed Area DRNAREA  
 Wetlands area (by NWI)

watershed centroid (E, N; UTM 19N; meters)  
 choose county from drop-down menu

**Worksheet prepared by:**  
 Charles S. Hebson, PE  
 Environmental Office  
 Maine Dept. Transportation  
 Augusta, ME 04333-0016  
 207-557-1052  
[Charles.Hebson@maine.gov](mailto:Charles.Hebson@maine.gov)

### Watershed Characteristics from StreamStats

STORNGAGE	14.54	
STORNWI	14.03	NWI Wetlands %
SANDGRAVF	0.03	sand & gravel aquifer as decimal fraction of watershed A
ELEV	333	mean basin elevation (ft)
BSLDEM10M	4.66	mean basin slope (%)
COASTDIST	61.00	distance from the coast (mi)
ELEVMAX	541	maximum basin elevation (ft)
LC06WATER	2.03	percent of drainage basin land cover as open water
PRECIP	44.4	mean annual precipitation
STATSGOA	2	mean basin percentage of hydrological soil group A

### References:

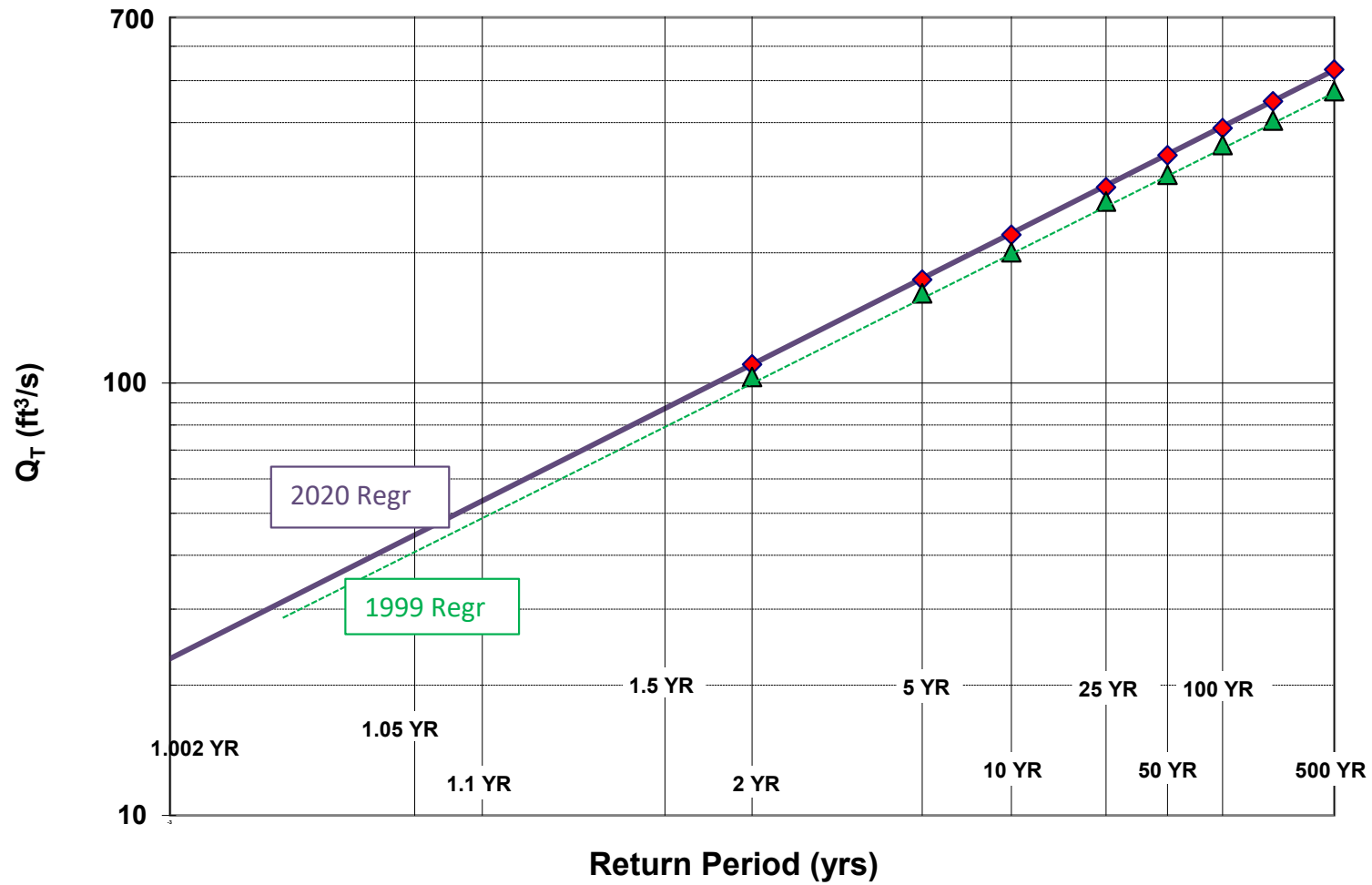
- Hodgkins, G.A., 1999.  
 Estimating the magnitude of peak flows for streams in Maine  
 for Selected Recurrence Intervals  
*WRIR 99-4008*, USGS Augusta, ME
- Lombard, P.J. & G.A. Hodgkins, 2015.  
 Peak flow regression equations for small, ungaged streams:  
 in Maine: Comparing Map-Based to Field-Based Variables  
*SIR 2015-4059*, USGS, Augusta, ME
- Lombard, P.J. & G.A. Hodgkins, 2020.  
 Estimating Flood Magnitude and Frequency on Gaged and  
 Ungaged Streams in Maine  
*SIR 2020-5092*, USGS, Augusta, ME.

Ret Pd T (yr)	I24	Q <sub>T</sub> (ft <sup>3</sup> /s)		Q <sub>T</sub> (ft <sup>3</sup> /s) <i>Design</i>
		1999 / 2015	2020	
1.1			53	55
2	3.01	103	110	110
5	3.80	161	173	175
10	4.46	200	220	220
25	5.36	263	284	285
50	6.04	303	336	335
100	6.76	355	389	390
200	7.60	404	448	450
500	8.90	473	530	530

### Instructions:

*Enter values in blue cells only, watershed data from StreamStats*  
 Copy I24 values from Stream Stats  
 Use results under "Design"  
 Check against gage data and FEMA studies if available  
 Questions? Check with ENV / Hydrology Section

# Log-Normal Probability Plot



WIN:	26156.00
Town:	Monmouth
Route No.:	Cobbossee Rd
Asset ID:	3671
Lat:	44.23210
Long:	-70.02590

Project Name:	0
Stream Name:	Mud Mills Stream
Bridge Name:	Bailey Flat
Analysis by:	csh
Date:	9/8/2022

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

**MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004, 2013, 2015)**

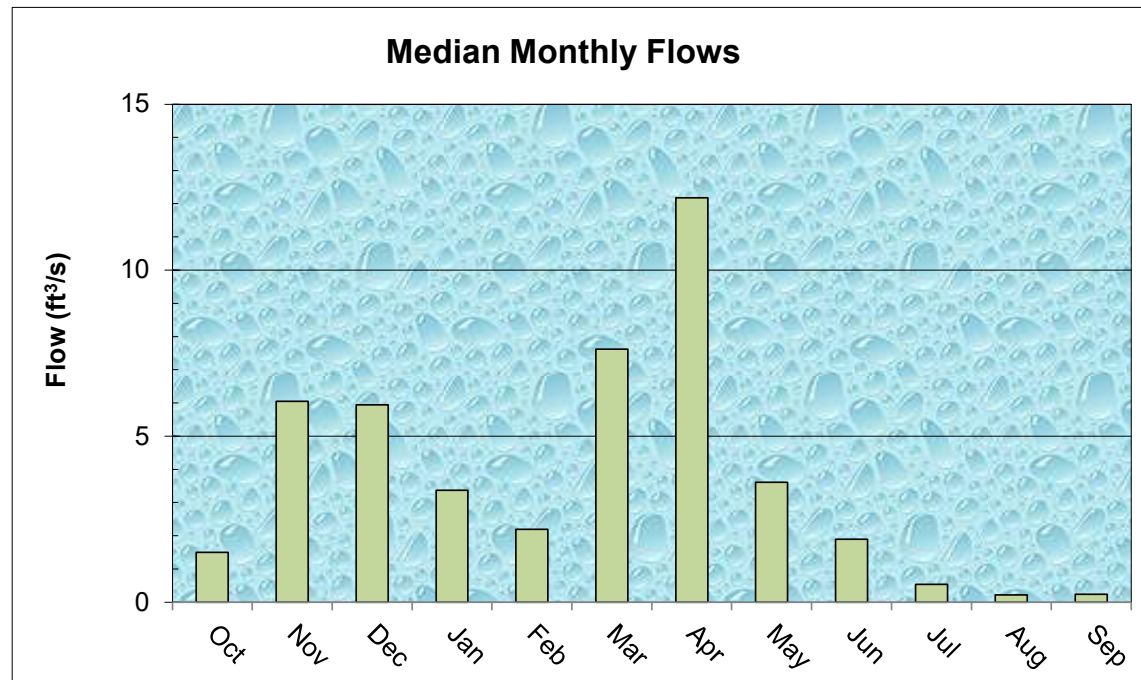
Value	Variable	Explanation
3.31	A	Area (mi <sup>2</sup> )
417665.7	P <sub>c</sub>	Watershed centroid (E,N; UTM; Zone 19; meters)
60.78	DIST	Distance from Coastal reference line (mi)
44.4	pptA	Mean Annual Precipitation (inches)
0.00	SG	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q <sub>median</sub> (ft <sup>3</sup> /s)	(m <sup>3</sup> /s)
Jan	3.37	0.0955
Feb	2.19	0.0621
Mar	7.62	0.2159
Apr	12.18	0.3451
May	3.61	0.1023
Jun	1.89	0.0536
Jul	0.53	0.0151
Aug	0.21	0.0060
Sep	0.23	0.0066
Oct	1.50	0.0426
Nov	6.05	0.1714
Dec	5.94	0.1684

Q <sub>bf</sub>	18.2
ann avg	7.4
ann med	3.1
Q <sub>1.002</sub>	23.1
Q <sub>1.01</sub>	31.1
Q <sub>1.05</sub>	44.6
Q <sub>bf</sub>	63.2

assume v = 4ft/s

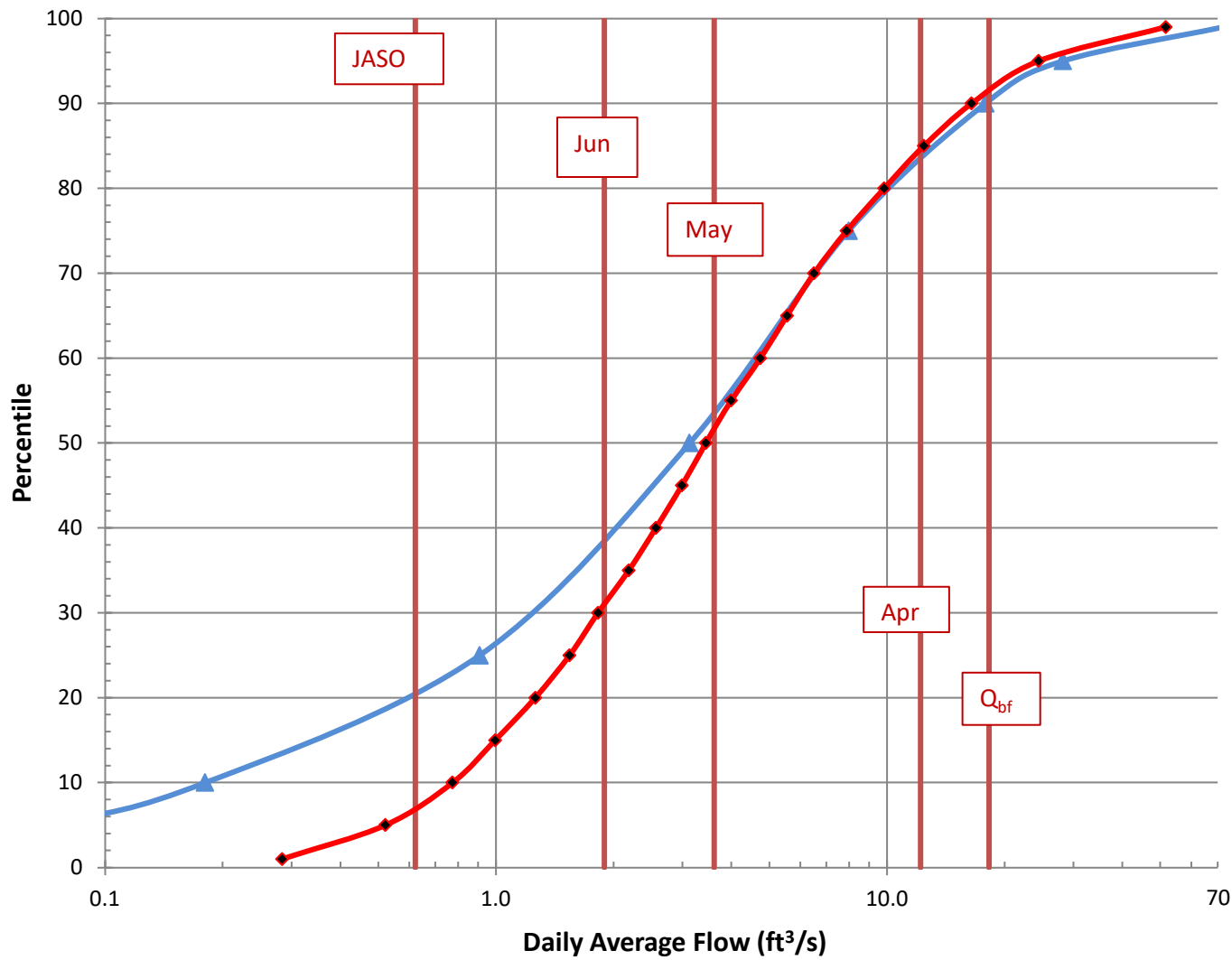
W <sub>bf</sub>	17.7	estimated bankfull width (ft)
d <sub>bf</sub>	0.9	estimated bankfull depth (ft)
A <sub>bf</sub>	12.7	estimated bankfull flow area (ft <sup>2</sup> )



**References**

- Dudley, 2013. FY2013 Progress Report - Phase 1 ..., USFWS QRP Project
- Dudley, 2004. Estimating Monthly Streamflows ... , SIR 2004-5026
- Dudley, 2015. Regression Equations for Monthly & Annual Mean..., USGS SIR 2015-5151

# Daily Average Flow Distribution



## Daily Avg Flow Dist

$A_{ws} = (mi^2)$  3.3

Q (ft<sup>3</sup>/s)

Pctl	Median	84 <sup>th</sup> pctl
1.00E-06	0.00	0.00
1	0.28	0.50
5	0.52	0.84
10	0.77	1.16
15	0.99	1.45
20	1.26	1.76
25	1.54	2.07
30	1.82	2.35
35	2.18	2.69
40	2.56	3.09
45	2.99	3.50
50	3.44	4.13
55	3.99	4.80
60	4.74	5.64
65	5.55	6.57
70	6.51	7.66
75	7.89	9.22
80	9.84	11.00
85	12.41	14.10
90	16.44	18.94
95	24.40	29.45
99	51.61	67.94

Q<sub>bf</sub> 18.2

Q<sub>1.002</sub> 23.1

Q<sub>1.1</sub> 53.4

Q<sub>2</sub> 110.4

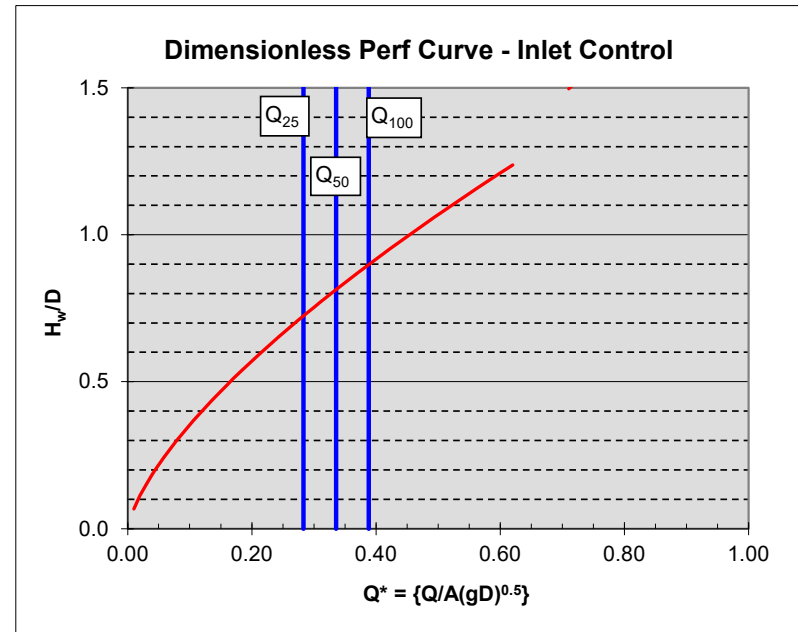
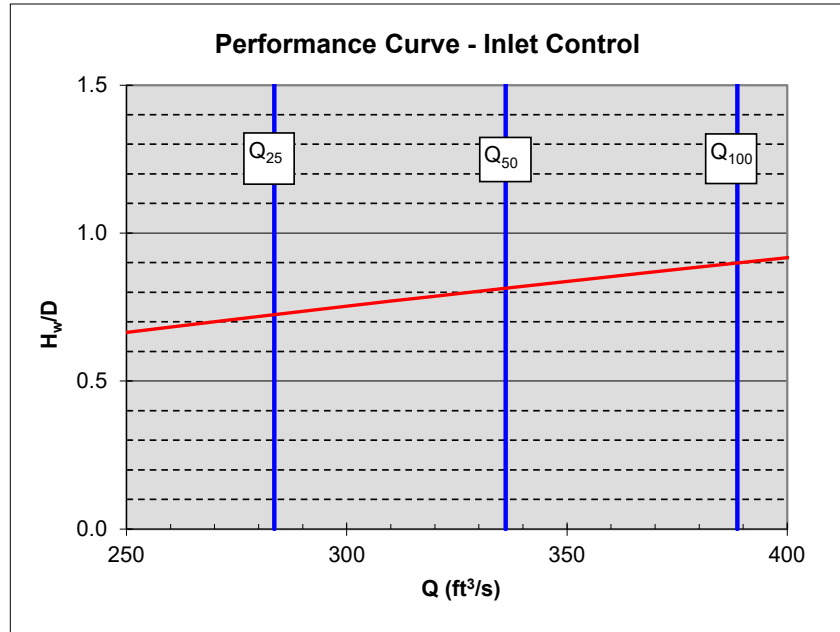
**NOTE:** This page is for preliminary sizing only.  
Final design should be done with HY8 or HDS-5

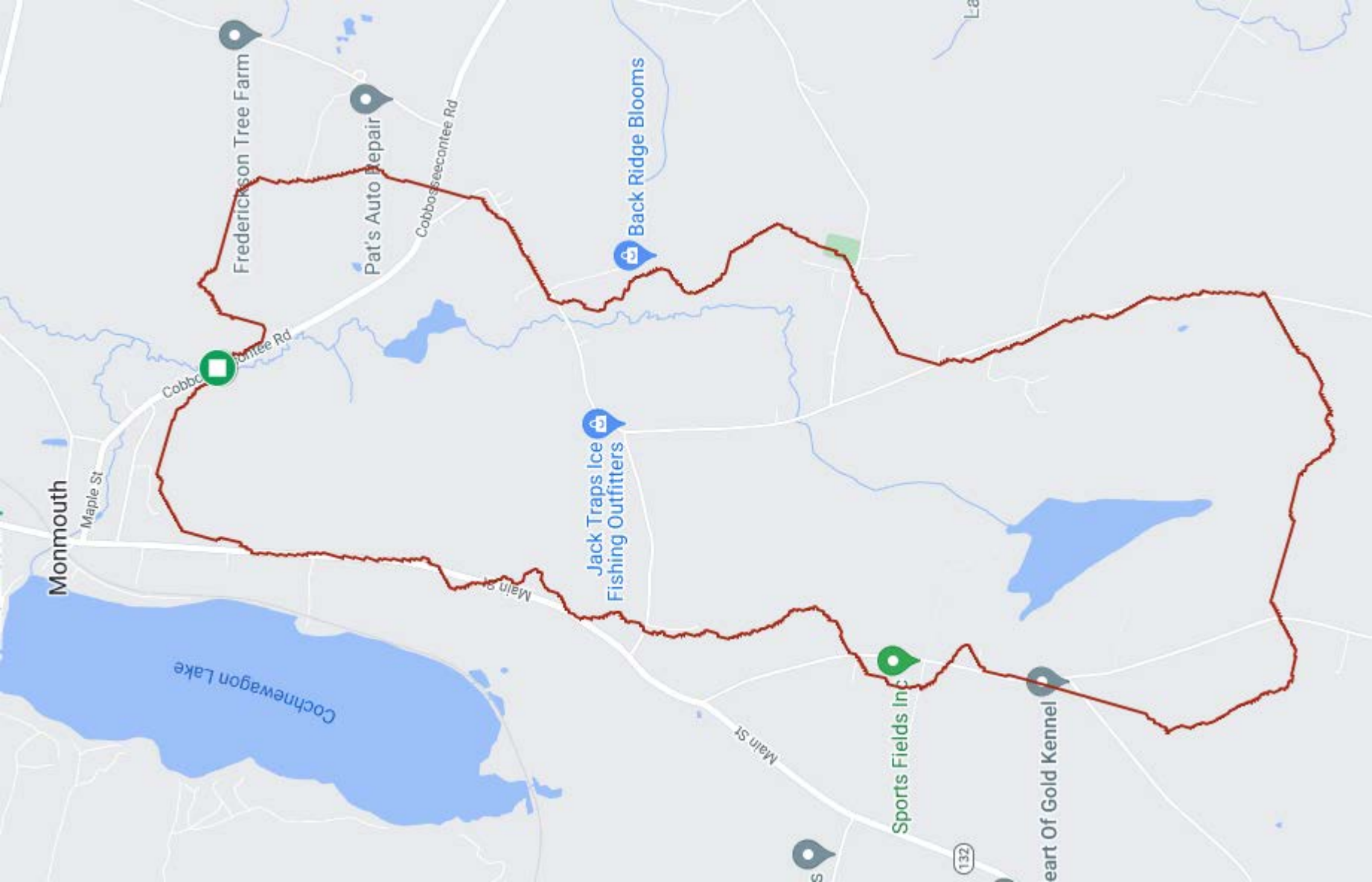
**Note:** culvert dimensions are for open flow area; adjust for lost capacity due to embedding / backfilling (min {2' / 25% rise} embedment)  
Finish analysis with HY-8

**Preliminary Culvert Sizing - Round & Box Culverts**

Shape:	Box			
Inlet Type:	Box 0 ww		Q <sub>25</sub> 283.5	
D or R (ft)	6 diam / rise	Q <sub>50</sub> 336.1	trial D / R = 8.5	
w (ft)	12 box span	Q <sub>100</sub> 388.7	trial w: BFW = 17.7	
Slope (ft/ft)	0.02			
A (ft <sup>2</sup> )	72.00			
g (ft/s <sup>2</sup> )	32.2			

Choose shape and inlet type by pull-down menu in green cells





Monmouth

Frederickson Tree Farm

Pat's Auto Repair

Back Ridge Blooms

Jack Traps Ice Fishing Outfitters

Sports Fields Inc

Heart Of Gold Kennel

Cochnewagon Lake

Cobbsmontee Rd

Cobbsmontee Rd

Main St

Main St

132

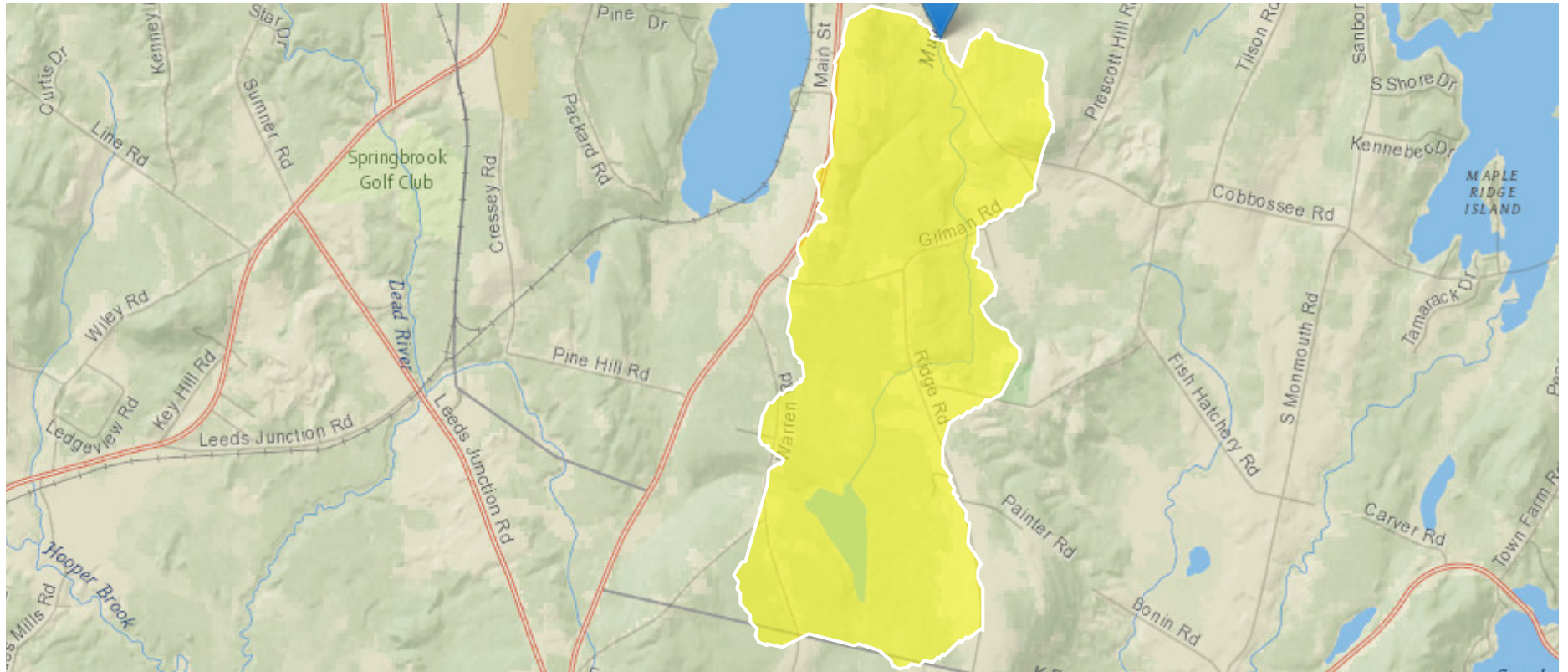
# Monmouth 26156 bailey Flat Bridge #3671

Region ID: ME

Workspace ID: ME20220907200225610000

Clicked Point (Latitude, Longitude): 44.23213, -70.02587

Time: 2022-09-07 16:02:52 -0400



+ Collapse All

➤ Basin Characteristics

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
I24H100Y	24 Hour 100 Year Precipitation	6.76	inches	3.99	9.88
I24H200Y	24 Hour 200 Year Precipitation	7.6	inches	5.26	11.1
I24H500Y	24 Hour 500 Year Precipitation	8.9	inches	5.95	13.1

### Peak-Flow Statistics Flow Report [Statewide multiparameter peakflows SIR 2020 5092]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	ASEp
50-percent AEP flood	111	ft <sup>3</sup> /s	59.5	207	39.1
20-percent AEP flood	174	ft <sup>3</sup> /s	94.7	320	38.1
10-percent AEP flood	222	ft <sup>3</sup> /s	119	413	38.9
4-percent AEP flood	286	ft <sup>3</sup> /s	152	539	39.9
2-percent AEP flood	337	ft <sup>3</sup> /s	176	646	39.7
1-percent AEP flood	391	ft <sup>3</sup> /s	205	745	40.7
0.5-percent AEP flood	451	ft <sup>3</sup> /s	229	889	42.8
0.2-percent AEP flood	534	ft <sup>3</sup> /s	267	1070	43.8

