Preliminary Design Report

Mill Bridge #0618
over
Dyer Creek

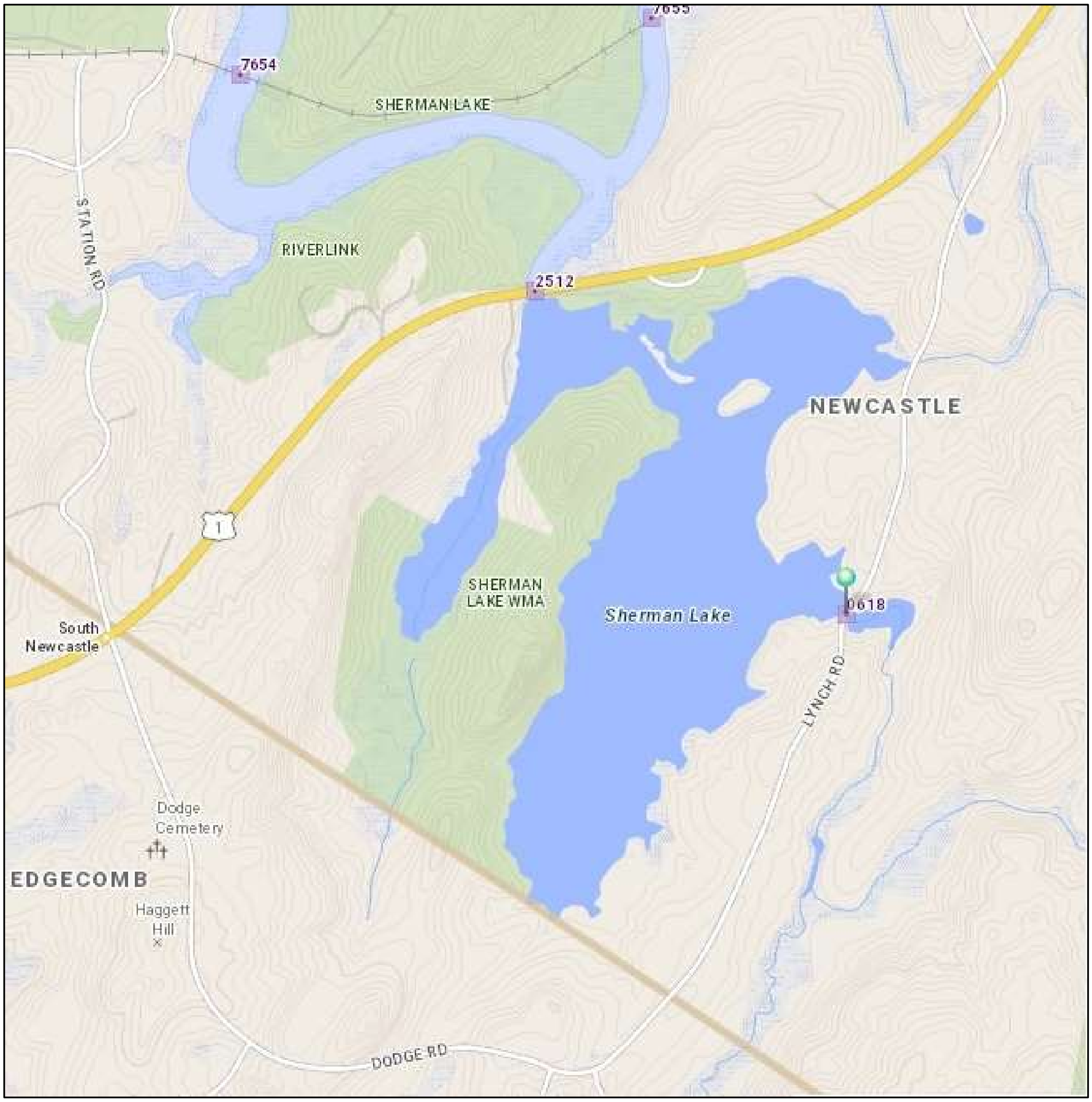
Newcastle, Maine

STP- TBD
WIN TBD

TABLE OF CONTENTS

LOCATION MAP

Newcastle, Mill Bridge #0618, WIN TBD
Lynch Road over Dyer Creek



Latitude: 44° 00' 13.1" N, Longitude: 69° 35' 16.9" W

PRELIMINARY DESIGN REPORT

WIN	TBD	**TOWN**	Newcastle
BRIDGE NO.	0618	**BRIDGE**	Mill Bridge

PROJECT MANAGER Town of Newcastle

DESIGNED BY	VHB Brian Reeves	**DATE**	9/29/2023
APPROVED BY	_______________	**DATE**	_______
APPROVED BY	_______________	**DATE**	_______

PROGRAM SCOPE: Bridge Replacement

PROGRAM DESCRIPTION: Replacement of precast three-sided frame bridge spanning 14'-0" (#0618) carrying Lynch Road over Dyer Creek, located in Newcastle.

PROJECT RECOMMENDATION: Replace existing bridge due to scour induced undermining of footings causing instability and damage of the existing structure.

BRIDGE ROADWAY SECTION: Existing bridge has two 11' lanes for a total guardrail-to-guardrail width of 22'. The guardrail system is offset from the headwall of the structure on both sides for a total out-to-out width of 36'-4".

ALIGNMENT DESCRIPTION: The horizontal alignment is tangent over the bridge with a 105' curve leading into the Northerly approach and an 80' curve leading into the Southerly approach. The existing vertical alignment has a low point on the southerly side of the bridge to shed water off the bridge. The proposed vertical alignment raises the grade over the bridge to create a tangent 0.65% slope to the south with a new low point approximately 20' south of the bridge. The proposed grade is less than 1' higher than existing over the bridge.

SPANS	14'-0"			**SKEW**	15°back
		JURISDICTION	Townway	**NHS**	No
FUNCTIONAL CLASSIFICATION			Local Road	**CORRIDOR PRIORITY**	5
TRAFFIC:	2022	**AADT**	210	**ACCIDENT DATA, CRF**	N/A
	2042	**AADT**		**DHV**	N/A

POSTED SPEED 35 mph

COMPLETE STREETS: N/A

MAINTENANCE OF TRAFFIC: Closure of Lynch Road during construction with detour using Route 1 and Dodge Road. Anticipated closure of one construction season.

CONSTRUCTION YEAR: 2024 **ADVERTISING DATE:** February 2024

TABLE OF ALTERNATIVES COSTS

	Replace In-Kind (FEMA)	4-Sided Box	Bridge (Recommend)
Final Design	$85,000	$85,000	$105,000
Right-of-Way	$10,000	$10,000	$10,000
Structure	$870,000	$1,000,000	$1,500,000
Approaches			$50,000
Constr. Support	$40,000	$40,000	$40,000
Total	**$1,005,000**	**$1,135,000**	**$1,705,000**

ADDITIONAL BORINGS REQUIRED? No

ADDITIONAL GEOTECHNICAL EVALUATIONS REQUIRED: No

APPROVED DESIGN EXCEPTIONS: N/A

MUNICIPAL/STATE AGREEMENT REQUIRED? N/A

COMMENTS BY ENGINEER OF DESIGN: Accelerated construction schedule requires substantial completion by November 2024. Procurement of precast concrete 3-sided or 4-sided box elements may be challenging.

EXISTING BRIDGE

YEAR BUILT 2010 **SPAN LENGTHS** 14'-0" **CURB TO CURB WIDTH** 22'

TYPE OF SUPERSTRUCTURE: Single span Precast 3-sided frame with asphalt pavement wearing surface on spread footings.

GENERAL CONDITION: The precast 3-sided frame is in overall fair condition with minor spalling at the last two downstream section and at the wall to footing interface. Due to scour the last two downstream segments have rotated and are misaligned up to 4".

TYPE OF SUBSTRUCTURE: Spread footing on soil.

GENERAL CONDITION: The southerly footing has been undermined the entire length of the foundation. The southerly footing has settled causing cracking, separation from and spalling of the frame wall.

LOAD RATINGS:	INVENTORY	OPERATING
HS 25 or Greater Rating Factor	32.7	45.4

STRUCTURALLY DEFICIENT **FUNCTIONALLY OBSOLETE** N/A

MAINTENANCE PROBLEMS: Scour has eroded the 12" D50 riprap placed at the time of construction leaving both footings exposed with undermining along the entire southerly footing and parts of the northerly footing.

MAINTENANCE WORK: Town of Newcastle placed flowable fill/grout after the last major rain event to stabilize and reopen the structure.

PREVIOUS STRUCTURE: Precast three-sided frame on spread footing.

OTHER COMMENTS: N/A

SUMMARY OF EXPECTED IMPACTS

RIGHT OF WAY	Number of:	Property Owners	4
		Buildings to Be Taken	None
	Type of Acquisitions:	☐ Fee Simple	☐ Easement
		☒ Temporary Rights	☐ Temporary Road

UTILITIES: T.B.D. (Overhead utilities present on site)

COAST GUARD PERMIT NEEDED? No

FAA PERMIT NEEDED? No

SUMMARY OF PRELIMINARY DESIGN

BACKGROUND

The existing crossing is a 14-foot, precast 3-sided frame. Scour has eroded the 12" D50 rirpap from within the structure exposing and undermining the footing. The southerly footing has been undermined the entire length of the structure causing settlement of the footing and instability of the 3-sided frame. The last two downstream sections of 3-sided frame have rotated and are misaligned up to 4".

PURPOSE AND NEED

The existing structure is in a compromised condition due to the scour undermining both footings. This scour has caused instability of the structure requiring emergency repairs to reopen the structure and the resulting displacements of the existing structural units have caused undue distress of the units such that their long-term usage is not recommended. A new structure is required to prevent further deterioration and closure of the existing structure and to increase the hydraulic capacity of the structure. Emergency funding sources require an accelerated schedule and substantial construction completion in November 2024.

MAINTENANCE OF TRAFFIC

The following maintenance of traffic alternatives were explored: road closure and phased construction. Phased construction would result in additional permanent impacts to widen the existing roadway and increased construction complexity at this location. The phased construction alternative was dismissed due to complexity and the instability of the existing structure. The recommended maintenance of traffic is a temporary closure of Lynch Road near the structure. The detour would reroute traffic onto Route 1 and Dodge Road while construction occurs. The Detour length is 4.9 miles abutment to abutment.

UTILITIES

There are aerial utilities approximately 55 feet to the east of the bridge with a utility pole present approximately 50 feet from the northeast guardrail end. No permanent utility impacts are anticipated.

RIGHT OF WAY

Property agreements will need to be evaluated by the Town. Existing right of way information was not available for this portion of the project and were approximated based on field survey information. It is recommended that full boundary survey of the area be completed prior to construction.

SUMMARY OF ALTERNATIVES

The following alternatives were considered:

1. Replace in-kind with Precast 3-sided frame on pedestal walls and spread footings;
2. Precast 4-sided Concrete Box Culvert meeting current hydraulic and stream crossing standards;
3. Bridge supported on spread footing founded on bedrock and glacial till.

Alternative 1: Replace In-kind with Three-sided Frame (Hydrologic and Hydraulic Report Alt. 3)

Replacement in-kind with a precast three-sided frame on spread footings was considered as an alternative for this project. The existing span creates a channel restriction leading to excessive scour and instability of the foundation. For a three-sided frame to be feasible a greater foundation depth will be required along with additional scour countermeasures. Previous structure plans indicated stone riprap protection with a D50 of 12”, the replacement structure will require riprap protection with a D50 of 24” in line with MaineDOT standard specification for heavy riprap. Due to the additional construction duration and cost of installing deeper, cast in place footing and scour countermeasures, and the history of scour related structure failures at this site (see Hydraulic Report, Appendix C) this alternative is neither recommended nor feasible.

Alternative 2: 4-Sided Box Culvert (Hydrologic and Hydraulic Report Alt. 1)

A concrete box culvert sized for hydraulic needs eliminates the need for a deeper foundation, reduces the risk of future scour concerns compared to Alternative 1, and reduces future maintenance costs. Embedment and the addition of a simulated stream bottom achieves habitat connectivity. Field measured bankfull width is 18’. A box culvert with span of 22 feet, 1.2 times bankfull width, and rise of 12 feet was checked for hydraulics and meets MaineDOT Bridge Design Guide standards. Special fill within the culvert consists of void filled heavy riprap to a depth of 2’ in the channel and 3.5’ for banks with a terrestrial wildlife shelf on either side. Procurement time of 4-sided box culvert units may be challenging given a construction substantially complete date of November 2024.

Alternative 3: Bridge (Hydrologic and Hydraulic Report Alt. 2)

A 50-foot steel I-beam bridge on spread footings founded on bedrock (North Abutment) and glacial till (South Abutment). Based on geotechnical information bedrock is located approximately 15-17 feet below ground surface on the north side and 24 feet on the south side. The north abutment will be a spread footing founded on bedrock while the southerly abutment will be a spread footing founded on dense glacial till approximately 17 feet below ground surface. To protect the south abutment from future scour it is recommended to armor slopes in front of the footing to an elevation of at least 9.6’ with void filled heavy riprap. The increased span reduces the constriction of the existing structure reducing stream velocities during high flow and tidal events. Alternative 3 includes a constructed stream simulation channel and banks with terrestrial wildlife shelf on either side. Material procurements for this alternative do not present any known challenges to meet a construction substantially complete date of November 2024.

PROPOSED ALTERNATIVE

The recommended alternative for this project is Alternative 3, a 50-foot span steel I-beam bridge. This alternative results in the lowest flood velocities and smallest calculated scour depths, as well as providing the greatest freeboard above flood elevations and climate resiliency against rising seawater elevations. Due to the accelerated schedule of the project, procurement of a steel I-beam superstructure best meets the schedule and reduces construction complexity.

The preliminary construction cost estimate for this replacement is $1,550,000. Total project cost, including Preliminary Engineering, Construction Engineering, and assumed Right-of-Way costs is $1,705,000. Estimates are based on adjusted market pricing. For more information please see Appendix D.

HYDROLOGY REPORT

The following table presents a summary of proposed hydraulic conditions for the alternative designs. Refer to the separate Hydrologic and Hydraulic (H&H) Report for detailed hydrologic, hydraulic, and scour analysis.

SUMMARY

		Replace in-kind	Alternative 2	Recommended Structure
		Precast 3 Sided Frame	22'x8' Box Culvert	50' Simple Span
Total Area of Waterway Opening	ft^2	114.24	200	380
Headwater elevation @ $Q_{1.1}$	ft	5.8	5.6	5.6
Headwater elevation @ Q_{10}	ft	6.2	5.7	5.7
Headwater elevation @ Q_{25}	ft	6.5	5.7	5.7
Headwater elevation @ Q_{50}	ft	6.7	5.8	5.7
Headwater elevation @ Q_{100}	ft	6.9	5.8	5.8
Headwater elevation @ Q_{500}	ft	7.4	6	5.9
Freeboard @ Q_{50}	ft	4.4	3.6	5.7
Freeboard @ Q_{100}	ft	4.2	3.6	5.6
Flood Of Record (Unknown)				
Outlet Velocity @ $Q_{1.1}$	ft/s	4.0	8.4	7.9
Outlet Velocity @ Q_{10}	ft/s	18.2	10.4	10.4
Outlet Velocity @ Q_{25}	ft/s	21.3	13.0	11.4
Outlet Velocity @ Q_{50}	ft/s	22.5	14.0	12.2
Outlet Velocity @ Q_{100}	ft/s	24.2	15.0	13.0
Outlet Velocity @ Q_{500}	ft/s	25.2	17.3	14.6

Reported by: Dave Cloutier
Date: October 12, 2023

Note: Bridge crossing is tidally-influenced; values provided here represent maximum headwater elevations (high tide condition) and outlet velocities (low tide condition) over the range of tailwater conditions at the crossing. All elevations referenced to the North American Vertical Datum of 1988 (NAVD88).

Appendix A

Preliminary Plans

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

SPECIFICATIONS

Design: Load and Resistance Factor Design per AASHTO LRFD Bridge Design Specifications, Ninth Edition 2020.

DESIGN LOADING

Live Load	HL - 93 Modified for Strength I

HYDROLOGIC DATA

Drainage Area	4.7 sq mi
Design Discharge (Q50)	519 cfs
Check Discharge (Q100)	602 cfs
Headwater Elevation (Q1.1)	5.6 ft
Headwater Elevation (Q25)	5.7 ft
Headwater Elevation (Q50)	5.7 ft
Headwater Elevation (Q100)	5.8 ft
Discharge Velocity (Q1.1)	7.9 fps
Discharge Velocity (Q50)	12.2 fps
Discharge Velocity (Q100)	13.0 fps
Mean Lower Low Water (MLLW)	-5.26 ft
Mean Low Water (MLW)	-3.63 ft
Mean Tide Level (MTL)	-3.58 ft
Mean High Water (MHW)	0.76 ft
Mean Higher High Water (MHHW)	5.15 ft
2100 Median Sea Level Rise Estimate	+/- 4 ft

MATERIALS

Concrete:	
Barriers, Curbs, Sidewalks & Transition Barriers	Class "LP"
Seals	Class "S"
All Other	Class "A"
Reinforcing:	
Plain Reinforcing Steel	ASTM A615, Grade 60
Structural Steel:	
All Material (except as noted)	ASTM A709, Grade 50W (unpainted)
High Strength Bolts	ASTM F3125, Grade A325, Type 3

BASIC DESIGN STRESSES

Concrete:	
Class "A"	f 'c = 4,000 psi
Class "LP"	f 'c = 5,000 psi
Class "S"	f 'c = 3,000 psi
Reinforcing:	
Plain Reinforcing Steel	f y = 60,000 psi
Structural Steel:	
ASTM A709, Grade 50W	F y = 50,000 psi
ASTM F3125, Grade A325	F µ = 120,000 psi

NEWCASTLE
LINCOLN COUNTY
MILL BRIDGE
OVER
DYER CREEK
LYNCH ROAD
BRIDGE REPLACEMENT
PROJECT LENGTH 0.02 mi.
BRIDGE NUMBER. 0618

LIST OF DRAWINGS

UTILITIES

Electric
Telephone
Cable TV
Water / Sewer

TRAFFIC DATA

Current (2023) AADT	210
Design Speed (mph)	35

MAINTENANCE OF TRAFFIC

Closure of Lynch Road at Mill Bridge for the duration of construction.
Detour utilizing US Route 1 and Dodge Road

PROJECT LOCATION	Bridge is located 0.85 miles northeast of Spring Hill Farm Road. Latitude 44°00'13.3" Longitude 69°35'16.8"
PROGRAM AREA	Town of Newcastle
OUTLINE OF WORK	Bridge Construction: Bridge replacement and related approach work.

STATE OF MAINE DEPARTMENT OF TRANSPORTATION
APPROVED | DATE
COMMISSIONER:
CHIEF ENGINEER:

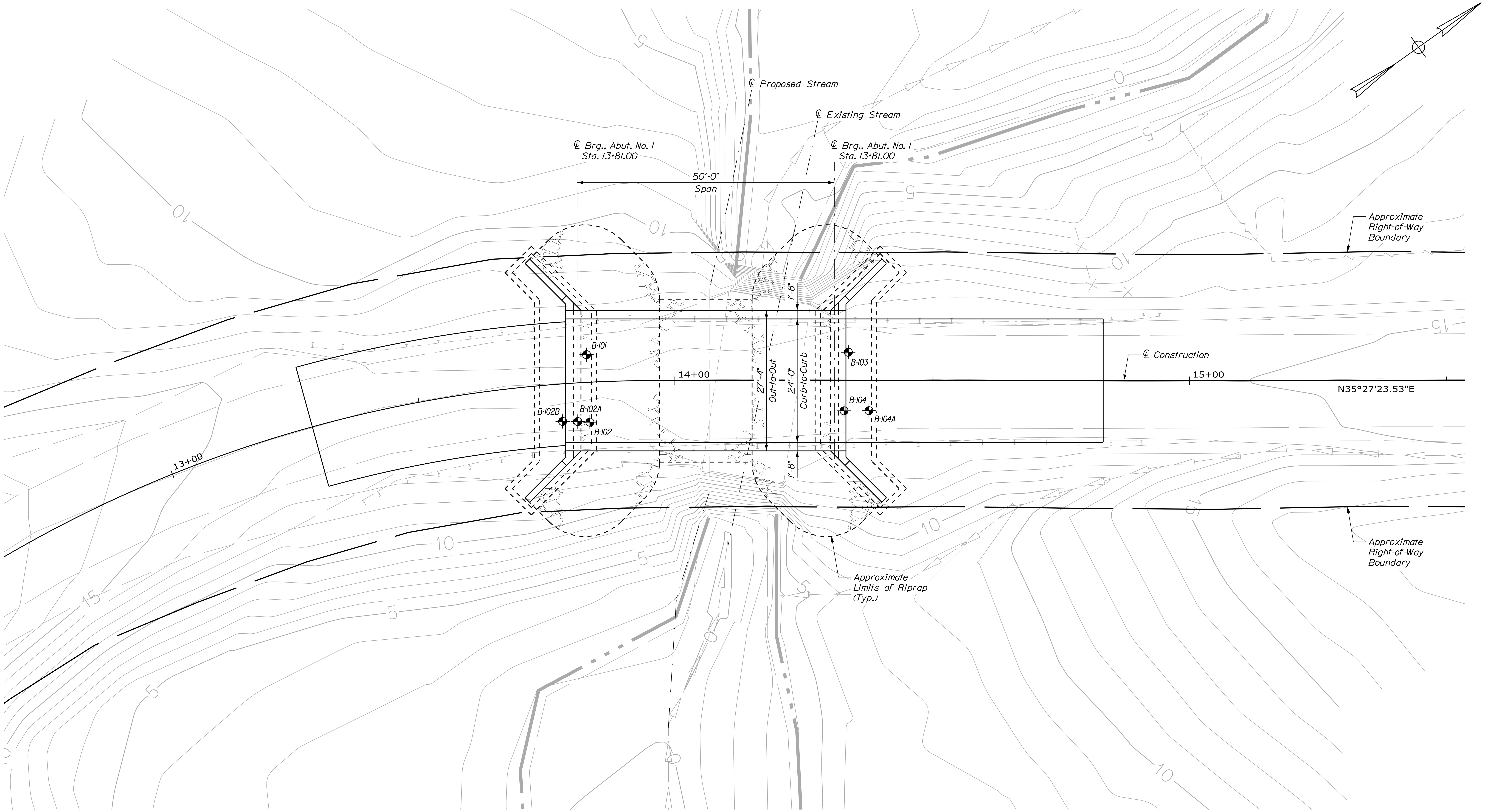
PROJECT INFORMATION | SIGNATURE | P.E. NUMBER | DATE

PROGRAM	BRIDGE
PROJECT MANAGER	RSBunt
DESIGNER	B. Reeves/C. Ayers
CONSULTANT	VHB
PROJECT RESIDENT	
CONTRACTOR	
PROJECT COMPLETION DATE	

NEWCASTLE
MILL BRIDGE
TITLE SHEET

SHEET NUMBER
1
OF 4

Filename:\BRIDGE\MSTA\001_Cover.dgn Division: HIGHWAY Username: breeves Date:10/17/2023



PLAN

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BRIDGE PLANS

BRIDGE NO. 0618

PROJ. MANAGER	--------		
DESIGN-DETAILED	JAH	BY	DATE
CHECKED-REVIEWED	JAH		
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

LYNCH ROAD OVER DYER CREEK

NEWCASTLE LINCOLN COUNTY

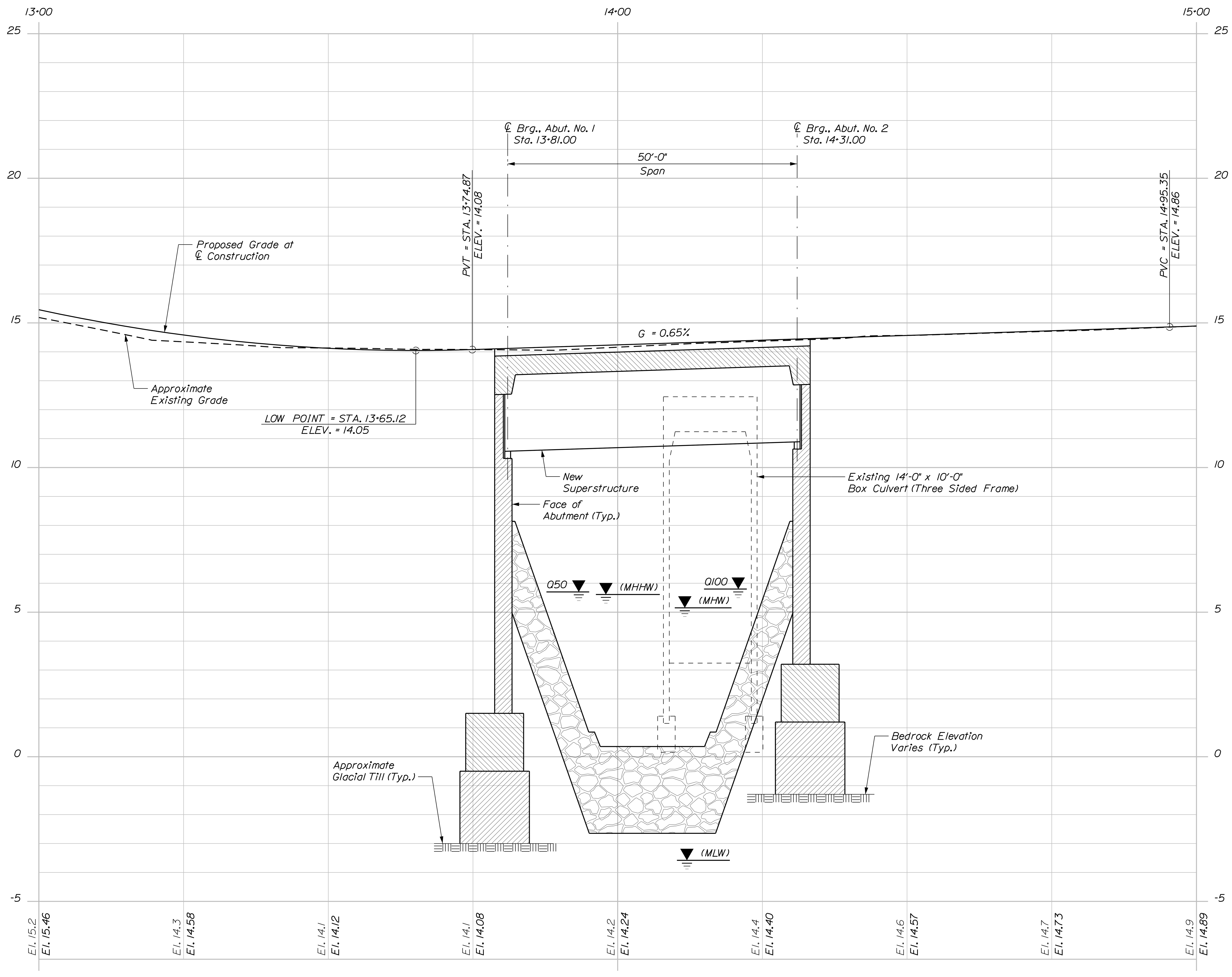
GENERAL PLAN

SHEET NUMBER

2

OF 4

Filename: ...\BRIDGE\MSTA\002_Genplan.dgn Division: HIGHWAY Username: kwentworth Date:10/17/2023



EXAGGERATED PROFILE

Horiz. 10 0 10 20

Vert. 5 0 5 10

Scale of Feet

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BRIDGE PLANS

BRIDGE NO. 0618

vhb

PROJ. MANAGER	-------	BY	DATE
DESIGN-DETAILED	JAH	JAH	
CHECKED-REVIEWED			
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

LYNCH ROAD OVER DYER CREEK

NEWCASTLE LINCOLN COUNTY

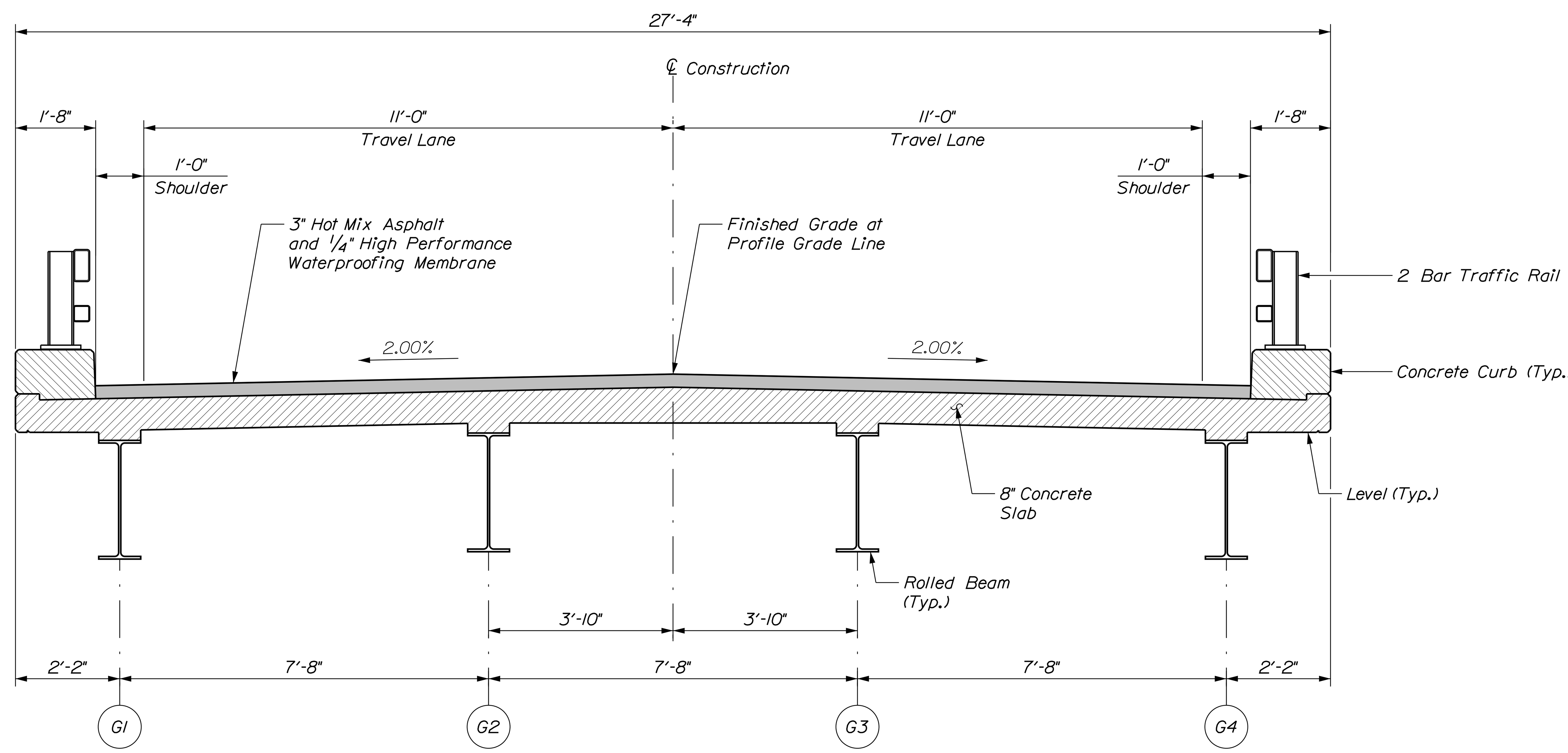
PROFILE

SHEET NUMBER

3

OF 4

Filename: ...\BRIDGE\MSTA\004_Btyp.dgn Division: HIGHWAY Username: kwentworth Date:10/17/2023



TRANSVERSE SECTION

(Looking Up Station)
Scale: 1/2" = 1'-0"

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BRIDGE PLANS

BRIDGE NO. 0618

		BY	DATE
PROJ. MANAGER	-------		
DESIGN-DETAILED	JAH	JAH	
CHECKED-REVIEWED			
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

LYNCH ROAD OVER DYER CREEK

NEWCASTLE LINCOLN COUNTY

TRANSVERSE SECTION

SHEET NUMBER

4

OF 4

Appendix B

Photographs

Looking Upstream from Bridge #0618

Looking Downstream through existing Bridge

Looking Downstream from Bridge #0618

Looking upstream at existing bridge

Looking North along Lynch Rd

Looking South along Lynch Rd

Separation of frame sections and footing damage

Distortion/Settlement of frame sections

Southern damaged footing

Exposed footing and undermining

Appendix C

Hydrologic

&

Hydraulic

Report

To: Kevin Sutherland, Town Manager
Town of Newcastle, Maine
townmanager@newcastlemaine.us

Date: October 11, 2023

Memorandum

Project #: 55718.00

From: David Cloutier, P.E.
Senior Water Resources Engineer

Re: DOT W.I.N. 023098.00
Hydrologic and Hydraulic (H&H) Report
Bridge No. 0618, Lynch Road over Dyer Creek
Newcastle, Maine

Background

VHB has prepared the following Level 2 hydraulic and scour analysis for the proposed replacement of the culvert carrying Lynch Road over Dyer Creek in Newcastle, Maine. In addition to this analysis, VHB has evaluated the existing and proposed design for compatibility with MaineDOT Habitat Connectivity Design (HCD), consistent with the guidelines of the Maine Atlantic Salmon Programmatic Consultation (MAP) User Guide (March 2017). The location of the project is shown in **Figure 1.**

All elevations in this memorandum are referenced to the North American Vertical Datum of 1988 (NAVD88).

Existing Conditions

The existing Bridge #0618 crossing structure is a 36-foot long, 14-foot span by 10-foot tall open-bottom precast concrete three sided frame set on cast-in-place concrete spread footings; wingwalls consist of stacked boulders and riprap. Excerpts from design plans dated April 2010 Plans are not available for the original stone masonry culvert, but plans dated 1931 are available.

The existing crossing structure carries Lynch Road over Dyer Brook; the crossing is located within the tidally-influenced reach where Dyer Brook enters Sherman Marsh, approximately 800 feet downstream of the head of tide. The stream generally flows northwesterly through the crossing reach, and the culvert structure is skewed approximately 10° to the roadway. The roadway is elevated approximately 15 feet above the stream channel.

The existing structure is in very poor condition; there is an extensive scour hole in the channel bed along the entire length of the culvert, both footings are undermined up to 2 feet vertically along the entire length of the culvert, there are large gaps between the culvert segments with the two downstream segments over 4 inches out of level, and there are voids and sinkholes in the roadway above the structure. Scattered riprap was observed across the channel bed up to 150 feet downstream of the culvert. There are voids between the stacked stones comprising the structure wingwalls.

There is an existing overhead electric line crossing Dyer Brook approximately 60 feet upstream of the culvert, but no other documented utilities near the crossing.

Information Collection

For this evaluation, VHB reviewed the following data:

- Topographic field survey of the existing crossing, channel bathymetry, and surrounding area collected by VHB in July 2023.
- Excerpts of design plans for the 2010 culvert replacement dated April 2010 provided by the Town of Newcastle.
- Highway Bridge Inspection Report "Bridge #0618 'Mill' Lynch Road over Dyer Creek" dated March 2020.
- Current and historic USGS topographic maps and aerial imagery for Newcastle, Maine.
- USGS StreamStats hydrologic delineation and watershed characterization
- Flood Insurance Rate Map (FIRM) Panel 23015C0265D for Lincoln County (Effective Date July 16, 2015)
- Flood Insurance Study (FIS) for Lincoln County (Effective Date July 16, 2015)
- High-resolution (1-foot) LiDAR topographic data provided by USGS and dated 2020.
- NOAA tidal elevation data (Station 8418150, Portland Maine)
- MaineDOT Sherman Marsh 2006-2010 tidal study
- VHB conducted a field assessment of the crossing on July 24, 2023, to evaluate bridge hydraulics and stream geomorphology. Photographs are included in **Appendix A.**

The proposed crossing is located within flood Zone A as depicted on FIRM Panel 23015C0265D, Effective Date July 16, 2015. Zone A areas are determined by approximate methods; the FIS does not provide any flood elevation data or other hydrologic/ hydrologic data for Dyer Brook. However, the FIS does include tidal storm surge elevation estimates for the Sheepscot River in Wiscasset approximately 6 miles downstream of the crossing.

The crossing is not located within a regulatory floodplain, and therefore is not subject to the NFIP 60.3.(d)3 "No-Rise" requirement.

Habitat Connectivity Design

Stream Channel Characteristics

Because the reach of Dyer Brook at the crossing location is tidally-influenced, Habitat Connectivity Design (HCD) incorporating USFWS Stream Simulation methodology for aquatic organism passage is not appropriate here. However, in order to identify an appropriately-sized stream channel geometry for the crossing VHB conducted an abbreviated field geomorphic assessment of a riverine reach of Dyer Brook approximately 900 feet upstream of the crossing, immediately upstream of the head of tide.

Dyer Brook is a tidal mudflat with salt marsh floodplains near the crossing; immediately downstream of the culvert, the channel drops steeply through a riprap-boulder cascade. The channel is exposed during low tide, but as the tide comes in under normal conditions flow reverses and the channel becomes submerged. The head of tide of Dyer Brook is located approximately 800 feet upstream of the crossing at a series of bedrock falls. Above these falls, the Dyer Brook is a cobble-gravel step-pool stream with bedrock outcrops flowing through a forested floodplain. Through this reach, bankfull widths (BFW) vary from 17 to 20 feet and bankfull height (BFH) is approximately 2 feet.

Photographs of representative stream features are included in **Appendix A.**

Longitudinal Profile

VHB collected topographic survey of the Dyer Creek thalweg extending 400 feet upstream and downstream of the existing culvert. This survey scope exceeds 20 times the average bankfull width and extends sufficiently far upstream to identify the limit of influence of the culvert on the upstream tidal flats. An annotated profile of the unnamed stream longitudinal profile is provided in **Figure 2.**

The longitudinal profile of the stream varies significantly through the surveyed reach: upstream of the crossing, the channel is nearly flat with average slope of 0.1%, then drops nearly 5 feet at slopes exceeding 10% immediately downstream of the culvert before returning to a nearly flat slope in the Sherman Marsh mudflat downstream. Upstream of the head of tide, the channel profile is approximately 1% to 2%.

Due to the tidal influence and anomalous channel slope at the crossing, VHB did not evaluate the Vertical Adjustment Profile (VAP) of the channel or select a reference reach for stream design.

Streambed Pebble Count

VHB staff conducted a pebble count on July 24, 2023, within the closest non-tidal reach approximately 900 feet upstream of the crossing. VHB did not perform a pebble count within the mudflats surrounding the existing culvert crossing. Visual assessment of the mudflats indicates a marine sediment mix of fine sand, silt, and organics with scattered gravel and cobbles.

The overall D50 of the non-tidal pebble counts was approximately 2.0 inches (pebble gravel/cobble), with a maximum observed pebble size of 17 inches (boulder). A gradation chart illustrating pebble count results are presented in **Figure 3.**

Proposed Channel Design

Due to the tidal influence at the crossing, VHB does not recommend a geomorphic-based stream simulation design. However, VHB incorporated some elements of stream-simulation to improve hydraulic capacity, scour resilience, and wildlife passage functionality. VHB evaluated three alternatives for the proposed replacement design:

- Alternative 1, Box Culvert – a 22-foot span by 12-foot high, 40-foot-long precast concrete four-sided box culvert
- Alternative 2, Bridge – a 50-foot span, 24-foot wide, single-span steel girder bridge
- Alternative 3, In-Kind Replacement – a 14-foot span by 10-foot-high open bottom precast three-sided frame

Alternatives 1 and 2 both incorporate a constructed stream simulation channel and banks with terrestrial wildlife shelf on either side. Both alternatives also adjust the layout to better accommodate the natural channel geomorphology at the crossing: the crossing is shifted south to better match the bend in the approaching stream channel, and the profile is lowered to reduce the waterfall effect at the culvert outlet with a channel slope of 1.15%, consistent with the natural channel profile above the head of tide. Both alternatives would maintain the existing 10° skew relative to the roadway. The constructed simulated stream channel bed would consist of void-filled heavy riprap, using channel streambed material to provide a natural stream surface over a heavy riprap layer providing scour protection. The cross-sectional channel would have a BFW of 18 feet and bank heights of 2.2 feet, with a triangular-shaped low-flow channel along the center of streambed and banklines set to tie-in to existing streambanks at the limit of work.

Alternative 3 is the "replace in kind" option and matches the alignment, size, materials, and grading of the existing structure; this alternative would raise the bed elevation at the crossing by approximately 5 feet relative to the existing scoured channel. However, to protect against a repeat of the existing scour damage, the bed material would be replaced with heavy riprap sized to resist modeled scour flows.

Table 1 provides a summary of the existing and proposed channel bankfull geometry:

Table 1 Habitat Connectivity Design Channel Geometry[1]

Watershed Area (mi^2)	Regression BFW (ft)	Measured BFW (ft)	Measured Channel Depth (ft)	1.2 BFW (ft)
4.7	17.2	18.0	2.0	21.6

1 Because the crossing is located within a tidally-influenced reach, full stream simulation Habitat Connectivity Design is not appropriate here. However, VHB has provided these values for reference.

Source: USGS Streamstats, USGS SIR 2004-5042, VHB 07/24/2023 field measurements

Hydrologic, Hydraulic, and Scour Analysis

Hydrologic Analysis

There is no stream gage data available for the Dyer Creek at this crossing. VHB calculated watershed size using the USGS StreamStats program and applied USGS Maine regression equations for ungaged streams (SIR 2020-5092) to estimate peak flood flow discharges for a range of flood frequencies. The results of this hydrologic analysis were applied to hydraulic modeling. **Table 2** presents a summary of peak flows at the crossing; the hydrologic analysis is included in **Appendix B**.

Table 2 Hydrologic Data for Proposed Design

Drainage Area	4.7 mi^2
Q2	169 cfs
Q5	267 cfs
Q10	340 cfs
Q25	439 cfs
Design Discharge (Q50)	519 cfs
Scour Discharge (Q100)	602 cfs
Check Scour Discharge (Q500)	816 cfs
Flood of Record	Unknown

Source: USGS StreamStats / SIR 2020-5092

Tidal Analysis

Bridge 0618 is located within a tidally-influenced reach of Dyer Creek, with tailwater elevations fluctuating by approximately 9 feet between low and high tide. This tidal variation has a major impact on hydraulics at the crossing, with conditions ranging from low velocities and high headwater elevations during high tide to high velocities and lower headwater elevations during low tide.

Prior to 2005, a downstream dam at the Route 1 crossing (approximately 0.75 miles northwest of Bridge 0618) maintained an impoundment (Sherman Lake) with a consistent water elevation of approximately 6.5 feet. That dam failed in September 2005, transforming the impounded freshwater Sherman Lake into a tidal estuary (Sherman Marsh). MaineDOT conducted an extended study of tidal elevations within Sherman Marsh following the initial dam failure in 2005 and Route 1 crossing stabilization and improvement work in 2008. Long-term historic tidal data for Casco Bay is also available from NOAA Portland tide gage data; measurements show that water levels at Sherman Marsh follow a similar tidal pattern to the NOAA Portland gage, but with slightly higher elevations.

Table 3 presents a summary of tidal elevations at the crossing; supporting data is included in **Appendix C**.

Table 3 Tidal Data for Proposed Design

	NOAA Gage 8418150, Portland	Sherman Marsh, Newcastle[1]
Mean Low Lower Water (MLLW)	-5.26 ft	-3.63 ft
Mean Low Water (MLW)	-4.91 ft	-3.58 ft
Mean Tide Level (MTL)	-0.35 ft	0.76 ft
Mean High Water (MHW)	4.21 ft	5.15 ft
Mean High Higher Water (MHHW)	4.65 ft	5.61 ft
Highest Observed Tide (HOT)[2]	6.84 ft	7.23 ft
10% Annual Chance Storm Surge[3]	8.0 ft	8.8 ft
2% Annual Chance Storm Surge[3]	8.6 ft	9.6 ft
1% Annual Chance Storm Surge[3]	8.9 ft	9.9 ft
0.2% Annual Chance Storm Surge[3]	9.5 ft	10.7 ft
2100 Median Sea Level Rise Estimate	±4 ft	±4 ft

Sources: NOAA Tides & Currents, MaineDOT Sherman Marsh Tidal Hydrology Study, FIS for Lincoln County and Cumberland County

1. Sherman Marsh tides from MaineDOT in-situ measurements
2. Highest Observed Tide recorded September 9, 2010. The recorded elevation at NOAA tide gage 8418150 (Portland, Maine) for this date is approximately 0.1 ft higher than the Highest Astronomical Tide (HAT).
3. Storm Surge elevations are stillwater elevations (do not include wave action) for the Ocean Gateway Pier in Portland and for the Sheepscot River in Wiscasset, respectively.

Hydraulic Analysis

Hydraulic modeling was developed using the US Army Corps of Engineers (USACE) HEC-RAS software, version 6.1.4, to evaluate hydraulic performance of existing conditions and of the proposed design. Hydraulic analysis included evaluation of the approximate bankfull 2-year (Q2) design discharge 50-year (Q50), scour discharge 100-year (Q100), and check scour discharge 500-year (Q500) flood events. Hydraulic analysis also evaluated the proposed design for low-flow conditions (represented by median flow rates) to evaluate fish passage conditions. Flow discharge rates were sourced from the hydrologic analysis noted above. HEC-RAS model geometry is based on 2023 topographic field survey of the culvert crossing and stream channel performed by VHB, supplemented by 2020 USGS LiDAR topographic data of the extended floodplain, field geomorphic channel measurements and observations, and proposed structure geometry. The model extends approximately 400 feet downstream of the crossing and approximately 900 feet upstream, to the head of tide.

Due to the crossing location, tidal conditions have a significant impact on hydraulics at the crossing. Therefore, the HEC-RAS model incorporates a dynamic tailwater condition representing the tidal hydrograph for Sherman Marsh from the MaineDOT study, ranging from MHHW to MLLW. HEC-RAS model results show a corresponding variation in flow velocities at the crossing, with the highest velocities (and highest scour risk) occurring during low tide when tailwater elevations are lowest, and the highest flood elevations (and smallest freeboard) occurring during high tide when tailwater elevations are highest. Therefore, hydraulic capacity of the proposed design evaluates both high tide and low tide conditions.

HEC-RAS model results are included in **Appendix D**. A summary of hydraulic data for the proposed design under the free-discharge tailwater scenario is presented in **Table 4** below.