#### *Peak-Flow Statistics Citations*

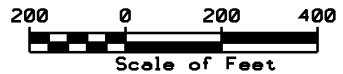
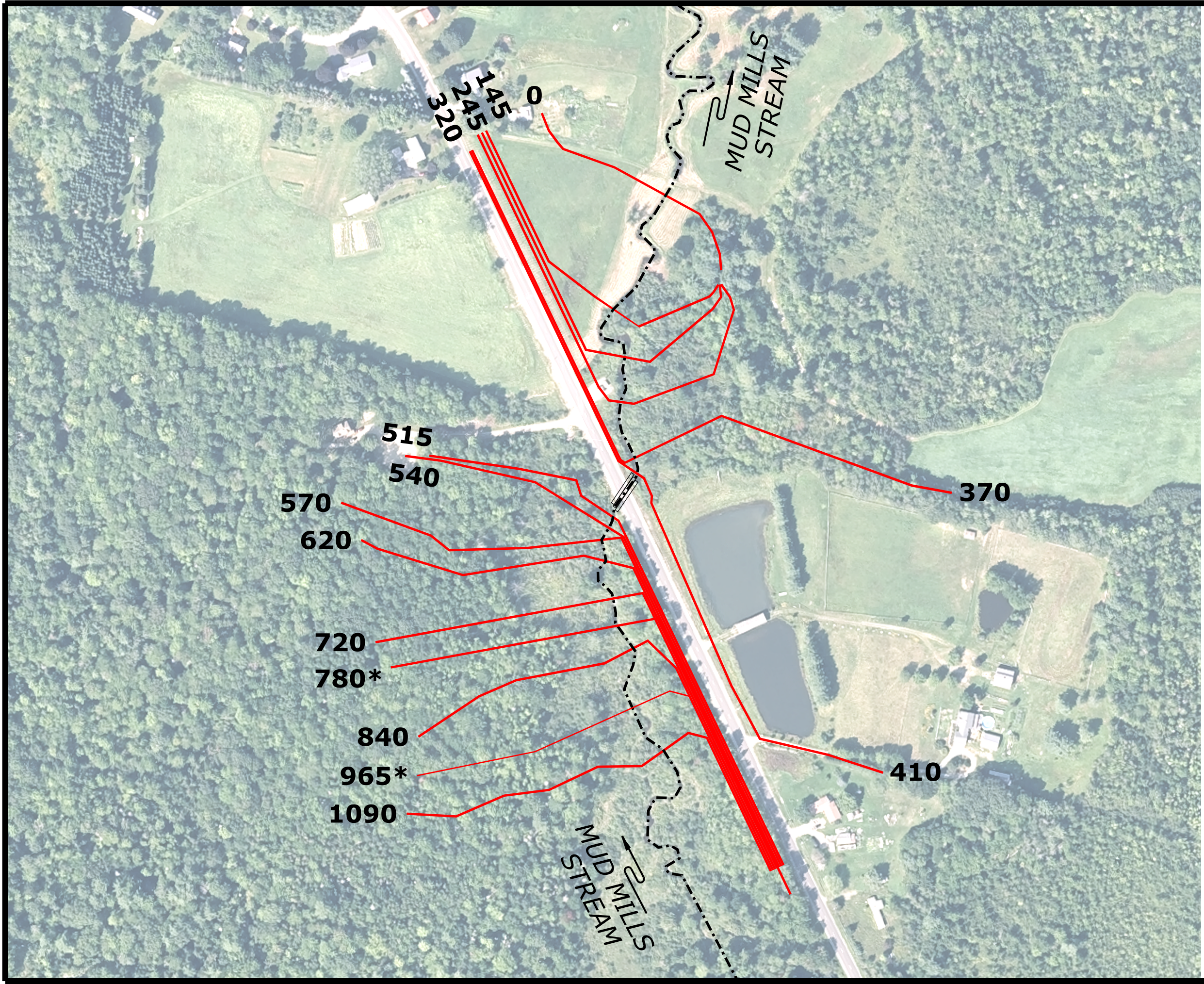
**Lombard, P.J., and Hodgkins, G.A., 2020, Estimating flood magnitude and frequency on gaged and ungaged streams in Maine: U.S. Geological Survey Scientific Investigations Report 2020–5092, 56 p. (<https://doi.org/10.3133/sir20205092>)**

### ➤ Flow-Duration Statistics

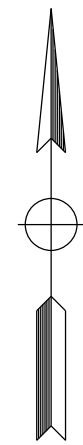
#### Flow-Duration Statistics Parameters [Statewide Annual SIR 2015 5151]

# APPENDIX C

Existing HEC-RAS Analysis



**HNTB**



STATE OF MAINE DEPARTMENT OF TRANSPORTATION		BRIDGE NO. 3671 WIN	
COBBOSSECONTEE ROAD OVER MUD MILLS STREAM TOWN OF MONMOUTH KENNEBEC COUNTY		CROSS-SECTION MAP	
SHEET NUMBER <b>FIG - 02</b>		DATE 11/22 11/22	
PROJ. MANAGER N.P. S.C.F.	BY N.P. S.C.F.	DESIGN DETAILED CHECKED-REVIEWED DESIGN DETAILED	SIGNATURE P.E. NUMBER DATE
REVISIONS 1 REVISIONS 2 REVISIONS 3 REVISIONS 4		FIELD CHANGES	

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	0	1.1-Yr	55.00	183.45	187.19	185.63	187.25	0.001973	1.99	28.09	19.57	0.26
Cobbossee Rd	0	2-Yr	110.00	183.45	187.99	186.36	188.08	0.001974	2.52	51.60	39.42	0.27
Cobbossee Rd	0	5-Yr	175.00	183.45	188.28	186.94	188.36	0.001973	2.69	137.88	323.09	0.28
Cobbossee Rd	0	10-Yr	220.00	183.45	188.39	187.31	188.46	0.001971	2.76	174.46	332.36	0.28
Cobbossee Rd	0	25-Yr	285.00	183.45	188.52	187.76	188.59	0.001971	2.84	220.00	343.56	0.28
Cobbossee Rd	0	50-Yr	335.00	183.45	188.61	188.33	188.68	0.001972	2.89	251.40	351.07	0.28
Cobbossee Rd	0	100-Yr	390.00	183.45	188.70	188.39	188.77	0.001971	2.95	283.63	358.62	0.28
Cobbossee Rd	0	200-Yr	450.00	183.45	188.79	188.43	188.87	0.001970	3.00	316.58	366.18	0.28
Cobbossee Rd	0	500-Yr	530.00	183.45	188.90	188.51	188.98	0.001972	3.06	357.63	375.38	0.29
Cobbossee Rd	145	1.1-Yr	55.00	183.60	187.40		187.44	0.000850	1.42	38.74	18.64	0.17
Cobbossee Rd	145	2-Yr	110.00	183.60	188.23		188.26	0.000766	1.57	120.67	332.31	0.17
Cobbossee Rd	145	5-Yr	175.00	183.60	188.49		188.51	0.000653	1.54	215.80	384.07	0.16
Cobbossee Rd	145	10-Yr	220.00	183.60	188.60		188.63	0.000682	1.62	259.62	405.70	0.16
Cobbossee Rd	145	25-Yr	285.00	183.60	188.74		188.76	0.000716	1.71	316.46	432.14	0.17
Cobbossee Rd	145	50-Yr	335.00	183.60	188.83		188.86	0.000739	1.77	356.84	449.98	0.17
Cobbossee Rd	145	100-Yr	390.00	183.60	188.92		188.95	0.000759	1.82	399.05	467.91	0.18
Cobbossee Rd	145	200-Yr	450.00	183.60	189.01		189.04	0.000774	1.88	443.57	484.57	0.18
Cobbossee Rd	145	500-Yr	530.00	183.60	189.13		189.16	0.000785	1.93	499.85	495.10	0.18
Cobbossee Rd	245	1.1-Yr	55.00	183.71	187.48		187.51	0.000620	1.27	43.24	19.49	0.15
Cobbossee Rd	245	2-Yr	110.00	183.71	188.30		188.34	0.000874	1.77	82.61	115.52	0.19
Cobbossee Rd	245	5-Yr	175.00	183.71	188.54		188.63	0.001495	2.45	114.80	145.67	0.25
Cobbossee Rd	245	10-Yr	220.00	183.71	188.65		188.76	0.001997	2.89	130.61	158.39	0.29
Cobbossee Rd	245	25-Yr	285.00	183.71	188.77		188.93	0.002755	3.48	150.72	173.22	0.34
Cobbossee Rd	245	50-Yr	335.00	183.71	188.85		189.04	0.003356	3.90	164.57	182.74	0.37
Cobbossee Rd	245	100-Yr	390.00	183.71	188.92		189.16	0.004033	4.34	178.55	191.87	0.41
Cobbossee Rd	245	200-Yr	450.00	183.71	188.99		189.28	0.004784	4.79	192.68	200.67	0.45
Cobbossee Rd	245	500-Yr	530.00	183.71	189.08		189.42	0.005816	5.37	209.72	210.99	0.50
Cobbossee Rd	320	1.1-Yr	55.00	183.80	187.53		187.55	0.000523	1.14	48.06	22.75	0.14
Cobbossee Rd	320	2-Yr	110.00	183.80	188.36		188.40	0.000673	1.56	93.19	116.72	0.16
Cobbossee Rd	320	5-Yr	175.00	183.80	188.66		188.72	0.001078	2.11	133.28	154.42	0.21
Cobbossee Rd	320	10-Yr	220.00	183.80	188.81		188.89	0.001360	2.44	156.93	172.85	0.24
Cobbossee Rd	320	25-Yr	285.00	183.80	188.99		189.09	0.001717	2.85	190.70	196.18	0.27
Cobbossee Rd	320	50-Yr	335.00	183.80	189.12		189.24	0.001950	3.11	216.73	212.35	0.29
Cobbossee Rd	320	100-Yr	390.00	183.80	189.25		189.38	0.002165	3.35	245.61	228.95	0.31
Cobbossee Rd	320	200-Yr	450.00	183.80	189.38		189.53	0.002354	3.58	277.56	246.01	0.32
Cobbossee Rd	320	500-Yr	530.00	183.80	189.55		189.71	0.002545	3.83	320.85	267.39	0.34
Cobbossee Rd	370	1.1-Yr	55.00	183.58	187.56		187.59	0.001013	1.50	36.68	18.48	0.19
Cobbossee Rd	370	2-Yr	110.00	183.58	188.39		188.46	0.001536	2.03	54.14	23.78	0.24
Cobbossee Rd	370	5-Yr	175.00	183.58	188.70		188.82	0.002833	2.83	61.77	26.16	0.33
Cobbossee Rd	370	10-Yr	220.00	183.58	188.85		189.02	0.003852	3.35	65.71	27.31	0.38
Cobbossee Rd	370	25-Yr	285.00	183.58	189.03		189.28	0.005353	4.03	71.50	66.77	0.45
Cobbossee Rd	370	50-Yr	335.00	183.58	189.14	187.77	189.45	0.006266	4.50	82.67	123.68	0.49
Cobbossee Rd	370	100-Yr	390.00	183.58	189.26	188.05	189.63	0.007070	4.92	101.14	182.28	0.53
Cobbossee Rd	370	200-Yr	450.00	183.58	189.39	188.32	189.80	0.007582	5.26	129.19	245.86	0.55
Cobbossee Rd	370	500-Yr	530.00	183.58	189.58	188.66	189.99	0.007524	5.47	182.83	335.40	0.55
Cobbossee Rd	410	1.1-Yr	55.00	184.55	187.60		187.61	0.000178	0.75	72.90	30.49	0.08
Cobbossee Rd	410	2-Yr	110.00	184.55	188.47		188.49	0.000268	1.12	98.86	37.29	0.11
Cobbossee Rd	410	5-Yr	175.00	184.55	188.85		188.89	0.000474	1.59	110.49	105.26	0.15
Cobbossee Rd	410	10-Yr	220.00	184.55	189.05		189.11	0.000627	1.90	116.95	200.11	0.17
Cobbossee Rd	410	25-Yr	285.00	184.55	189.32		189.40	0.000844	2.30	125.61	235.21	0.20
Cobbossee Rd	410	50-Yr	335.00	184.55	189.50		189.60	0.001010	2.59	131.52	258.74	0.22
Cobbossee Rd	410	100-Yr	390.00	184.55	189.67		189.80	0.001199	2.90	137.24	281.53	0.24
Cobbossee Rd	410	200-Yr	450.00	184.55	189.83		189.99	0.001421	3.23	142.42	302.15	0.26
Cobbossee Rd	410	500-Yr	530.00	184.55	189.98		190.19	0.001773	3.68	147.30	321.57	0.30
Cobbossee Rd	460		Culvert									
Cobbossee Rd	515	1.1-Yr	55.00	184.34	187.67	185.21	187.68	0.000128	0.64	86.55	34.95	0.07
Cobbossee Rd	515	2-Yr	110.00	184.34	188.61	185.53	188.62	0.000179	0.91	124.26	93.00	0.09
Cobbossee Rd	515	5-Yr	175.00	184.34	189.13	185.83	189.15	0.000275	1.24	152.31	191.01	0.11
Cobbossee Rd	515	10-Yr	220.00	184.34	189.45	186.02	189.48	0.000324	1.42	173.38	260.37	0.12
Cobbossee Rd	515	25-Yr	285.00	184.34	189.90	186.26	189.94	0.000370	1.63	203.60	408.19	0.13
Cobbossee Rd	515	50-Yr	335.00	184.34	190.25	186.43	190.30	0.000389	1.75	226.67	551.68	0.14
Cobbossee Rd	515	100-Yr	390.00	184.34	190.63	186.60	190.68	0.000399	1.87	252.08	617.95	0.14
Cobbossee Rd	515	200-Yr	450.00	184.34	191.06	186.79	191.11	0.000400	1.97	280.08	690.97	0.14

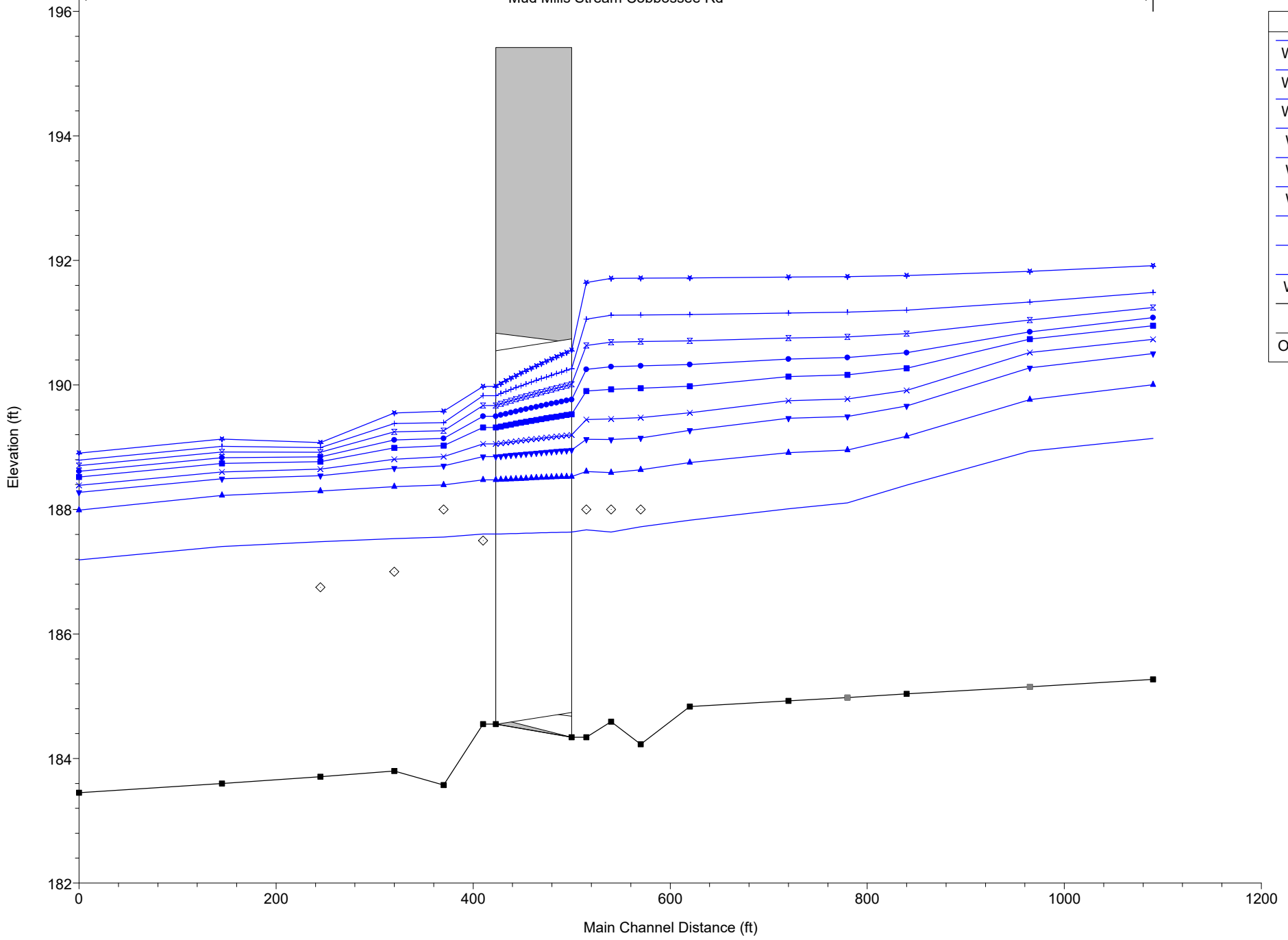
HEC-RAS Plan: EC\_CM River: Mud Mills Stream Reach: Cobbossee Rd (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	515	500-Yr	530.00	184.34	191.65	187.02	191.71	0.000386	2.06	319.01	792.50	0.14
Cobbossee Rd	540	1.1-Yr	55.00	184.59	187.64		187.71	0.002278	2.07	26.52	15.04	0.28
Cobbossee Rd	540	2-Yr	110.00	184.59	188.59		188.65	0.001357	2.07	112.52	160.33	0.23
Cobbossee Rd	540	5-Yr	175.00	184.59	189.12		189.17	0.001098	2.10	210.30	217.07	0.21
Cobbossee Rd	540	10-Yr	220.00	184.59	189.45		189.49	0.000920	2.06	291.90	277.47	0.19
Cobbossee Rd	540	25-Yr	285.00	184.59	189.93		189.95	0.000664	1.90	444.26	364.38	0.17
Cobbossee Rd	540	50-Yr	335.00	184.59	190.29		190.31	0.000457	1.67	684.00	738.53	0.14
Cobbossee Rd	540	100-Yr	390.00	184.59	190.69		190.70	0.000279	1.39	980.42	760.62	0.11
Cobbossee Rd	540	200-Yr	450.00	184.59	191.12		191.12	0.000177	1.17	1312.89	784.65	0.09
Cobbossee Rd	540	500-Yr	530.00	184.59	191.71		191.72	0.000105	0.97	1788.62	817.81	0.07
Cobbossee Rd	570	1.1-Yr	55.00	184.23	187.72		187.78	0.002291	1.88	29.29	19.80	0.27
Cobbossee Rd	570	2-Yr	110.00	184.23	188.64		188.71	0.002727	2.13	51.62	117.24	0.30
Cobbossee Rd	570	5-Yr	175.00	184.23	189.15		189.23	0.003102	2.36	91.40	205.05	0.33
Cobbossee Rd	570	10-Yr	220.00	184.23	189.48		189.54	0.002092	2.20	168.96	271.10	0.28
Cobbossee Rd	570	25-Yr	285.00	184.23	189.95		189.99	0.001145	1.88	322.18	379.54	0.21
Cobbossee Rd	570	50-Yr	335.00	184.23	190.31		190.33	0.000661	1.56	574.35	771.06	0.17
Cobbossee Rd	570	100-Yr	390.00	184.23	190.70		190.71	0.000355	1.25	881.33	801.84	0.12
Cobbossee Rd	570	200-Yr	450.00	184.23	191.12		191.13	0.000205	1.04	1231.15	835.53	0.10
Cobbossee Rd	570	500-Yr	530.00	184.23	191.71		191.72	0.000112	0.85	1739.35	882.19	0.07
Cobbossee Rd	620	1.1-Yr	55.00	184.83	187.83		187.88	0.001848	1.80	30.59	19.05	0.25
Cobbossee Rd	620	2-Yr	110.00	184.83	188.75		188.82	0.002019	2.13	51.56	26.71	0.27
Cobbossee Rd	620	5-Yr	175.00	184.83	189.27		189.38	0.002403	2.61	77.10	109.44	0.30
Cobbossee Rd	620	10-Yr	220.00	184.83	189.55		189.66	0.002326	2.78	119.58	193.10	0.31
Cobbossee Rd	620	25-Yr	285.00	184.83	189.98		190.07	0.001740	2.66	230.52	333.27	0.27
Cobbossee Rd	620	50-Yr	335.00	184.83	190.33		190.37	0.001004	2.17	468.55	731.20	0.21
Cobbossee Rd	620	100-Yr	390.00	184.83	190.71		190.73	0.000528	1.69	754.86	767.31	0.15
Cobbossee Rd	620	200-Yr	450.00	184.83	191.13		191.14	0.000293	1.36	1087.36	807.22	0.12
Cobbossee Rd	620	500-Yr	530.00	184.83	191.72		191.73	0.000153	1.07	1578.46	862.80	0.09
Cobbossee Rd	720	1.1-Yr	55.00	184.93	188.01		188.03	0.001314	1.24	44.52	39.84	0.20
Cobbossee Rd	720	2-Yr	110.00	184.93	188.91		188.94	0.000654	1.28	114.56	115.68	0.16
Cobbossee Rd	720	5-Yr	175.00	184.93	189.46		189.49	0.000620	1.47	191.02	161.66	0.16
Cobbossee Rd	720	10-Yr	220.00	184.93	189.75		189.78	0.000626	1.58	242.39	216.53	0.16
Cobbossee Rd	720	25-Yr	285.00	184.93	190.14		190.17	0.000561	1.62	383.32	567.90	0.16
Cobbossee Rd	720	50-Yr	335.00	184.93	190.41		190.44	0.000454	1.54	545.93	594.64	0.14
Cobbossee Rd	720	100-Yr	390.00	184.93	190.75		190.77	0.000333	1.41	752.56	626.96	0.13
Cobbossee Rd	720	200-Yr	450.00	184.93	191.16		191.17	0.000231	1.25	1012.29	665.37	0.11
Cobbossee Rd	720	500-Yr	530.00	184.93	191.73		191.74	0.000144	1.07	1411.98	720.48	0.09
Cobbossee Rd	780.00*	1.1-Yr	55.00	184.98	188.11		188.18	0.004070	2.12	25.89	22.87	0.35
Cobbossee Rd	780.00*	2-Yr	110.00	184.98	188.95		189.02	0.003167	2.12	51.83	38.54	0.32
Cobbossee Rd	780.00*	5-Yr	175.00	184.98	189.49		189.57	0.002465	2.32	92.33	117.79	0.30
Cobbossee Rd	780.00*	10-Yr	220.00	184.98	189.78		189.86	0.002183	2.40	132.07	160.89	0.29
Cobbossee Rd	780.00*	25-Yr	285.00	184.98	190.16		190.23	0.001611	2.30	250.05	460.15	0.26
Cobbossee Rd	780.00*	50-Yr	335.00	184.98	190.44		190.49	0.001159	2.09	384.68	510.61	0.22
Cobbossee Rd	780.00*	100-Yr	390.00	184.98	190.77		190.80	0.000750	1.82	560.07	543.50	0.18
Cobbossee Rd	780.00*	200-Yr	450.00	184.98	191.17		191.19	0.000467	1.55	783.27	582.67	0.15
Cobbossee Rd	780.00*	500-Yr	530.00	184.98	191.74		191.75	0.000261	1.28	1132.47	639.17	0.11
Cobbossee Rd	840	1.1-Yr	55.00	185.04	188.39		188.53	0.007958	3.00	18.32	14.89	0.48
Cobbossee Rd	840	2-Yr	110.00	185.04	189.18		189.33	0.007834	3.18	34.59	26.65	0.49
Cobbossee Rd	840	5-Yr	175.00	185.04	189.66		189.86	0.008369	3.54	49.39	34.45	0.52
Cobbossee Rd	840	10-Yr	220.00	185.04	189.91		190.13	0.008639	3.76	58.56	38.50	0.54
Cobbossee Rd	840	25-Yr	285.00	185.04	190.27	189.44	190.42	0.005413	3.36	166.01	403.04	0.44
Cobbossee Rd	840	50-Yr	335.00	185.04	190.52		190.61	0.003303	2.86	270.61	428.95	0.35
Cobbossee Rd	840	100-Yr	390.00	185.04	190.82		190.88	0.001891	2.37	406.76	460.50	0.27
Cobbossee Rd	840	200-Yr	450.00	185.04	191.20		191.23	0.001050	1.95	587.42	499.29	0.21
Cobbossee Rd	840	500-Yr	530.00	185.04	191.76		191.77	0.000520	1.55	881.47	556.69	0.15
Cobbossee Rd	965.00*	1.1-Yr	55.00	185.15	188.94		188.98	0.002028	1.73	31.72	22.09	0.26
Cobbossee Rd	965.00*	2-Yr	110.00	185.15	189.76		189.82	0.002294	1.99	55.17	34.87	0.28
Cobbossee Rd	965.00*	5-Yr	175.00	185.15	190.27		190.35	0.002186	2.23	110.27	209.91	0.28
Cobbossee Rd	965.00*	10-Yr	220.00	185.15	190.52		190.59	0.001924	2.26	171.33	283.60	0.27
Cobbossee Rd	965.00*	25-Yr	285.00	185.15	190.73		190.81	0.001962	2.43	238.37	346.39	0.28
Cobbossee Rd	965.00*	50-Yr	335.00	185.15	190.85		190.93	0.002052	2.57	280.67	368.71	0.29
Cobbossee Rd	965.00*	100-Yr	390.00	185.15	191.04		191.11	0.001801	2.53	352.32	387.74	0.27
Cobbossee Rd	965.00*	200-Yr	450.00	185.15	191.33		191.38	0.001311	2.31	468.82	416.83	0.24

HEC-RAS Plan: EC\_CM River: Mud Mills Stream Reach: Cobbossee Rd (Continued)

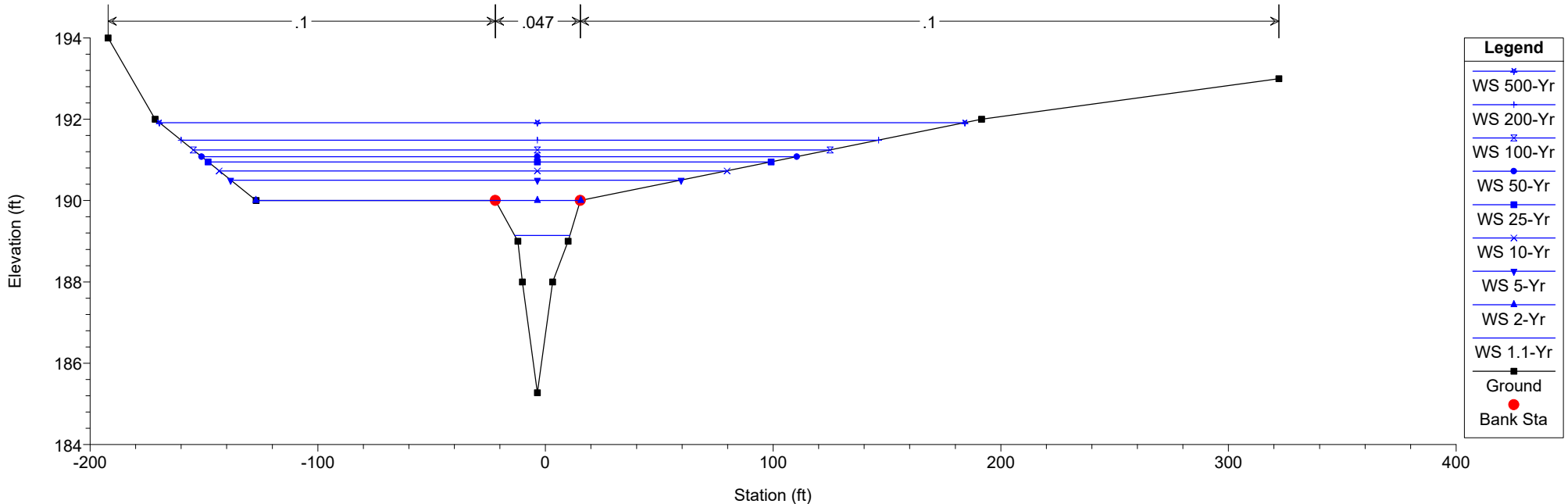
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	965.00*	500-Yr	530.00	185.15	191.82		191.85	0.000757	1.94	686.97	468.37	0.18
Cobbossee Rd	1090	1.1-Yr	55.00	185.27	189.14		189.17	0.001145	1.41	38.93	24.24	0.20
Cobbossee Rd	1090	2-Yr	110.00	185.27	190.00		190.05	0.001406	1.68	65.84	142.77	0.22
Cobbossee Rd	1090	5-Yr	175.00	185.27	190.50		190.55	0.001214	1.84	150.89	197.85	0.22
Cobbossee Rd	1090	10-Yr	220.00	185.27	190.73		190.78	0.001196	1.95	198.96	223.04	0.22
Cobbossee Rd	1090	25-Yr	285.00	185.27	190.95		191.01	0.001309	2.16	250.73	247.32	0.23
Cobbossee Rd	1090	50-Yr	335.00	185.27	191.08		191.14	0.001428	2.33	283.41	261.49	0.24
Cobbossee Rd	1090	100-Yr	390.00	185.27	191.24		191.31	0.001446	2.43	327.99	279.67	0.25
Cobbossee Rd	1090	200-Yr	450.00	185.27	191.49		191.55	0.001288	2.42	398.84	306.34	0.24
Cobbossee Rd	1090	500-Yr	530.00	185.27	191.92		191.96	0.000932	2.23	540.85	353.79	0.21

Mud Mills Stream Cobbossee Rd

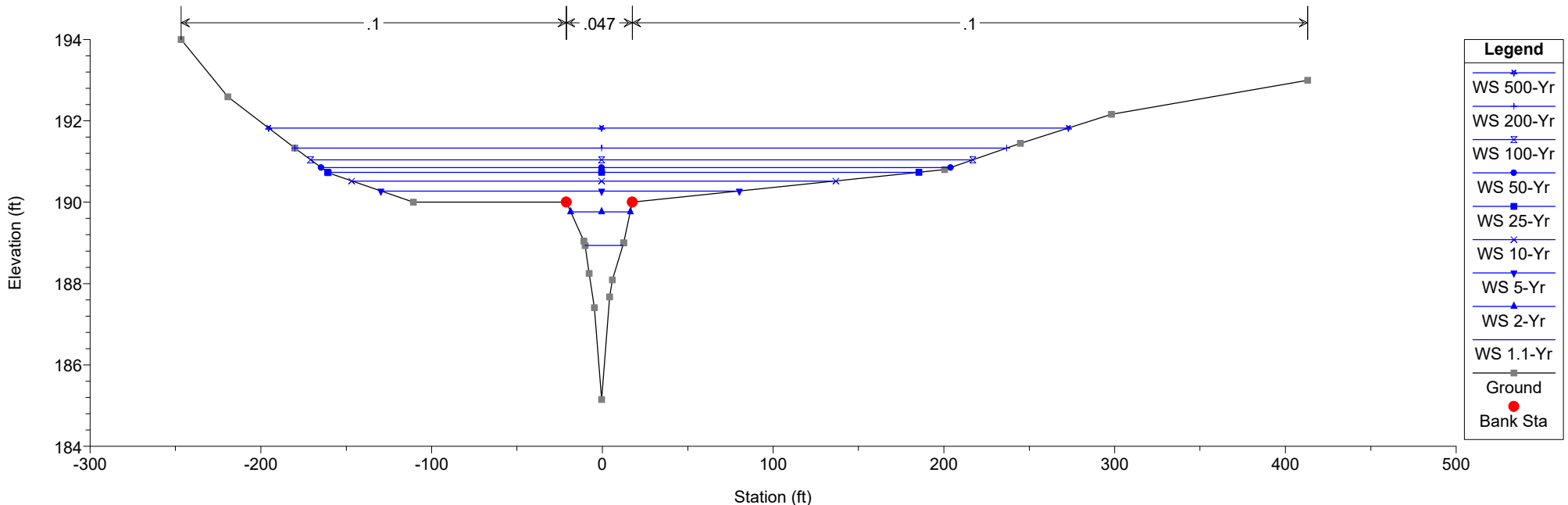


Legend	
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WS 25-Yr	■
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WS 5-Yr	▼
WS 2-Yr	▲
WS 1.1-Yr	■
Ground	■
OWS 1.1-Yr	◇

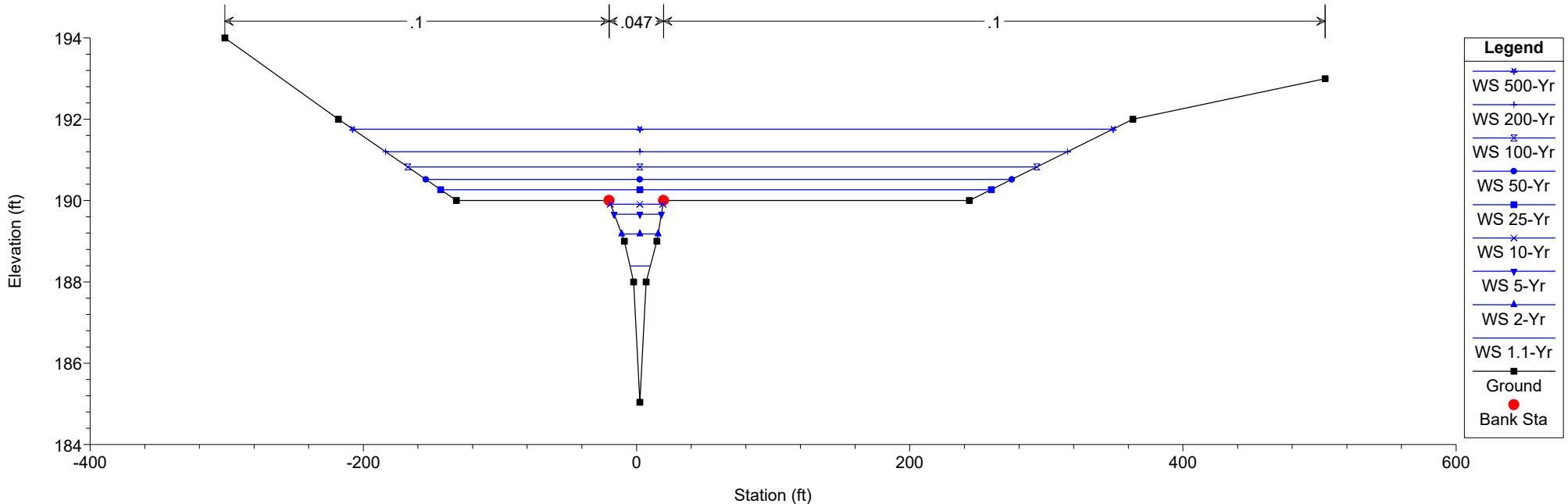
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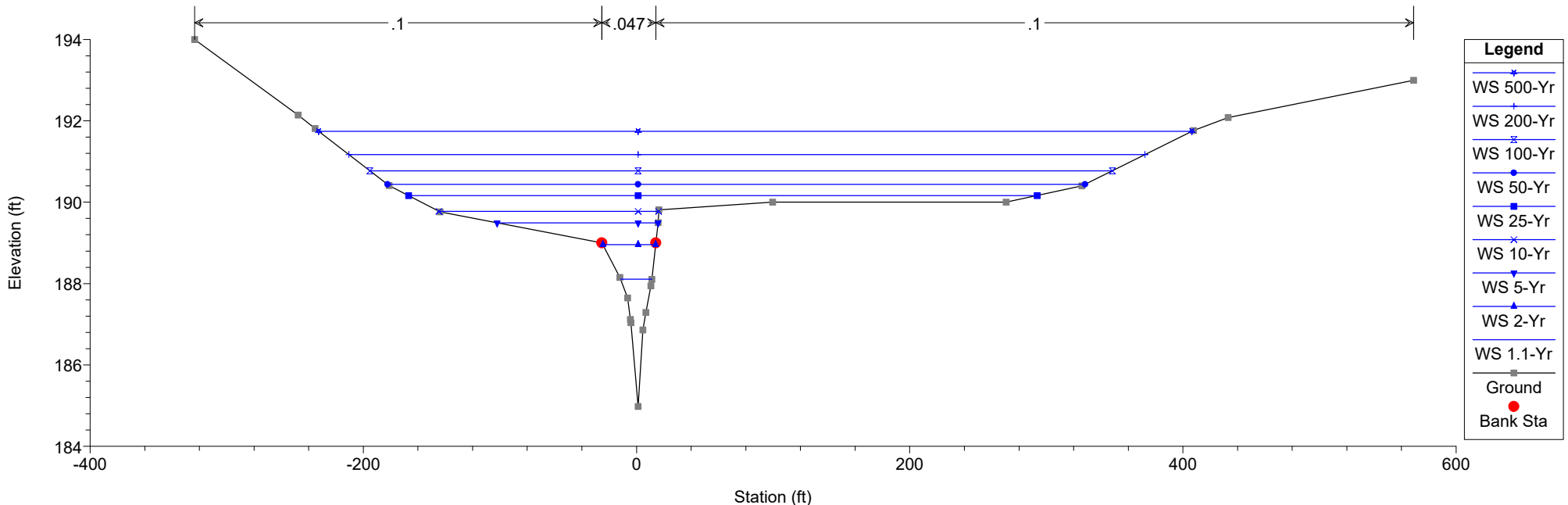
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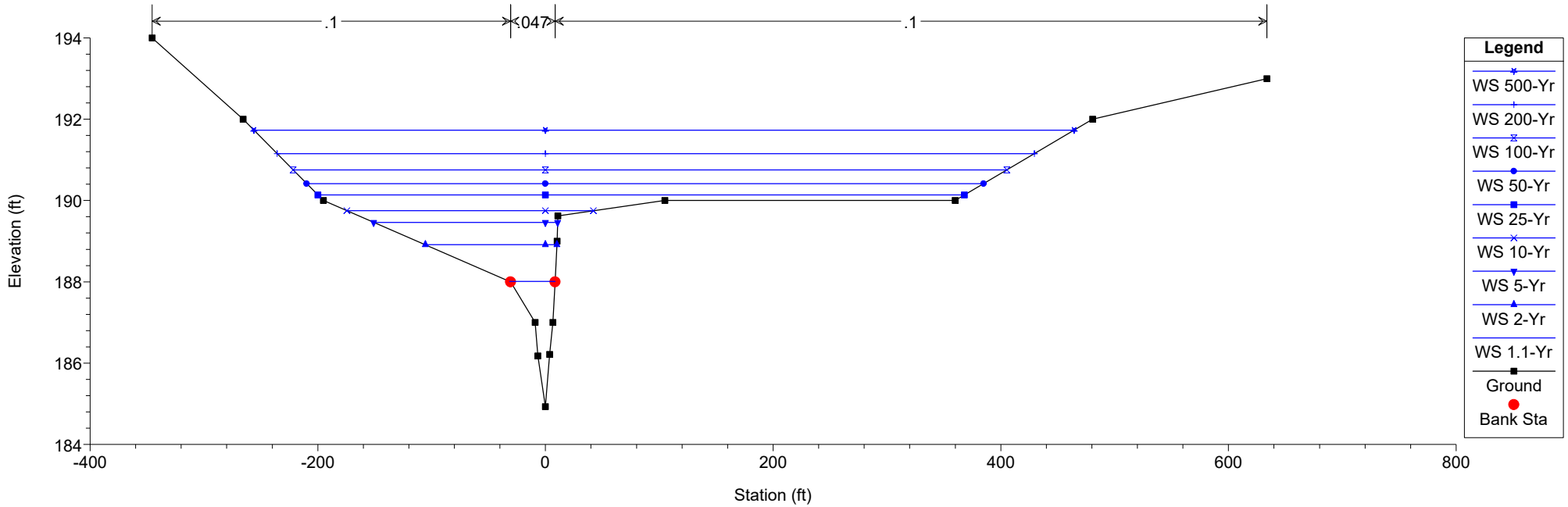
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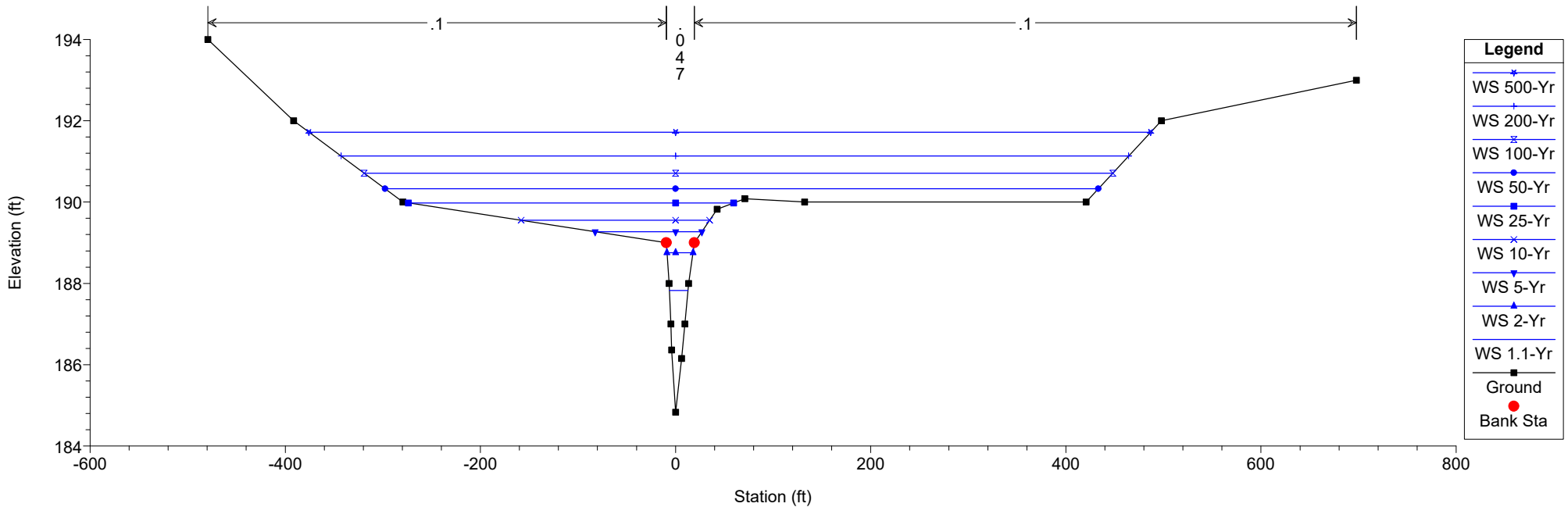
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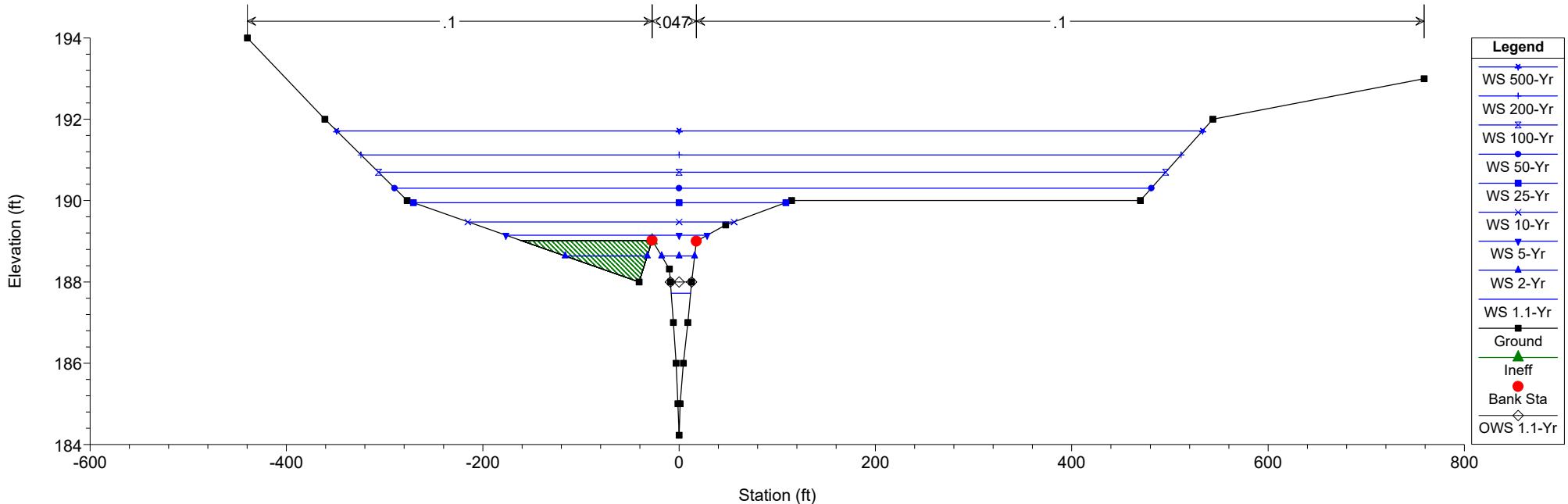
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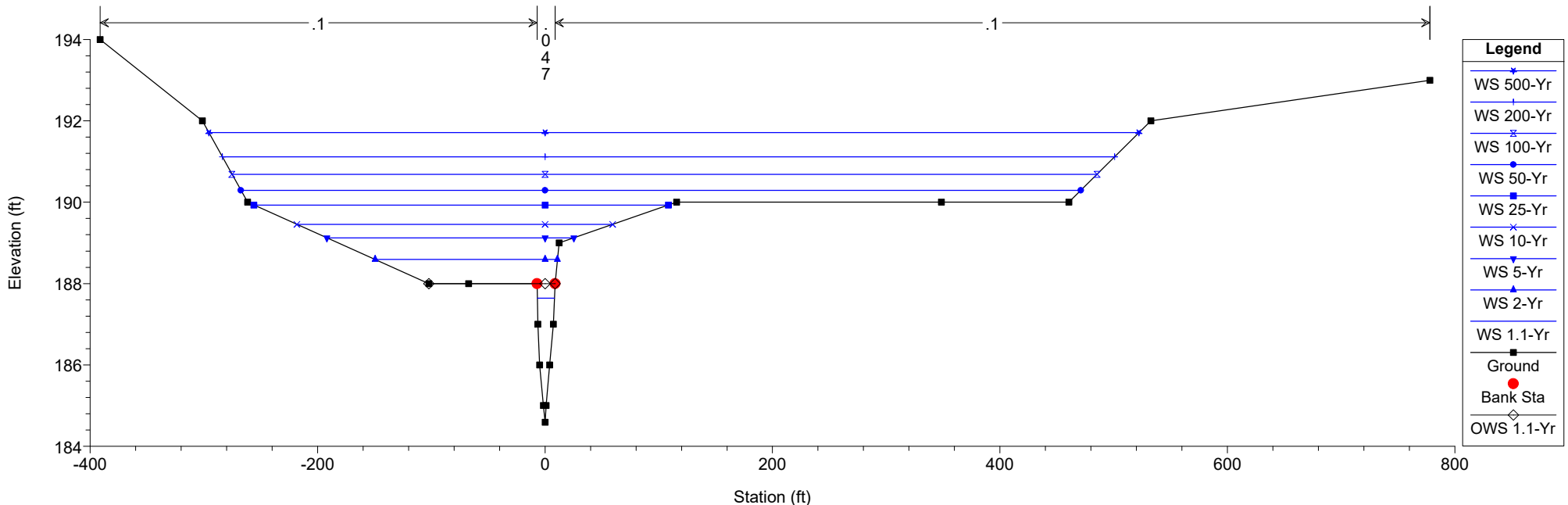


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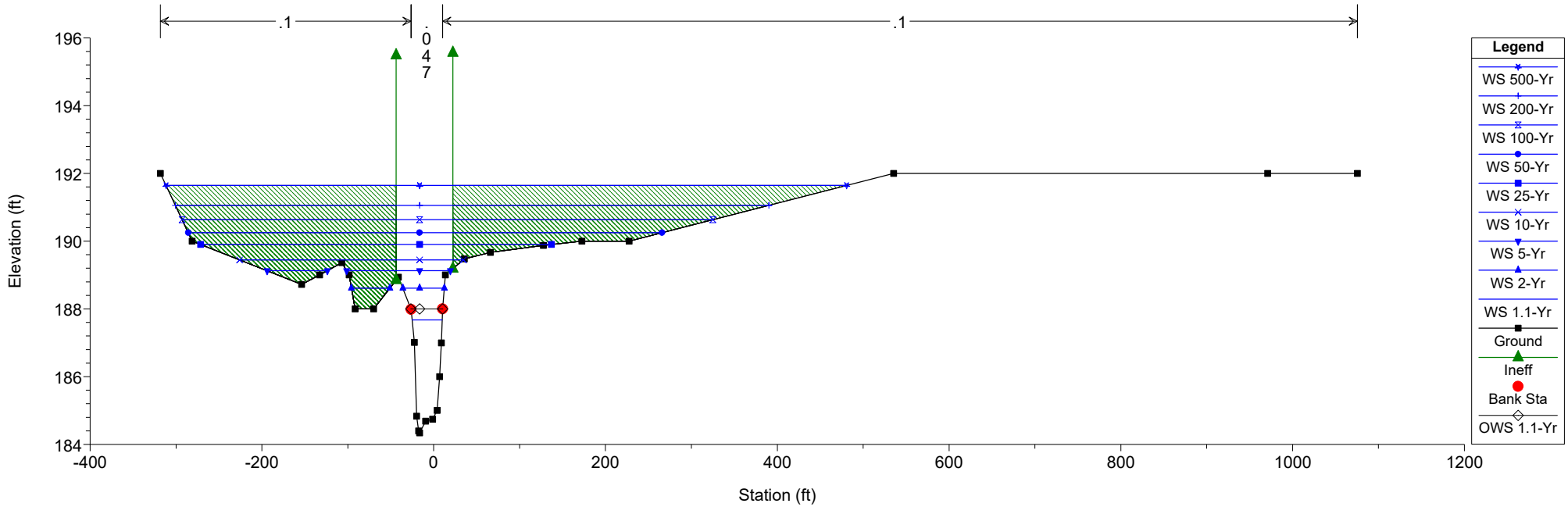
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  - WS 10-Yr
  - WS 5-Yr
  - WS 2-Yr
  - WS 1.1-Yr
  - Ground
  - Ineff
  - Bank Sta
  - OWS 1.1-Yr

67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Existing Conditions\_Calibration\_Max 9/6/2024

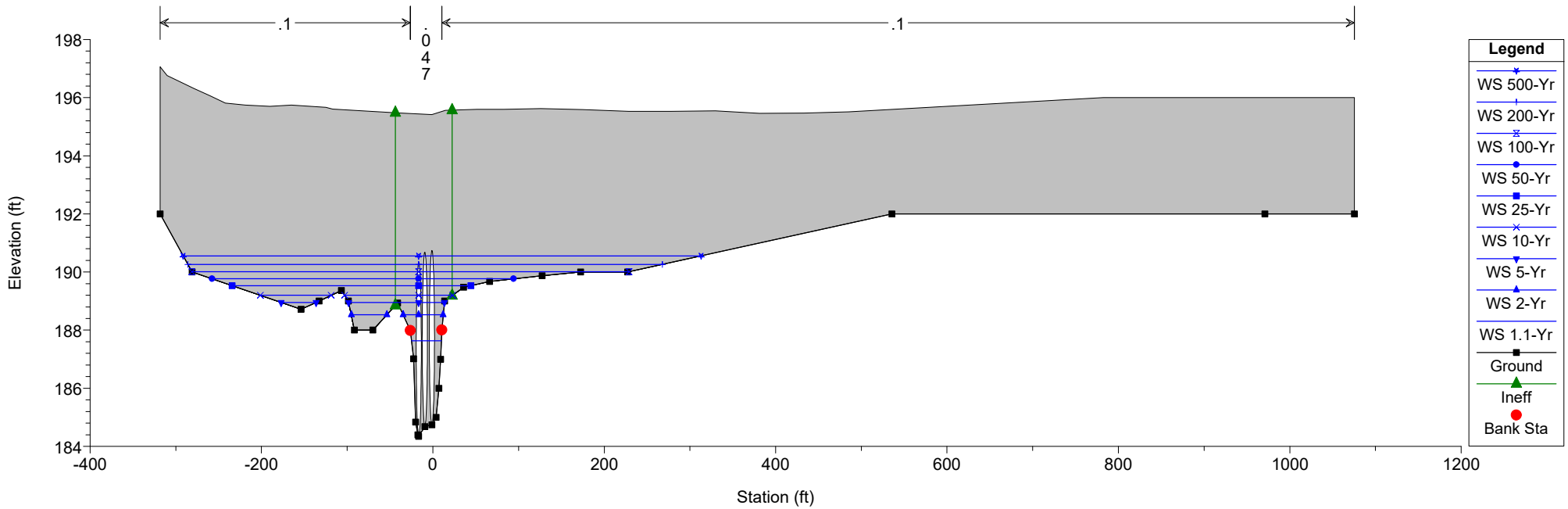


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  - WS 1.1-Yr
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  - OWS 1.1-Yr

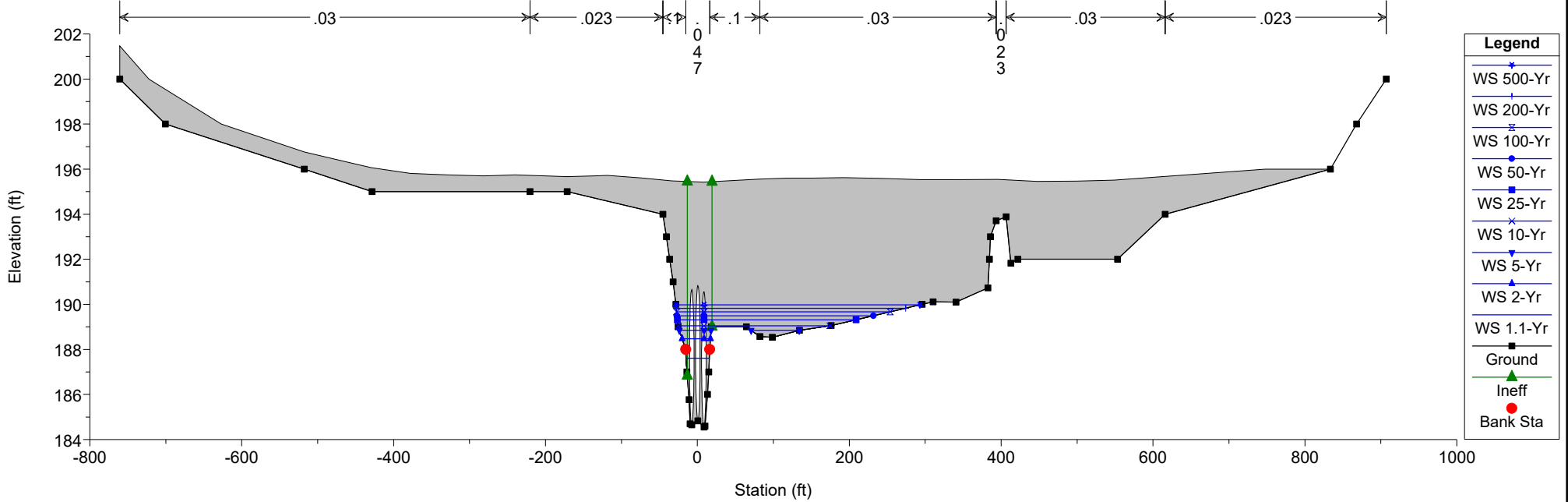
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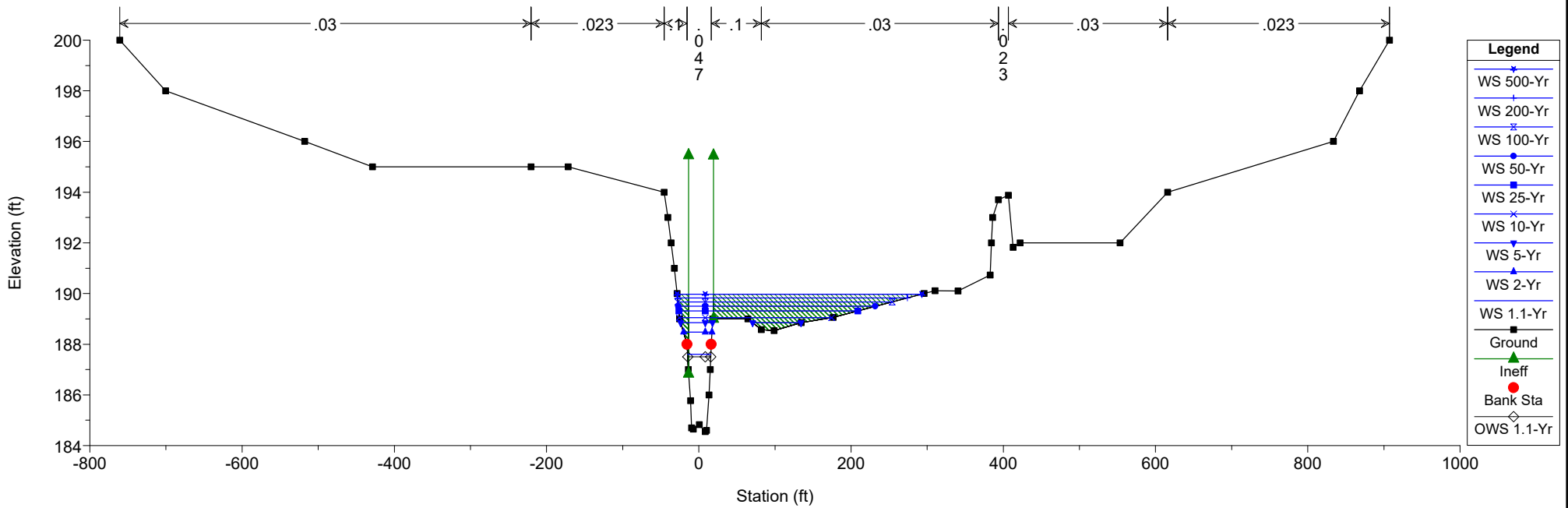
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Cobbosee Rd



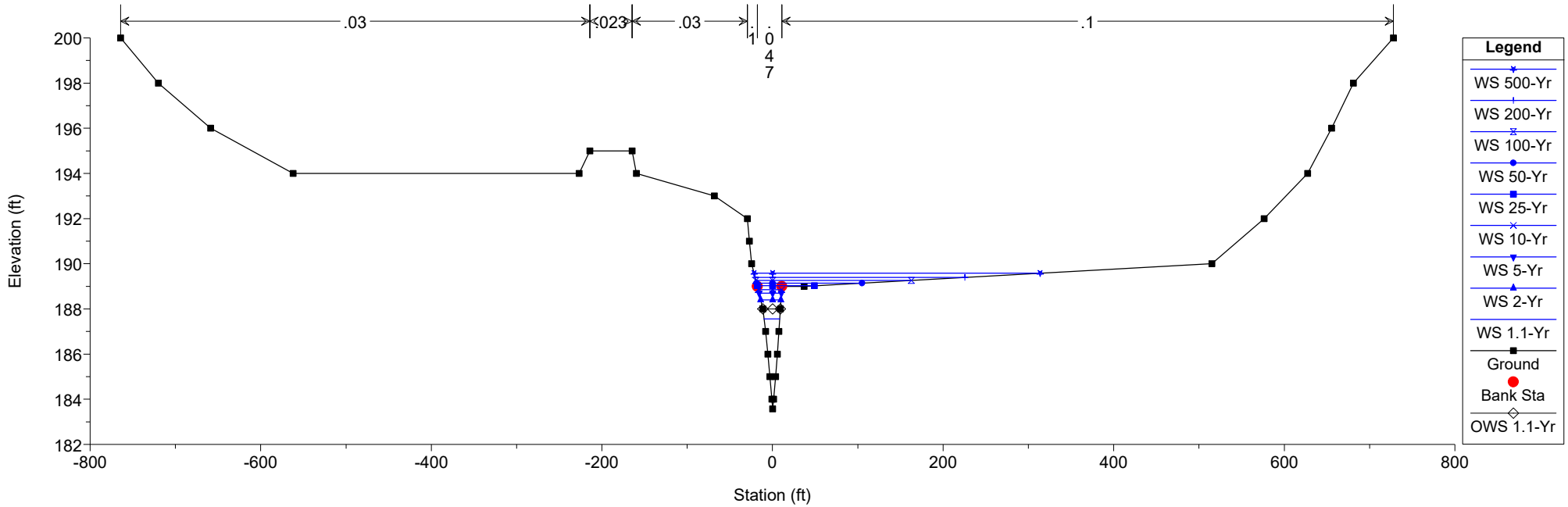
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Cobbossee Rd