Table 4 Hydraulic Data Summary for Existing and Proposed Designs

	Existing Conditions[4]	Alt 1: 22′ Box Culvert	Alt 2: 50′ Bridge	Alt 3: 14′ Culvert
Total Area of Waterway Opening (sf)	186	200	380	114
Headwater Elevation[1] (Q2) (ft)	5.6	5.6	5.6	5.8
Headwater Elevation[1] (Q10) (ft)	5.7	5.7	5.7	6.2
Headwater Elevation[1] (Q25) (ft)	5.8	5.7	5.7	6.5
Headwater Elevation[1] (Q50) (ft)	5.8	5.8	5.7	6.7
Headwater Elevation[1] (Q100) (ft)	5.9	5.8	5.8	6.9
Headwater Elevation[1] (Q500) (ft)	6.1	6.0	5.9	7.4
Freeboard at Q50[2] (ft)	5.3	3.6	5.7	4.4
Freeboard at Q100[2] (ft)	5.2	3.6	5.6	4.2
Outlet Velocity[3] (Q2) (fps)	7.6	8.4	7.9	4.0
Outlet Velocity[3] (Q10) (fps)	11.2	10.4	10.4	18.2
Outlet Velocity[3] (Q25) (fps)	13.0	13.0	11.4	21.3
Outlet Velocity[3] (Q50) (fps)	14.1	14.0	12.2	22.5
Outlet Velocity[3] (Q100) (fps)	15.3	15.0	13.0	24.2
Outlet Velocity[3] (Q500) (fps)	17.9	17.3	14.6	25.2
Flood of Record	(Unknown)			

1 Headwater elevations measured 50 feet upstream of structure, channel centerline STA 6+10, at high tide (model time 01:18)
2 Freeboard measured from lowest structure low chord to headwater elevation
3 Outlet velocity measured 10 feet downstream of structure, channel centerline STA 7+00, at low tide (model time 08:00)
4 Existing conditions data represents the existing scoured stream channel and structure condition present at the time of survey, as compared to alternative 3, replace-in-kind, which represents a stream and structure configuration identical to the 2010 planset.
Source: VHB HEC-RAS Model

Scour Analysis

Bridge contraction and abutment maximum scour depths were calculated based on the methodology presented in Hydraulic Engineering Circular (HEC) 18 published by the FHWA in April 2012. Because the highest scour risk occurs when flow velocities through the crossing are highest, scour calculations are based on hydraulic conditions during low tide in the HEC-RAS model.

A summary of scour calculations is provided in **Table 5** below; detailed scour calculations are included in **Appendix E**.

Table 5 Scour Analysis Results

	Box		Bridge		Frame	
	Q_{100} Design (Alt 1)	Q_{500} Check (Alt 1)	Q_{100} Design (Alt 2)	Q_{500} Check (Alt 2)	Q_{100} Design (Alt 3)	Q_{500} Check (Alt 3)
Discharge (cfs)	602	816	602	816	602	816
Channel Velocity[1] (fps)	10.1	11.6	9.5	10.7	12.8	14.9
Contraction Scour[2] (ft)	0.6	1.1	0.4	0.8	1.9	2.8
Right Abutment Scour[2] (ft)	**1.4**	**2.1**	**1.2**	**1.8**	**2.8**	**4.0**
Left Abutment Scour[2] (ft)	**1.4**	**2.1**	**1.2**	**1.8**	**2.8**	**4.0**
Max. Scour Elevation[3] (ft)	-1.0	-1.7	-0.5	-0.9	0.4	-0.8
Remaining Embedment[4] (ft)	2.5	1.8	-7.5	-7.9	0.5	-0.7

1 Channel velocity is average velocity through contracted bridge or culvert opening
2 Contraction and Abutment scour represent difference between average channel depth prior to scour and average channel depth after scour is applied. Abutment scour includes general contraction scour plus local scour at abutment substructure.
3 Maximum scour elevation represents average channel bed elevation incorporating both contraction and abutment scour.
4 Embedment represents minimum remaining depth below scoured channel elevation above bottom of substructure footing. For bridge alternate(s), the bottom of the shallowest abutment footing is used to calculate minimum embedment.

Source: VHB HEC-RAS model, HEC-18 calculations

Calculations show the greatest potential scour for Alt 3 (the smallest hydraulic opening) and the lowest potential scour for Alt 2 (the largest hydraulic opening). Although the natural channel of Dyer Brook consists of highly mobile sediments, scour calculations assume a “clear-water” scour condition due to the armored channel bed (D_{50} = 2”) through the crossing. However, scour could be significantly greater in locations where average bed material is smaller; without armoring present, “live-bed” scour depths are up to five times greater and would be below bottom of footing elevations for all alternative designs.

There is an extensive scour history at the crossing since 2005 when the downstream dam breached and tailwater conditions changed from an elevated impounded lake surface to a fluctuating tidal condition. The flood event that breached the dam also damaged the Lynch Road culvert and it was replaced in 2006. That replacement culvert was damaged by a flood event in Spring 2010 and replaced by the current open-bottom structure. All three of these structures consisted of relatively small hydraulic openings with a bottom elevation elevated above the surrounding natural channel bed elevation.

On May 1, 2023, the current structure was damaged by scour from flooding associated with a large rain event. Rainfall measurements indicate a total rain depth of 6.3 inches in Newcastle, corresponding to a Q25 to Q50 magnitude based on NOAA Atlas 14 precipitation-frequency estimates. Scour from this event resulted in a scour hole approximately 5 feet deeper than the bed elevation shown in design plans. This empirical depth is greater than the estimated scour for Alt 3 (replace in kind), indicating that HEC-18 clear-water scour calculations under-estimate scour at the crossing. The artificially-elevated channel bed through the culvert contributes to this increased scour risk; channel material would be but 5 feet below the original design through the culvert) is consistent with this scour mechanism. Because the proposed channel bed elevations for Alt 1 and Alt 2 would be set at or below existing channel elevations, they would not be susceptible to this additional scour risk.

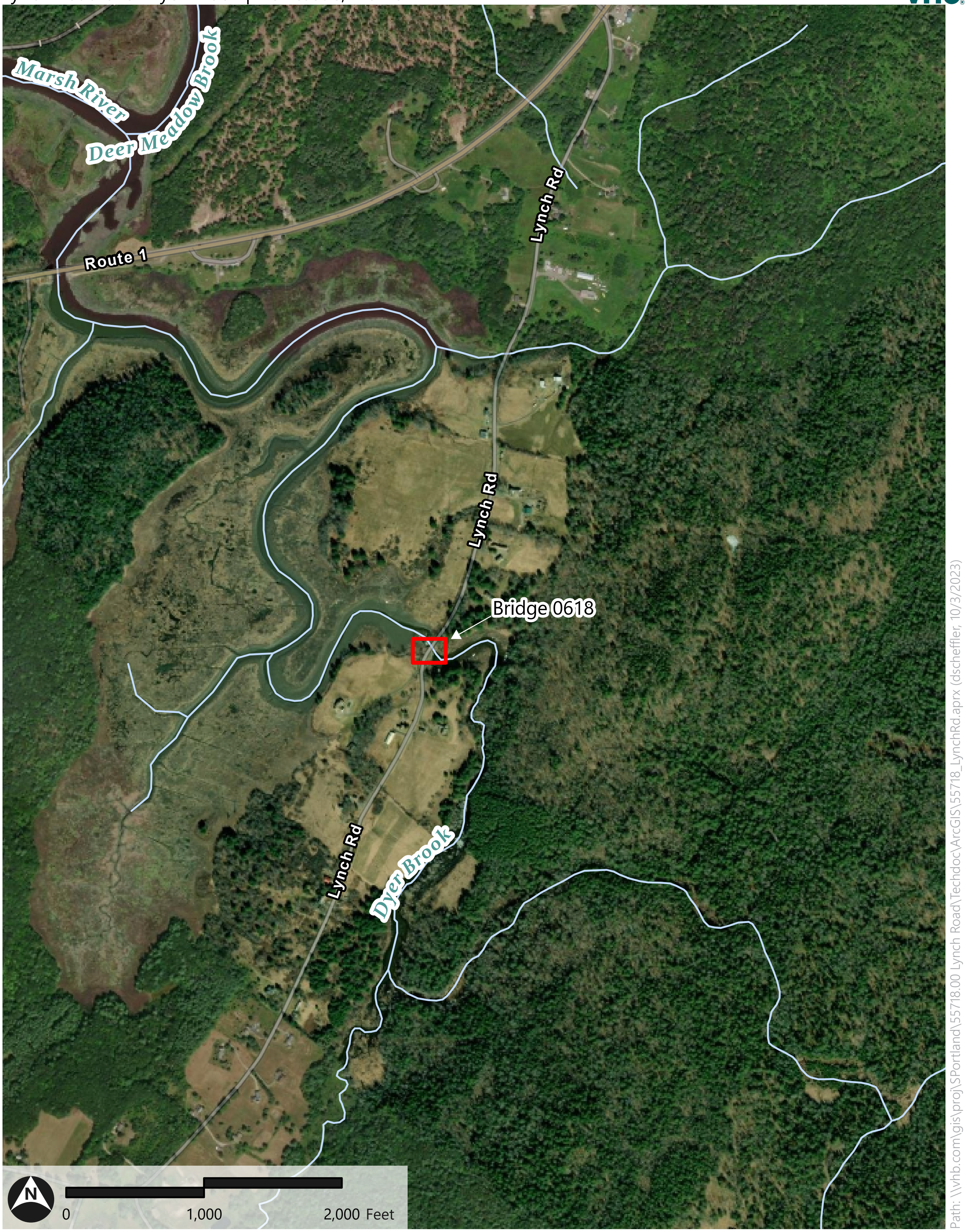
Given the calculated scour risk, the high flow velocities through the crossing, and given the documented history of scour at the crossing, the selected alternative should be constructed with channel bed and banks protected by Heavy Riprap (MaineDOT Item 703.28). Riprap should extend up the embankment slopes on both sides of the roadway to at least elevation 9.6 ft (MHHW plus 4 ft sea level rise). Riprap sizing calculations are included in **Appendix E**.

Recommendations

Based on the results of this, VHB recommends Alternative 2 (bridge option). The bridge design results in the lowest flood velocities and smallest calculated scour depths, and provides the greatest freeboard above flood elevations. The increased vertical clearance also makes the bridge option the most resilient against coastal storm surge and future sea level rise, and provides the greatest openness ratio and potential pathways for aquatic and terrestrial animal passage. Alternative 1 (four-sided culvert) would be the next preferable option, providing similar hydraulic performance with added scour resiliency due to the closed bottom; however, it would provide less resilience against sea level rise. Alternative 3 is not recommended; the narrow span, open-bottom design, and raised bed elevation make it particularly vulnerable to scour – both calculated and empirical as observed in the 2005, 2010, and 2023 scour events at this location.

Figure 1: Project Location

Lynch Road over Dyer Brook | Newcastle, Maine



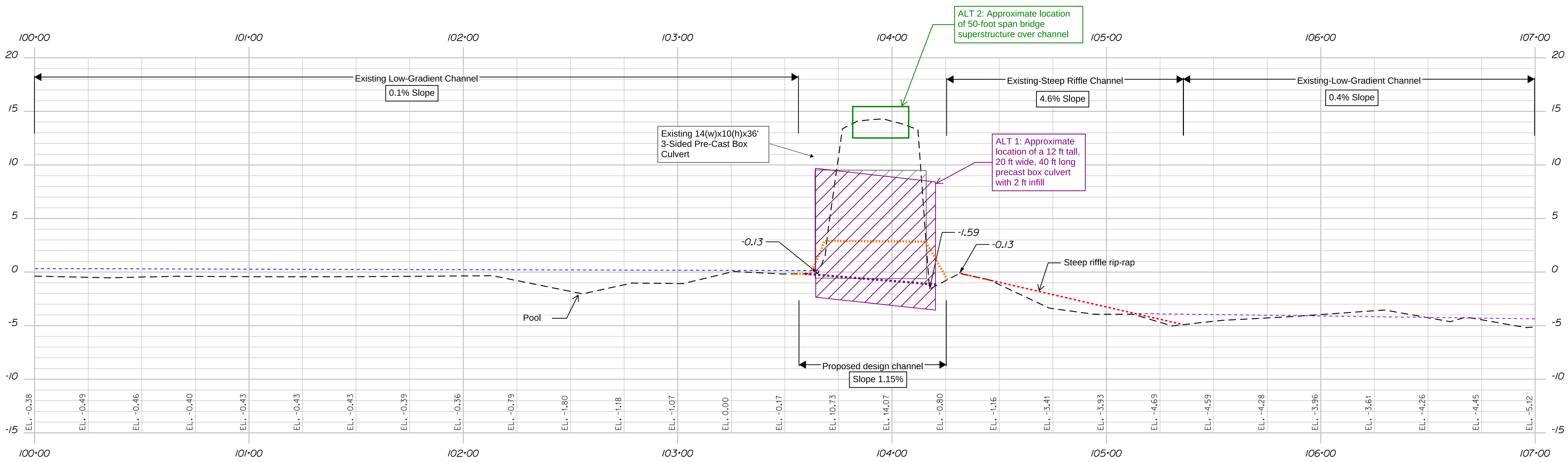
Legend

Stream Centerline (NHD)

Sources: VHB, ESRI, USGS

Figure 2: Longitudinal Profile, H&H Memo
Lynch Road over Dyer Brook, Newcastle, Maine

Legend
Upstream Profile
Downstream Profile
Alt 1/Alt 2 Proposed Design Profile
Alt 3 Proposed Design Profile
Steep Downstream Profile
Existing Culvert
Alt 1 Culvert Design
Alt 2 Bridge Location



PROFILE

Date:10/4/2023
Username: evicon
Division: HIGHWAY
Filename: ...\MSTA\007_Stream_Profile.dgn

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

CAPITAL PROJECTS

HIGHWAY PLANS

vhb

		BY	DATE
PROJ. MANAGER	E. MARTIN		
DESIGN-DETAILED	ELV	JBD	10/4/2023
CHECKED-REVIEWED	ECF	AG	10/4/2023
DESIGN2-DETAILED2			
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

NEWCASTLE
LYNCH ROAD

PROFILE

SHEET NUMBER

1

OF 1

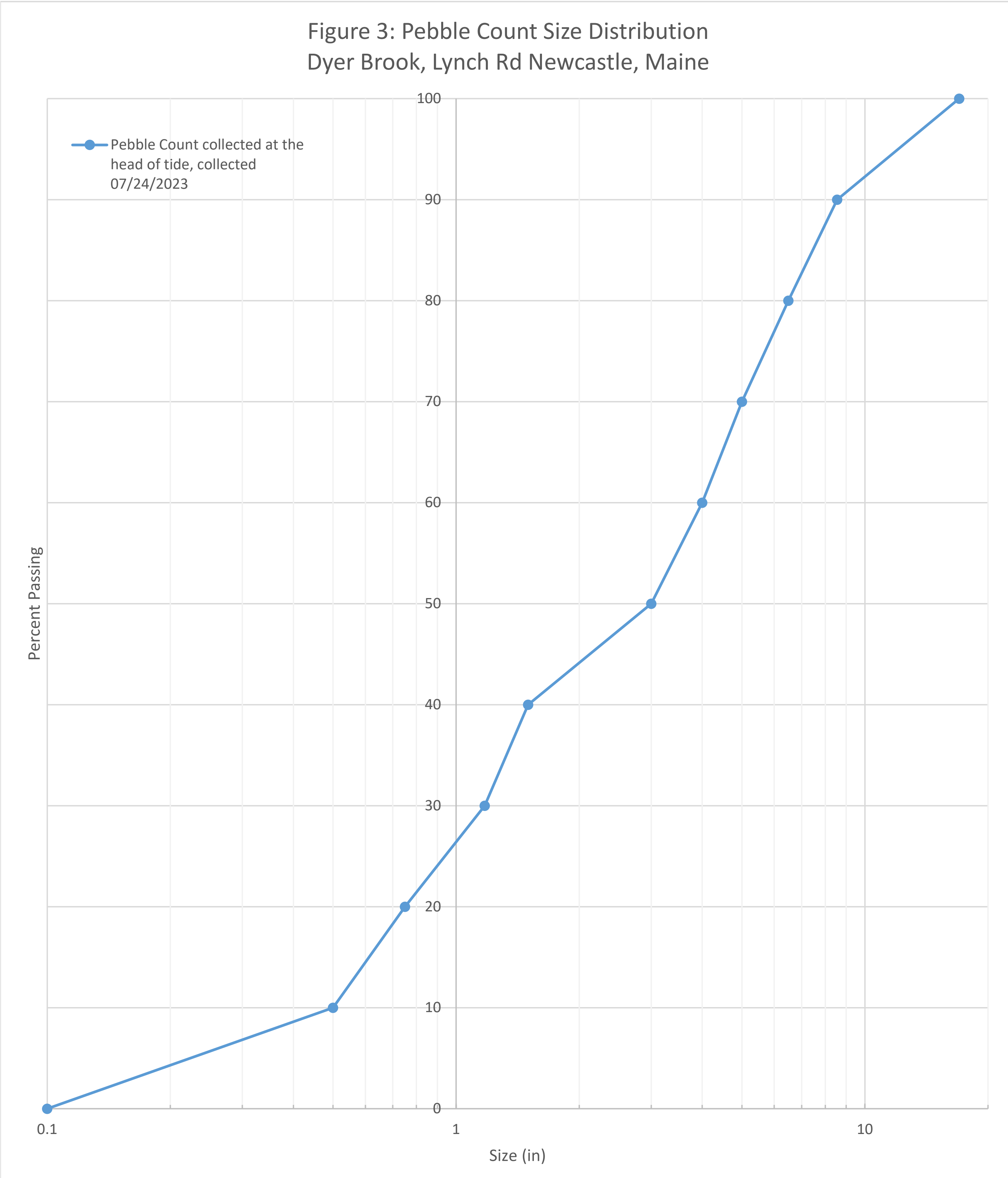


Figure 3: Pebble Count Size Distribution
Dyer Brook, Lynch Rd Newcastle, Maine
Pebble Count collected at the head of tide, collected 07/24/2023
Percent Passing
Size (in)
0
10
20
30
40
50
60
70
80
90
100
0.1
1
10

Photo 1: View upstream from crossing

Photo 2: View downstream from crossing

Photo 3: View South along Lynch Rd (Left Approach)

Photo 4: View North along Lynch Rd (Right Approach)

Photo 5: Upstream elevation (inlet) of existing culvert

Photo 6: Downstream elevation (outlet) of existing culvert

Photo 7: Typical channel upstream

Photo 8: Typical channel downstream

Photo 9: Reference non-tidal reach (approximately 750 feet upstream of crossing) looking upstream

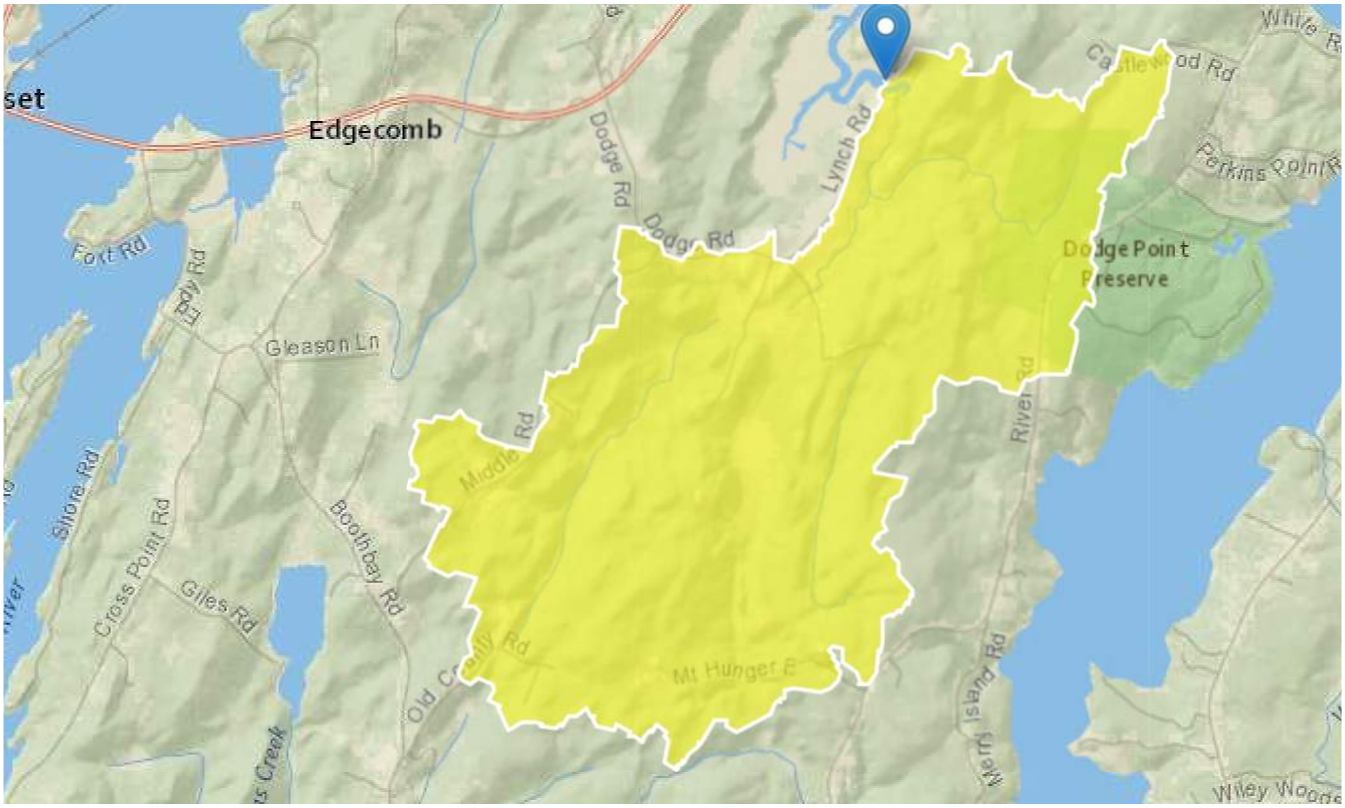
Photo 10: Reference non-tidal reach (approximately 750 feet upstream of crossing) looking downstream

Photo 11: Key Feature: misaligned culvert section due to undermined footing

Photo 12: Key Feature: scattered deposits of riprap scoured from channel through culvert.