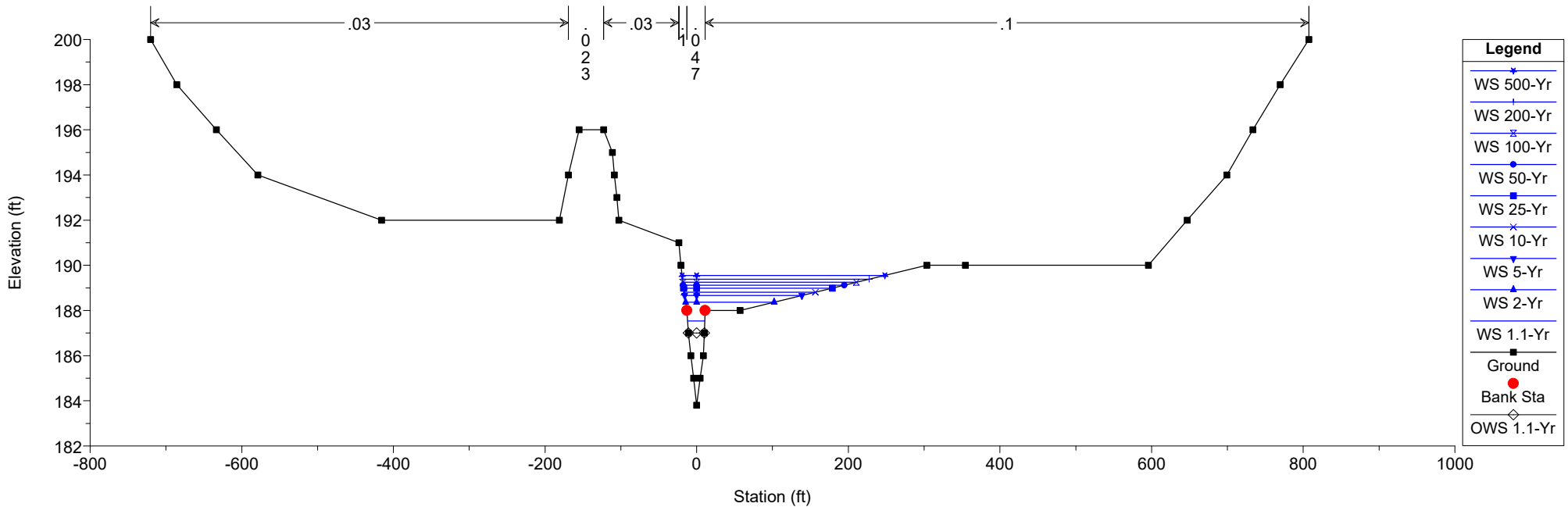
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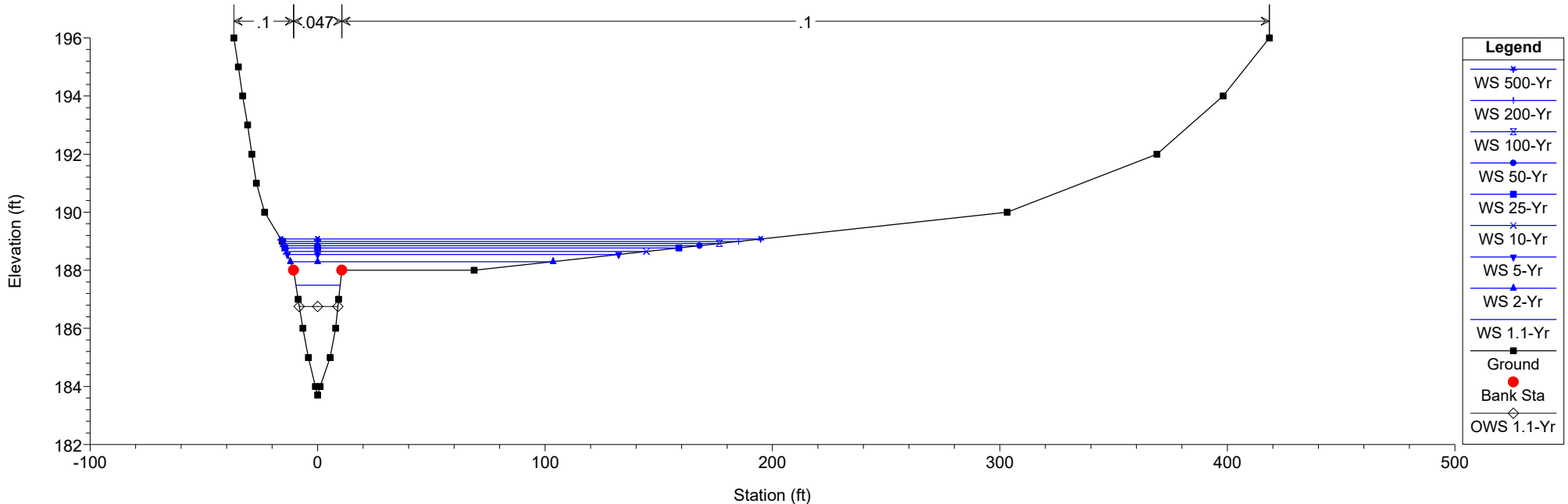
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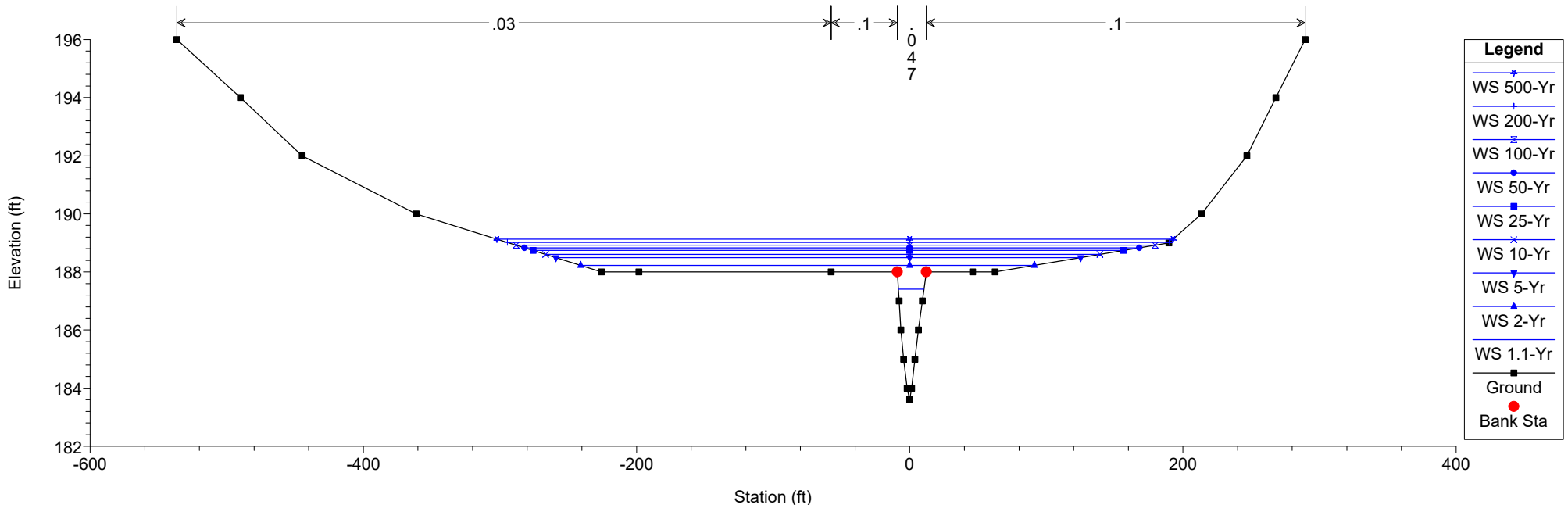
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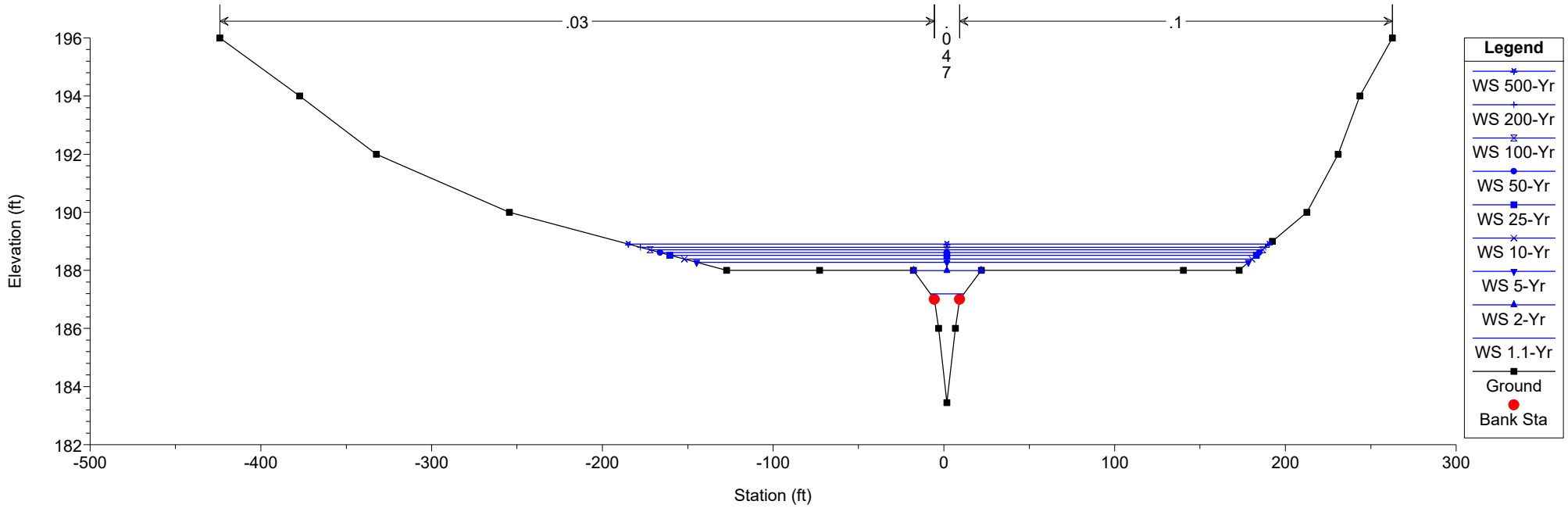
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67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Existing Conditions\_Calibration\_Max 9/6/2024



67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Existing Conditions\_Calibration\_Max 9/6/2024



# APPENDIX D

Proposed HEC-RAS Analysis

# Proposed 22' Span HEC-RAS Analysis

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	0	1.1-Yr	55.00	183.45	187.19	185.63	187.25	0.001973	1.99	28.09	19.57	0.26
Cobbossee Rd	0	2-Yr	110.00	183.45	187.99	186.36	188.08	0.001974	2.52	51.60	39.42	0.27
Cobbossee Rd	0	5-Yr	175.00	183.45	188.28	186.92	188.36	0.001973	2.69	137.88	323.09	0.28
Cobbossee Rd	0	10-Yr	220.00	183.45	188.39	187.31	188.46	0.001971	2.76	174.47	332.37	0.28
Cobbossee Rd	0	25-Yr	285.00	183.45	188.52	187.75	188.59	0.001971	2.84	220.00	343.56	0.28
Cobbossee Rd	0	50-Yr	335.00	183.45	188.61	188.33	188.68	0.001972	2.89	251.40	351.07	0.28
Cobbossee Rd	0	100-Yr	390.00	183.45	188.70	188.39	188.77	0.001971	2.95	283.64	358.62	0.28
Cobbossee Rd	0	200-Yr	450.00	183.45	188.79	188.43	188.87	0.001970	3.00	316.58	366.18	0.28
Cobbossee Rd	0	500-Yr	530.00	183.45	188.90	188.50	188.98	0.001972	3.06	357.66	375.39	0.29
Cobbossee Rd	145	1.1-Yr	55.00	183.60	187.40		187.44	0.000850	1.42	38.74	18.64	0.17
Cobbossee Rd	145	2-Yr	110.00	183.60	188.23		188.26	0.000766	1.57	120.67	332.30	0.17
Cobbossee Rd	145	5-Yr	175.00	183.60	188.49		188.51	0.000653	1.54	215.76	384.05	0.16
Cobbossee Rd	145	10-Yr	220.00	183.60	188.60		188.63	0.000682	1.62	259.53	405.65	0.16
Cobbossee Rd	145	25-Yr	285.00	183.60	188.74		188.76	0.000717	1.71	316.41	432.12	0.17
Cobbossee Rd	145	50-Yr	335.00	183.60	188.83		188.85	0.000740	1.77	356.51	449.84	0.17
Cobbossee Rd	145	100-Yr	390.00	183.60	188.92		188.95	0.000759	1.82	399.01	467.89	0.18
Cobbossee Rd	145	200-Yr	450.00	183.60	189.01		189.04	0.000777	1.88	442.95	484.45	0.18
Cobbossee Rd	145	500-Yr	530.00	183.60	189.13		189.16	0.000787	1.94	499.31	495.00	0.18
Cobbossee Rd	245	1.1-Yr	55.00	183.71	187.48		187.51	0.000620	1.27	43.24	19.49	0.15
Cobbossee Rd	245	2-Yr	110.00	183.71	188.30		188.34	0.000874	1.77	82.61	115.52	0.19
Cobbossee Rd	245	5-Yr	175.00	183.71	188.54		188.63	0.001495	2.45	114.78	145.65	0.25
Cobbossee Rd	245	10-Yr	220.00	183.71	188.65		188.76	0.001998	2.89	130.58	158.37	0.29
Cobbossee Rd	245	25-Yr	285.00	183.71	188.77		188.93	0.002755	3.48	150.71	173.21	0.34
Cobbossee Rd	245	50-Yr	335.00	183.71	188.85		189.04	0.003359	3.90	164.46	182.67	0.37
Cobbossee Rd	245	100-Yr	390.00	183.71	188.92		189.16	0.004034	4.34	178.54	191.86	0.41
Cobbossee Rd	245	200-Yr	450.00	183.71	188.99		189.28	0.004792	4.79	192.47	200.55	0.45
Cobbossee Rd	245	500-Yr	530.00	183.71	189.07		189.42	0.005826	5.37	209.50	210.86	0.50
Cobbossee Rd	320	1.1-Yr	55.00	183.80	187.53		187.55	0.000523	1.14	48.06	22.75	0.14
Cobbossee Rd	320	2-Yr	110.00	183.80	188.36		188.40	0.000673	1.56	93.19	116.72	0.16
Cobbossee Rd	320	5-Yr	175.00	183.80	188.66		188.72	0.001078	2.11	133.27	154.41	0.21
Cobbossee Rd	320	10-Yr	220.00	183.80	188.81		188.89	0.001360	2.44	156.91	172.83	0.24
Cobbossee Rd	320	25-Yr	285.00	183.80	188.99		189.09	0.001718	2.85	190.69	196.18	0.27
Cobbossee Rd	320	50-Yr	335.00	183.80	189.12		189.24	0.001951	3.11	216.67	212.31	0.29
Cobbossee Rd	320	100-Yr	390.00	183.80	189.25		189.38	0.002165	3.35	245.61	228.94	0.31
Cobbossee Rd	320	200-Yr	450.00	183.80	189.38		189.53	0.002355	3.58	277.47	245.96	0.32
Cobbossee Rd	320	500-Yr	530.00	183.80	189.55		189.71	0.002546	3.83	320.78	267.36	0.34
Cobbossee Rd	370	1.1-Yr	55.00	183.58	187.56		187.59	0.001013	1.50	36.68	18.48	0.19
Cobbossee Rd	370	2-Yr	110.00	183.58	188.39		188.46	0.001536	2.03	54.14	23.78	0.24
Cobbossee Rd	370	5-Yr	175.00	183.58	188.70		188.82	0.002833	2.83	61.77	26.16	0.33
Cobbossee Rd	370	10-Yr	220.00	183.58	188.85		189.02	0.003853	3.35	65.70	27.31	0.38
Cobbossee Rd	370	25-Yr	285.00	183.58	189.03		189.28	0.005353	4.03	71.50	66.76	0.45
Cobbossee Rd	370	50-Yr	335.00	183.58	189.14	187.77	189.45	0.006268	4.50	82.64	123.56	0.49
Cobbossee Rd	370	100-Yr	390.00	183.58	189.26	188.05	189.63	0.007070	4.92	101.14	182.28	0.53
Cobbossee Rd	370	200-Yr	450.00	183.58	189.39	188.32	189.80	0.007587	5.26	129.10	245.68	0.55
Cobbossee Rd	370	500-Yr	530.00	183.58	189.58	188.66	189.99	0.007528	5.47	182.74	335.28	0.55
Cobbossee Rd	410	1.1-Yr	55.00	185.00	187.61		187.61	0.000140	0.69	79.37	48.33	0.08
Cobbossee Rd	410	2-Yr	110.00	185.00	188.48		188.49	0.000210	1.03	106.64	66.15	0.10
Cobbossee Rd	410	5-Yr	175.00	185.00	188.86		188.89	0.000374	1.48	118.48	142.19	0.13
Cobbossee Rd	410	10-Yr	220.00	185.00	189.06		189.11	0.000495	1.76	124.90	194.38	0.16
Cobbossee Rd	410	25-Yr	285.00	185.00	189.33		189.40	0.000669	2.14	133.29	231.51	0.18
Cobbossee Rd	410	50-Yr	335.00	185.00	189.51		189.60	0.000803	2.41	139.02	256.89	0.20
Cobbossee Rd	410	100-Yr	390.00	185.00	189.69		189.80	0.000955	2.70	144.61	281.62	0.22
Cobbossee Rd	410	200-Yr	450.00	185.00	189.85		189.99	0.001133	3.01	149.70	304.15	0.24
Cobbossee Rd	410	500-Yr	530.00	185.00	190.01		190.19	0.001411	3.43	154.61	325.82	0.27
Cobbossee Rd	460		Culvert									
Cobbossee Rd	515	1.1-Yr	55.00	185.10	187.61	185.67	187.62	0.000222	0.81	68.30	37.34	0.09
Cobbossee Rd	515	2-Yr	110.00	185.10	188.49	185.99	188.51	0.000300	1.16	94.59	99.26	0.12
Cobbossee Rd	515	5-Yr	175.00	185.10	188.88	186.30	188.92	0.000514	1.65	106.34	149.67	0.15
Cobbossee Rd	515	10-Yr	220.00	185.10	189.10	186.49	189.16	0.000666	1.95	112.87	195.30	0.18
Cobbossee Rd	515	25-Yr	285.00	185.10	189.39	186.72	189.48	0.000873	2.34	121.54	254.59	0.21
Cobbossee Rd	515	50-Yr	335.00	185.10	189.59	186.89	189.70	0.001025	2.63	127.61	294.75	0.22
Cobbossee Rd	515	100-Yr	390.00	185.10	189.80	187.06	189.93	0.001191	2.92	133.67	364.20	0.24
Cobbossee Rd	515	200-Yr	450.00	185.10	189.99	187.23	190.15	0.001378	3.23	139.42	447.86	0.26

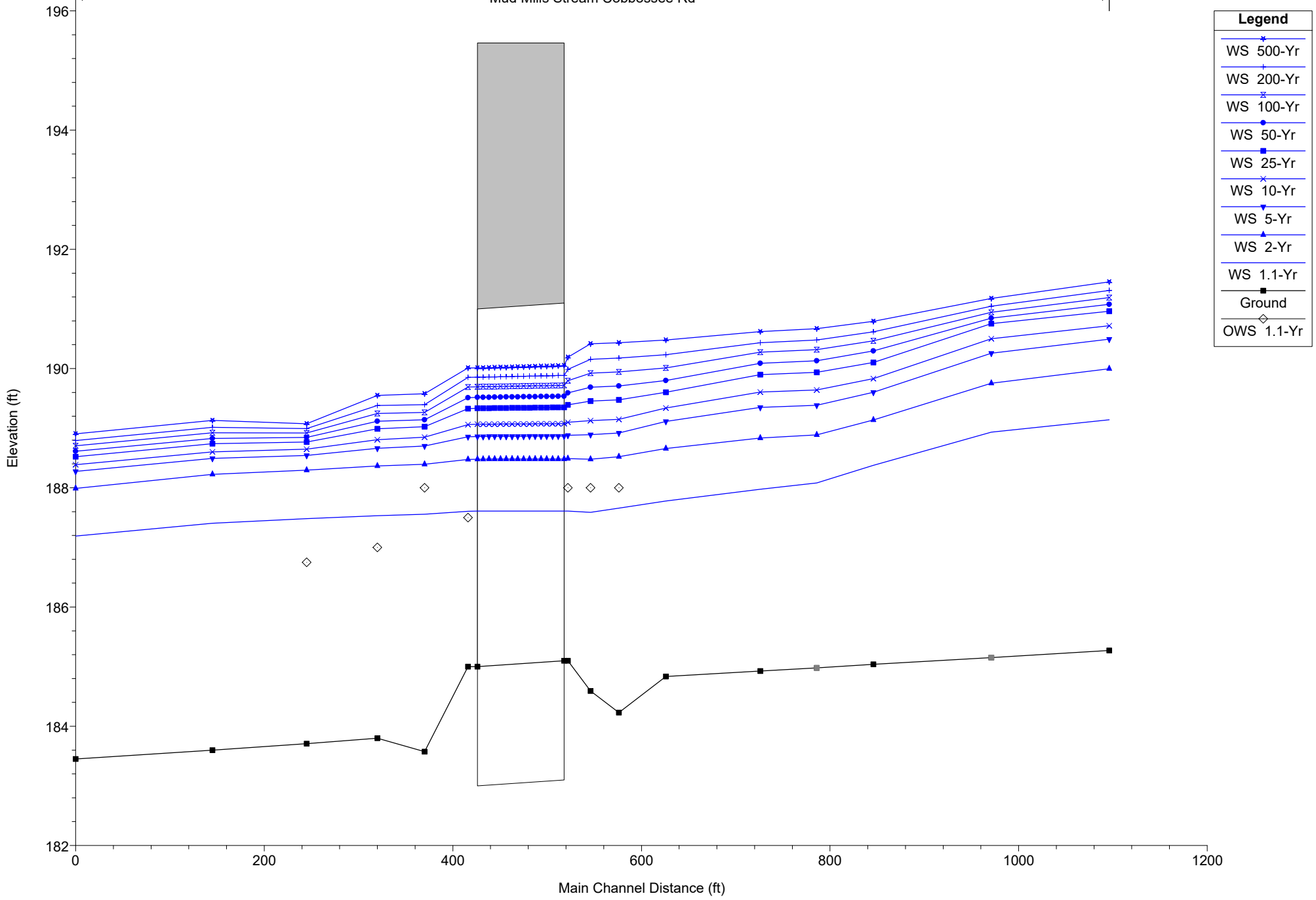
HEC-RAS Plan: A2CM River: Mud Mills Stream Reach: Cobbossee Rd (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	515	500-Yr	530.00	185.10	190.19	187.45	190.40	0.001657	3.64	145.52	541.57	0.29
Cobbossee Rd	540	1.1-Yr	55.00	184.59	187.59		187.65	0.002149	1.94	28.29	17.28	0.27
Cobbossee Rd	540	2-Yr	110.00	184.59	188.48		188.53	0.001451	2.05	99.62	153.16	0.23
Cobbossee Rd	540	5-Yr	175.00	184.59	188.89		188.95	0.001432	2.26	169.93	187.18	0.24
Cobbossee Rd	540	10-Yr	220.00	184.59	189.13		189.18	0.001393	2.35	217.03	219.16	0.24
Cobbossee Rd	540	25-Yr	285.00	184.59	189.45		189.50	0.001247	2.38	298.37	278.41	0.23
Cobbossee Rd	540	50-Yr	335.00	184.59	189.69		189.73	0.001132	2.37	368.24	320.69	0.22
Cobbossee Rd	540	100-Yr	390.00	184.59	189.92		189.96	0.001026	2.36	448.76	363.36	0.21
Cobbossee Rd	540	200-Yr	450.00	184.59	190.15		190.19	0.000915	2.31	588.60	730.76	0.20
Cobbossee Rd	540	500-Yr	530.00	184.59	190.41		190.44	0.000744	2.17	780.87	745.31	0.18
Cobbossee Rd	570	1.1-Yr	55.00	184.23	187.66		187.72	0.002572	1.96	28.05	19.37	0.29
Cobbossee Rd	570	2-Yr	110.00	184.23	188.52		188.60	0.003048	2.30	47.92	98.60	0.32
Cobbossee Rd	570	5-Yr	175.00	184.23	188.92		189.04	0.004906	2.81	62.27	162.53	0.41
Cobbossee Rd	570	10-Yr	220.00	184.23	189.15		189.28	0.004930	2.98	90.96	204.63	0.41
Cobbossee Rd	570	25-Yr	285.00	184.23	189.47		189.58	0.003524	2.85	168.54	270.74	0.36
Cobbossee Rd	570	50-Yr	335.00	184.23	189.71		189.80	0.002731	2.71	238.53	324.85	0.32
Cobbossee Rd	570	100-Yr	390.00	184.23	189.95		190.02	0.002152	2.57	321.63	379.21	0.29
Cobbossee Rd	570	200-Yr	450.00	184.23	190.18		190.24	0.001676	2.41	475.34	760.87	0.26
Cobbossee Rd	570	500-Yr	530.00	184.23	190.43		190.47	0.001197	2.17	673.98	781.18	0.22
Cobbossee Rd	620	1.1-Yr	55.00	184.83	187.78		187.83	0.002014	1.86	29.63	18.78	0.26
Cobbossee Rd	620	2-Yr	110.00	184.83	188.66		188.74	0.002291	2.24	49.00	25.85	0.29
Cobbossee Rd	620	5-Yr	175.00	184.83	189.11		189.24	0.003120	2.84	63.46	62.06	0.34
Cobbossee Rd	620	10-Yr	220.00	184.83	189.34		189.49	0.003397	3.16	84.98	129.11	0.36
Cobbossee Rd	620	25-Yr	285.00	184.83	189.60		189.78	0.003547	3.47	130.05	208.63	0.38
Cobbossee Rd	620	50-Yr	335.00	184.83	189.80		189.97	0.003386	3.56	176.80	267.15	0.37
Cobbossee Rd	620	100-Yr	390.00	184.83	190.01	188.69	190.17	0.003058	3.55	244.33	639.89	0.36
Cobbossee Rd	620	200-Yr	450.00	184.83	190.23		190.35	0.002333	3.25	399.96	722.28	0.32
Cobbossee Rd	620	500-Yr	530.00	184.83	190.48		190.55	0.001700	2.91	579.58	745.41	0.27
Cobbossee Rd	720	1.1-Yr	55.00	184.93	187.98		188.00	0.001429	1.27	43.16	38.34	0.21
Cobbossee Rd	720	2-Yr	110.00	184.93	188.84		188.86	0.000759	1.35	106.03	109.29	0.17
Cobbossee Rd	720	5-Yr	175.00	184.93	189.35		189.38	0.000752	1.57	172.87	152.03	0.18
Cobbossee Rd	720	10-Yr	220.00	184.93	189.61		189.64	0.000779	1.70	214.80	173.48	0.18
Cobbossee Rd	720	25-Yr	285.00	184.93	189.90		189.94	0.000833	1.88	278.34	265.82	0.19
Cobbossee Rd	720	50-Yr	335.00	184.93	190.09		190.13	0.000848	1.98	356.17	563.32	0.19
Cobbossee Rd	720	100-Yr	390.00	184.93	190.27		190.32	0.000803	2.00	463.62	581.26	0.19
Cobbossee Rd	720	200-Yr	450.00	184.93	190.43		190.48	0.000790	2.04	557.29	596.46	0.19
Cobbossee Rd	720	500-Yr	530.00	184.93	190.62		190.66	0.000776	2.10	670.69	614.36	0.19
Cobbossee Rd	780.00*	1.1-Yr	55.00	184.98	188.08		188.15	0.004302	2.18	25.29	22.47	0.36
Cobbossee Rd	780.00*	2-Yr	110.00	184.98	188.89		188.96	0.003592	2.23	49.25	37.27	0.34
Cobbossee Rd	780.00*	5-Yr	175.00	184.98	189.39		189.48	0.003091	2.50	80.61	100.71	0.33
Cobbossee Rd	780.00*	10-Yr	220.00	184.98	189.64		189.74	0.002869	2.63	111.55	141.18	0.33
Cobbossee Rd	780.00*	25-Yr	285.00	184.98	189.94		190.04	0.002655	2.78	161.96	225.30	0.32
Cobbossee Rd	780.00*	50-Yr	335.00	184.98	190.13		190.23	0.002410	2.79	234.69	453.56	0.31
Cobbossee Rd	780.00*	100-Yr	390.00	184.98	190.32		190.40	0.002092	2.73	323.52	490.43	0.29
Cobbossee Rd	780.00*	200-Yr	450.00	184.98	190.48		190.56	0.001907	2.71	404.86	514.50	0.28
Cobbossee Rd	780.00*	500-Yr	530.00	184.98	190.67		190.74	0.001732	2.70	503.43	533.10	0.27
Cobbossee Rd	840	1.1-Yr	55.00	185.04	188.38		188.52	0.008113	3.03	18.14	14.71	0.48
Cobbossee Rd	840	2-Yr	110.00	185.04	189.14		189.31	0.008396	3.28	33.58	26.03	0.51
Cobbossee Rd	840	5-Yr	175.00	185.04	189.60		189.81	0.009285	3.70	47.36	33.49	0.55
Cobbossee Rd	840	10-Yr	220.00	185.04	189.83		190.08	0.009875	3.96	55.53	37.21	0.57
Cobbossee Rd	840	25-Yr	285.00	185.04	190.10	189.44	190.36	0.009413	4.15	100.72	385.99	0.57
Cobbossee Rd	840	50-Yr	335.00	185.04	190.30	189.65	190.48	0.006792	3.80	177.53	405.98	0.49
Cobbossee Rd	840	100-Yr	390.00	185.04	190.47		190.61	0.005275	3.55	248.08	423.51	0.44
Cobbossee Rd	840	200-Yr	450.00	185.04	190.62		190.74	0.004469	3.43	312.45	438.89	0.41
Cobbossee Rd	840	500-Yr	530.00	185.04	190.79		190.90	0.003817	3.33	391.06	456.97	0.38
Cobbossee Rd	965.00*	1.1-Yr	55.00	185.15	188.93		188.98	0.002035	1.74	31.67	22.05	0.26
Cobbossee Rd	965.00*	2-Yr	110.00	185.15	189.75		189.82	0.002328	2.01	54.83	34.72	0.28
Cobbossee Rd	965.00*	5-Yr	175.00	185.15	190.26		190.33	0.002282	2.26	106.50	204.49	0.29
Cobbossee Rd	965.00*	10-Yr	220.00	185.15	190.50		190.57	0.002023	2.31	165.41	277.31	0.28
Cobbossee Rd	965.00*	25-Yr	285.00	185.15	190.76		190.82	0.001869	2.39	245.56	351.76	0.27
Cobbossee Rd	965.00*	50-Yr	335.00	185.15	190.84		190.92	0.002088	2.59	278.03	367.99	0.29
Cobbossee Rd	965.00*	100-Yr	390.00	185.15	190.94		191.03	0.002252	2.76	314.38	377.78	0.30
Cobbossee Rd	965.00*	200-Yr	450.00	185.15	191.05		191.14	0.002370	2.90	354.32	388.25	0.31

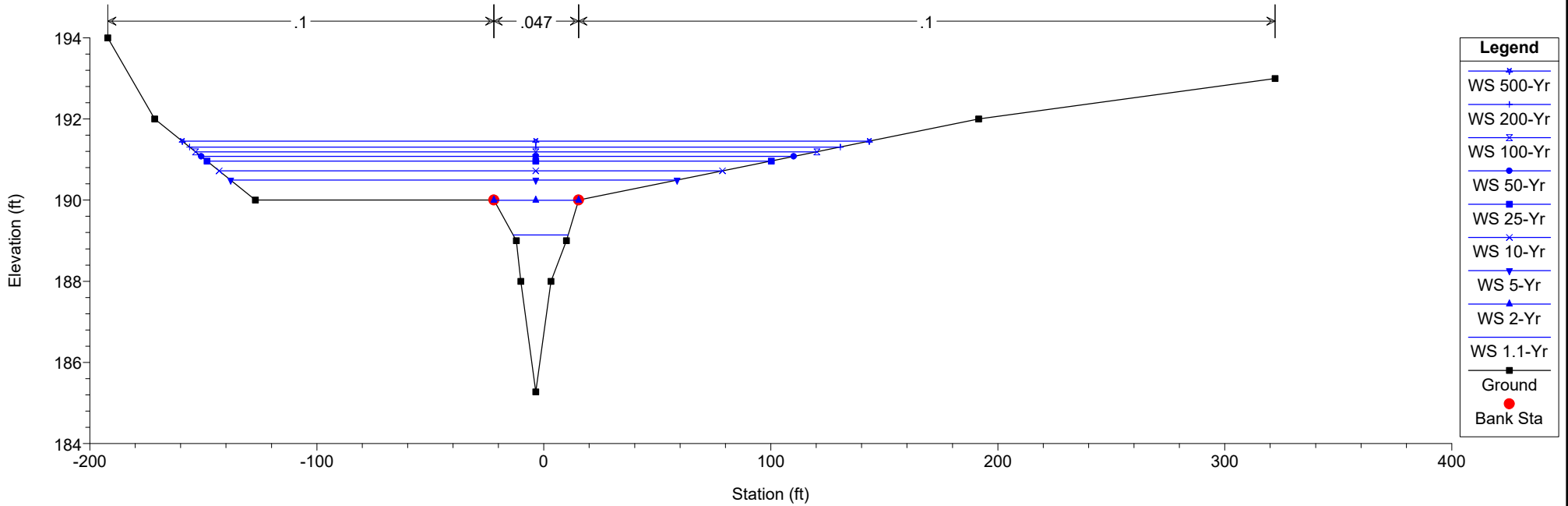
HEC-RAS Plan: A2CM River: Mud Mills Stream Reach: Cobbossee Rd (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	965.00*	500-Yr	530.00	185.15	191.18		191.27	0.002482	3.07	406.00	401.40	0.32
Cobbossee Rd	1090	1.1-Yr	55.00	185.27	189.14	187.26	189.17	0.001147	1.41	38.89	24.22	0.20
Cobbossee Rd	1090	2-Yr	110.00	185.27	190.00	187.91	190.04	0.001421	1.69	65.25	37.25	0.22
Cobbossee Rd	1090	5-Yr	175.00	185.27	190.49	188.48	190.54	0.001240	1.86	148.90	196.74	0.22
Cobbossee Rd	1090	10-Yr	220.00	185.27	190.72	188.78	190.77	0.001225	1.97	196.30	221.72	0.22
Cobbossee Rd	1090	25-Yr	285.00	185.27	190.96	189.15	191.02	0.001281	2.14	253.59	248.60	0.23
Cobbossee Rd	1090	50-Yr	335.00	185.27	191.08	189.40	191.14	0.001437	2.33	282.43	261.08	0.24
Cobbossee Rd	1090	100-Yr	390.00	185.27	191.19	189.63	191.26	0.001586	2.52	313.30	273.81	0.26
Cobbossee Rd	1090	200-Yr	450.00	185.27	191.31	189.80	191.39	0.001725	2.70	346.25	286.78	0.27
Cobbossee Rd	1090	500-Yr	530.00	185.27	191.45	190.37	191.54	0.001887	2.91	388.59	302.62	0.29

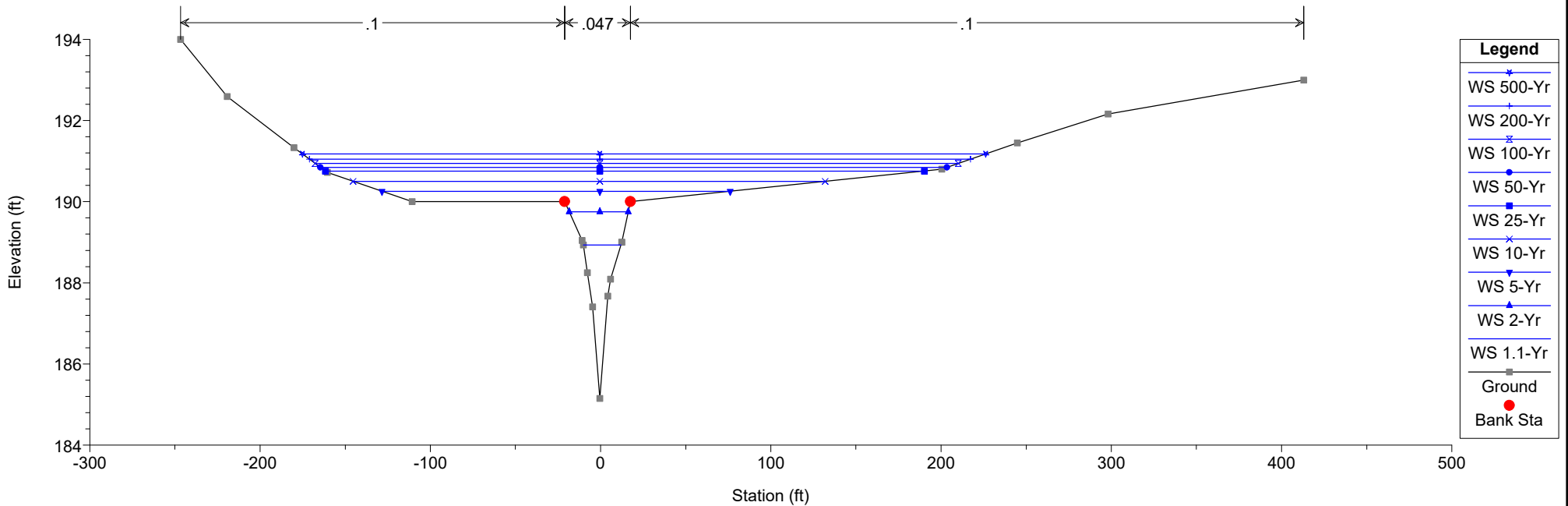
Mud Mills Stream Cobbossee Rd



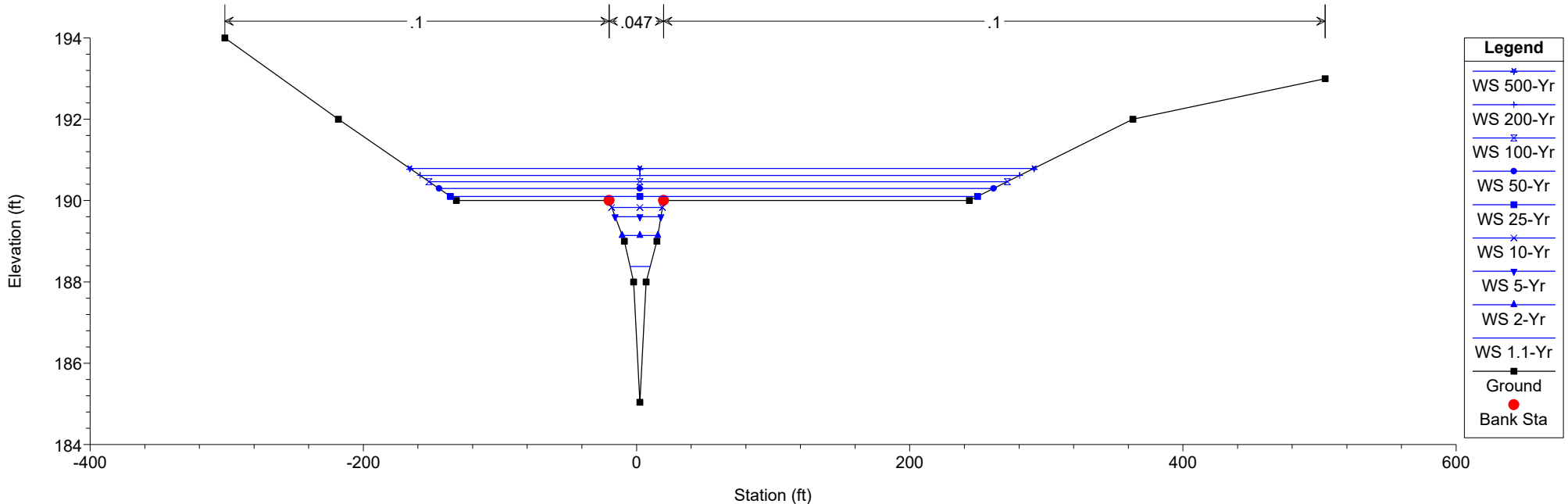
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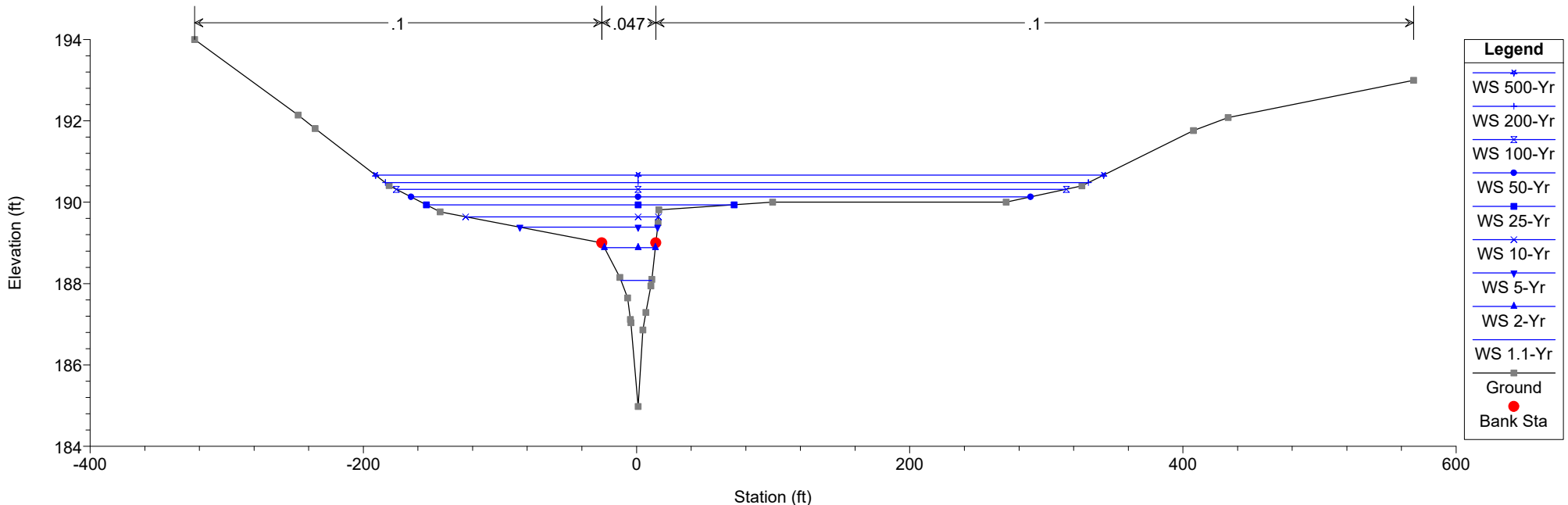
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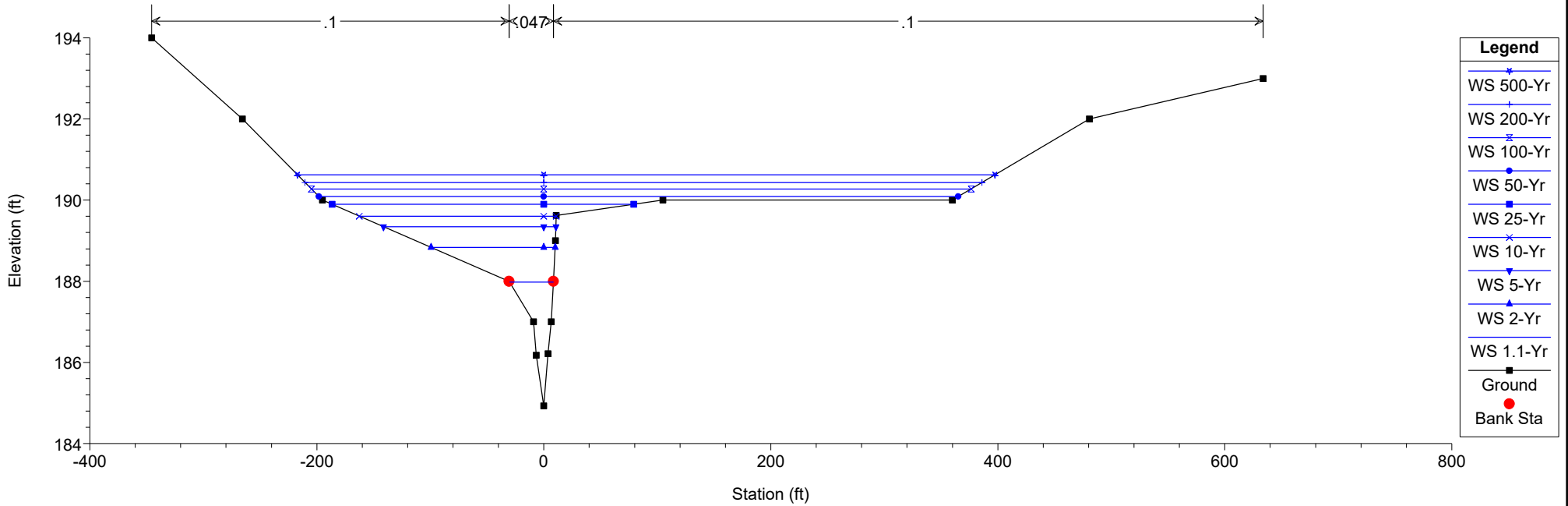
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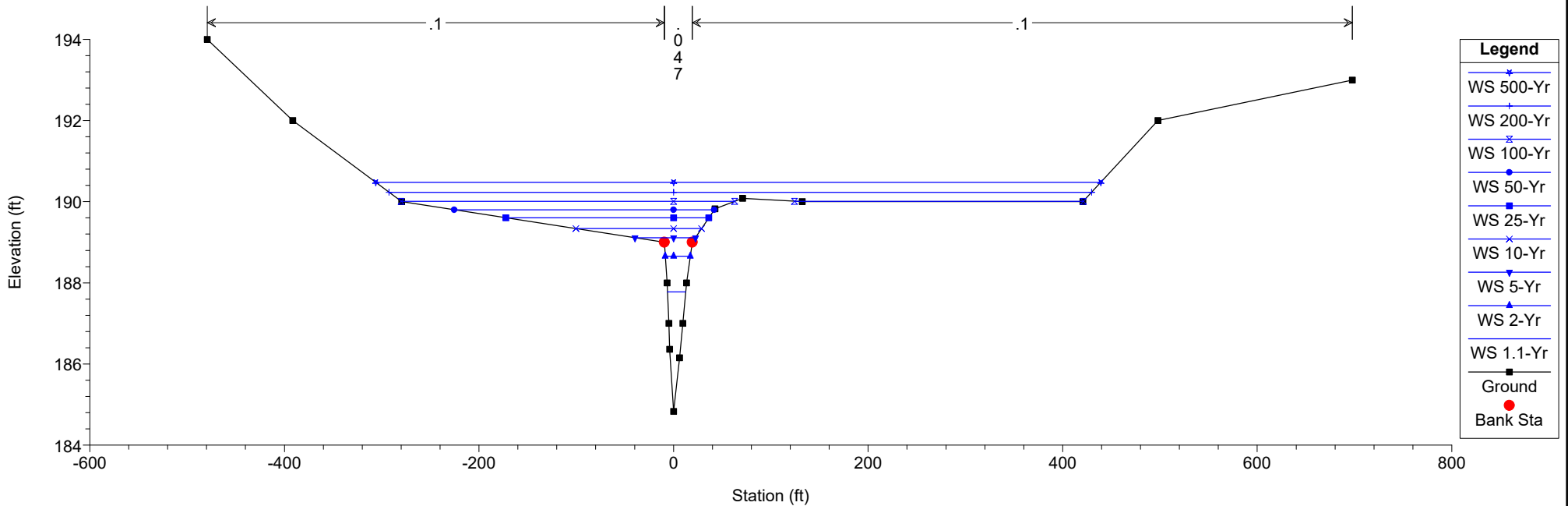
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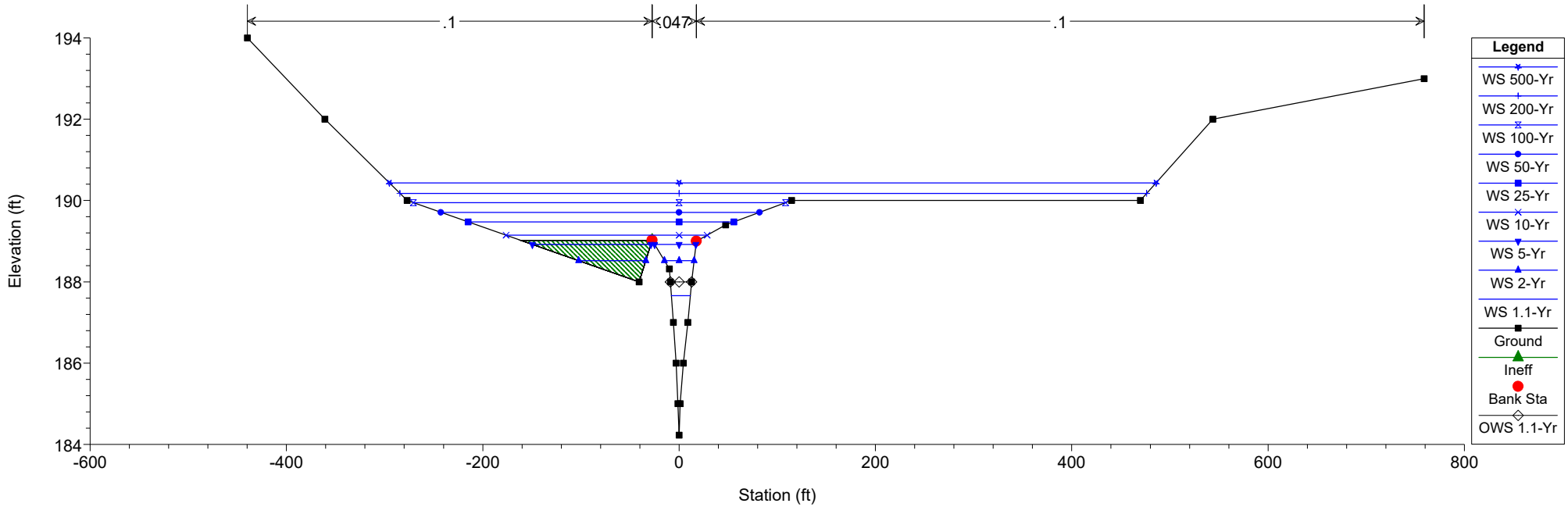
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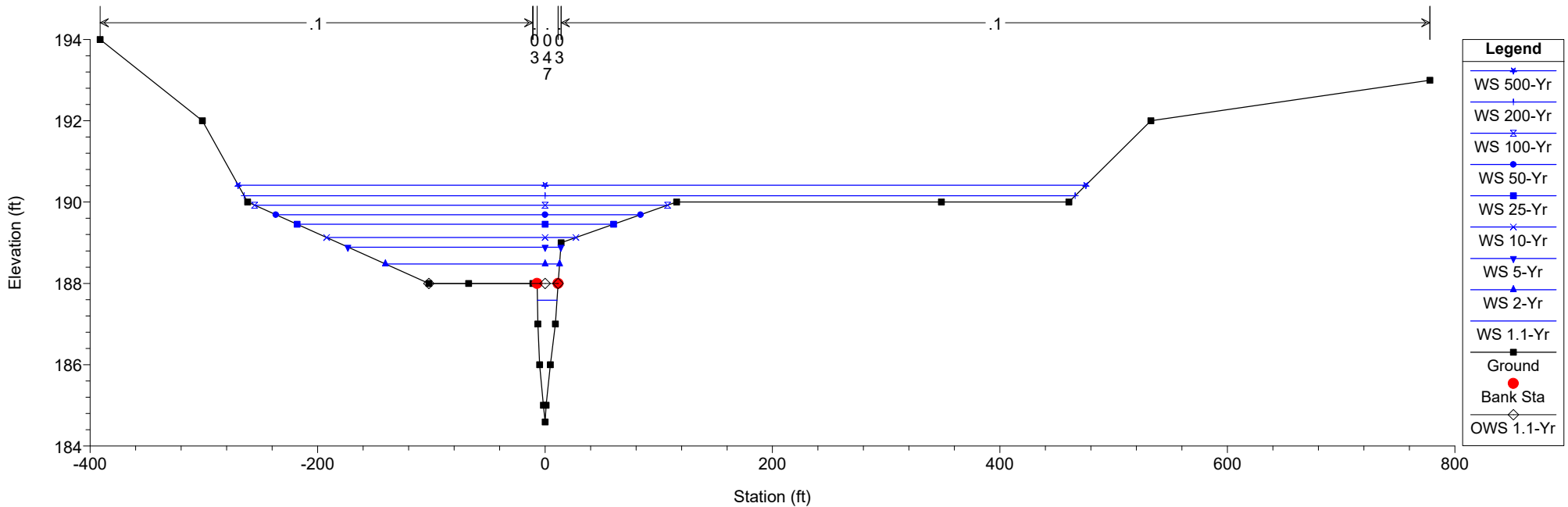
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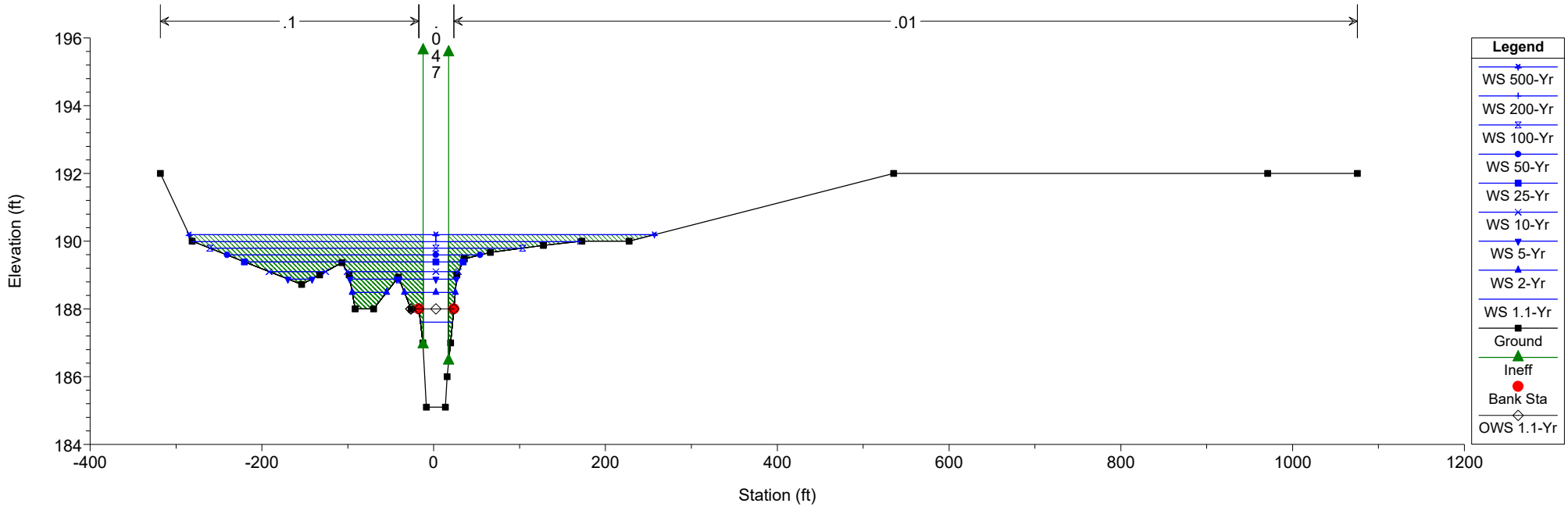
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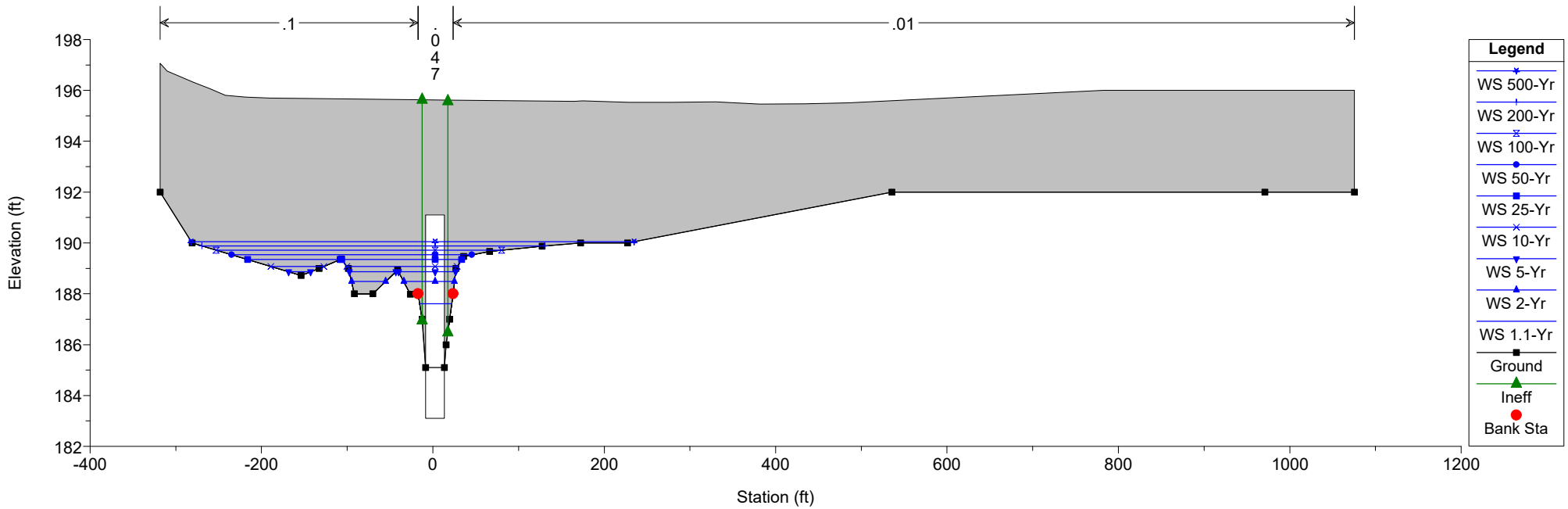


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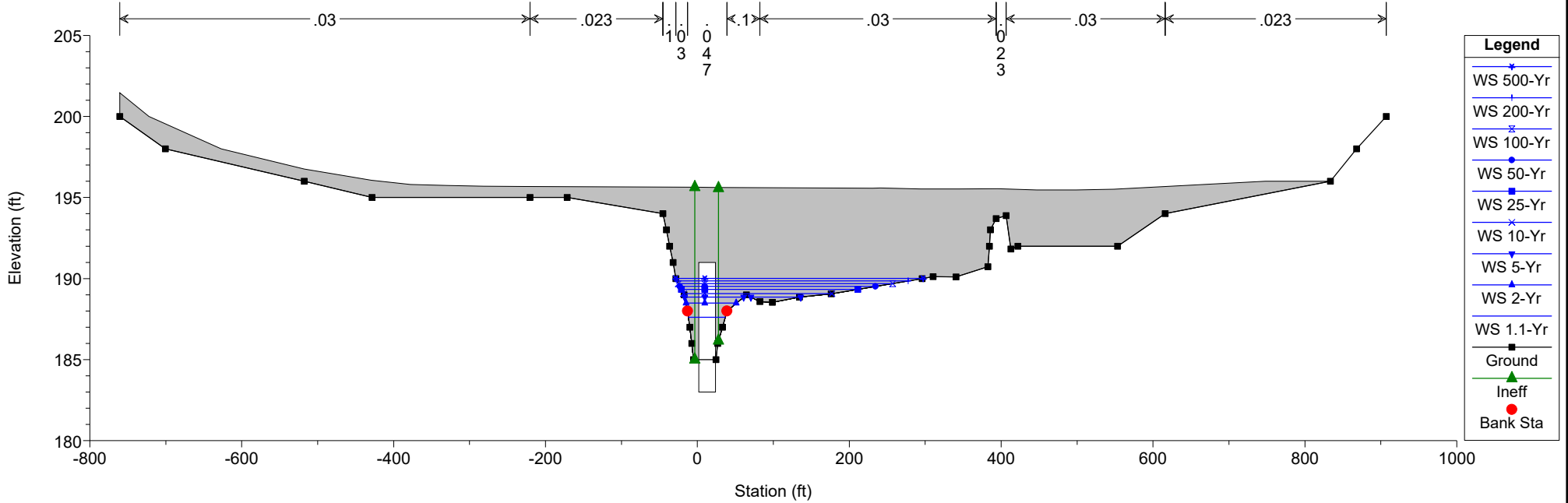
67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 02\_Calibration\_Max 9/6/2024