Appendix B: Hydrologic Calculations, Hydrologic and Hydraulic (H&H) Report #0618, Lynch Road over Dyer Brook, Newcastle, Maine

Region ID: ME
Workspace ID: ME20230531190303816000
Clicked Point (Latitude, Longitude): 44.00373, -69.58807
Time: 2023-05-31 15:03:28 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM10M	Mean basin slope computed from 10 m DEM	11.7	percent
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	452087.66	meters
CENTROIDY	Basin centroid vertical (y) location in state plane units	4870187.84	meters

Parameter Code	Parameter Description	Value	Unit
COASTDIST	Shortest distance from the coastline to the basin centroid	37.3	miles
DRNAREA	Area that drains to a point on a stream	4.7	square miles
ELEV	Mean Basin Elevation	135.5	feet
ELEVMAX	Maximum basin elevation	278.6	feet
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	7.36	inches
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	4.82	inches
I24H200Y	Maximum 24-hour precipitation that occurs on average once in 200 years	8.3	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	5.82	inches
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	3.21	inches
I24H500Y	Maximum 24-hour precipitation that occurs on average once in 500 years	9.79	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	6.57	inches
I24H5Y	Maximum 24-hour precipitation that occurs on average once in 5 years	4.09	inches
JULAVPRE	Mean July Precipitation	3.43	inches
LC06WATER	Percent of open water, class 11, from NLCD 2006	0.05	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24		percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset		percent
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	0	percent
PRDECFEB90	Basin average mean precipitation for December to February from PRISM 1961-1990	12	inches

Parameter Code	Parameter Description	Value	Unit
PRECIP	Mean Annual Precipitation	45.2	inches
SANDGRAVAF	Fraction of land surface underlain by sand and gravel aquifers	0	dimensionless
SANDGRAVAP	Percentage of land surface underlain by sand and gravel aquifers	0	percent
STATSGOA	Percentage of area of Hydrologic Soil Type A from STATSGO	0	percent
STORAGE	Percentage of area of storage (lakes ponds reservoirs wetlands)	13.763	percent
STORNWI	Percentage of strorage (combined water bodies and wetlands) from the Nationa Wetlands Inventory	13.5	percent

Peak-Flow Statistics

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

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4.7	square miles	0.26	5680
I24H2Y	24 Hour 2 Year Precipitation	3.21	inches	1.92	4.17
STORAGE	Percent Storage	13.763	percent	0	29.4
I24H5Y	24 Hour 5 Year Precipitation	4.09	inches	2.48	5.38
I24H10Y	24 Hour 10 Year Precipitation	4.82	inches	2.84	6.38
I24H25Y	24 Hour 25 Year Precipitation	5.82	inches	3.3	7.75
I24H50Y	24 Hour 50 Year Precipitation	6.57	inches	3.65	8.79
I24H100Y	24 Hour 100 Year Precipitation	7.36	inches	3.99	9.88

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
I24H200Y	24 Hour 200 YearPrecipitation	8.3	inches	5.26	11.1
I24H500Y	24 Hour 500 Year Precipitation	9.79	inches	5.95	13.1

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

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

Statistic	Value	Unit	PIl	PIu	ASEp
50-percent AEP flood	169	ft^3/s	90.7	315	39.1
20-percent AEP flood	267	ft^3/s	145	490	38.1
10-percent AEP flood	340	ft^3/s	183	633	38.9
4-percent AEP flood	439	ft^3/s	233	828	39.9
2-percent AEP flood	519	ft^3/s	271	996	39.7
1-percent AEP flood	602	ft^3/s	316	1150	40.7
0.5-percent AEP flood	692	ft^3/s	351	1370	42.8
0.2-percent AEP flood	816	ft^3/s	407	1630	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)

Bankfull Statistics

Bankfull Statistics Parameters [Central and Coastal Bankfull 2004 5042]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4.7	square miles	2.92	298

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4.7	square miles	0.07722	940.1535

Bankfull Statistics Parameters [New England P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4.7	square miles	3.799224	138.999861

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4.7	square miles	0.07722	59927.7393

Bankfull Statistics Flow Report [Central and Coastal Bankfull 2004 5042]

Statistic	Value	Unit
Bankfull Streamflow	26.4	ft^3/s
Bankfull Width	17.2	ft
Bankfull Depth	1.01	ft
Bankfull Area	17.2	ft^2

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	28.9	ft
Bieger_D_channel_depth	1.75	ft
Bieger_D_channel_cross_sectional_area	51.3	ft^2

Bankfull Statistics Flow Report [New England P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	39	ft
Bieger_P_channel_depth	1.93	ft
Bieger_P_channel_cross_sectional_area	76.2	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	21.4	ft
Bieger_USA_channel_depth	1.68	ft
Bieger_USA_channel_cross_sectional_area	39.4	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bankfull Streamflow	26.4	ft^3/s
Bankfull Width	17.2	ft
Bankfull Depth	1.01	ft
Bankfull Area	17.2	ft^2
Bieger_D_channel_width	28.9	ft
Bieger_D_channel_depth	1.75	ft
Bieger_D_channel_cross_sectional_area	51.3	ft^2
Bieger_P_channel_width	39	ft
Bieger_P_channel_depth	1.93	ft
Bieger_P_channel_cross_sectional_area	76.2	ft^2
Bieger_USA_channel_width	21.4	ft
Bieger_USA_channel_depth	1.68	ft
Bieger_USA_channel_cross_sectional_area	39.4	ft^2

Bankfull Statistics Citations

Dudley, R.W.,2004, Hydraulic-Geometry Relations for Rivers in Coastal and Central Maine: U.S. Geological Survey Scientific Investigations Report 2004-5042, 30 p (http://pubs.usgs.gov/sir/2004/5042/pdf/sir2004-5042.pdf)

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCoverPages)

Monthly Flow Statistics

Appendix C: Tidal Data, Hydrologic and Hydraulic (H&H) Report #0618, Lynch Road over Dyer Brook, Newcastle, Maine

Sherman Marsh Tidal Hydrology Overview

Introduction

Tidal data have been collected at Sherman Marsh every summer, starting with 2006. Most years, the efforts have also encompassed spring and fall. Locations always included the "Lower Marsh" (just upstream of the US1 bridge) and the "Marsh River" (downstream of the bridge). "Mid" and "Upper" Marsh locations were also observed during several of the years; however, they added little in the way of useful additional information. Similar to the salinity data collection, the Lower Marsh tidal stage data capture the marsh tidal regime, while the Marsh River data represent the hydrologic driving force as well as the "natural" tidal regime that would presumably prevail in a completely open marsh.

Sherman Marsh is the uppermost marsh on the Marsh River, a tributary to the tidal Sheepscot River. Marsh River joins the Sheepscot just below head of tide. Thus, Sherman Marsh is significantly removed from the direct Gulf of Maine tides and is strongly influenced by freshwater discharge from the Sheepscot River as well from the Sherman Marsh watershed.

In this overview, three tidal data sources are utilized. The Portland tide station is the primary station for secondary stations in the midcoast area, so Portland data are presented as reference and are utilized to estimate long-term tidal datums at the marsh. The 2006 data are presented because they best represent the tidal regime created by the temporary emergency stabilization after the October 2005 causeway failure. Data from 2010 are presented because they are the most consistent data set that captures the tidal regime created by the permanent stabilization and improvement constructed in winter 2008/2009.

Tidal Datums

Table 1 shows the tidal datums for the 1983 – 2001 tidal epoch for Portland (NOAA Tides and Currents / Bench Marks web page) as well as the corresponding datums estimated for Marsh River using the Modified Range Ratio Method (Computational Techniques for Tidal Datums Handbook, NOAA Special Publication NOS CO-OPS 2, September 2003). Typical marsh surface elevations are in the range 5.25-ft to 5.75-ft (Laura Jones, USM Thesis, 2007, Figure 3, p. 44) with lower elevations along the channel banks. The data period 3 July – 2 October 2010 was used to estimate the Marsh River long-term values, because this was a relatively dry period and Marsh River tides were not excessively influenced by Sheepscot River flows. The corresponding datum values for the data period are shown in Table 2; Table 2 also includes calculations for the lower marsh. However, long term tidal datums were not transferred to the Lower Marsh station because the falling stage is still limited by a hard control elevation also displays a residual drainage recession curve behavior.

Table 1: Portland and Marsh River Tidal Datums (ft NAVD) for 1983-2001 epoch

Datum (1983-2001 epoch)	**Portland**	**Marsh River (est)**
Highest observed water level	8.869 (2Jul78)	--
Mean Higher High Water	4.651	5.31
Mean High Water	4.215	4.90
Mean Sea Level	-0.315	-0.13
Mean Tide Level	-0.348	-0.23
Mean Low Water	-4.907	-5.36
Mean Lower Low Water	-5.251	-5.86
Lowest Observed Water Level	-8.705 (30Nov55)	--
Marsh Surface	5.25' – 5.75' and lower along banks	

Table 2: Portland and Marsh River Tidal Datums (ft NAVD) for 3 July – 2 October 2010

Datum (3 July – 2 Oct 2010)	**Portland**	**Marsh River**	**Lower Marsh**
Highest observed water level	6.84 (9 Sep)	7.34 (9 Sep)	7.23 (9 Sep)
Mean Higher High Water	5.02	5.67	5.61
Mean High Water	4.52	5.21	5.15
Mean Sea Level	0.05	0.23	0.47
Mean Tide Level	0.00	0.12	0.76
Mean Low Water	-4.52	-4.92	-3.58
Mean Lower Low Water	-4.67	-5.27	-3.63
Lowest Observed Water Level	-6.46 (11 Aug)	-6.48 (10 Sep)	-3.78 (8 Aug)
Marsh Surface	5.25' – 5.75' and lower along banks		

Sherman Marsh Tides and Implications for Marsh Restoration

The purpose of collecting tidal data were several-fold. Initially, the goal was simply to develop a general understanding of tides in the newly reopened marsh. This goal was quickly refined to that of determining whether the new tidal regime was sufficient to maintain a healthy marsh. Figure 1 shows a sample trace from July 2006 data (red = Portland, + = marsh River, blue = Lower Marsh). The flow and drainage restriction between the Marsh and Marsh River is obvious. Head losses between the two bodies of water are on the order of 1-ft and the effective control elevation is about 2.5-ft. This severely limits drainage of the marsh on the outgoing tide. The Marsh falling limb is nothing like a sinusoidal falling tidal stage; rather, it exhibits all the traits of classic reservoir drainage. These results pointed the way towards design of a permanent stabilization and improvement of the Marsh outlet that make the marsh tides more nearly like those in the Marsh River just downstream. The final design was a combination of a significant enlargement of the opening as well as lowering of the outlet control elevation.

Figure 1: Sample Tide Trace, July 2006

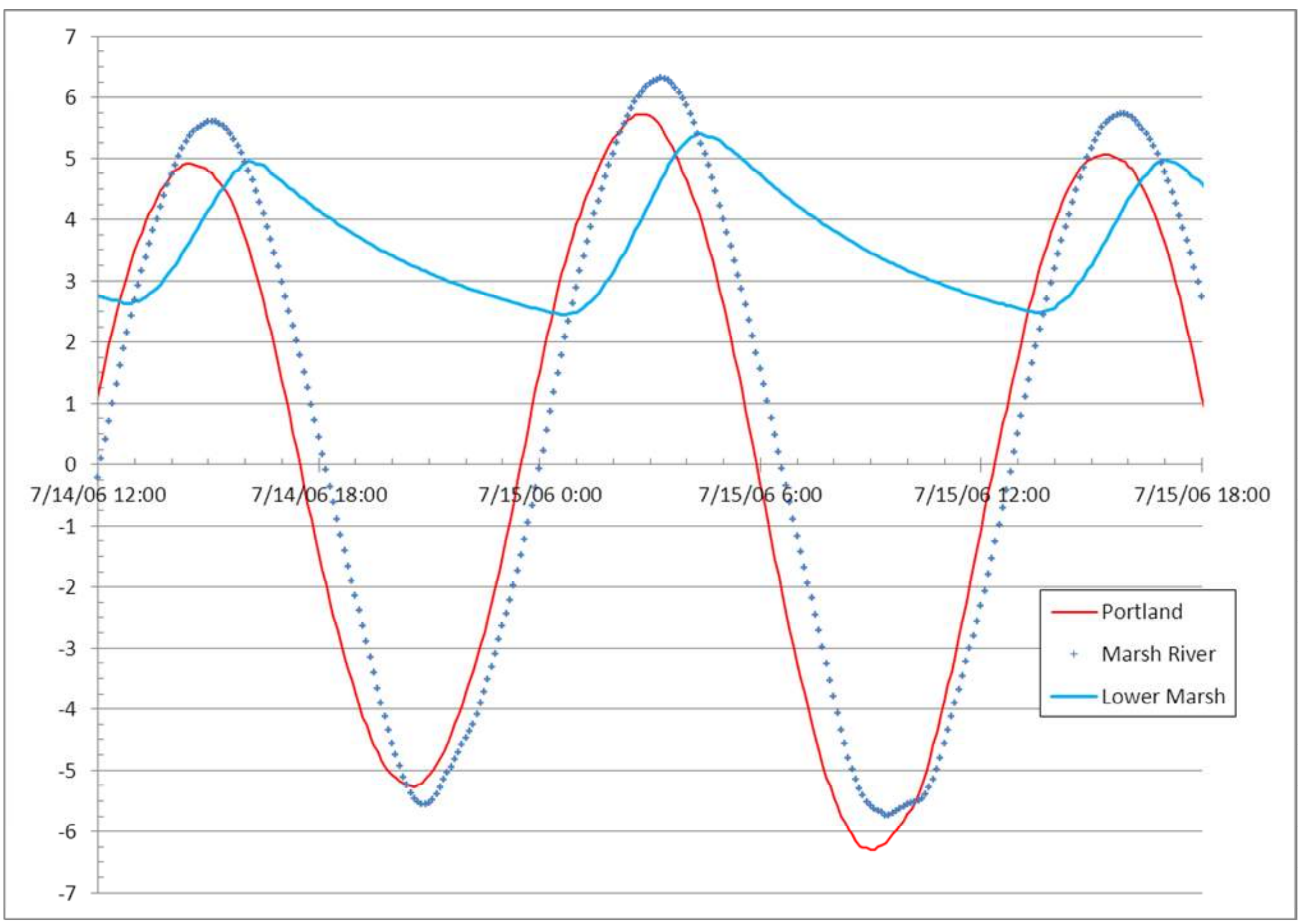
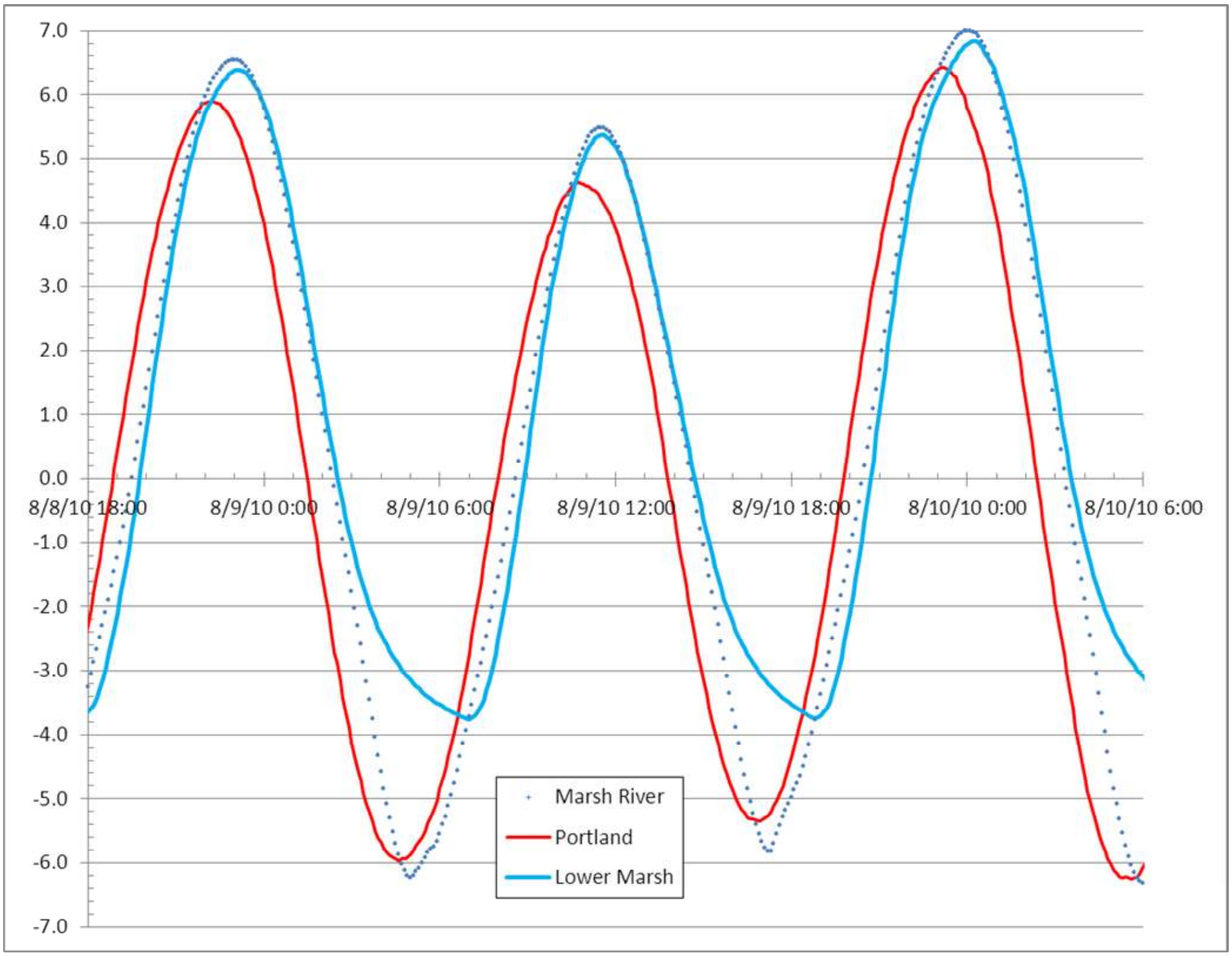


Figure 2 shows a sample data trace from August 2010, showing the dramatic effects of the stabilization and improvement work of winter 2008/2009. The head loss through the bridge has been largely eliminated and the effective control elevation has been lowered by about 5.5-ft, greatly improving marsh drainage.

Figure 2: Sample Tide Trace after Permanent Improvements



(https://www.noaa.gov/) TIDES & CURRENTS (/)

Home (/) / Products (products.html) / Datums (stations.html?type=Datums) / 8418150 Portland, ME Favorite Stations

Station Info | Tides/Water Levels | Meteorological Obs. (/met.html?id=8418150)

Phys. Oceanography (/physocean.html?id=8418150)

OFS (/ofs/ofs_station.html?stname=Portland&ofs=gom&stnid=8418150&subdomain=0)

Datums for 8418150, Portland ME

NOTICE: All data values are relative to the NAVD88.

Elevations on NAVD88

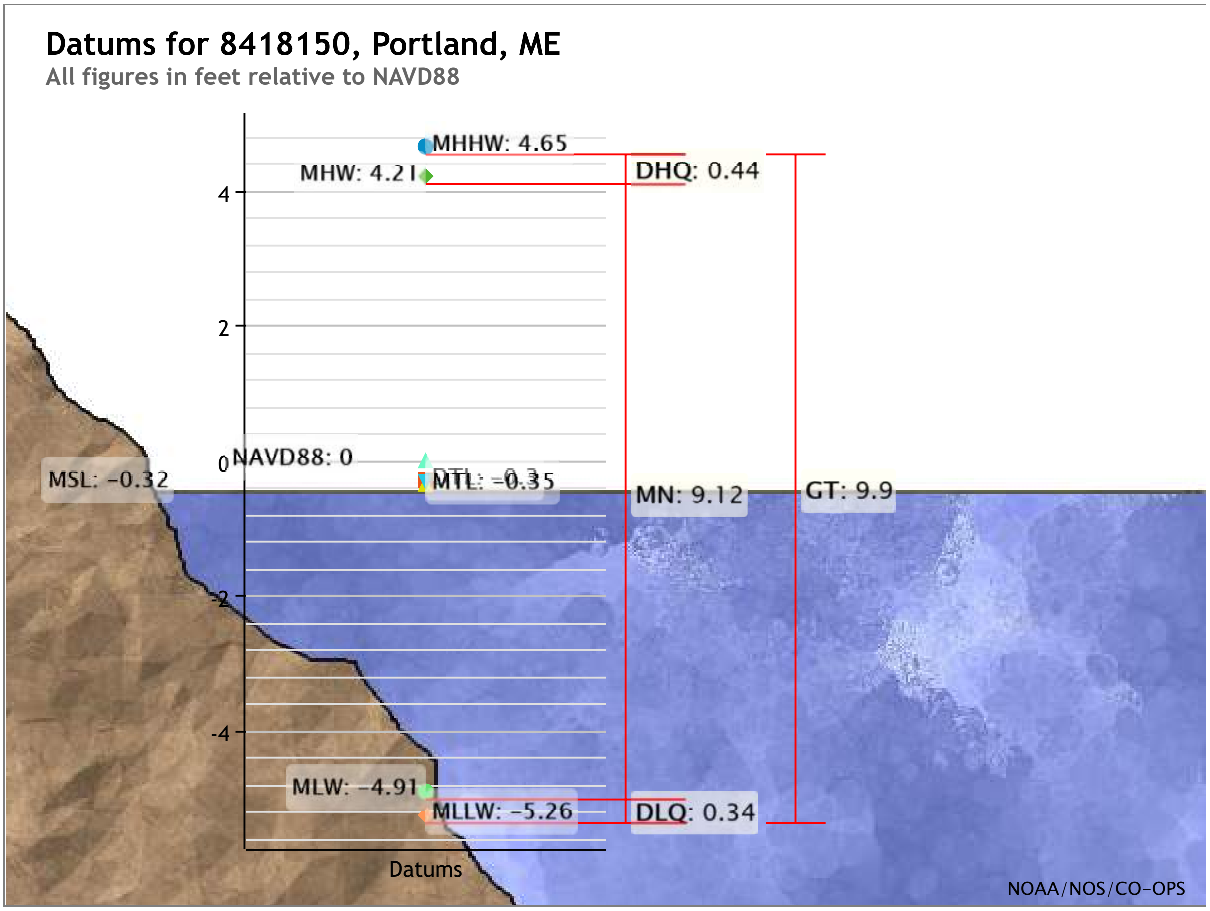
Station: 8418150, Portland, ME
Status: Accepted (Apr 17 2003)
Units: Feet
Control Station:
T.M.: 0
Epoch: (/datum_options.html#NTDE) 1983-2001
Datum: NAVD88

Datum	Value	Description
MHHW (/datum_options.html#MHHW)	4.65	Mean Higher-High Water
MHW (/datum_options.html#MHW)	4.21	Mean High Water
MTL (/datum_options.html#MTL)	-0.35	Mean Tide Level
MSL (/datum_options.html#MSL)	-0.32	Mean Sea Level
DTL (/datum_options.html#DTL)	-0.30	Mean Diurnal Tide Level
MLW (/datum_options.html#MLW)	-4.91	Mean Low Water
MLLW (/datum_options.html#MLLW)	-5.26	Mean Lower-Low Water
NAVD88 (/datum_options.html)	0.00	North American Vertical Datum of 1988
STND (/datum_options.html#STND)	-13.81	Station Datum
GT (/datum_options.html#GT)	9.90	Great Diurnal Range
MN (/datum_options.html#MN)	9.12	Mean Range of Tide

Datum	Value	Description
DHQ (/datum_options.html#DHQ)	0.44	Mean Diurnal High Water Inequality
DLQ (/datum_options.html#DLQ)	0.34	Mean Diurnal Low Water Inequality
HWI (/datum_options.html#HWI)	3.59	Greenwich High Water Interval (in hours)
LWI (/datum_options.html#LWI)	9.75	Greenwich Low Water Interval (in hours)
Max Tide (/datum_options.html#MAXTIDE)	8.87	Highest Observed Tide
Max Tide Date & Time (/datum_options.html#MAXTIDEDT)	02/07/1978 10:30	Highest Observed Tide Date & Time
Min Tide (/datum_options.html#MINTIDE)	-8.71	Lowest Observed Tide
Min Tide Date & Time (/datum_options.html#MINTIDEDT)	11/30/1955 17:18	Lowest Observed Tide Date & Time
HAT (/datum_options.html#HAT)	6.71	Highest Astronomical Tide
HAT Date & Time	05/19/2034 04:06	HAT Date and Time
LAT (/datum_options.html#LAT)	-7.38	Lowest Astronomical Tide
LAT Date & Time	01/14/2036 22:42	LAT Date and Time

Tidal Datum Analysis Periods

01/01/1983 - 12/31/2001



Showing datums for

8418150 Portland, ME

Datum

NAVD88

Data Units ◉ Feet
○ Meters

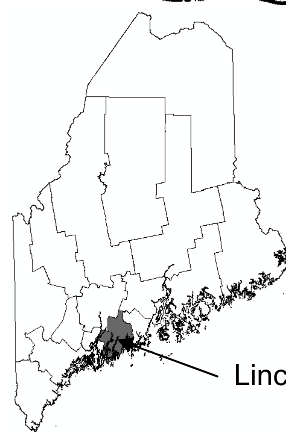
Epoch ◉ Present (1983-2001)
○ Superseded (1960-1978)

Submit

Show nearby stations

FLOOD INSURANCE STUDY

LINCOLN COUNTY, MAINE
(ALL JURISDICTIONS)