Cobbossee Rd

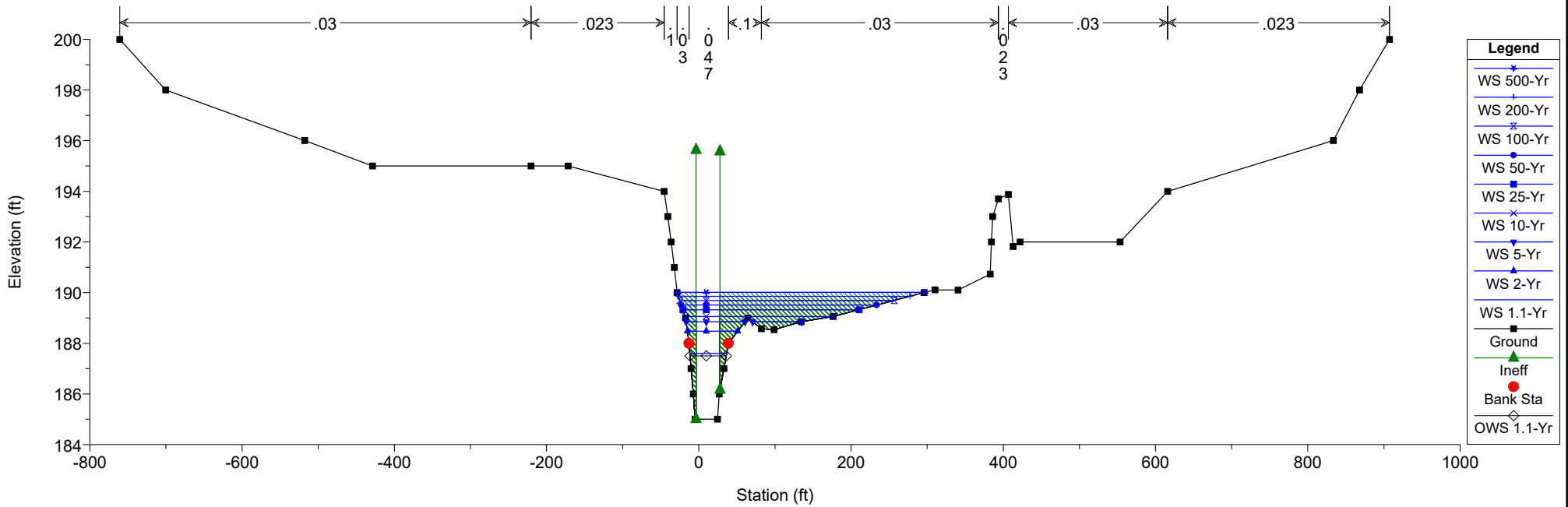


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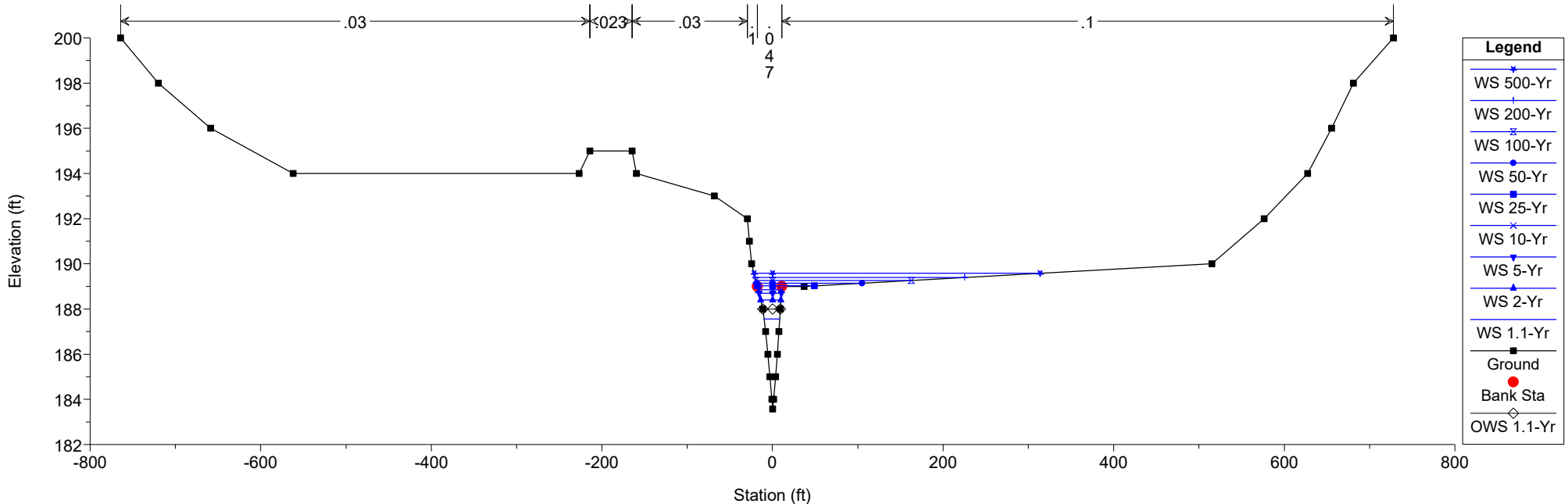
Cobbossee Rd



67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 02\_Calibration\_Max 9/6/2024

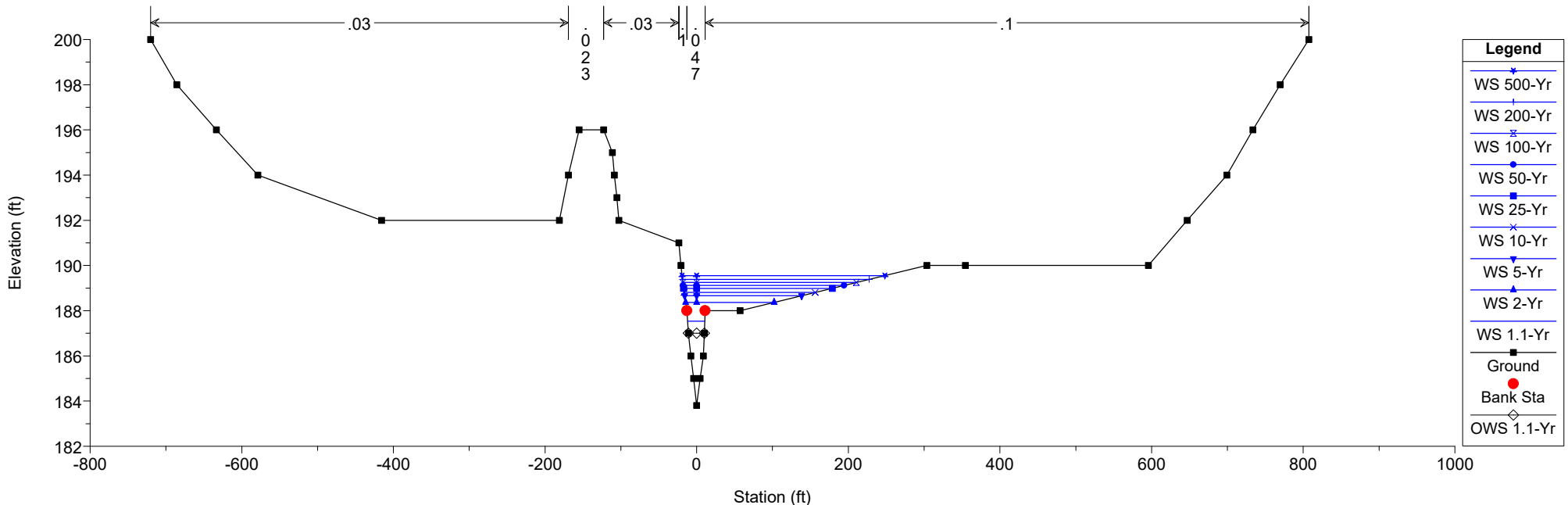


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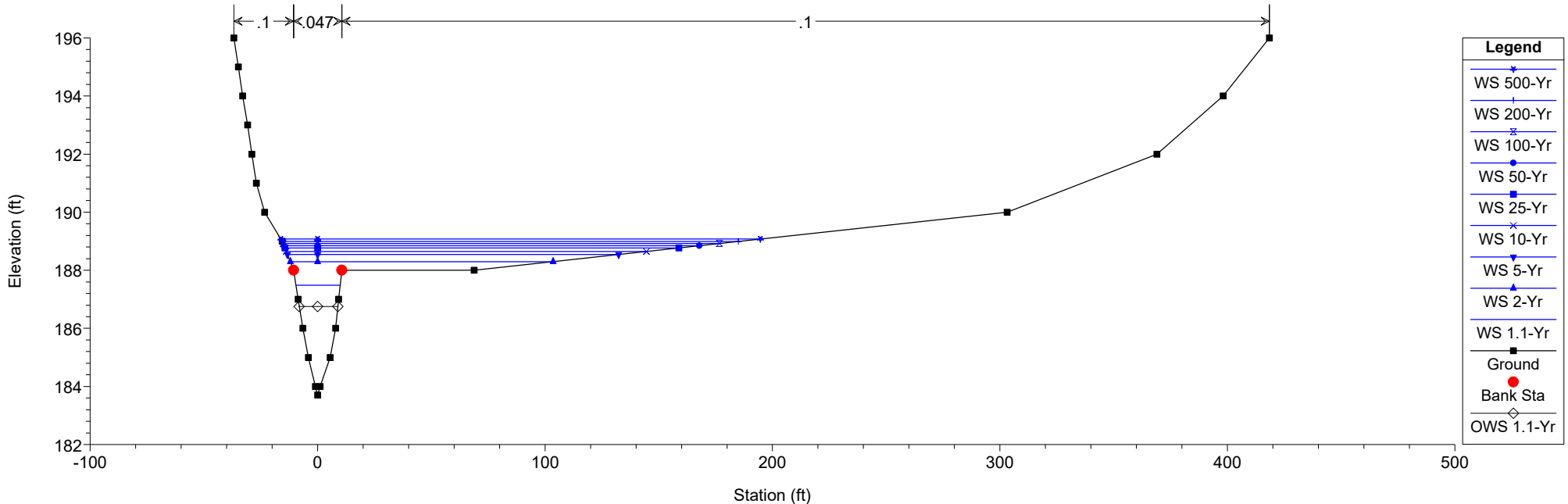
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  - WS 2-Yr
  - WS 1.1-Yr
  - Ground
  - Bank Sta
  - OWS 1.1-Yr

67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 02\_Calibration\_Max 9/6/2024

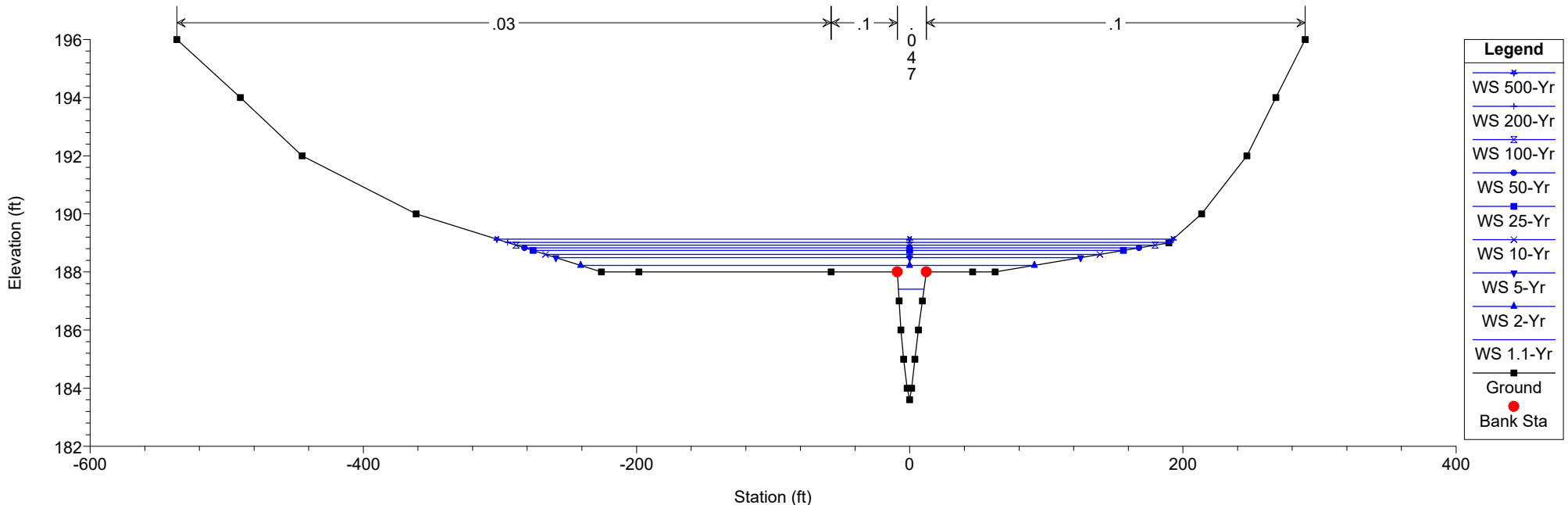


- Legend**
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  - WS 2-Yr
  - WS 1.1-Yr
  - Ground
  - Bank Sta
  - OWS 1.1-Yr

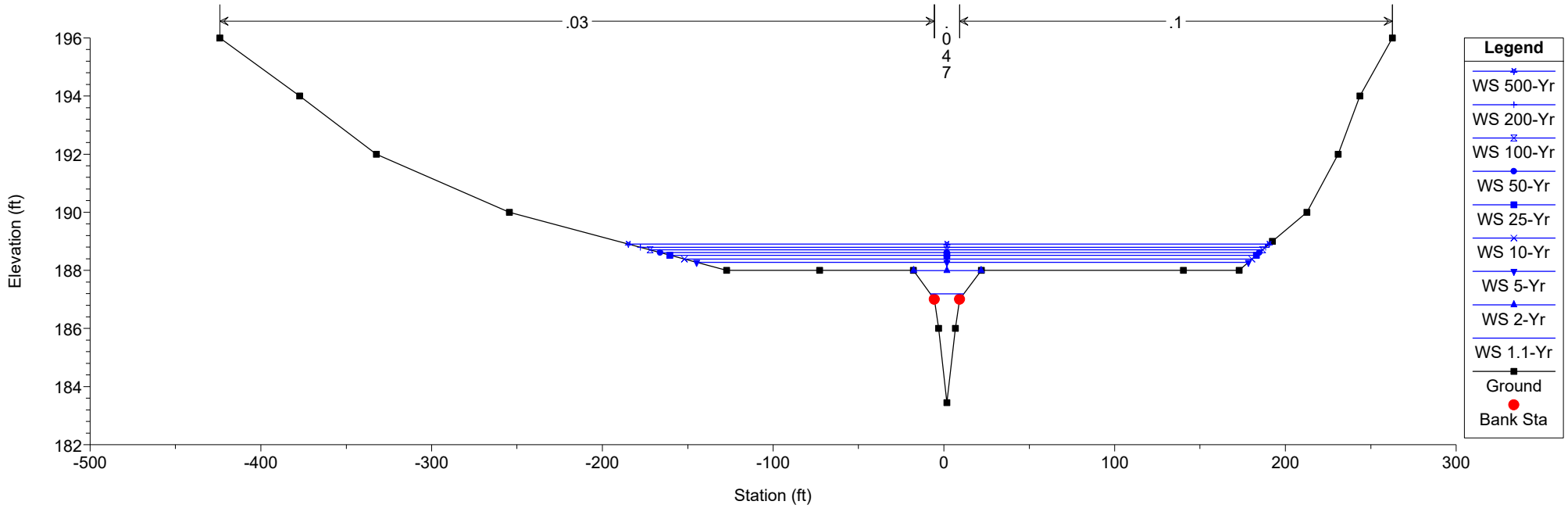
67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 02\_Calibration\_Max 9/6/2024



67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 02\_Calibration\_Max 9/6/2024



67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 02\_Calibration\_Max 9/6/2024



# Proposed 16' Span HEC-RAS Analysis

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	0	1.1-Yr	55.00	183.45	187.19	185.63	187.25	0.001973	1.99	28.09	19.57	0.26
Cobbossee Rd	0	2-Yr	110.00	183.45	187.99	186.36	188.08	0.001974	2.52	51.60	39.42	0.27
Cobbossee Rd	0	5-Yr	175.00	183.45	188.28	186.93	188.36	0.001973	2.69	137.88	323.09	0.28
Cobbossee Rd	0	10-Yr	220.00	183.45	188.39	187.31	188.46	0.001972	2.76	174.44	332.36	0.28
Cobbossee Rd	0	25-Yr	285.00	183.45	188.52	187.77	188.59	0.001971	2.84	219.99	343.56	0.28
Cobbossee Rd	0	50-Yr	335.00	183.45	188.61	188.33	188.68	0.001972	2.89	251.40	351.07	0.28
Cobbossee Rd	0	100-Yr	390.00	183.45	188.70	188.39	188.77	0.001971	2.95	283.64	358.62	0.28
Cobbossee Rd	0	200-Yr	450.00	183.45	188.79	188.44	188.87	0.001970	3.00	316.58	366.18	0.28
Cobbossee Rd	0	500-Yr	530.00	183.45	188.91	188.47	188.98	0.001971	3.06	357.74	375.40	0.29
Cobbossee Rd	145	1.1-Yr	55.00	183.60	187.40		187.44	0.000850	1.42	38.74	18.64	0.17
Cobbossee Rd	145	2-Yr	110.00	183.60	188.23		188.26	0.000766	1.57	120.67	332.30	0.17
Cobbossee Rd	145	5-Yr	175.00	183.60	188.49		188.51	0.000653	1.54	215.77	384.05	0.16
Cobbossee Rd	145	10-Yr	220.00	183.60	188.60		188.63	0.000682	1.62	259.55	405.66	0.16
Cobbossee Rd	145	25-Yr	285.00	183.60	188.74		188.76	0.000720	1.71	315.76	431.83	0.17
Cobbossee Rd	145	50-Yr	335.00	183.60	188.83		188.85	0.000741	1.77	356.28	449.74	0.17
Cobbossee Rd	145	100-Yr	390.00	183.60	188.92		188.95	0.000759	1.82	398.98	467.88	0.18
Cobbossee Rd	145	200-Yr	450.00	183.60	189.01		189.04	0.000777	1.88	442.95	484.45	0.18
Cobbossee Rd	145	500-Yr	530.00	183.60	189.13		189.16	0.000787	1.94	499.36	495.01	0.18
Cobbossee Rd	245	1.1-Yr	55.00	183.71	187.48		187.51	0.000620	1.27	43.24	19.49	0.15
Cobbossee Rd	245	2-Yr	110.00	183.71	188.30		188.34	0.000874	1.77	82.61	115.52	0.19
Cobbossee Rd	245	5-Yr	175.00	183.71	188.54		188.63	0.001495	2.45	114.79	145.66	0.25
Cobbossee Rd	245	10-Yr	220.00	183.71	188.65		188.76	0.001997	2.89	130.59	158.37	0.29
Cobbossee Rd	245	25-Yr	285.00	183.71	188.77		188.93	0.002760	3.48	150.51	173.07	0.34
Cobbossee Rd	245	50-Yr	335.00	183.71	188.84		189.04	0.003361	3.90	164.39	182.62	0.37
Cobbossee Rd	245	100-Yr	390.00	183.71	188.92		189.16	0.004034	4.34	178.53	191.86	0.41
Cobbossee Rd	245	200-Yr	450.00	183.71	188.99		189.28	0.004792	4.79	192.47	200.55	0.45
Cobbossee Rd	245	500-Yr	530.00	183.71	189.07		189.42	0.005825	5.37	209.53	210.88	0.50
Cobbossee Rd	320	1.1-Yr	55.00	183.80	187.53		187.55	0.000523	1.14	48.06	22.75	0.14
Cobbossee Rd	320	2-Yr	110.00	183.80	188.36		188.40	0.000673	1.56	93.19	116.72	0.16
Cobbossee Rd	320	5-Yr	175.00	183.80	188.66		188.72	0.001078	2.11	133.28	154.41	0.21
Cobbossee Rd	320	10-Yr	220.00	183.80	188.81		188.89	0.001360	2.44	156.92	172.84	0.24
Cobbossee Rd	320	25-Yr	285.00	183.80	188.99		189.09	0.001720	2.85	190.55	196.09	0.27
Cobbossee Rd	320	50-Yr	335.00	183.80	189.12		189.24	0.001952	3.11	216.62	212.28	0.29
Cobbossee Rd	320	100-Yr	390.00	183.80	189.25		189.38	0.002165	3.35	245.60	228.94	0.31
Cobbossee Rd	320	200-Yr	450.00	183.80	189.38		189.53	0.002355	3.58	277.47	245.96	0.32
Cobbossee Rd	320	500-Yr	530.00	183.80	189.55		189.71	0.002546	3.83	320.79	267.36	0.34
Cobbossee Rd	370	1.1-Yr	55.00	183.58	187.56		187.59	0.001013	1.50	36.68	18.48	0.19
Cobbossee Rd	370	2-Yr	110.00	183.58	188.39		188.46	0.001536	2.03	54.14	23.78	0.24
Cobbossee Rd	370	5-Yr	175.00	183.58	188.70		188.82	0.002833	2.83	61.77	26.16	0.33
Cobbossee Rd	370	10-Yr	220.00	183.58	188.85		189.02	0.003853	3.35	65.70	27.31	0.38
Cobbossee Rd	370	25-Yr	285.00	183.58	189.02		189.28	0.005357	4.03	71.46	66.48	0.45
Cobbossee Rd	370	50-Yr	335.00	183.58	189.14	187.77	189.45	0.006269	4.50	82.62	123.48	0.49
Cobbossee Rd	370	100-Yr	390.00	183.58	189.26	188.05	189.63	0.007071	4.92	101.13	182.26	0.53
Cobbossee Rd	370	200-Yr	450.00	183.58	189.39	188.32	189.80	0.007587	5.26	129.10	245.68	0.55
Cobbossee Rd	370	500-Yr	530.00	183.58	189.58	188.66	189.99	0.007527	5.47	182.75	335.29	0.55
Cobbossee Rd	410	1.1-Yr	55.00	185.00	187.61		187.61	0.000140	0.69	79.37	48.33	0.08
Cobbossee Rd	410	2-Yr	110.00	185.00	188.48		188.49	0.000210	1.03	106.64	66.15	0.10
Cobbossee Rd	410	5-Yr	175.00	185.00	188.86		188.89	0.000374	1.48	118.48	142.19	0.13
Cobbossee Rd	410	10-Yr	220.00	185.00	189.06		189.11	0.000495	1.76	124.90	194.39	0.16
Cobbossee Rd	410	25-Yr	285.00	185.00	189.33		189.40	0.000669	2.14	133.27	231.45	0.18
Cobbossee Rd	410	50-Yr	335.00	185.00	189.51		189.60	0.000804	2.41	139.02	256.88	0.20
Cobbossee Rd	410	100-Yr	390.00	185.00	189.69		189.80	0.000955	2.70	144.61	281.62	0.22
Cobbossee Rd	410	200-Yr	450.00	185.00	189.85		189.99	0.001133	3.01	149.70	304.15	0.24
Cobbossee Rd	410	500-Yr	530.00	185.00	190.01		190.19	0.001411	3.43	154.61	325.82	0.27
Cobbossee Rd	460		Culvert									
Cobbossee Rd	515	1.1-Yr	55.00	185.10	187.62	185.67	187.63	0.000220	0.80	68.51	37.40	0.09
Cobbossee Rd	515	2-Yr	110.00	185.10	188.51	185.99	188.53	0.000293	1.15	95.28	100.57	0.11
Cobbossee Rd	515	5-Yr	175.00	185.10	188.93	186.30	188.98	0.000489	1.62	107.94	162.07	0.15
Cobbossee Rd	515	10-Yr	220.00	185.10	189.18	186.49	189.24	0.000621	1.91	115.28	212.35	0.17
Cobbossee Rd	515	25-Yr	285.00	185.10	189.52	186.72	189.60	0.000788	2.27	125.35	275.57	0.20
Cobbossee Rd	515	50-Yr	335.00	185.10	189.76	186.89	189.86	0.000901	2.53	132.67	350.91	0.21
Cobbossee Rd	515	100-Yr	390.00	185.10	190.02	187.06	190.14	0.001014	2.78	140.27	511.27	0.23
Cobbossee Rd	515	200-Yr	450.00	185.10	190.27	187.23	190.42	0.001131	3.04	147.92	555.44	0.24

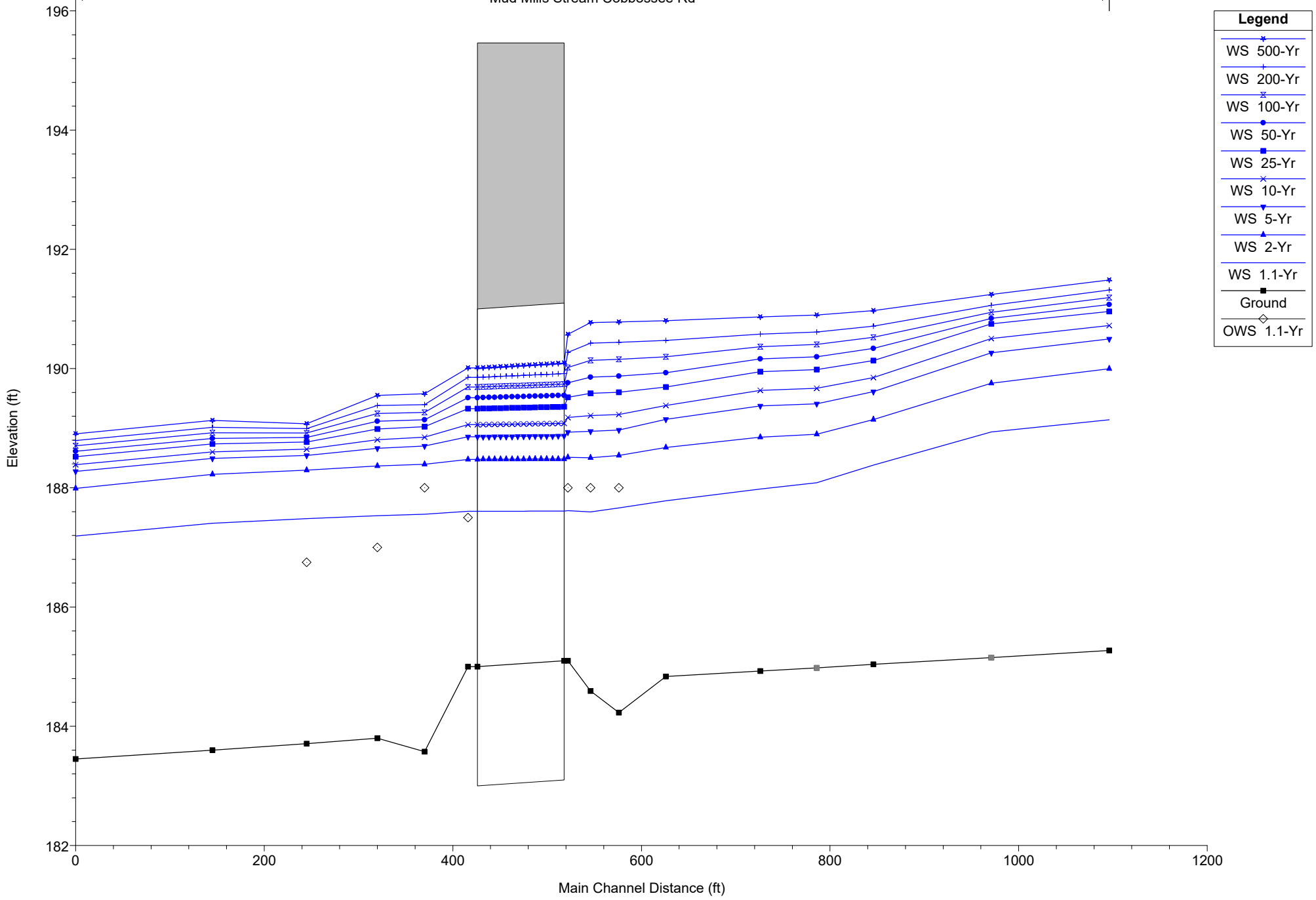
HEC-RAS Plan: A3CM River: Mud Mills Stream Reach: Cobbossee Rd (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	515	500-Yr	530.00	185.10	190.57	187.45	190.75	0.001287	3.38	156.96	607.63	0.26
Cobbossee Rd	540	1.1-Yr	55.00	184.59	187.59		187.65	0.002123	1.94	28.41	17.30	0.27
Cobbossee Rd	540	2-Yr	110.00	184.59	188.50		188.55	0.001369	2.00	103.38	155.16	0.23
Cobbossee Rd	540	5-Yr	175.00	184.59	188.95		189.00	0.001274	2.16	180.38	191.72	0.22
Cobbossee Rd	540	10-Yr	220.00	184.59	189.21		189.26	0.001179	2.20	236.18	234.46	0.22
Cobbossee Rd	540	25-Yr	285.00	184.59	189.58		189.62	0.000985	2.17	336.01	301.92	0.20
Cobbossee Rd	540	50-Yr	335.00	184.59	189.86		189.89	0.000848	2.12	424.55	351.08	0.19
Cobbossee Rd	540	100-Yr	390.00	184.59	190.14		190.17	0.000710	2.03	577.46	729.91	0.18
Cobbossee Rd	540	200-Yr	450.00	184.59	190.43		190.45	0.000523	1.83	790.55	746.04	0.15
Cobbossee Rd	540	500-Yr	530.00	184.59	190.77		190.78	0.000382	1.64	1049.71	765.19	0.13
Cobbossee Rd	570	1.1-Yr	55.00	184.23	187.66		187.72	0.002543	1.95	28.17	19.41	0.29
Cobbossee Rd	570	2-Yr	110.00	184.23	188.54		188.62	0.002991	2.26	48.57	102.03	0.32
Cobbossee Rd	570	5-Yr	175.00	184.23	188.97		189.08	0.004585	2.72	64.40	170.54	0.39
Cobbossee Rd	570	10-Yr	220.00	184.23	189.23		189.34	0.003984	2.77	108.24	220.35	0.37
Cobbossee Rd	570	25-Yr	285.00	184.23	189.60		189.68	0.002564	2.54	204.92	300.09	0.31
Cobbossee Rd	570	50-Yr	335.00	184.23	189.87		189.94	0.001866	2.35	294.87	362.59	0.27
Cobbossee Rd	570	100-Yr	390.00	184.23	190.16		190.20	0.001330	2.14	459.73	759.25	0.23
Cobbossee Rd	570	200-Yr	450.00	184.23	190.44		190.47	0.000848	1.83	679.53	781.74	0.19
Cobbossee Rd	570	500-Yr	530.00	184.23	190.78		190.80	0.000548	1.58	949.40	808.51	0.15
Cobbossee Rd	620	1.1-Yr	55.00	184.83	187.78		187.84	0.001997	1.85	29.72	18.80	0.26
Cobbossee Rd	620	2-Yr	110.00	184.83	188.67		188.75	0.002238	2.22	49.47	26.01	0.28
Cobbossee Rd	620	5-Yr	175.00	184.83	189.15		189.27	0.002944	2.79	65.88	72.75	0.33
Cobbossee Rd	620	10-Yr	220.00	184.83	189.38		189.53	0.003141	3.08	91.16	142.67	0.35
Cobbossee Rd	620	25-Yr	285.00	184.83	189.69		189.84	0.003018	3.27	149.28	234.47	0.35
Cobbossee Rd	620	50-Yr	335.00	184.83	189.93		190.07	0.002648	3.24	214.37	314.30	0.33
Cobbossee Rd	620	100-Yr	390.00	184.83	190.20		190.29	0.001921	2.93	375.42	719.06	0.29
Cobbossee Rd	620	200-Yr	450.00	184.83	190.47		190.53	0.001245	2.49	574.88	744.81	0.23
Cobbossee Rd	620	500-Yr	530.00	184.83	190.80		190.83	0.000792	2.11	826.38	776.07	0.19
Cobbossee Rd	720	1.1-Yr	55.00	184.93	187.98		188.00	0.001418	1.27	43.29	38.42	0.21
Cobbossee Rd	720	2-Yr	110.00	184.93	188.85		188.88	0.000738	1.34	107.53	110.45	0.17
Cobbossee Rd	720	5-Yr	175.00	184.93	189.37		189.41	0.000720	1.54	176.80	154.17	0.17
Cobbossee Rd	720	10-Yr	220.00	184.93	189.63		189.67	0.000745	1.68	219.98	179.05	0.18
Cobbossee Rd	720	25-Yr	285.00	184.93	189.95		189.99	0.000773	1.83	291.68	281.93	0.18
Cobbossee Rd	720	50-Yr	335.00	184.93	190.16		190.20	0.000738	1.87	397.71	570.32	0.18
Cobbossee Rd	720	100-Yr	390.00	184.93	190.37		190.40	0.000673	1.86	517.60	590.07	0.18
Cobbossee Rd	720	200-Yr	450.00	184.93	190.58		190.61	0.000605	1.84	643.91	610.18	0.17
Cobbossee Rd	720	500-Yr	530.00	184.93	190.87		190.89	0.000507	1.77	824.52	637.83	0.16
Cobbossee Rd	780.00*	1.1-Yr	55.00	184.98	188.08		188.16	0.004279	2.17	25.35	22.51	0.36
Cobbossee Rd	780.00*	2-Yr	110.00	184.98	188.90		188.97	0.003512	2.21	49.71	37.50	0.34
Cobbossee Rd	780.00*	5-Yr	175.00	184.98	189.41		189.50	0.002940	2.46	83.02	104.46	0.33
Cobbossee Rd	780.00*	10-Yr	220.00	184.98	189.67		189.77	0.002712	2.59	115.54	145.57	0.32
Cobbossee Rd	780.00*	25-Yr	285.00	184.98	189.98		190.08	0.002418	2.69	172.85	248.13	0.31
Cobbossee Rd	780.00*	50-Yr	335.00	184.98	190.20		190.28	0.002051	2.62	266.13	466.94	0.29
Cobbossee Rd	780.00*	100-Yr	390.00	184.98	190.40		190.48	0.001709	2.52	366.59	506.99	0.27
Cobbossee Rd	780.00*	200-Yr	450.00	184.98	190.61		190.67	0.001408	2.40	474.43	527.70	0.25
Cobbossee Rd	780.00*	500-Yr	530.00	184.98	190.90		190.94	0.001075	2.23	628.76	555.85	0.22
Cobbossee Rd	840	1.1-Yr	55.00	185.04	188.38		188.52	0.008098	3.03	18.15	14.73	0.48
Cobbossee Rd	840	2-Yr	110.00	185.04	189.15		189.31	0.008297	3.26	33.76	26.14	0.51
Cobbossee Rd	840	5-Yr	175.00	185.04	189.61		189.82	0.009089	3.66	47.77	33.68	0.54
Cobbossee Rd	840	10-Yr	220.00	185.04	189.85		190.09	0.009625	3.92	56.10	37.45	0.56
Cobbossee Rd	840	25-Yr	285.00	185.04	190.13	189.44	190.37	0.008478	3.99	113.25	389.32	0.54
Cobbossee Rd	840	50-Yr	335.00	185.04	190.34	189.65	190.50	0.005884	3.59	195.01	410.39	0.46
Cobbossee Rd	840	100-Yr	390.00	185.04	190.52		190.65	0.004398	3.30	273.08	429.54	0.40
Cobbossee Rd	840	200-Yr	450.00	185.04	190.71		190.81	0.003399	3.08	355.45	448.87	0.36
Cobbossee Rd	840	500-Yr	530.00	185.04	190.97		191.04	0.002424	2.79	476.03	475.75	0.31
Cobbossee Rd	965.00*	1.1-Yr	55.00	185.15	188.94		188.98	0.002033	1.74	31.68	22.06	0.26
Cobbossee Rd	965.00*	2-Yr	110.00	185.15	189.75		189.82	0.002322	2.00	54.89	34.75	0.28
Cobbossee Rd	965.00*	5-Yr	175.00	185.15	190.26		190.34	0.002248	2.25	107.80	206.37	0.29
Cobbossee Rd	965.00*	10-Yr	220.00	185.15	190.50		190.58	0.002005	2.30	166.45	278.42	0.28
Cobbossee Rd	965.00*	25-Yr	285.00	185.15	190.75		190.82	0.001895	2.40	243.50	350.23	0.27
Cobbossee Rd	965.00*	50-Yr	335.00	185.15	190.84		190.92	0.002107	2.60	276.62	367.60	0.29
Cobbossee Rd	965.00*	100-Yr	390.00	185.15	190.94		191.03	0.002249	2.75	314.59	377.83	0.30
Cobbossee Rd	965.00*	200-Yr	450.00	185.15	191.06		191.15	0.002297	2.87	359.88	389.69	0.31

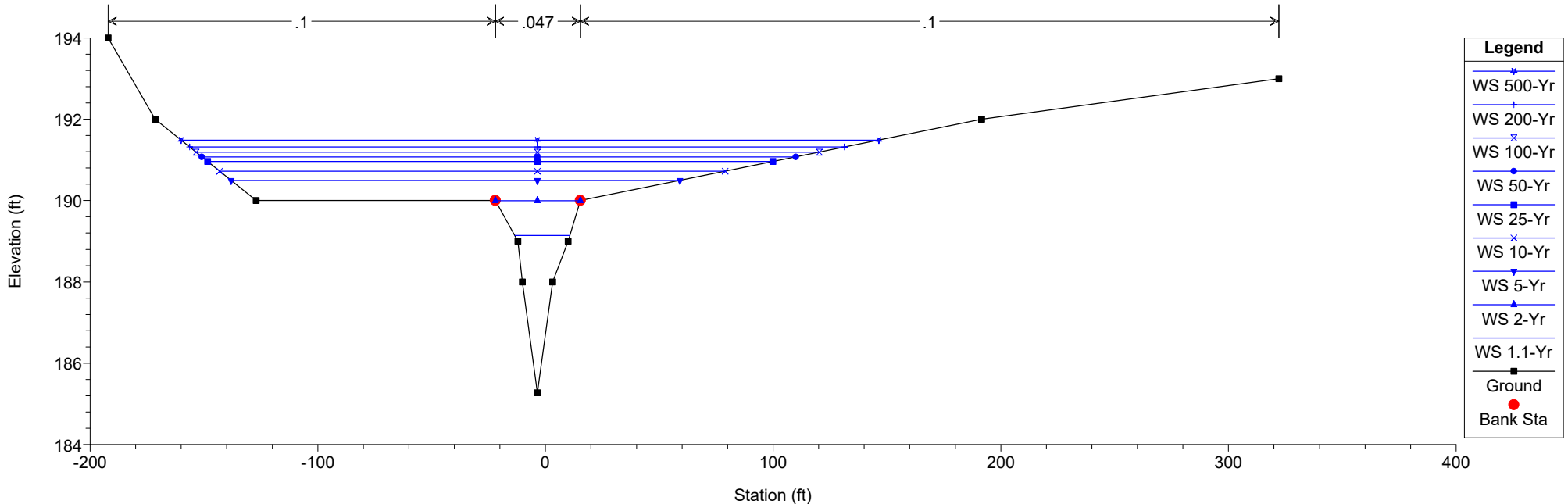
HEC-RAS Plan: A3CM River: Mud Mills Stream Reach: Cobbossee Rd (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Cobbossee Rd	965.00*	500-Yr	530.00	185.15	191.24		191.33	0.002165	2.91	432.89	408.08	0.30
Cobbossee Rd	1090	1.1-Yr	55.00	185.27	189.14		189.17	0.001147	1.41	38.90	24.22	0.20
Cobbossee Rd	1090	2-Yr	110.00	185.27	190.00		190.04	0.001419	1.68	65.30	37.27	0.22
Cobbossee Rd	1090	5-Yr	175.00	185.27	190.50		190.54	0.001231	1.85	149.58	197.12	0.22
Cobbossee Rd	1090	10-Yr	220.00	185.27	190.72		190.77	0.001220	1.97	196.77	221.96	0.22
Cobbossee Rd	1090	25-Yr	285.00	185.27	190.96		191.02	0.001289	2.15	252.76	248.23	0.23
Cobbossee Rd	1090	50-Yr	335.00	185.27	191.07		191.14	0.001442	2.34	281.93	260.86	0.25
Cobbossee Rd	1090	100-Yr	390.00	185.27	191.19		191.26	0.001585	2.52	313.37	273.84	0.26
Cobbossee Rd	1090	200-Yr	450.00	185.27	191.32		191.39	0.001705	2.68	348.27	287.55	0.27
Cobbossee Rd	1090	500-Yr	530.00	185.27	191.49		191.57	0.001784	2.85	399.14	306.44	0.28

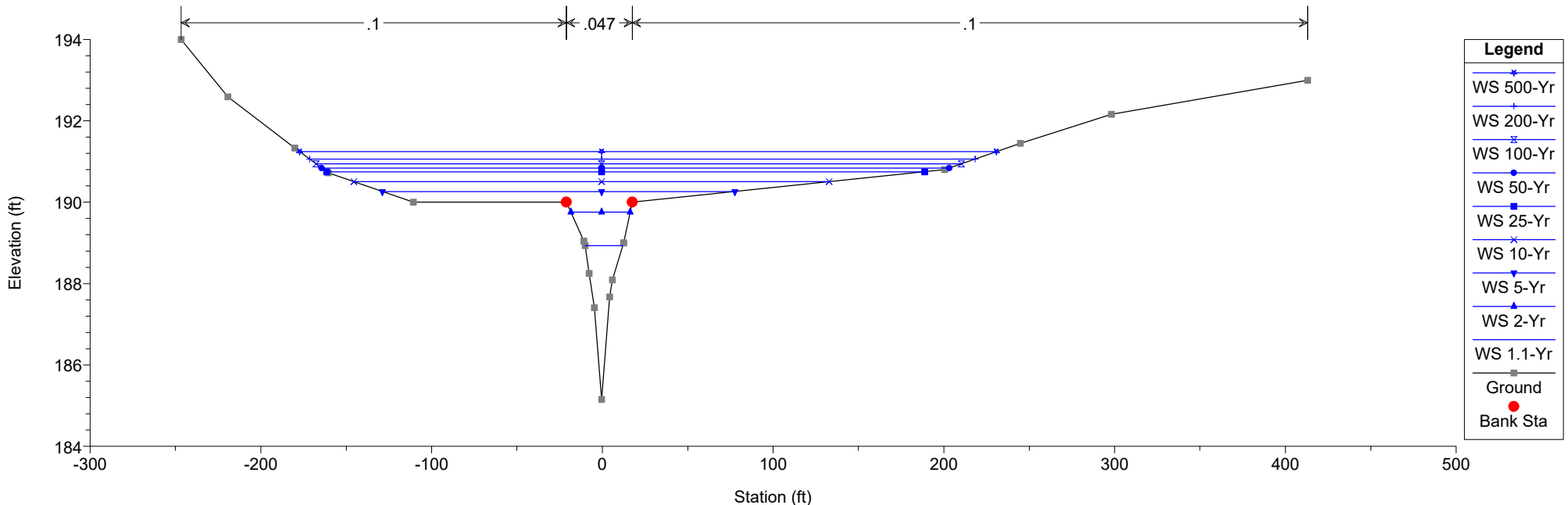
Mud Mills Stream Cobbossee Rd



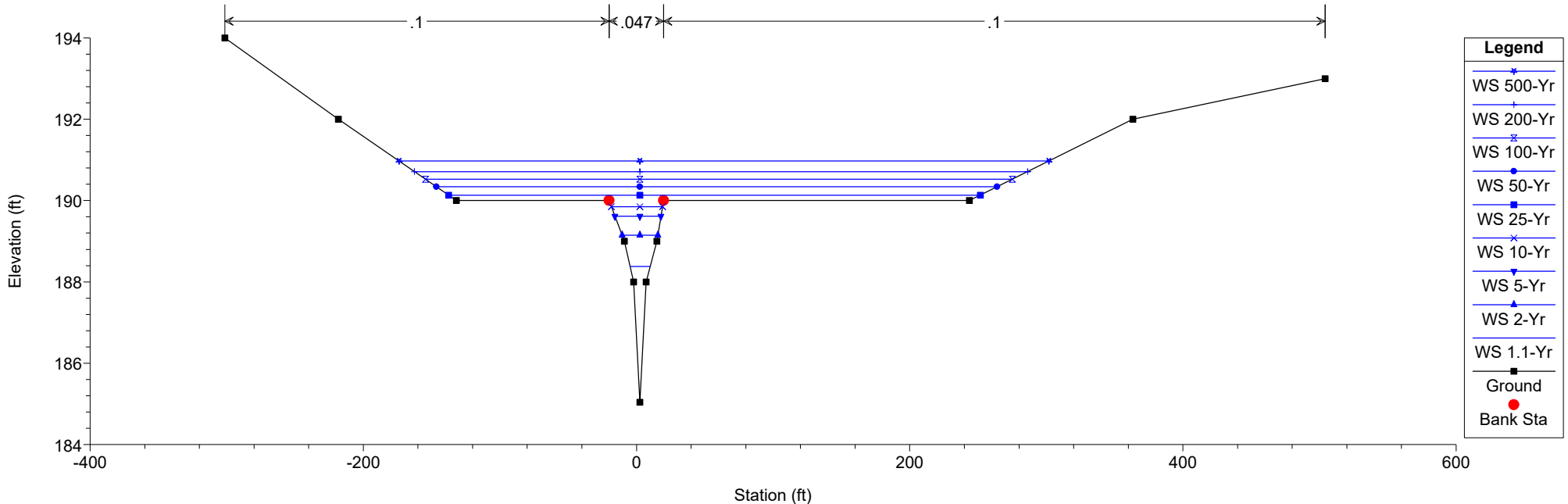
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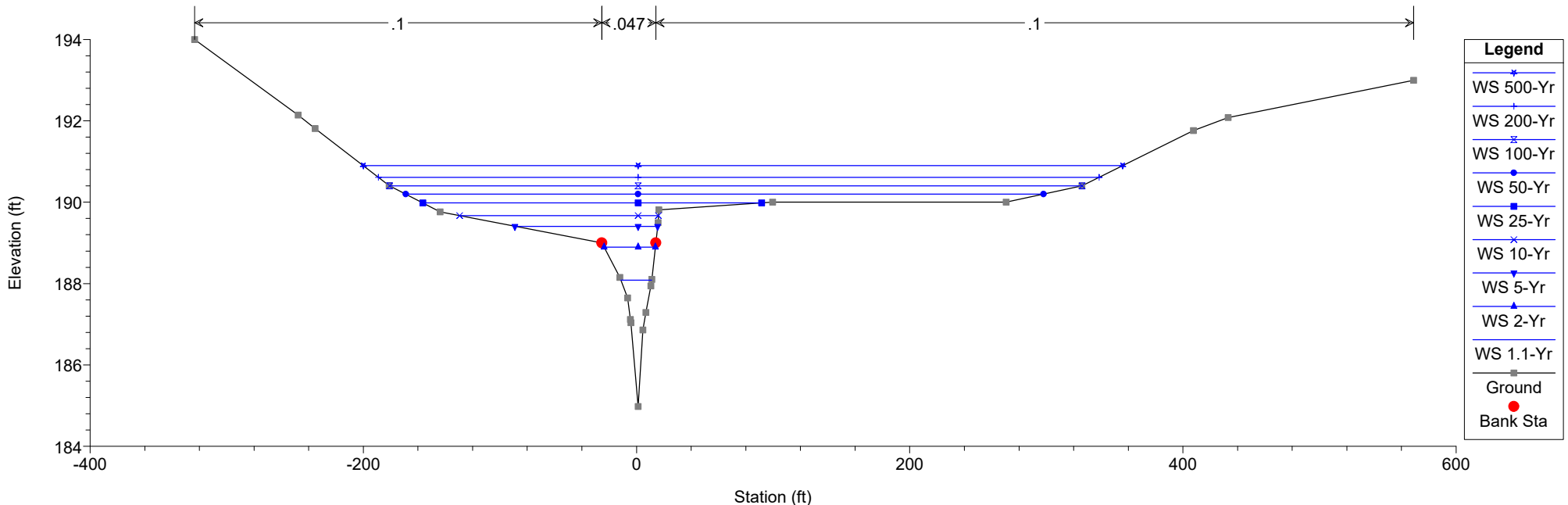
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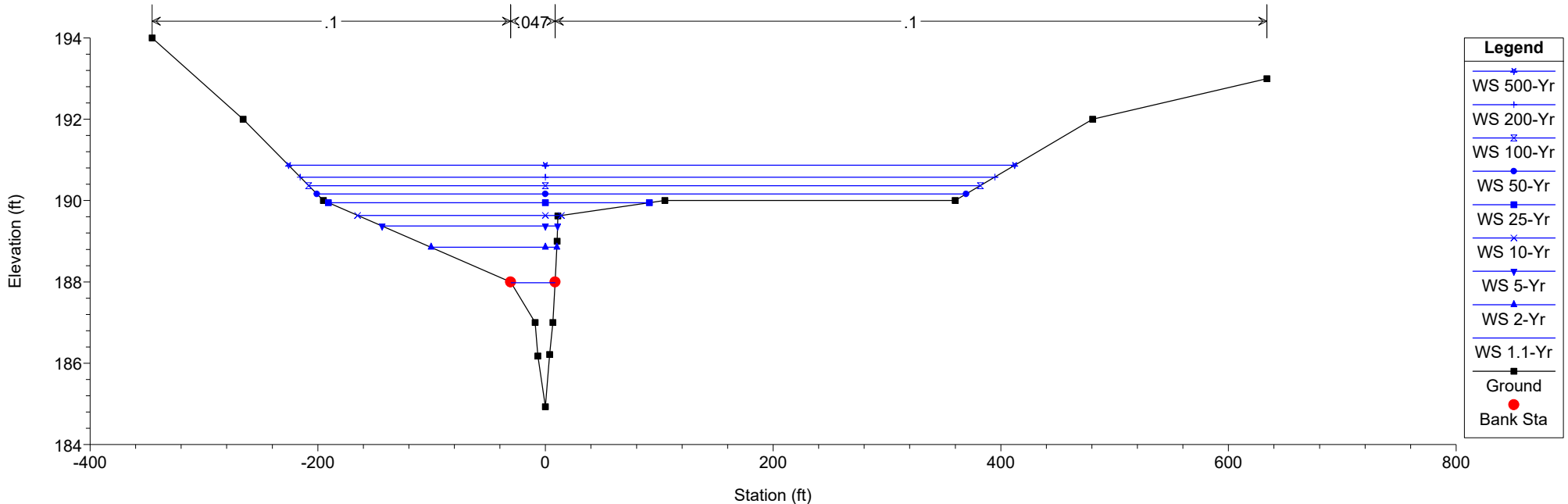
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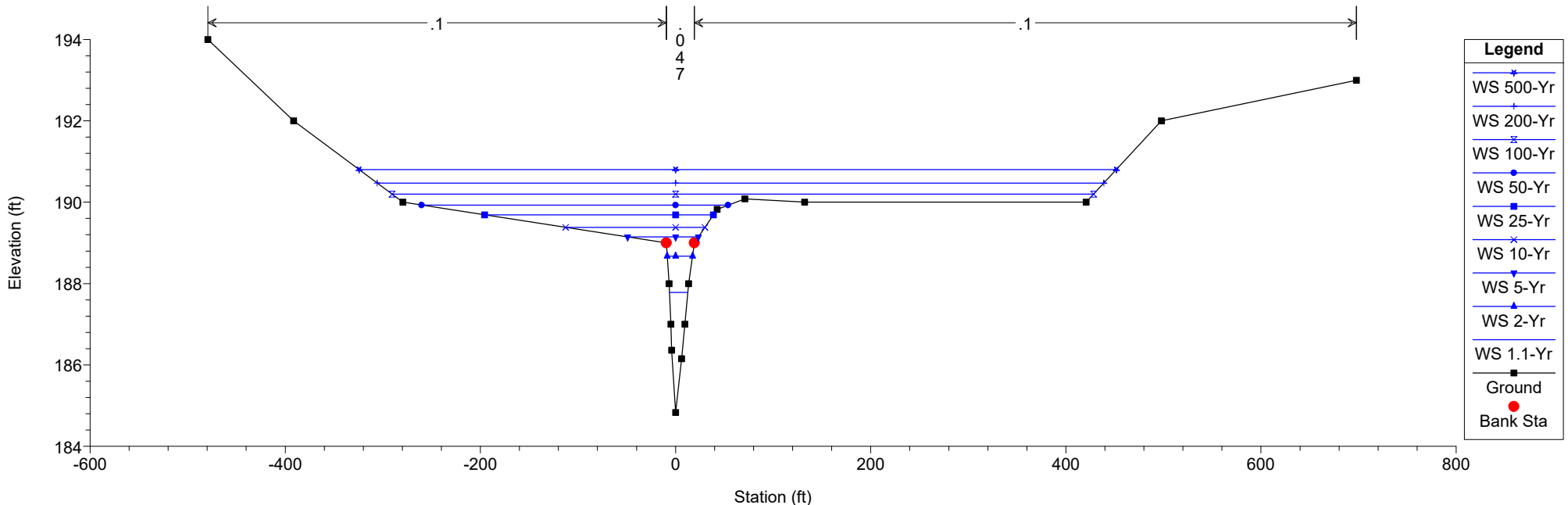
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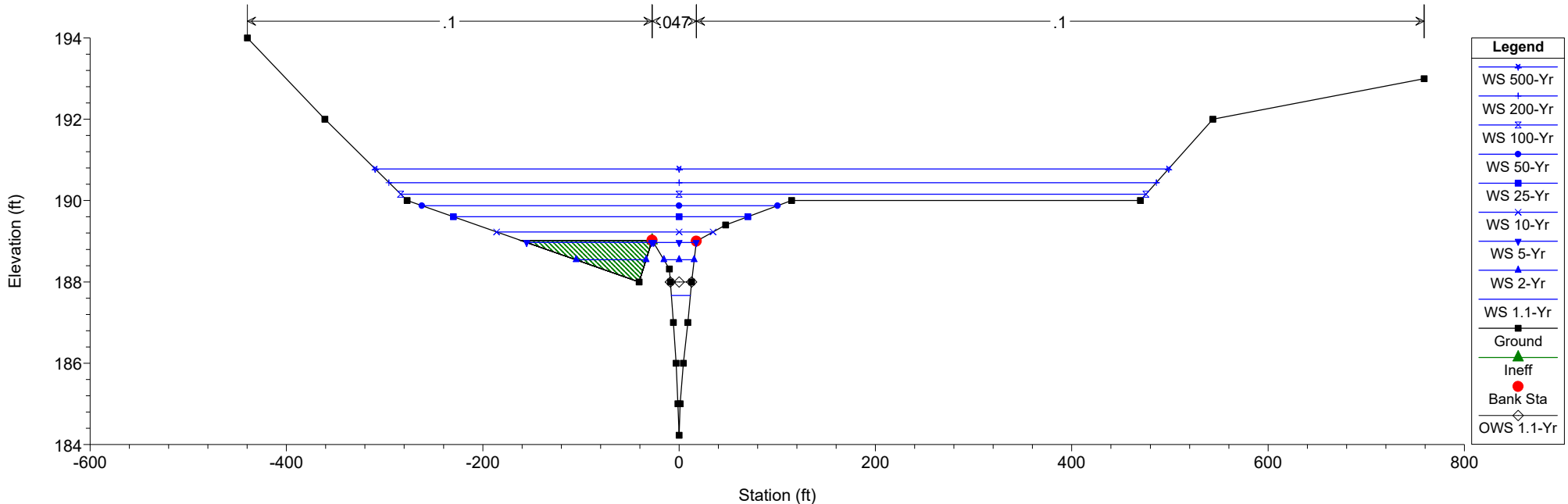
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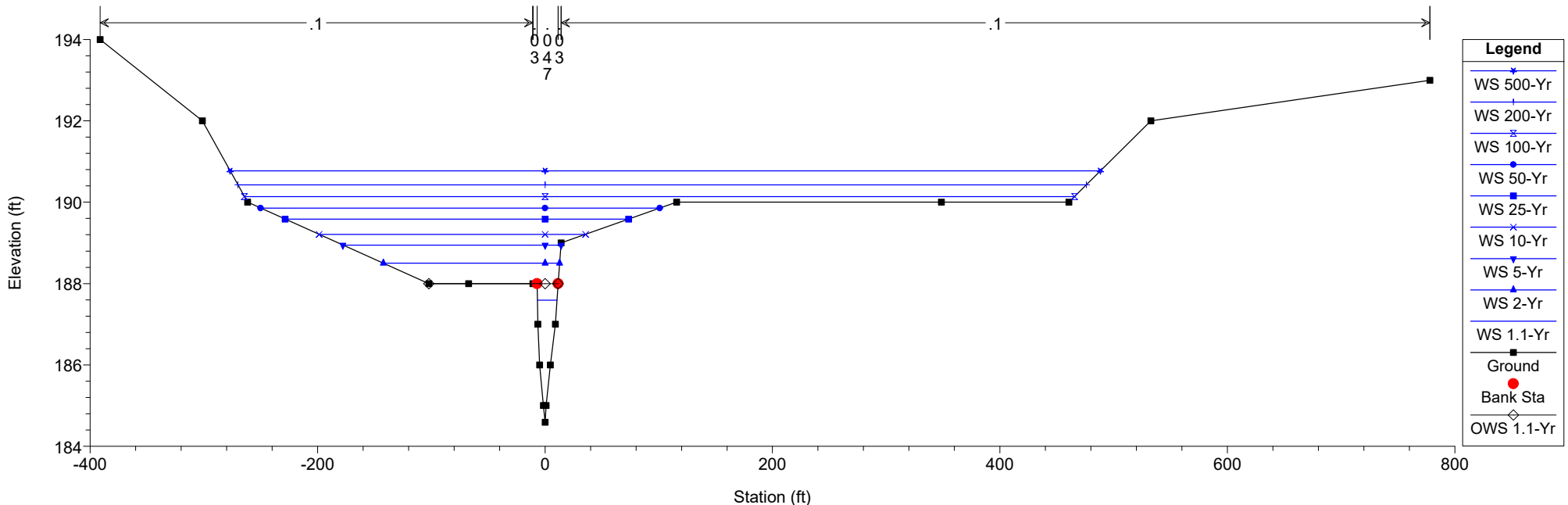
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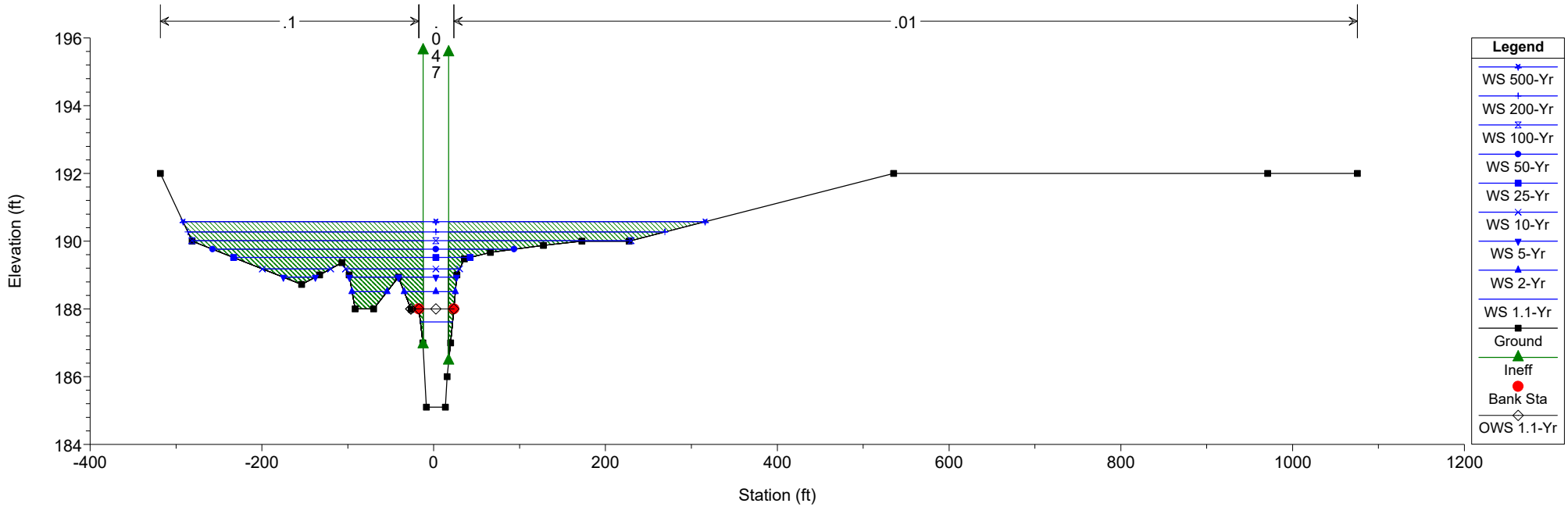
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67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024