COMMUNITY NAME	COMMUNITY NUMBER	COMMUNITY NAME	COMMUNITY NUMBER
Alna, Town of	230083	Monhegan Plantation	230511
Bar Island	230916	Newcastle, Town of	230218
Boothbay, Town of	230212	Nobleboro, Town of	230219
Boothbay Harbor, Town of	230213	Polins Ledges Island	230929
Bremen, Town of	230214	Ross Island	230922
Bristol, Town of	230215	Somerville, Town of	230512
Damariscotta, Town of	230216	South Bristol, Town of	230220
Dresden, Town of	230084	Southport, Town of	230221
Edgecomb, Town of	230217	Thief Island	230920
Haddock Island	230918	Thrumcap Island	230928
Hibberts Gore, Township of	230712	Waldoboro, Town of	230086
Hungry Island	230917	Webber Dry Ledge Island	230930
Indian Island	230919	Western Egg Rock Island	230926
Jefferson, Town of	230085	Westport Island, Town of	230222
Jones Garden Island	230925	Whitefield, Town of	230087
Killick Stone Island	230927	Wiscasset, Town of	230223
Louds Island	230915	Wreck Island	230924
Marsh Island	230921	Wreck Island Ledge	230923

EFFECTIVE DATE: July 16, 2015

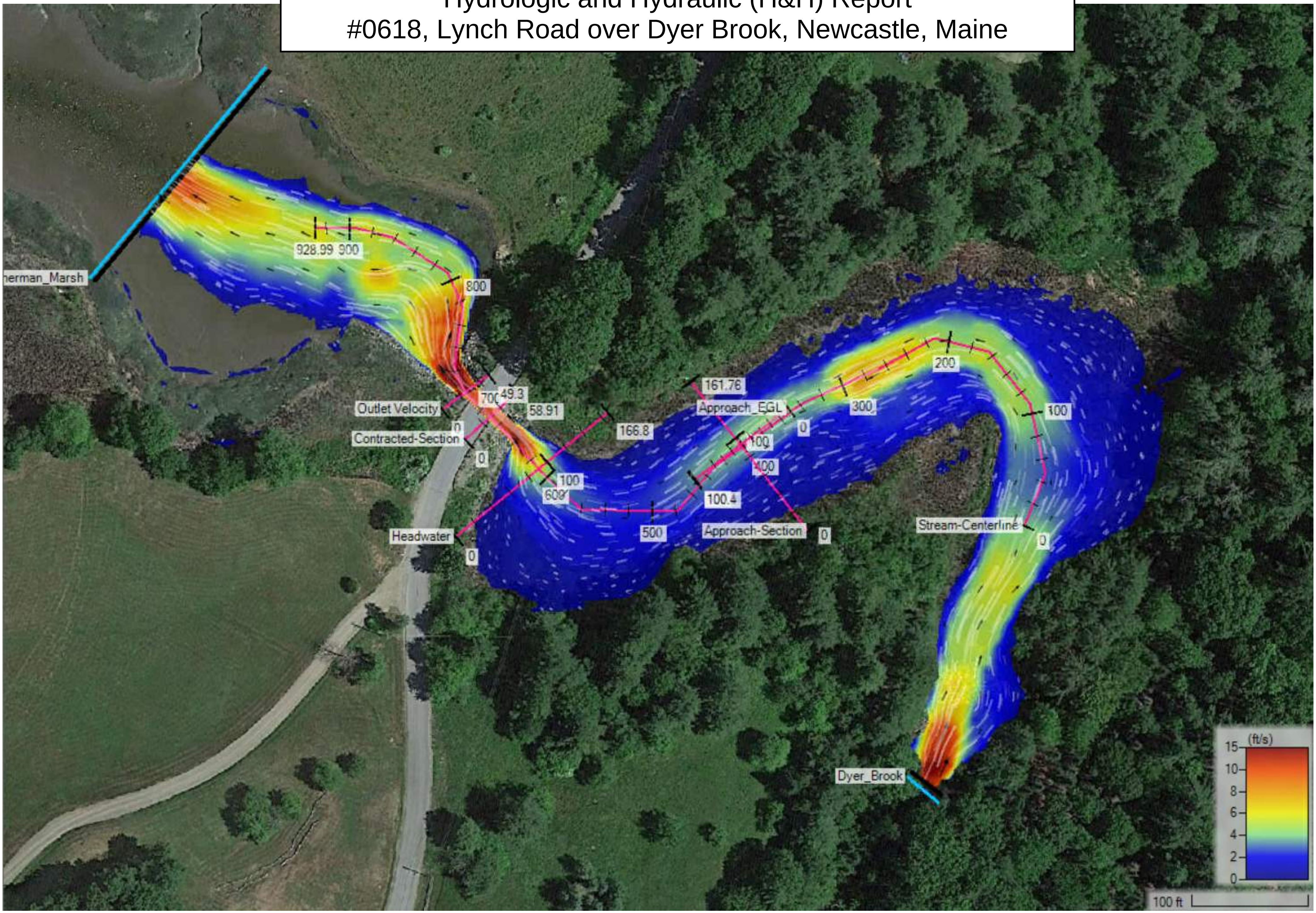
Federal Emergency Management Agency

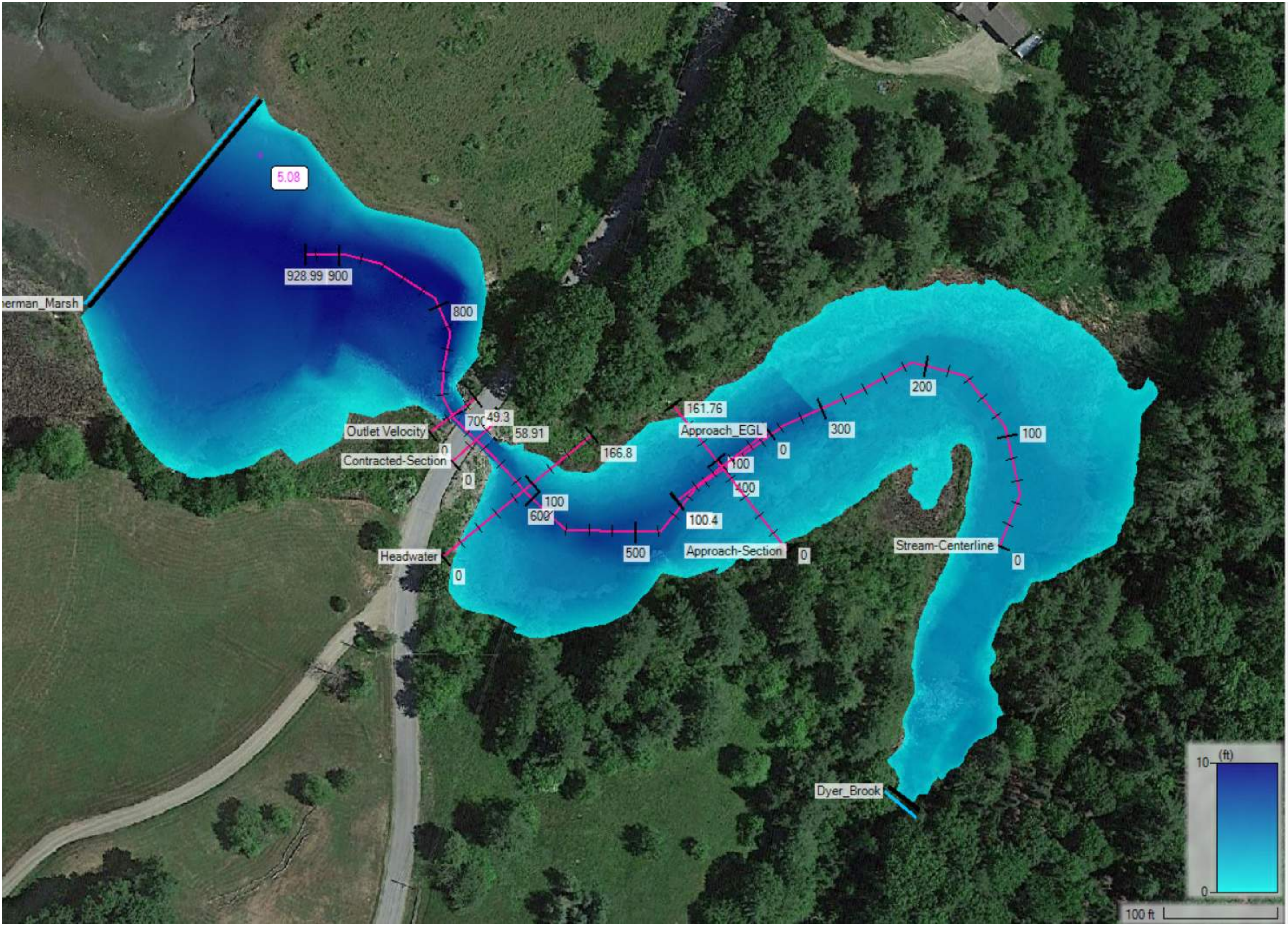
FLOOD INSURANCE STUDY NUMBER
23015CV000A

Table 6 – Summary of Stillwater Elevations

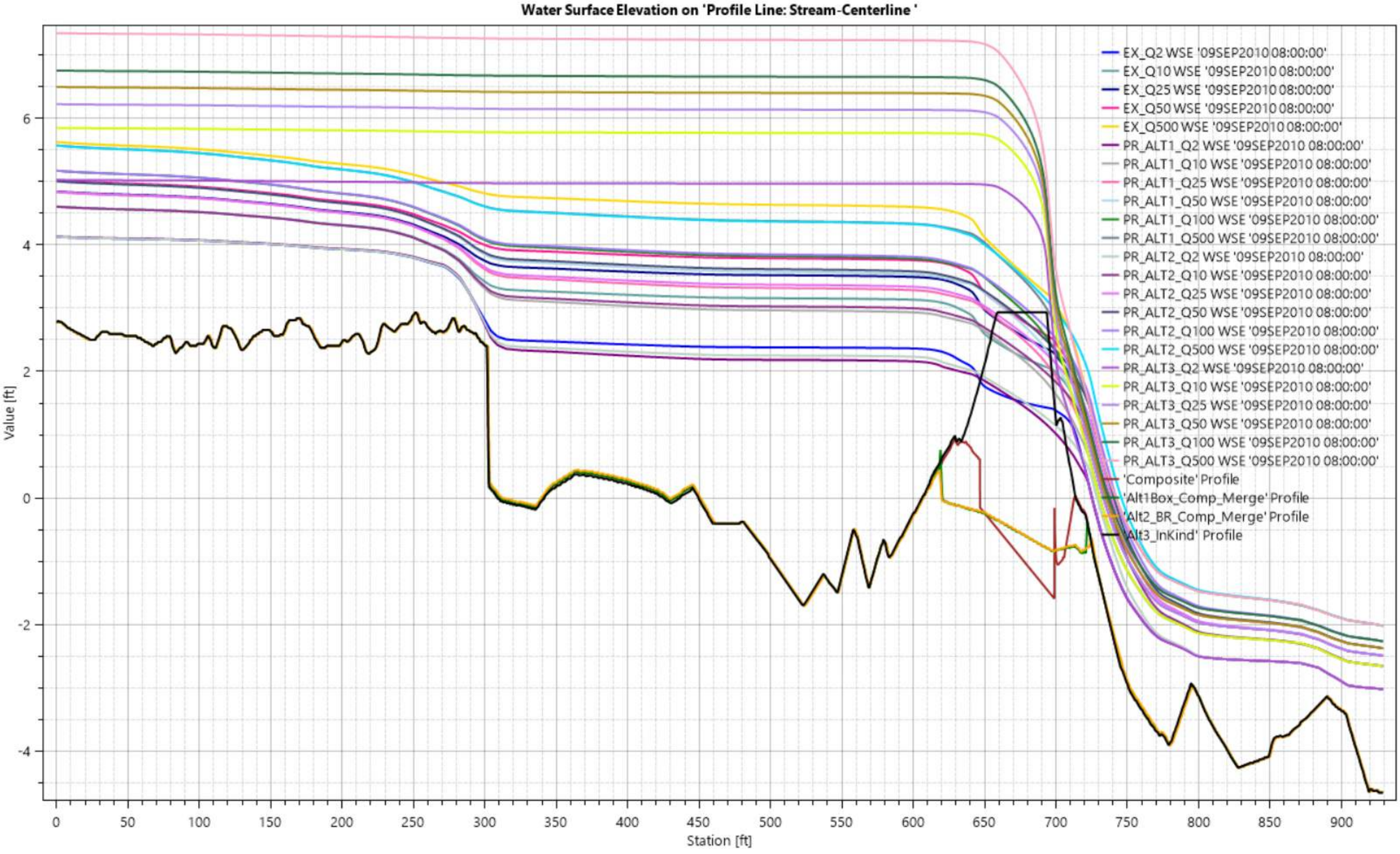
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ. MILES)	ELEVATION (feet NAVD88[1]) 10%-ANNUAL-CHANCE	2%-ANNUAL-CHANCE	1%-ANNUAL-CHANCE	0.2%-ANNUAL-CHANCE
BACK/SHEEPSCOT RIVERS					
At State Route 144	*	8.8	9.6	9.9	10.7
BISCAY POND	28.1	*	*	80.0	*
CLARY LAKE	9.56	*	*	152.9	*
DAMARISCOTTA LAKE	56.8	*	*	57.1	*
DAMARISCOTTA RIVER					
Damariscotta-Bristol corporate limits to head of Salt Bay	Ocean Estuary	*	*	9.2	*
East Boothbay	*	8.4	9.2	9.4	10.3
At Boothbay-Edgecomb corporate limits	*	8.6	9.4	9.6	10.5
Wentworth Point	*	8.6	9.4	9.8	10.8
Northern corporate limits of the Town of South Bristol	*	8.9	9.7	10.2	11.5
DUCKPUDDLE POND	*	*	*	80.5	*
DYER LONG POND	17.5	*	*	134.7	*
JAMES POND	*	*	*	199.1[2]	*
LITTLE MEDOMAK POND	*	133.5	135.2	136.3	137.7
LONG POND	*	*	*	186.7[2]	*

* Data Not Available
[1] North American Vertical Datum of 1988 (NAVD88)
[2] These elevations do not consider the effects of wave action

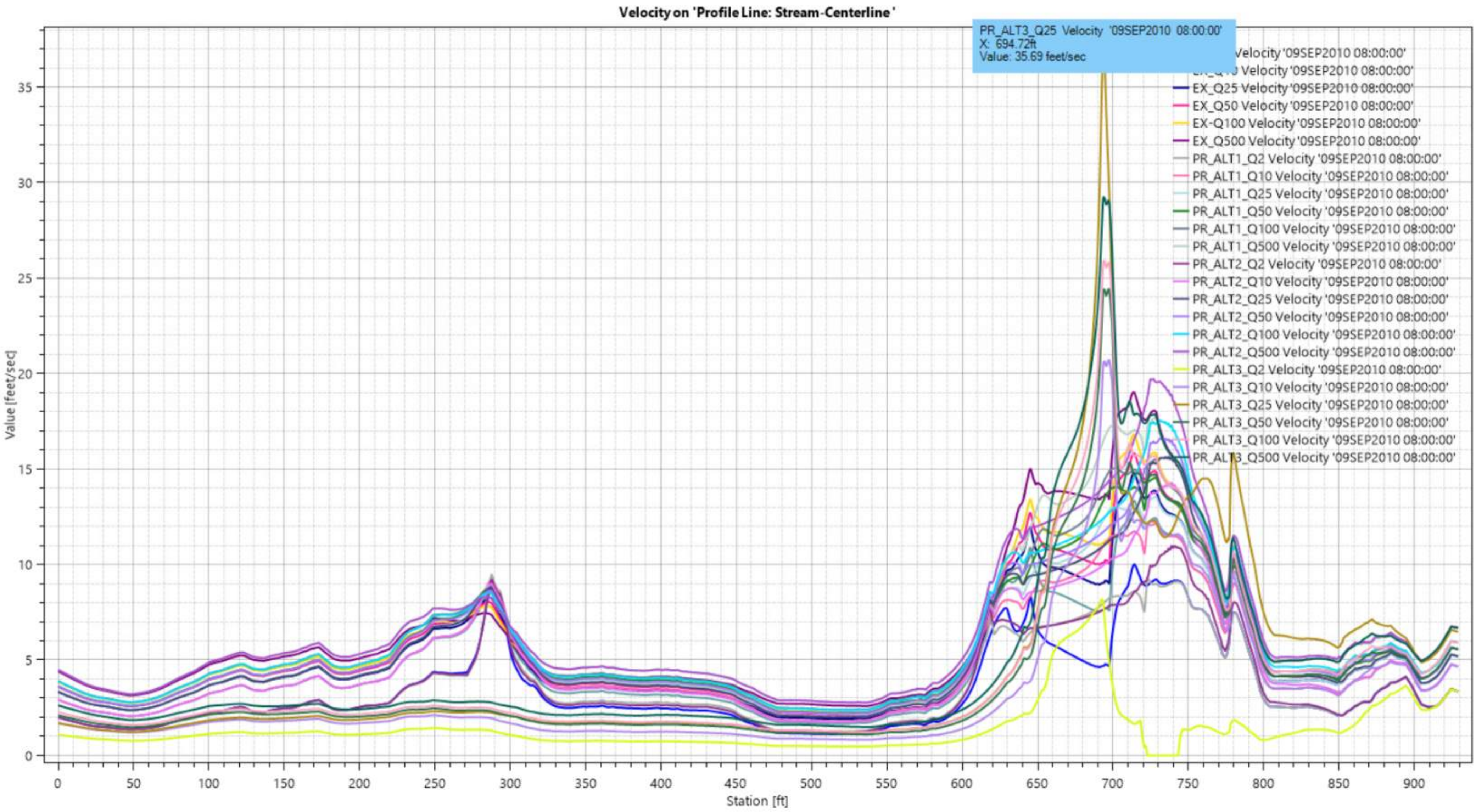

herman_Marsh
928.99
900
800
700
49.3
58.91
Outlet Velocity
Contracted-Section
0
166.8
161.76
Approach_EGL
0
100
400
100.4
600
Headwater
0
500
Approach-Section
0
300
200
100
Stream-Centerline
0
Dyer_Brook
(ft/s)
15
10
8
6
4
2
0
100 ft



5.08
928.99
900
800
erman_Marsh
700
49.3
58.91
Outlet Velocity
Contracted-Section
0
0
0
161.76
Approach_EGL
166.8
0
100
400
300
200
100
100
600
100.4
500
Headwater
0
Approach-Section
0
Stream-Centerline
0
Dyer_Brook
10
(ft)
0
100 ft



Water Surface Elevation on 'Profile Line: Stream-Centerline '
EX_Q2 WSE '09SEP2010 08:00:00'
EX_Q10 WSE '09SEP2010 08:00:00'
EX_Q25 WSE '09SEP2010 08:00:00'
EX_Q50 WSE '09SEP2010 08:00:00'
EX_Q500 WSE '09SEP2010 08:00:00'
PR_ALT1_Q2 WSE '09SEP2010 08:00:00'
PR_ALT1_Q10 WSE '09SEP2010 08:00:00'
PR_ALT1_Q25 WSE '09SEP2010 08:00:00'
PR_ALT1_Q50 WSE '09SEP2010 08:00:00'
PR_ALT1_Q100 WSE '09SEP2010 08:00:00'
PR_ALT1_Q500 WSE '09SEP2010 08:00:00'
PR_ALT2_Q2 WSE '09SEP2010 08:00:00'
PR_ALT2_Q10 WSE '09SEP2010 08:00:00'
PR_ALT2_Q25 WSE '09SEP2010 08:00:00'
PR_ALT2_Q50 WSE '09SEP2010 08:00:00'
PR_ALT2_Q100 WSE '09SEP2010 08:00:00'
PR_ALT2_Q500 WSE '09SEP2010 08:00:00'
PR_ALT3_Q2 WSE '09SEP2010 08:00:00'
PR_ALT3_Q10 WSE '09SEP2010 08:00:00'
PR_ALT3_Q25 WSE '09SEP2010 08:00:00'
PR_ALT3_Q50 WSE '09SEP2010 08:00:00'
PR_ALT3_Q100 WSE '09SEP2010 08:00:00'
PR_ALT3_Q500 WSE '09SEP2010 08:00:00'
'Composite' Profile
'Alt1Box_Comp_Merge' Profile
'Alt2_BR_Comp_Merge' Profile
'Alt3_InKind' Profile
Value [ft]
6
4
2
0
-2
-4
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
Station [ft]


Velocity on 'Profile Line: Stream-Centerline'
PR_ALT3_Q25 Velocity '09SEP2010 08:00:00'
X: 694.72ft
Value: 35.69 feet/sec
Velocity '09SEP2010 08:00:00'
Velocity '09SEP2010 08:00:00'
EX_Q25 Velocity '09SEP2010 08:00:00'
EX_Q50 Velocity '09SEP2010 08:00:00'
EX-Q100 Velocity '09SEP2010 08:00:00'
EX_Q500 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q2 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q10 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q25 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q50 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q100 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q500 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q2 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q10 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q25 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q50 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q100 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q500 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q2 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q10 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q25 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q50 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q100 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q500 Velocity '09SEP2010 08:00:00'
Value [feet/sec]
0
5
10
15
20
25
30
35
Station [ft]
0
50
100
150
200
250
300
350
400
450
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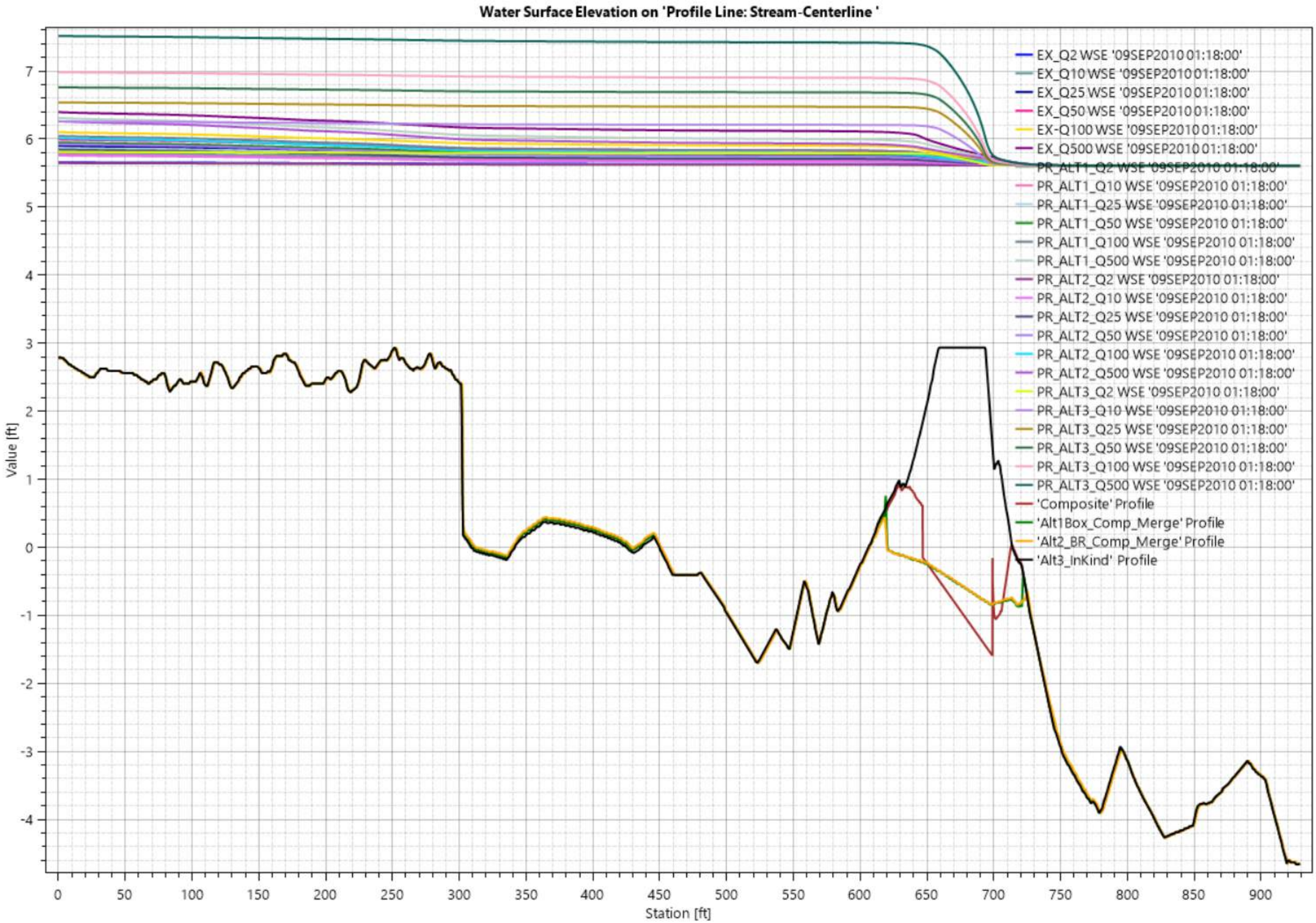
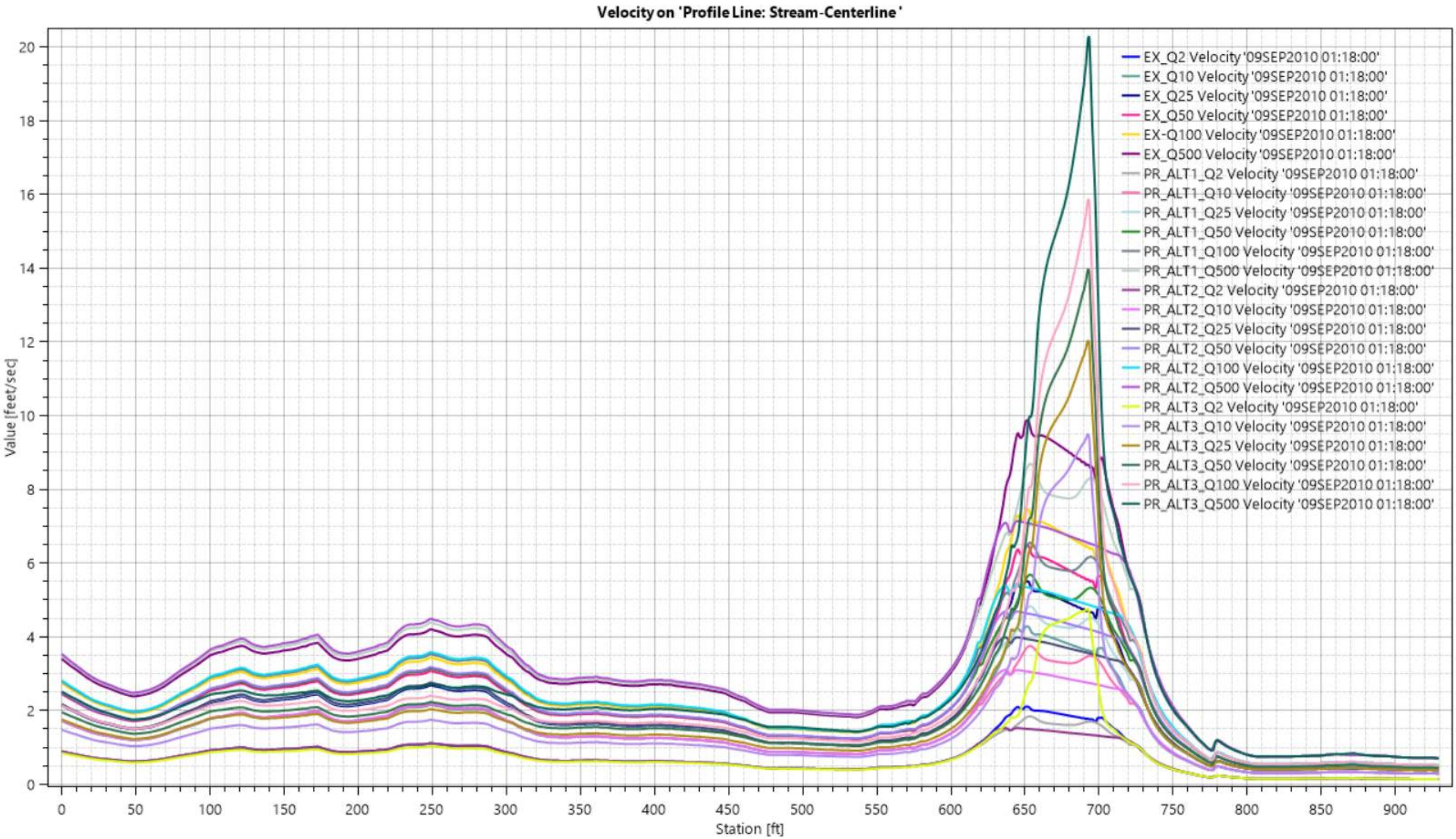
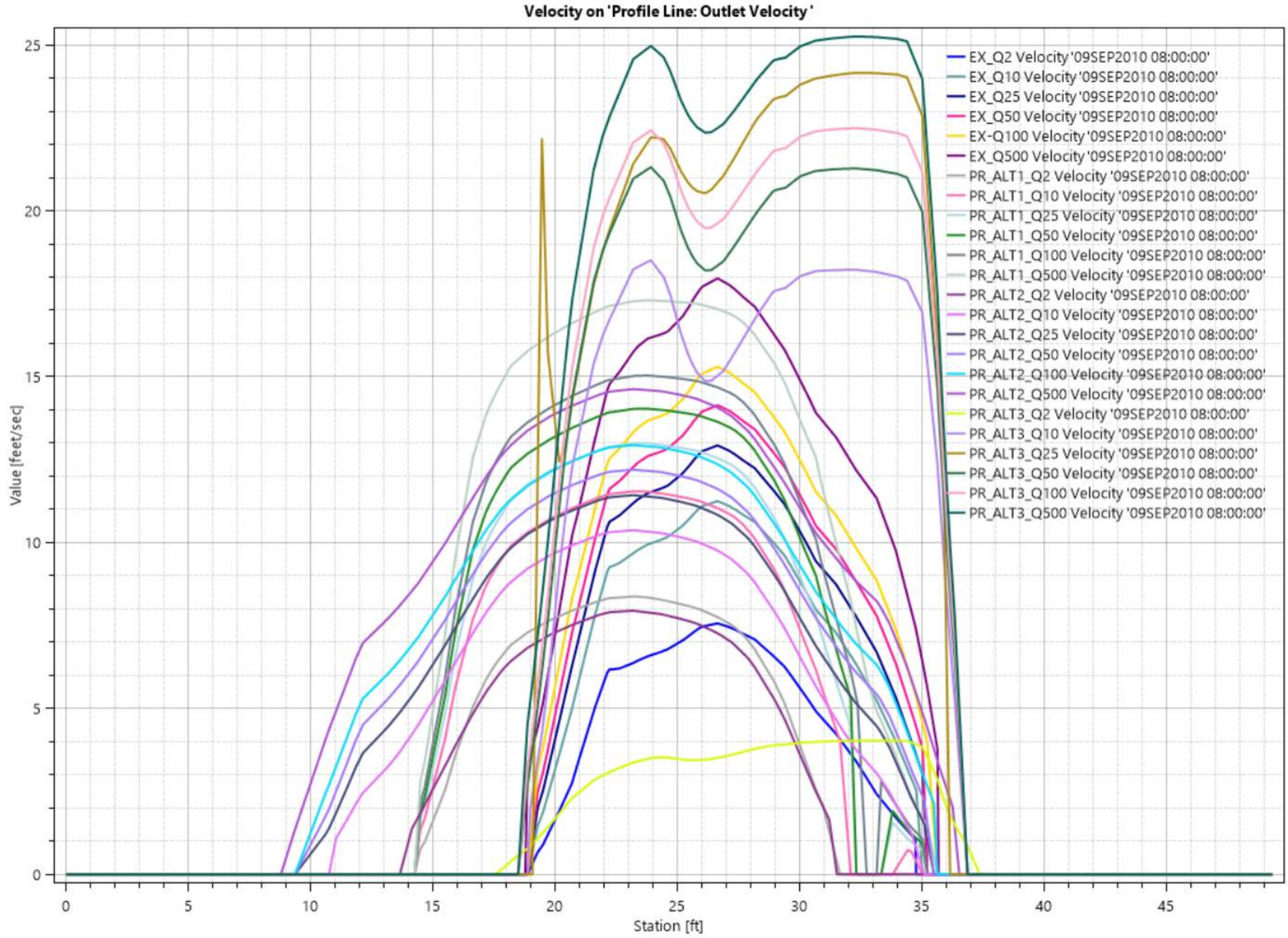
550
600
650
700
750
800
850
900

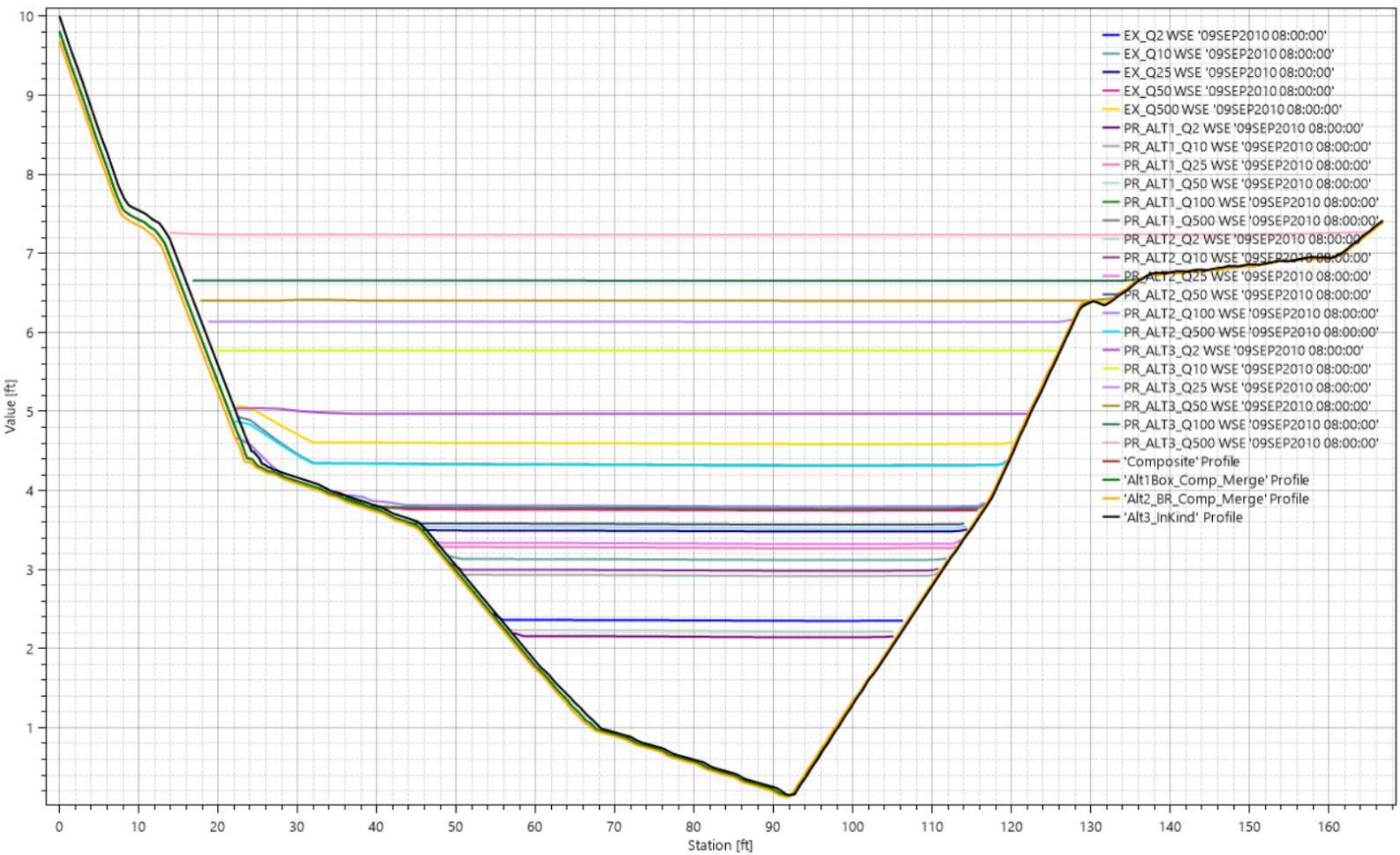

Water Surface Elevation on 'Profile Line: Stream-Centerline '
Value [ft]
Station [ft]
EX_Q2 WSE '09SEP2010 01:18:00'
EX_Q10 WSE '09SEP2010 01:18:00'
EX_Q25 WSE '09SEP2010 01:18:00'
EX_Q50 WSE '09SEP2010 01:18:00'
EX-Q100 WSE '09SEP2010 01:18:00'
EX_Q500 WSE '09SEP2010 01:18:00'
PR_ALT1_Q2 WSE '09SEP2010 01:18:00'
PR_ALT1_Q10 WSE '09SEP2010 01:18:00'
PR_ALT1_Q25 WSE '09SEP2010 01:18:00'
PR_ALT1_Q50 WSE '09SEP2010 01:18:00'
PR_ALT1_Q100 WSE '09SEP2010 01:18:00'
PR_ALT1_Q500 WSE '09SEP2010 01:18:00'
PR_ALT2_Q2 WSE '09SEP2010 01:18:00'
PR_ALT2_Q10 WSE '09SEP2010 01:18:00'
PR_ALT2_Q25 WSE '09SEP2010 01:18:00'
PR_ALT2_Q50 WSE '09SEP2010 01:18:00'
PR_ALT2_Q100 WSE '09SEP2010 01:18:00'
PR_ALT2_Q500 WSE '09SEP2010 01:18:00'
PR_ALT3_Q2 WSE '09SEP2010 01:18:00'
PR_ALT3_Q10 WSE '09SEP2010 01:18:00'
PR_ALT3_Q25 WSE '09SEP2010 01:18:00'
PR_ALT3_Q50 WSE '09SEP2010 01:18:00'
PR_ALT3_Q100 WSE '09SEP2010 01:18:00'
PR_ALT3_Q500 WSE '09SEP2010 01:18:00'
'Composite' Profile
'Alt1Box_Comp_Merge' Profile
'Alt2_BR_Comp_Merge' Profile
'Alt3_InKind' Profile

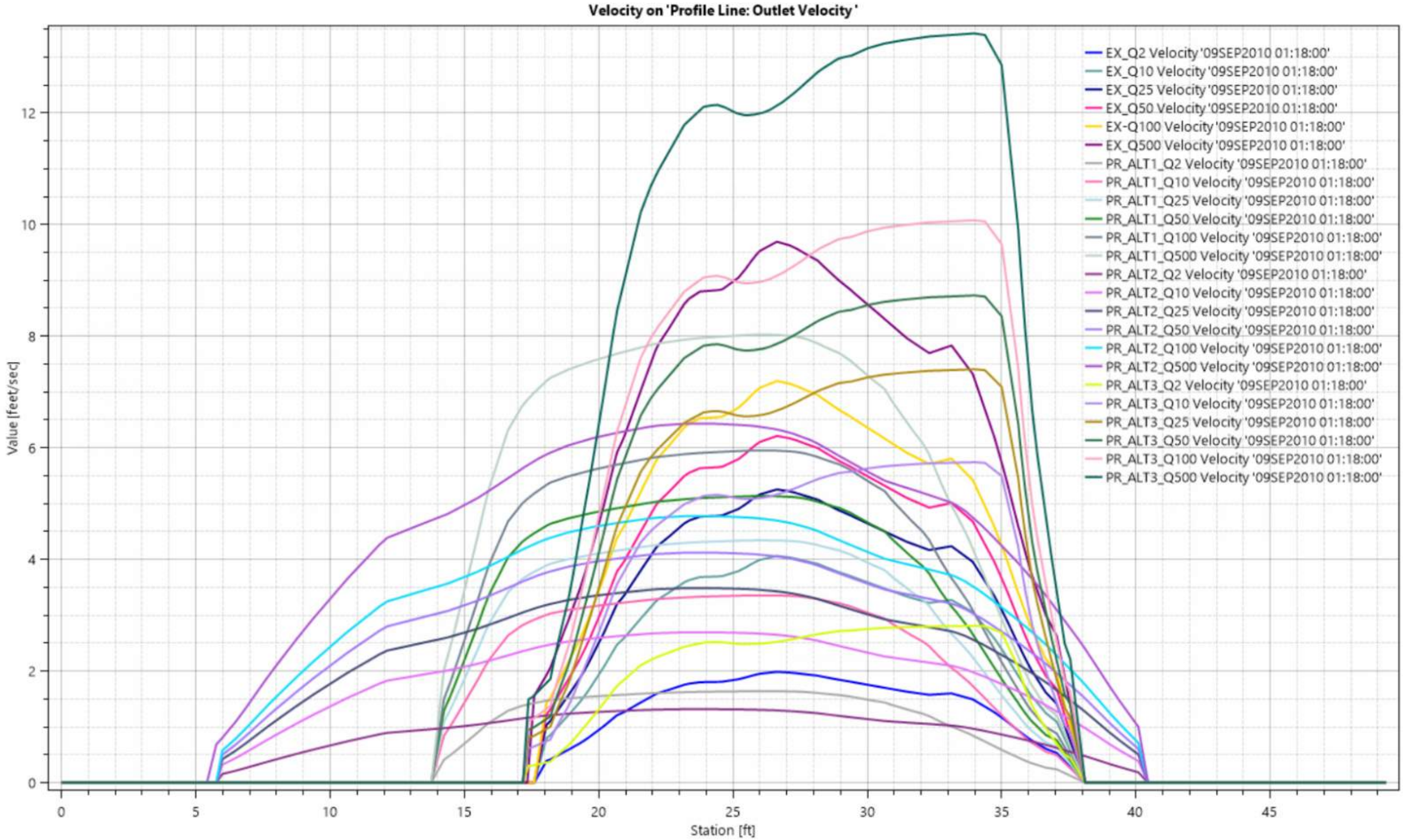

Velocity on 'Profile Line: Stream-Centerline'
Value [feet/sec]
Station [ft]
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
EX_Q2 Velocity '09SEP2010 01:18:00'
EX_Q10 Velocity '09SEP2010 01:18:00'
EX_Q25 Velocity '09SEP2010 01:18:00'
EX_Q50 Velocity '09SEP2010 01:18:00'
EX-Q100 Velocity '09SEP2010 01:18:00'
EX_Q500 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q2 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q10 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q25 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q50 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q100 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q500 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q2 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q10 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q25 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q50 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q100 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q500 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q2 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q10 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q25 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q50 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q100 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q500 Velocity '09SEP2010 01:18:00'



Velocity on 'Profile Line: Outlet Velocity '
Value [feet/sec]
Station [ft]
0
5
10
15
20
25
30
35
40
45
EX_Q2 Velocity '09SEP2010 08:00:00'
EX_Q10 Velocity '09SEP2010 08:00:00'
EX_Q25 Velocity '09SEP2010 08:00:00'
EX_Q50 Velocity '09SEP2010 08:00:00'
EX-Q100 Velocity '09SEP2010 08:00:00'
EX_Q500 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q2 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q10 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q25 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q50 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q100 Velocity '09SEP2010 08:00:00'
PR_ALT1_Q500 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q2 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q10 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q25 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q50 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q100 Velocity '09SEP2010 08:00:00'
PR_ALT2_Q500 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q2 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q10 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q25 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q50 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q100 Velocity '09SEP2010 08:00:00'
PR_ALT3_Q500 Velocity '09SEP2010 08:00:00'

Water Surface Elevation on 'Profile Line: Headwater '