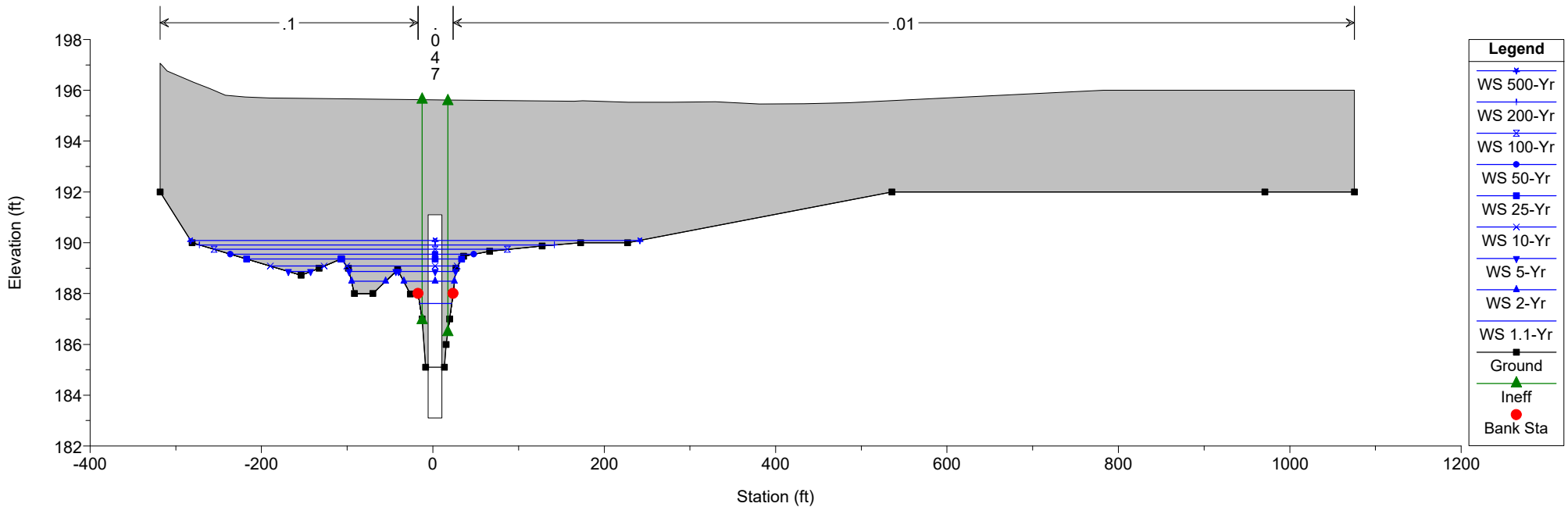
67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024



Legend	
WS 500-Yr	Blue star
WS 200-Yr	Blue plus
WS 100-Yr	Blue cross
WS 50-Yr	Blue circle
WS 25-Yr	Blue square
WS 10-Yr	Blue cross
WS 5-Yr	Blue triangle
WS 2-Yr	Blue triangle
WS 1.1-Yr	Blue diamond
Ground	Black square
Ineff	Green triangle
Bank Sta	Red circle
OWS 1.1-Yr	White diamond

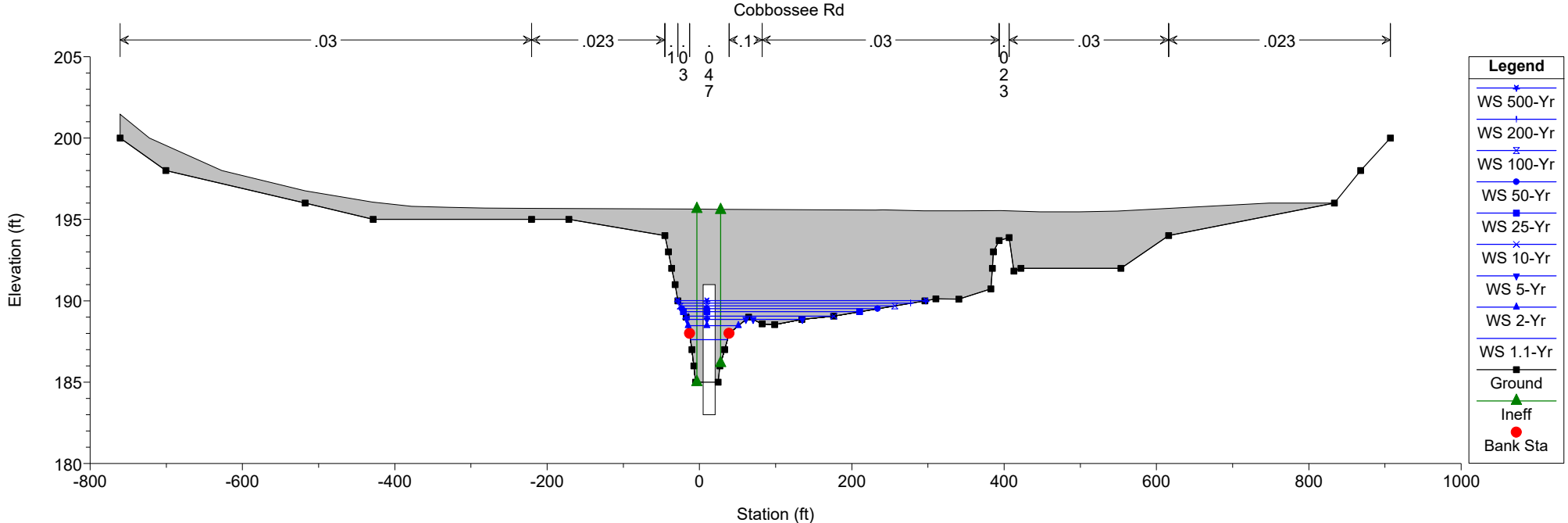
67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024

Cobbossee Rd



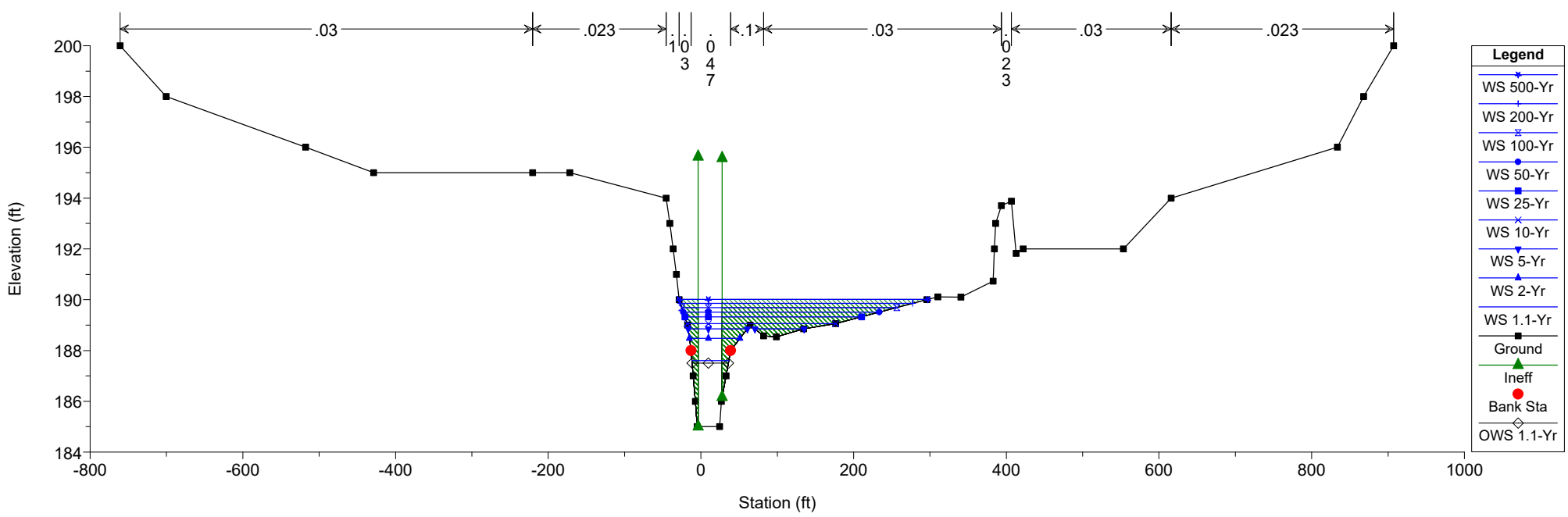
Legend	
WS 500-Yr	Blue star
WS 200-Yr	Blue plus
WS 100-Yr	Blue cross
WS 50-Yr	Blue circle
WS 25-Yr	Blue square
WS 10-Yr	Blue cross
WS 5-Yr	Blue triangle
WS 2-Yr	Blue triangle
WS 1.1-Yr	Blue diamond
Ground	Black square
Ineff	Green triangle
Bank Sta	Red circle

67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024



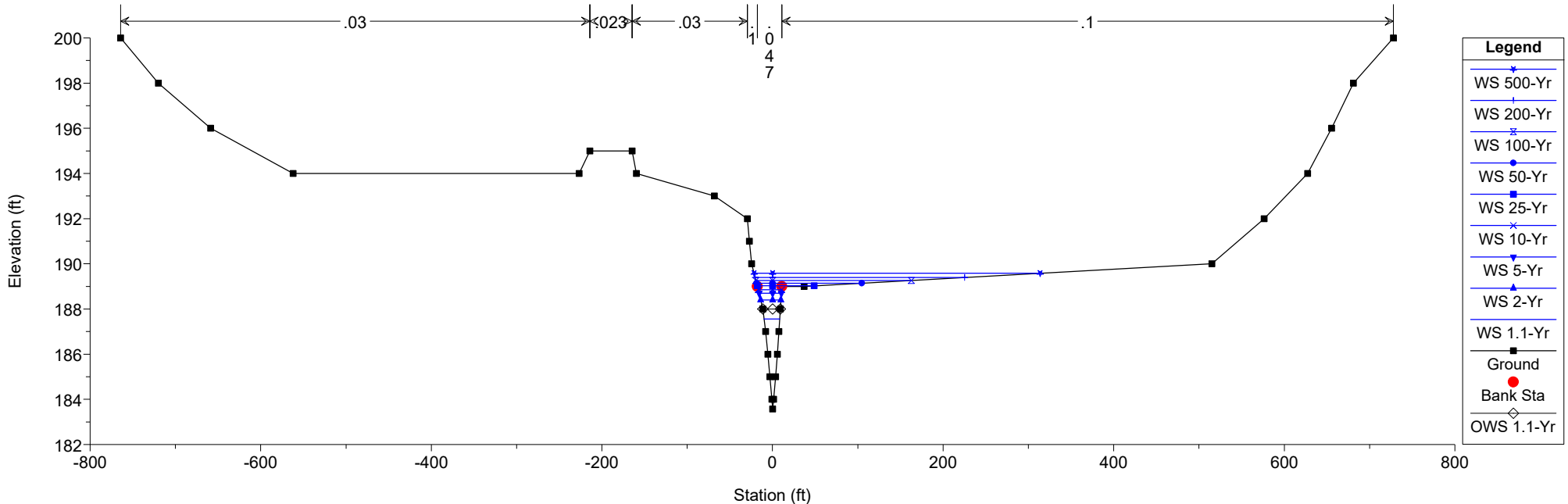
Legend	
WS 500-Yr	Blue line with asterisk
WS 200-Yr	Blue line with plus
WS 100-Yr	Blue line with cross
WS 50-Yr	Blue line with circle
WS 25-Yr	Blue line with square
WS 10-Yr	Blue line with x
WS 5-Yr	Blue line with inverted triangle
WS 2-Yr	Blue line with triangle
WS 1.1-Yr	Blue line with diamond
Ground	Black line with square
Ineff	Green line with triangle
Bank Sta	Red line with circle

67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024

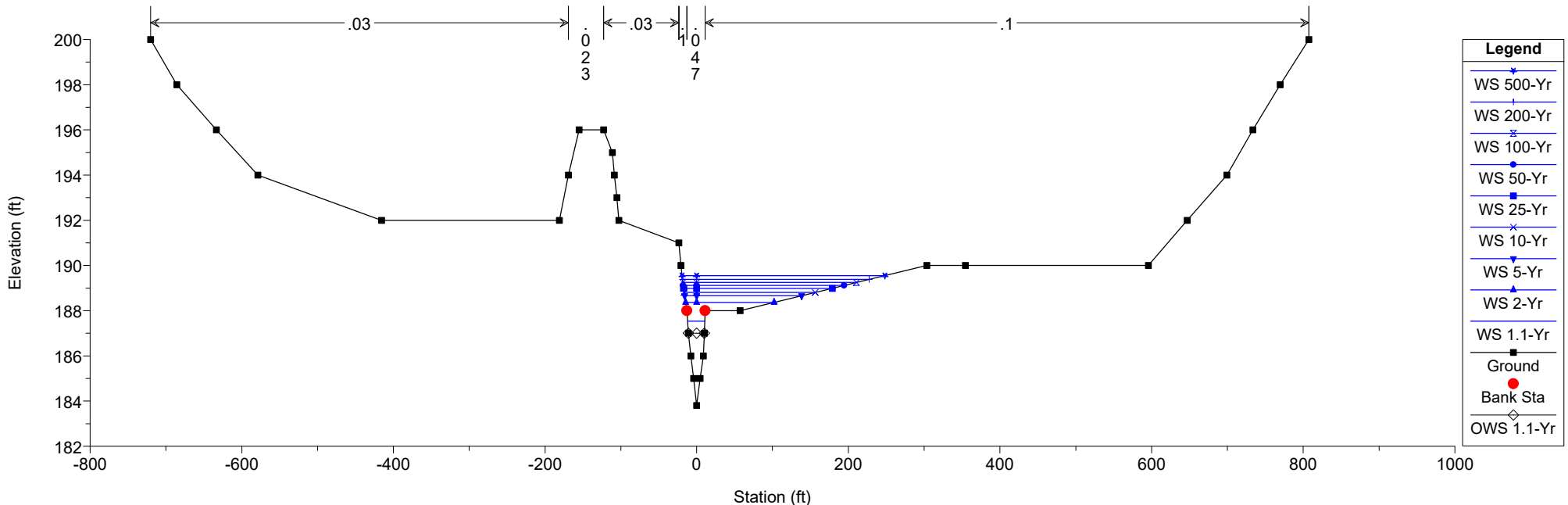


Legend	
WS 500-Yr	Blue line with asterisk
WS 200-Yr	Blue line with plus
WS 100-Yr	Blue line with cross
WS 50-Yr	Blue line with circle
WS 25-Yr	Blue line with square
WS 10-Yr	Blue line with x
WS 5-Yr	Blue line with inverted triangle
WS 2-Yr	Blue line with triangle
WS 1.1-Yr	Blue line with diamond
Ground	Black line with square
Ineff	Green line with triangle
Bank Sta	Red line with circle
OWS 1.1-Yr	White line with diamond

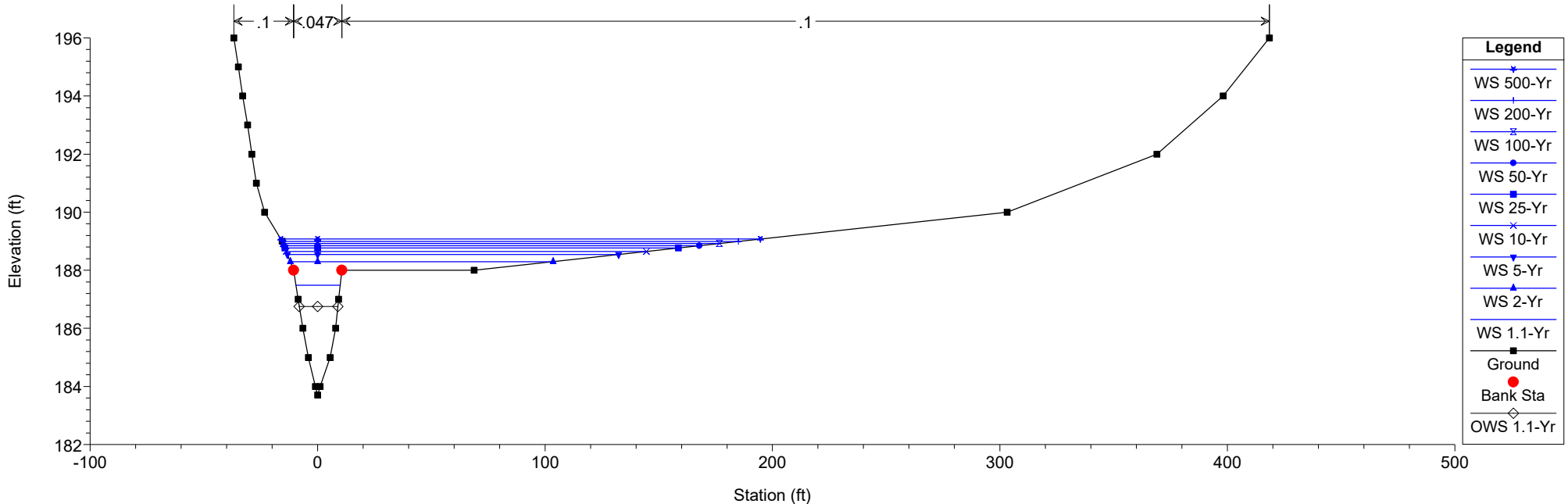
67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024



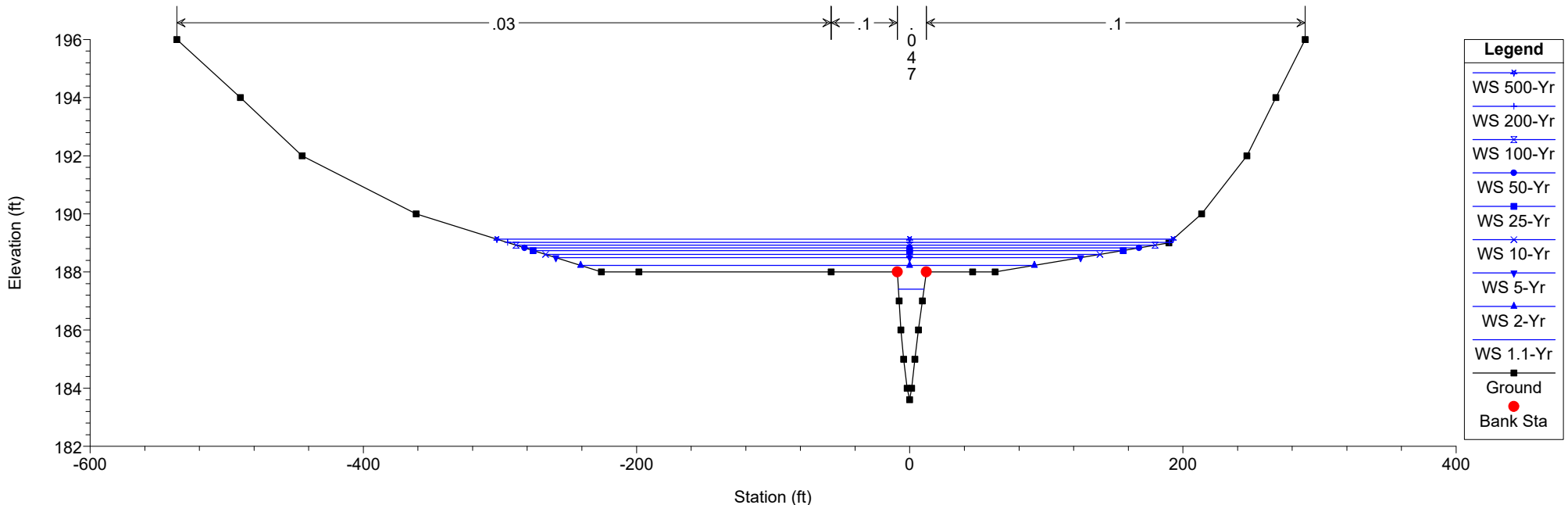
67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024



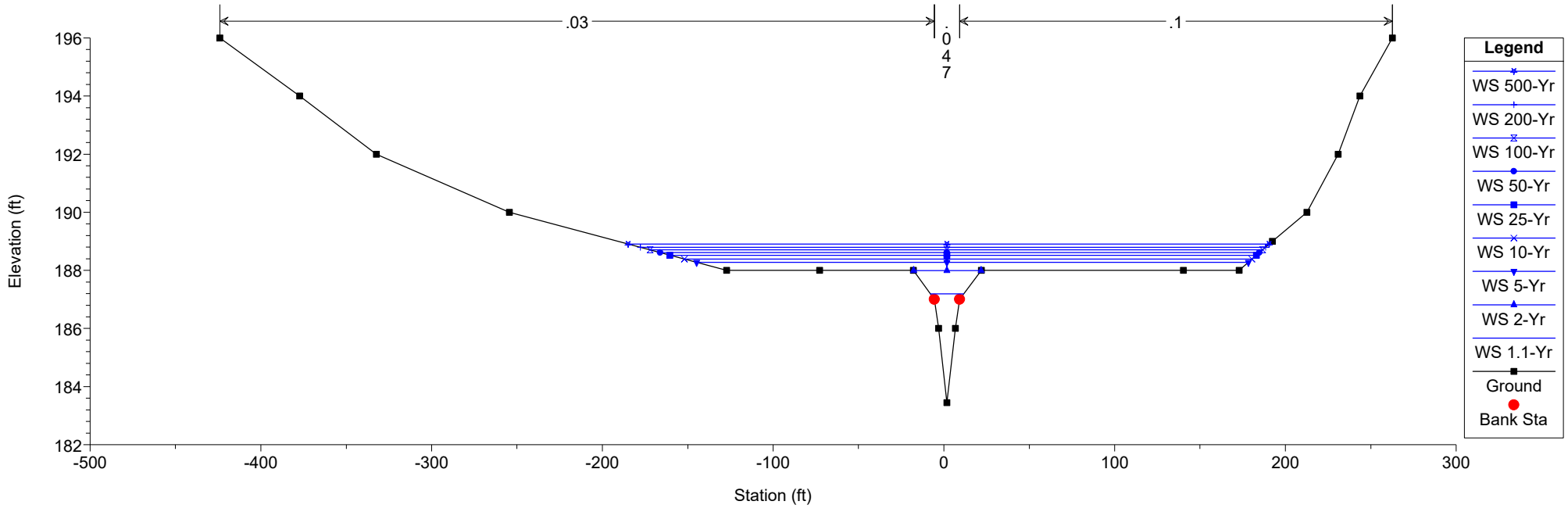
67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024



67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024



67328\_MaineDOT Bailey Flat Bridge\_2024 Plan: Alternative 03\_Calibration\_Max 9/6/2024



Legend	
WS 500-Yr	Blue line with asterisk marker
WS 200-Yr	Blue line with plus marker
WS 100-Yr	Blue line with asterisk marker
WS 50-Yr	Blue line with circle marker
WS 25-Yr	Blue line with square marker
WS 10-Yr	Blue line with asterisk marker
WS 5-Yr	Blue line with downward triangle marker
WS 2-Yr	Blue line with upward triangle marker
WS 1.1-Yr	Blue line with square marker
Ground	Black line with square marker
Bank Sta	Red circle

# APPENDIX E

## Scour Countermeasure Analysis

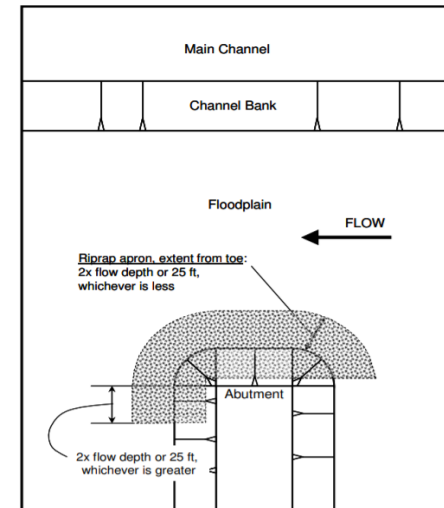
### FHWA HEC-23 Design Guideline 14 - Rock Riprap at Bridge Abutments

Design Storm: 1% Chance Event													
Abutment Location	Abutment Cross Section Location	Abutment Type	K	S <sub>g</sub>	V (ft/s)	g (ft/s <sup>2</sup> )	WSEL (ft NAVD88)	Abutment Toe Elevation (ft NAVD88)	y (ft)	Froude Number	D <sub>50</sub> (ft)	D <sub>50</sub> (in)	Design D <sub>50</sub> (in)
North	Left	Vertical Wall	1.02	2.65	2.78	32.2	190.02	185.10	4.92	0.22	0.15	1.8	6
South	Right	Vertical Wall	1.02	2.65	2.78	32.2	190.02	185.10	4.92	0.22	0.15	1.8	6

Design Storm: 0.5% Chance Event													
Abutment Location	Abutment Cross Section Location	Abutment Type	K	S <sub>g</sub>	V (ft/s)	g (ft/s <sup>2</sup> )	WSEL (ft NAVD88)	Abutment Toe Elevation (ft NAVD88)	y (ft)	Froude Number	D <sub>50</sub> (ft)	D <sub>50</sub> (in)	Design D <sub>50</sub> (in)
North	Left	Vertical Wall	1.02	2.65	3.04	32.2	190.27	185.10	5.17	0.24	0.18	2.1	6
South	Right	Vertical Wall	1.02	2.65	3.04	32.2	190.27	185.10	5.17	0.24	0.18	2.1	6

#### Riprap Extents

Design Event	Abutment Location	Horizontal Extents Into Floodplain (ft)	Horizontal Extents Along Downstream Face (ft)
1% Chance Event	North	9.84	25.00
	South	9.84	25.00
0.5% Chance Event	North	10.34	25.00
	South	10.34	25.00



Legend	
K	For Froude # ≤ 0.80: 0.89 for Spill-Through Abutment 1.02 for Vertical Wall Abutment For Froude # > 0.80: 0.61 for Spill-Through Abutment 0.69 for Vertical Wall Abutment
S <sub>g</sub>	Specific Gravity of Rock Riprap (Assume 2.65)
V	Characteristic Average Velocity in the Contracted Section (ft/s)
g	Gravitational Acceleration (32.2 ft/s <sup>2</sup> )
y	Depth of Flow in the Contracted Bridge Opening (ft)
D <sub>50</sub>	Median Stone Diameter (ft)

#### Equations:

$$\frac{D_{50}}{y} = \frac{K}{(S_g - 1)} \left[ \frac{V^2}{gy} \right] \text{ when } Fr \leq 0.80$$

$$\frac{D_{50}}{y} = \frac{K}{(S_g - 1)} \left[ \frac{V^2}{gy} \right]^{0.14} \text{ when } Fr > 0.80$$

## FHWA HEC-23 Design Guideline 4 - Riprap Revetment

## Design Storm: 100-Year

HEC-RAS Section	Bank Location	C <sub>v</sub>	Embankment Slope (ft/ft)	K <sub>1</sub>	C <sub>s</sub>	S <sub>f</sub>	V (ft/s)	g (ft/s <sup>2</sup> )	y (ft)	S <sub>g</sub>	C <sub>T</sub>	Rc (ft)
515 (US Bridge Face)	Straight Channel	1.00	2:1	0.87	0.3	1.1	2.78	32.2	4.92	2.65	1.00	9999.00
410 (DS Bridge Face)	Straight Channel	1.00	2:1	0.87	0.3	1.1	2.70	32.2	4.92	2.65	1.00	9999.00

HEC-RAS Section	W <sub>w</sub> (ft)	V <sub>DES</sub> (ft/s)	D <sub>30</sub> (ft)	D <sub>50</sub> (ft)	D <sub>50</sub> (in)	Design D <sub>50</sub> (in)
515 (US Bridge Face)	--	2.8	0.02	0.03	0.3	6
410 (DS Bridge Face)	--	2.7	0.02	0.03	0.3	6

## Check Storm: 200-Year

HEC-RAS Section	Bank Location	C <sub>v</sub>	Embankment Slope (ft/ft)	K <sub>1</sub>	C <sub>s</sub>	S <sub>f</sub>	V (ft/s)	g (ft/s <sup>2</sup> )	y (ft)	S <sub>g</sub>	C <sub>T</sub>	Rc (ft)
515 (US Bridge Face)	Straight Channel	1.00	2:1	0.87	0.3	1	3.04	32.2	5.17	2.65	1.00	9999.00
410 (DS Bridge Face)	Straight Channel	1.00	2:1	0.87	0.3	1	3.01	32.2	5.17	2.65	1.00	9999.00

HEC-RAS Section	W <sub>w</sub> (ft)	V <sub>DES</sub> (ft/s)	D <sub>30</sub> (ft)	D <sub>50</sub> (ft)	D <sub>50</sub> (in)	Design D <sub>50</sub> (in)
515 (US Bridge Face)	---	3.04	0.03	0.03	0.4	6
410 (DS Bridge Face)	---	3.01	0.03	0.03	0.4	6

Legend	
C <sub>v</sub>	Velocity Distribution Coefficient Straight Channel: 1.0 Inside Bend: 1.0 Outside Bend: 1.283 - 0.2 * LOG(R <sub>c</sub> /W)
R <sub>c</sub>	Centerline Radius of Channel
W	Width of Water Surface At Upstream End of Bend
C <sub>s</sub>	Stability Coefficient Angular Rock: 0.30 Rounded Rock: 0.375
S <sub>f</sub>	Safety Factor (> 1.0)
C <sub>T</sub>	Blanket Thickness Coefficient (Assumed 1.0)
S <sub>g</sub>	Specific Gravity of Rock Riprap (Assume 2.65)
V	Characteristic Average Velocity in the Contracted Section (ft/s)
g	Gravitational Acceleration (32.2 ft/s <sup>2</sup> )
y	Depth of Flow in the Contracted Bridge Opening (ft)
V <sub>DES</sub>	Characteristic Velocity for Design (ft/s)
K <sub>1</sub>	Side Slope Correction Factor
D <sub>30</sub>	Particle Size for Which 30% is Finer By Weight(ft)
D <sub>50</sub>	Median Stone Diameter (ft) (D <sub>50</sub> = 1.2 * D <sub>30</sub> )

## Equations:

$$d_{30} = y(S_f C_s C_v C_T) \left[ \frac{(V_{des})}{\sqrt{K_1(S_g - 1)gy}} \right]^{2.5}$$

$$K_1 = \sqrt{1 - \left( \frac{\sin(\theta - 14^\circ)}{\sin(32^\circ)} \right)^{1.6}}$$

$$V_{des} = V_{avg}(1.74 - 0.52\log(R_c/W))$$

$$V_{des} = V_{avg} \text{ for } R_c/W > 26$$