Velocity on 'Profile Line: Outlet Velocity'
Value [feet/sec]
Station [ft]
EX_Q2 Velocity '09SEP2010 01:18:00'
EX_Q10 Velocity '09SEP2010 01:18:00'
EX_Q25 Velocity '09SEP2010 01:18:00'
EX_Q50 Velocity '09SEP2010 01:18:00'
EX-Q100 Velocity '09SEP2010 01:18:00'
EX_Q500 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q2 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q10 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q25 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q50 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q100 Velocity '09SEP2010 01:18:00'
PR_ALT1_Q500 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q2 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q10 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q25 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q50 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q100 Velocity '09SEP2010 01:18:00'
PR_ALT2_Q500 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q2 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q10 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q25 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q50 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q100 Velocity '09SEP2010 01:18:00'
PR_ALT3_Q500 Velocity '09SEP2010 01:18:00'
0
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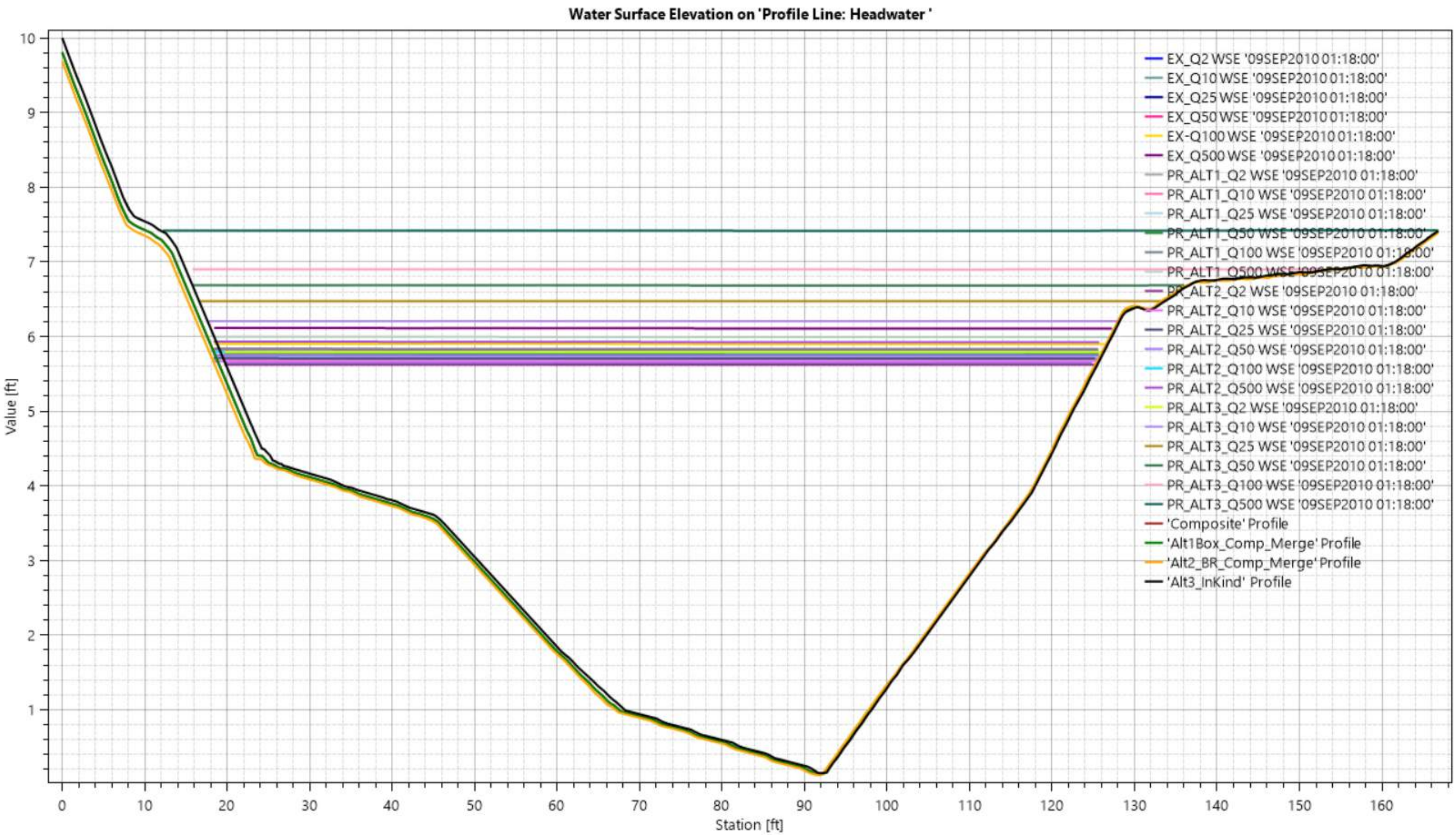
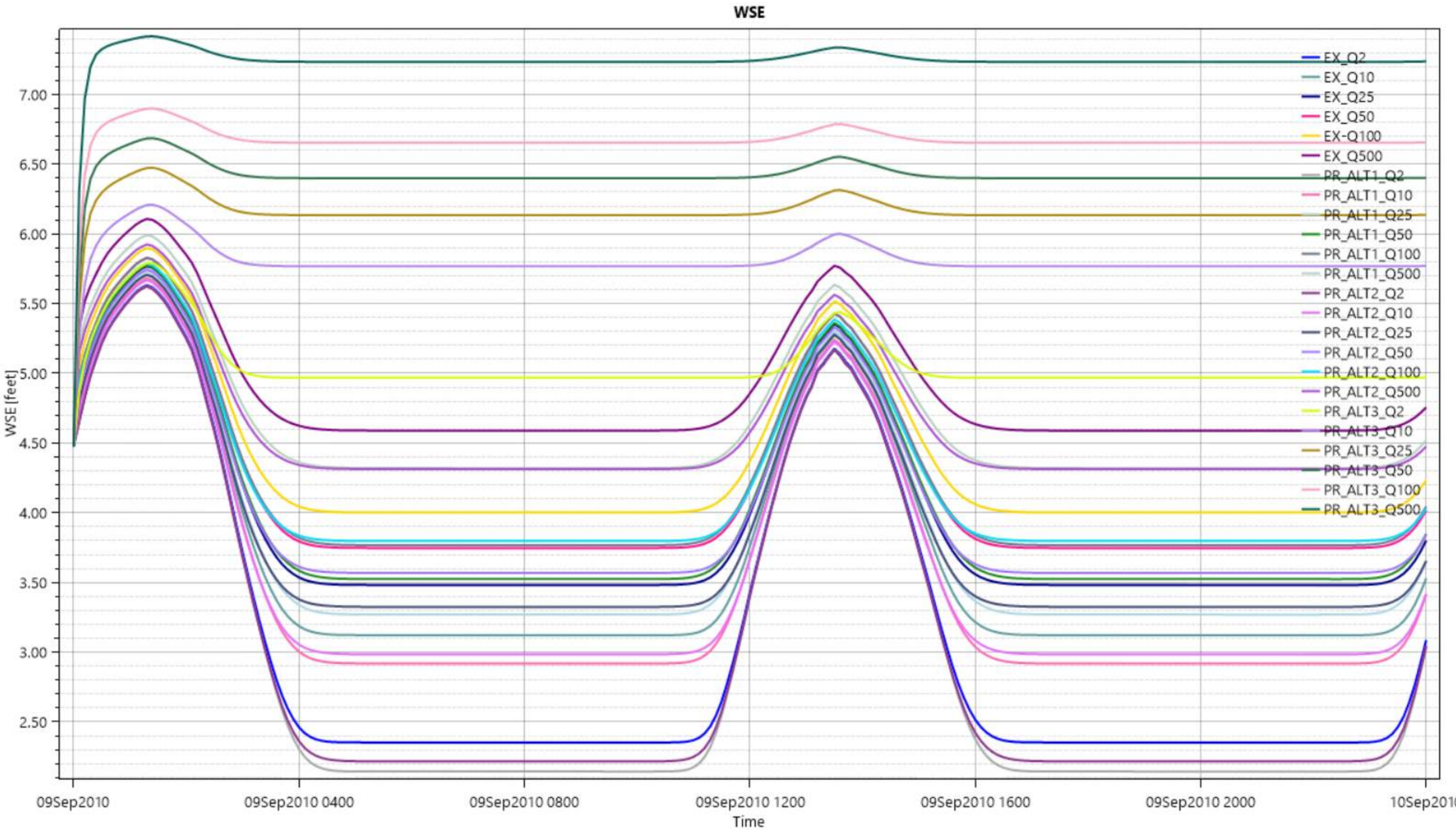
8
10
12
0
5
10
15
20
25
30
35
40
45



Water Surface Elevation on 'Profile Line: Headwater '
Value [ft]
Station [ft]
EX_Q2 WSE '09SEP2010 01:18:00'
EX_Q10 WSE '09SEP2010 01:18:00'
EX_Q25 WSE '09SEP2010 01:18:00'
EX_Q50 WSE '09SEP2010 01:18:00'
EX-Q100 WSE '09SEP2010 01:18:00'
EX_Q500 WSE '09SEP2010 01:18:00'
PR_ALT1_Q2 WSE '09SEP2010 01:18:00'
PR_ALT1_Q10 WSE '09SEP2010 01:18:00'
PR_ALT1_Q25 WSE '09SEP2010 01:18:00'
PR_ALT1_Q50 WSE '09SEP2010 01:18:00'
PR_ALT1_Q100 WSE '09SEP2010 01:18:00'
PR_ALT1_Q500 WSE '09SEP2010 01:18:00'
PR_ALT2_Q2 WSE '09SEP2010 01:18:00'
PR_ALT2_Q10 WSE '09SEP2010 01:18:00'
PR_ALT2_Q25 WSE '09SEP2010 01:18:00'
PR_ALT2_Q50 WSE '09SEP2010 01:18:00'
PR_ALT2_Q100 WSE '09SEP2010 01:18:00'
PR_ALT2_Q500 WSE '09SEP2010 01:18:00'
PR_ALT3_Q2 WSE '09SEP2010 01:18:00'
PR_ALT3_Q10 WSE '09SEP2010 01:18:00'
PR_ALT3_Q25 WSE '09SEP2010 01:18:00'
PR_ALT3_Q50 WSE '09SEP2010 01:18:00'
PR_ALT3_Q100 WSE '09SEP2010 01:18:00'
PR_ALT3_Q500 WSE '09SEP2010 01:18:00'
'Composite' Profile
'Alt1Box_Comp_Merge' Profile
'Alt2_BR_Comp_Merge' Profile
'Alt3_InKind' Profile
10
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160


WSE
WSE [feet]
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
09Sep2010
09Sep2010 0400
09Sep2010 0800
09Sep2010 1200
09Sep2010 1600
09Sep2010 2000
10Sep2010
Time
EX_Q2
EX_Q10
EX_Q25
EX_Q50
EX-Q100
EX_Q500
PR_ALT1_Q2
PR_ALT1_Q10
PR_ALT1_Q25
PR_ALT1_Q50
PR_ALT1_Q100
PR_ALT1_Q500
PR_ALT2_Q2
PR_ALT2_Q10
PR_ALT2_Q25
PR_ALT2_Q50
PR_ALT2_Q100
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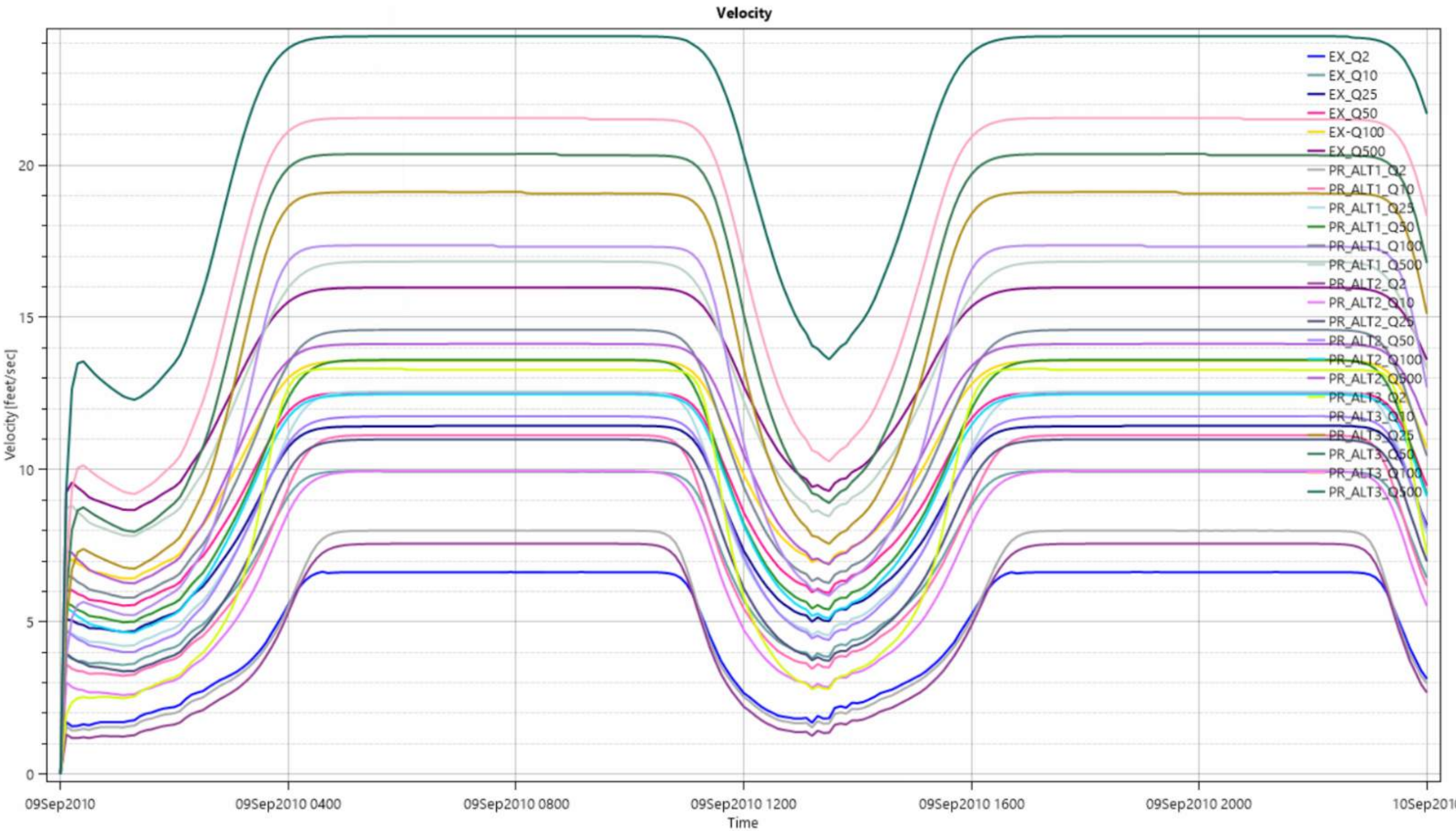
PR_ALT3_Q500



Velocity
EX_Q2
EX_Q10
EX_Q25
EX_Q50
EX-Q100
EX_Q500
PR_ALT1_Q2
PR_ALT1_Q10
PR_ALT1_Q25
PR_ALT1_Q50
PR_ALT1_Q100
PR_ALT1_Q500
PR_ALT2_Q2
PR_ALT2_Q10
PR_ALT2_Q25
PR_ALT2_Q50
PR_ALT2_Q100
PR_ALT2_Q500
PR_ALT3_Q2
PR_ALT3_Q10
PR_ALT3_Q25
PR_ALT3_Q50
PR_ALT3_Q100
PR_ALT3_Q500
Velocity [feet/sec]
20
15
10
5
0
09Sep2010
09Sep2010 0400
09Sep2010 0800
09Sep2010 1200
09Sep2010 1600
09Sep2010 2000
10Sep2010
Time

Scour Computations Worksheet

INPUTS AND ASSUMPTIONS

Project:	Bridge 0618 Dyer Creek-Lynch Rd	Project #	55718.00
Location:	Newcastle, Maine	Sheet	Inputs and Assumptions
Calculated by:	DWC	Date:	10/4/2023
Checked by:		Date:	
Title:	Scour Calculations - Lynch Road		

Basis of Design: Calculations based on methodology outlined in HEC-18 5th Edition (FHWA-HIF-12-003, 2012)

Design Guide MaineDOT 2003 Bridge Design Guide (June 2018 Update), Section 2.3
https://www.maine.gov/mdot/bdg/docs/bpdg/Complete2003BDGwithUpdatesto2018.pdf

1. Data Sources:

Hydrology	\\vhb.com\gbl\proj\SPortland\55718.00 Lynch Road\tech\H&H\Hydrology
Hydraulic Model	\\vhb.com\gis\proj\SPortland\55718.00 Lynch Road\Techdoc\HEC-RAS
Bridge Plans	\\vhb.com\gbl\proj\SPortland\55718.00 Lynch Road\Cad_MEDot\MaineDOT\HIGHWAY\MSTA\Plot
Topo/Bathy Survey	\\vhb.com\gbl\proj\SPortland\55718.00 Lynch Road\Cad_MEDot\MaineDOT\SURVEY\MSTA\VHB Survey July
Geotechnical	\\vhb.com\gbl\proj\SPortland\55718.00 Lynch Road\tech\Geotech
Hydraulic Toolbox	\\vhb.com\gbl\proj\SPortland\55718.00 Lynch Road\tech\H&H\Scour Calcs

2. Crossing Information:

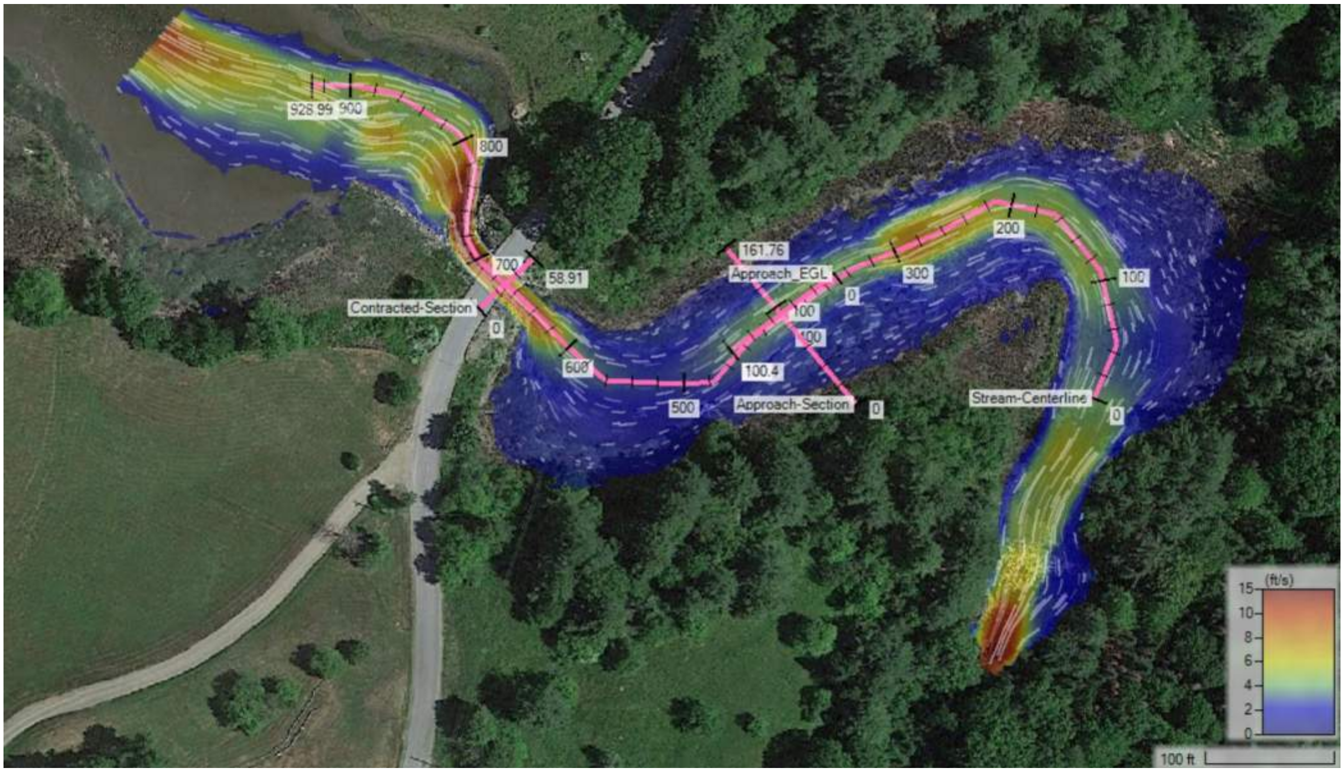
River/Stream Crossed:	Dyer Brook
Crossing Road/Structure:	Lynch Road
Existing or Proposed Structure?	PR
Design Scour Event:	Q100
Check Scour Event:	Q500

Substructure Elevations:	***Alt 1***	***Alt 2***	***Alt 3***	***Notes***
Minimum Channel:	-0.5	-0.5	3.24	
Average Channel Bed:	0.39	0.88	3.26	
Left Abutment:				
Bed Elevation at Abutment Toe:	1.7	1.7	3.24	
Top of Footing:	-2.5	10	1.18	
Bottom of Footing:	-3.5	7	-0.07	
Right Abutment:				
Bed Elevation at Abutment Toe:	1.7	1.7	3.24	
Top of Footing:	-2.5	10	1.18	
Bottom of Footing:	-3.5	(Bedrock)	-0.07	

3. Hydraulic Model Analysis Locations:

Contracted Section: cross-section corresponding to upstream fascia of bridge/culvert above road
Station: 670
Approach Section: cross-section corresponding to representative average upstream width and velocity, located along straight reach with representative channel and floodplain width
Station: 400

HEC-RAS Model Analysis Locations:



4. Geotechnical Information:

Channel Bed D50:	*(mm)*	*(inches)*	*(feet)*	
Approach Section:	0.2	0.0079	0.0007	*Silt and fine sand (assumed)*
Contracted Section:	50.8	2.0000	0.1667	*Proposed cobble-gravel streambed special fill*
Contracted Section D84:	203.2	8.0000	0.6667	
D50/84 sources and locations:	Approach Section: visual estimate of sediment approx. 200 ft US of crossing. Contracted Section: Proposed gradation based on pebble count of channel, located approx. 800 ft US of crossing.			

5. HEC-18 Scour Calculation Inputs (Hydraulic Toolbox Scour Module)

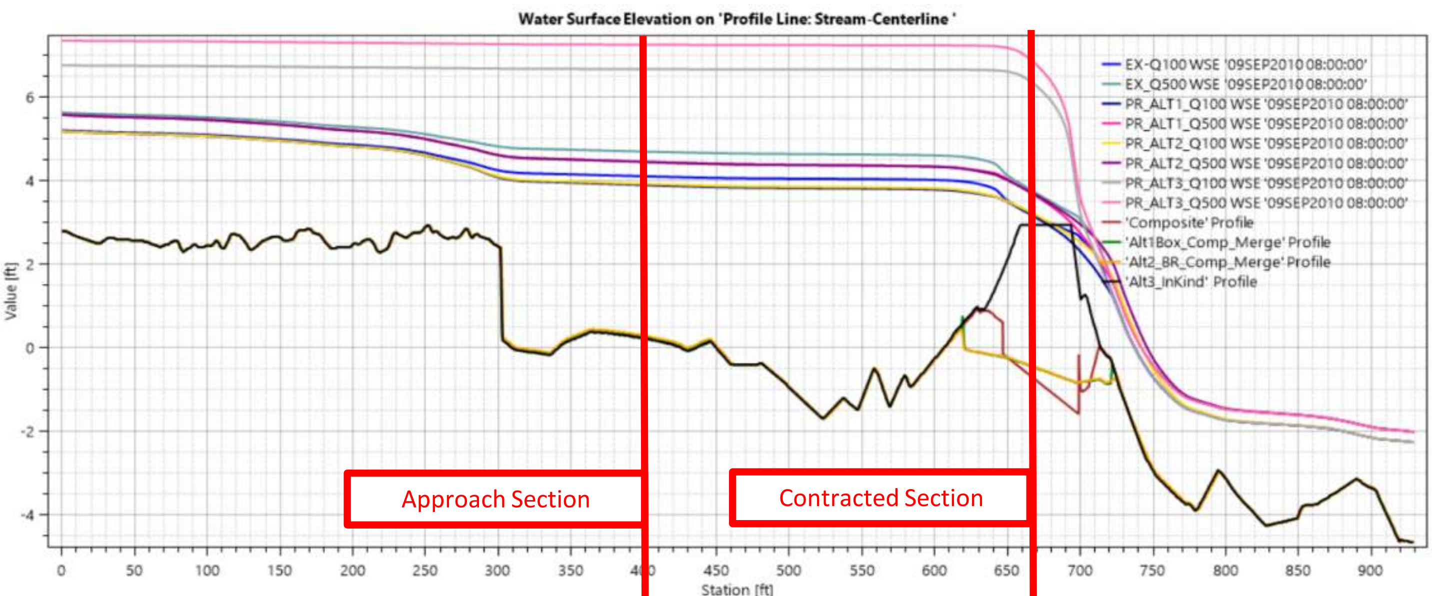
	Alternative 1		**Alternative 2**		**Alternative 3**			
Input Variable	***Design Scour***	***Check Scour***	***Design Scour***	***Check Scour***	***Design Scour***	***Check Scour***	***Unit***	***Notes***
CONTRACTION SCOUR								
Approach Section:								
Event Magnitude:	Q100	Q500	Q100	Q500	Q100	Q500		
Average Channel Depth:	**3.10**	**3.68**	**3.13**	**3.66**	**5.86**	**6.45**	(ft)	
Streambed D50:	**0.20**	**0.20**	**0.20**	**0.20**	**0.20**	**0.20**	(mm)	
Channel Width:	**45.71**	**46.07**	**45.71**	**45.71**	**46.64**	**46.64**	(ft)	
Average Channel Velocity:	**3.67**	**3.99**	**3.62**	**4.02**	**1.60**	**1.92**	(ft/sec)	
Energy Gradeline Slope:	**0.0020**	**0.0020**	**0.0020**	**0.0020**	**0.0002**	**0.0003**	(ft/ft)	
Discharge in Channel:	**519.49**	**677.61**	**518.22**	**673.55**	**436.88**	**576.36**	(cfs)	
Approach WSE:	3.89	4.45	3.92	4.45	6.67	7.25		
Contracted/Bridge Section:								
Contracted Flow:	**598.52**	**811.44**	**598.32**	**811.36**	**599.07**	**812.16**	(cfs)	
Contracted Flow Width:	**21.72**	**21.72**	**26.35**	**27.39**	**14.00**	**14.00**	(ft)	
Average Depth of Flow:	**2.72**	**3.22**	**2.40**	**2.76**	**3.01**	**3.50**	(ft)	
Average Velocity:	10.12	11.59	9.45	10.72	12.77	14.90	(ft/sec)	
Contracted WSE:	3.10	3.61	3.16	3.64	6.25	6.76	(ft)	
Streambed D50:	**50.80**	**50.80**	**50.80**	**50.80**	**50.80**	**50.80**	(mm)	

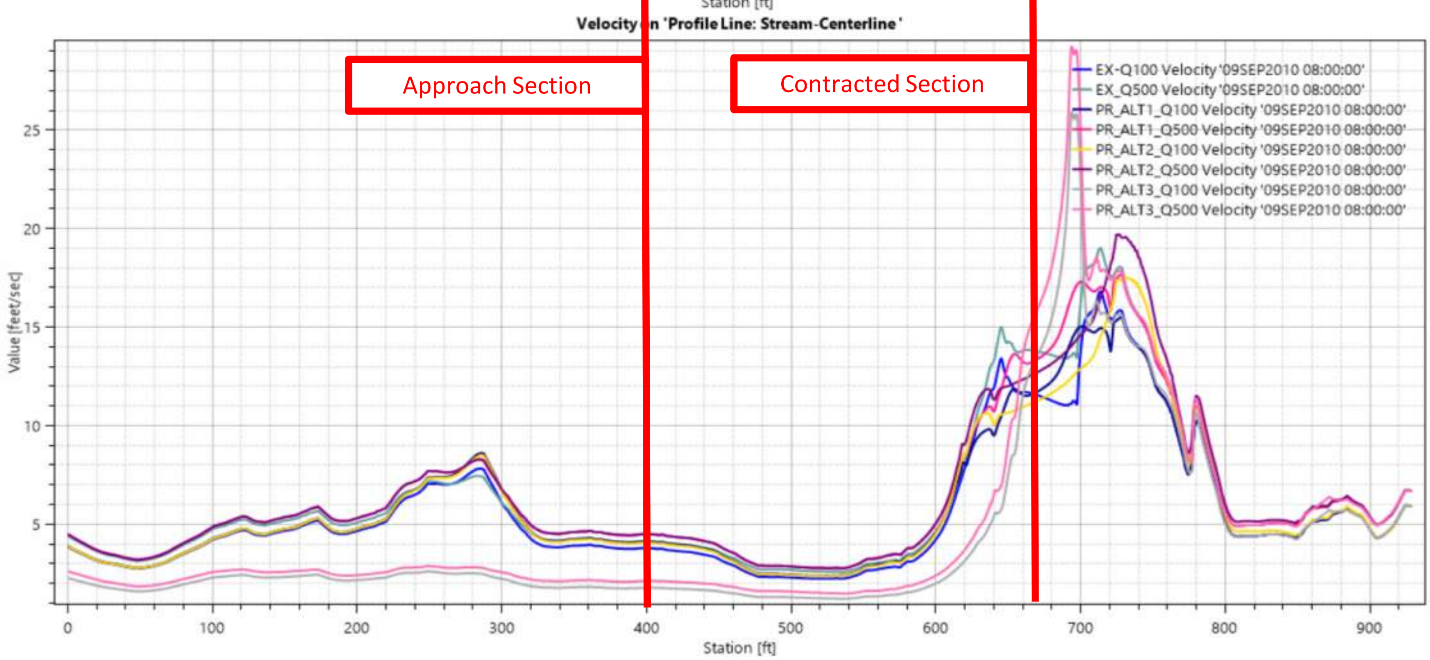
ABUTMENT SCOUR							
Scour Condition:	**Type A**	**Type A**	**Type A**	**Type A**	**Type A**	**Type A**	
	Type A (Main Channel) or Type B (Overbanks). For Type B Scour, add overbank hydraulic data						
Abutment Type:	**Vertical With WW**	**Vertical With WW**	**Spill-Through**	**Spill-Through**	**Vertical Wall**	**Vertical Wall**	
	Vertical Wall, Vertical Wall with Wingwalls, Spill-through						
Approach Unit Discharge:	**11.36**	**14.71**	**11.34**	**14.73**	**9.37**	**12.36**	(cfs/ft)
Contracted Unit Discharge:	**27.56**	**37.37**	**22.71**	**29.62**	**42.79**	**58.01**	(cfs/ft)
Contracted Streambed D50:	**50.80**	**50.80**	**50.80**	**50.80**	**50.80**	**50.80**	(mm)
Approach Channel Depth:	**3.10**	**3.68**	**3.13**	**3.66**	**5.86**	**6.45**	
Contracted WSE:	3.10	3.61	3.16	3.64	6.25	6.76	(ft)
Bed El at Abutment Toe:	1.70	1.70	1.70	1.70	3.24	3.24	(ft)
Flow Depth at Abutment Toe:	**1.40**	**1.91**	**1.46**	**1.94**	**3.01**	**3.52**	(ft)

Scour Computations Worksheet

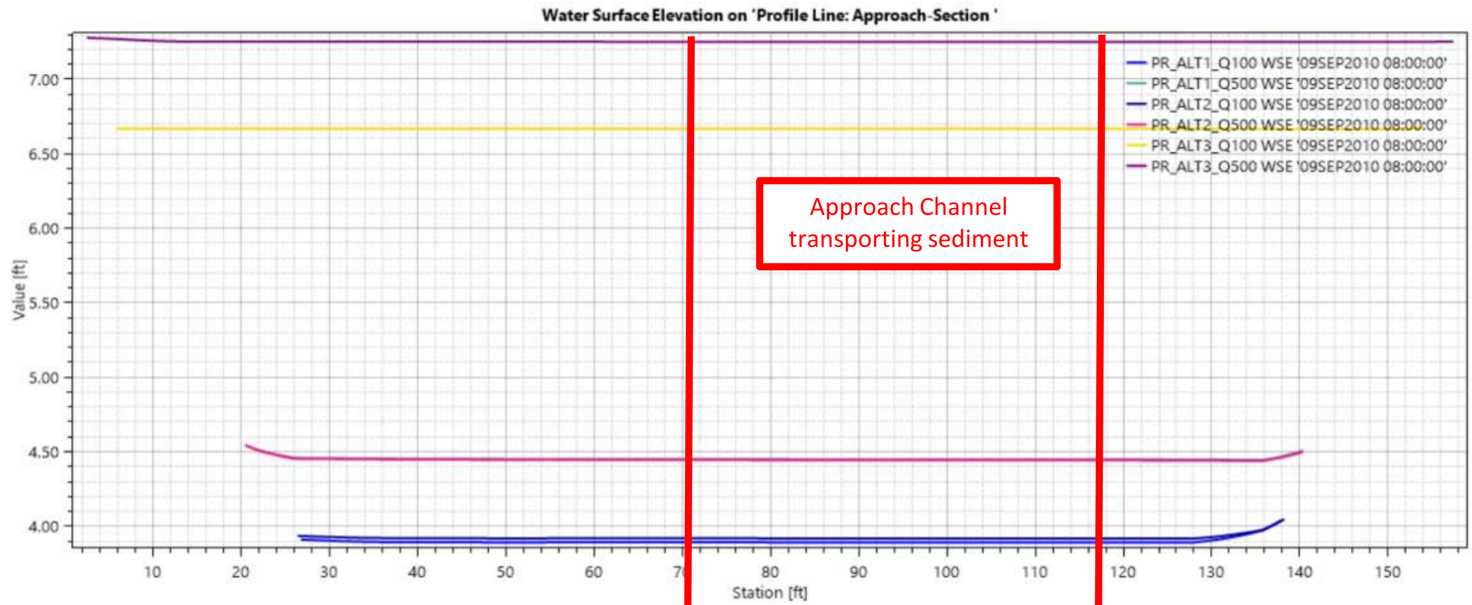
2D MODEL RESULTS				
	Project:	Bridge 0618 Dyer Creek-Lynch Rd	Project #	55718.00
	Location:	Newcastle, Maine	Sheet	Results Summary
	Calculated by:	DWC	Date:	10/4/2023
	Checked by:		Date:	
	Title:	Scour Calculations - Lynch Road		

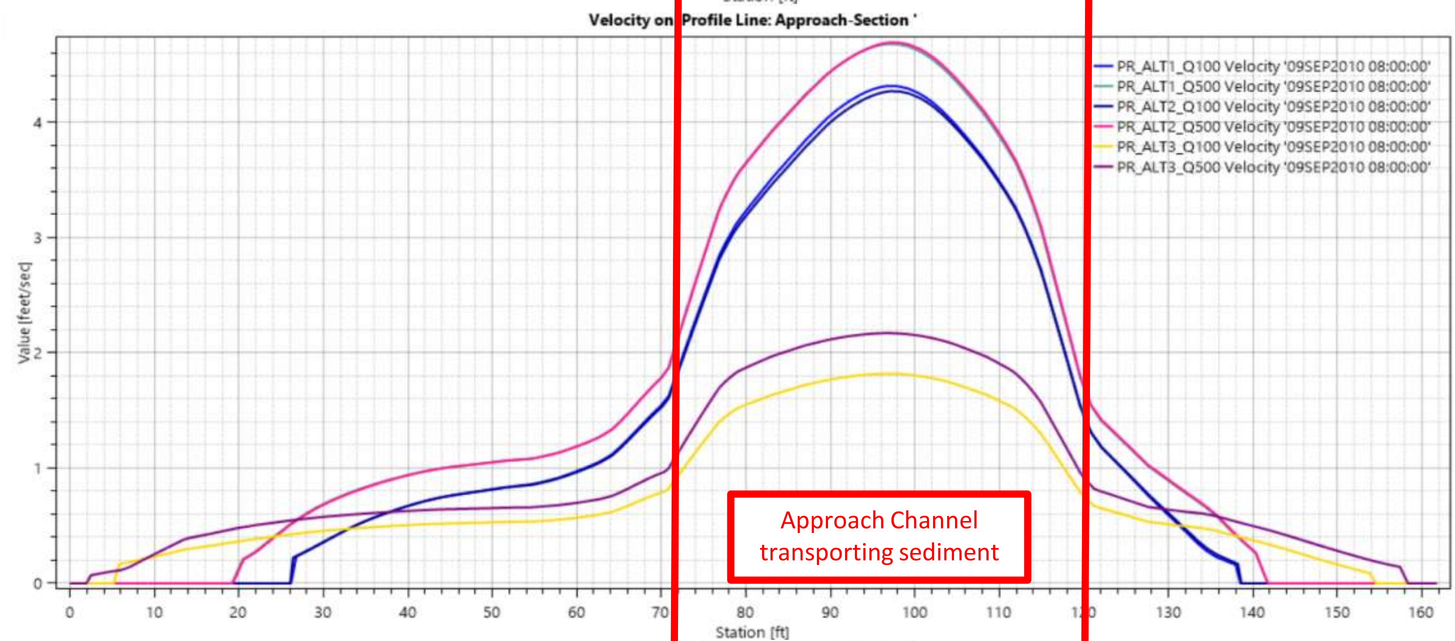
1. Stream Profile

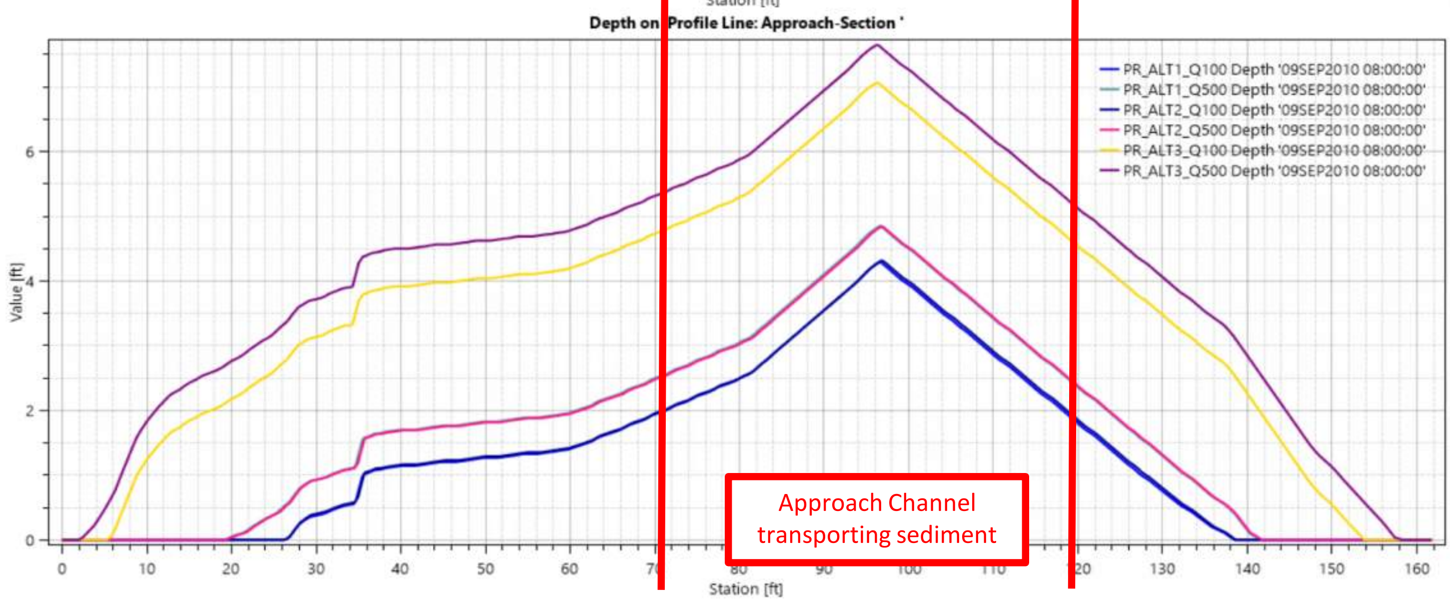




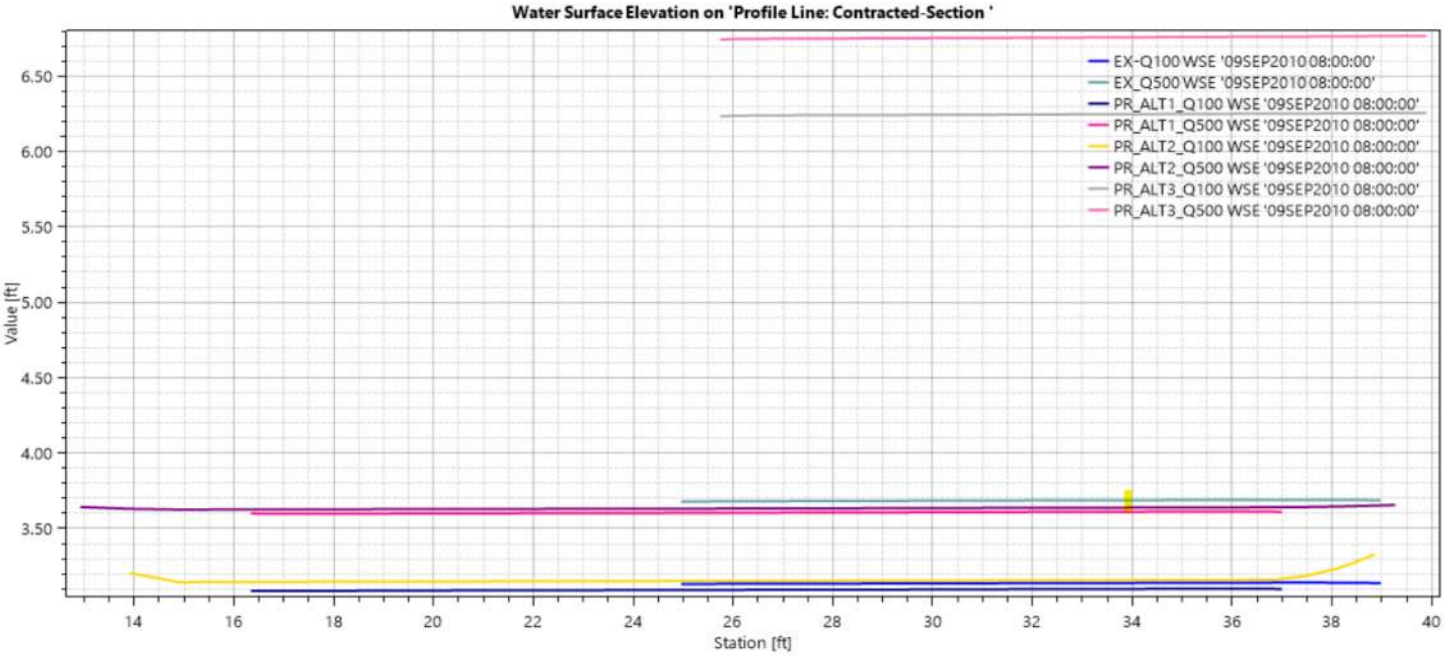
2. Approach Section

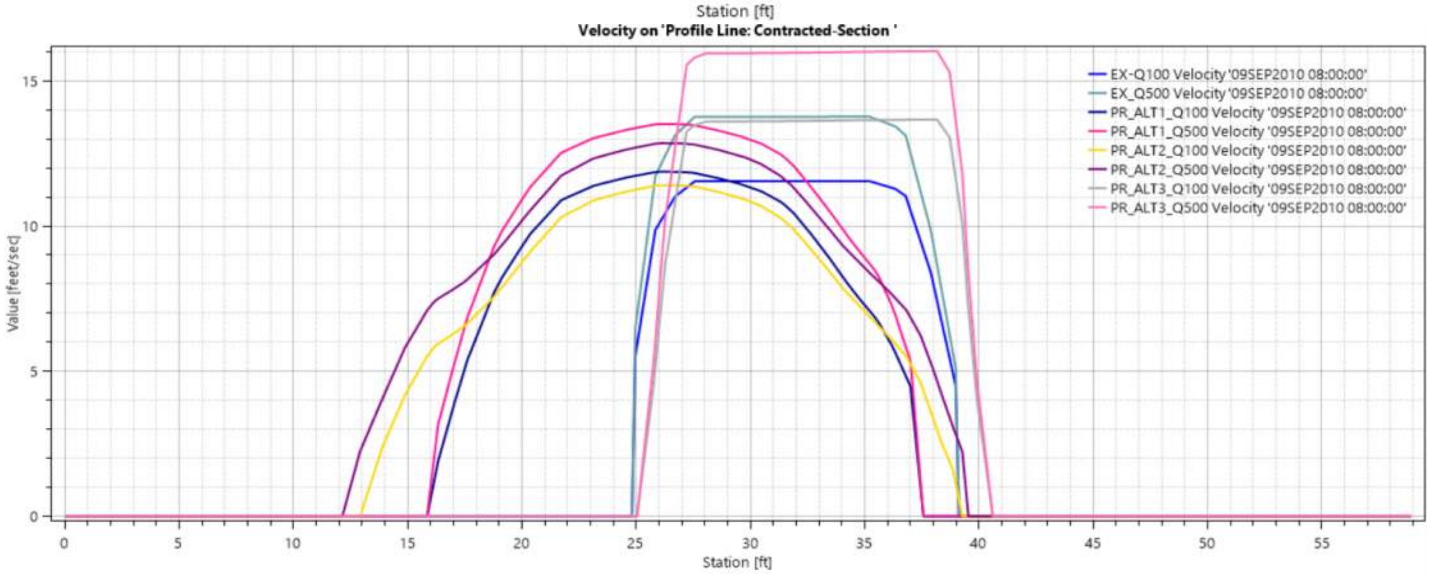


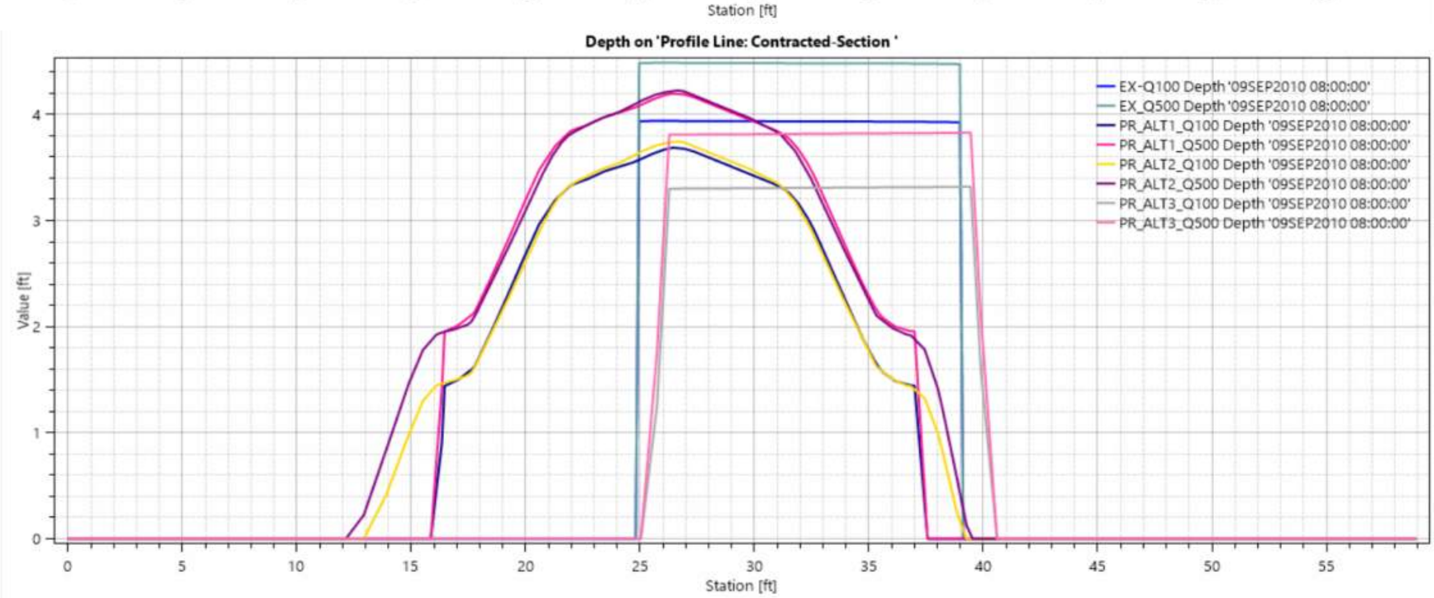




3. Contracted Section







Scour Computations Worksheet

SCOUR CALCULATIONS SUMMARY				
	Project:	Bridge 0618 Dyer Creek-Lynch Rd	Project #	55718.00
	Location:	Newcastle, Maine	Sheet	Scour Calculations Summary
	Calculated by:	DWC	Date:	10/4/2023
	Checked by:		Date:	
	Title:	Scour Calculations - Lynch Road		

1. HEC-18 Scour Calculation Results (Hydraulic Toolbox Scour Module)

	Alternative 1		Alternative 2		Alternative 3			
	Design Scour	***Check Scour***	***Design Scour***	***Check Scour***	***Design Scour***	***Check Scour***	***Unit***	***Notes***
Event Magnitude:	Q100	Q500	Q100	Q500	Q100	Q500		
Discharge:	598.5	811.4	598.3	811.4	599.1	812.2	cfs	
Channel Velocity:	10.1	11.6	9.5	10.7	12.8	14.9	fps	
Water Surface Elevation:	3.1	3.6	3.2	3.6	6.3	6.8	ft	
Pre-Scour Flow Depth:	*2.7*	*3.2*	*2.4*	*2.8*	*3.0*	*3.5*	ft	
Contraction Scour Flow Depth:	3.3	4.3	2.8	3.6	4.9	6.3	ft	
Left Abutment Scour Flow Depth:	4.1	5.3	3.6	4.5	5.8	7.6	ft	
Right Abutment Scour Flow Depth:	4.1	5.3	3.6	4.5	5.8	7.6	ft	
Contraction Scour:	**0.6**	**1.1**	**0.4**	**0.8**	**1.9**	**2.8**	ft	
Left Abutment Scour:	**1.4**	**2.1**	**1.2**	**1.8**	**2.8**	**4.0**	ft	
Right Abutment Scour:	**1.4**	**2.1**	**1.2**	**1.8**	**2.8**	**4.0**	ft	
Maximum Scour Elevation:	**-1.0**	**-1.7**	**-0.5**	**-0.9**	**0.4**	**-0.8**	ft	
Bottom of Footing Elevation:	-3.5	-3.5	7.0	7.0	-0.1	-0.1	ft	
Remaining Embedment:	**2.5**	**1.8**	**-7.5**	**-7.9**	**0.5**	**-0.7**	ft	

Note: Scour depth represents maximum flow depth including scour.
Maximum scour elevation corresponds to maximum scour depth below water surface elevation.

Note: Per HEC-18, live-bed contraction scour depths may be limited by armoring of the bed by large sediment particles in the bed material or by sediment transport of the bed material into the bridge cross-section. Under these conditions, live-bed contraction scour at a bridge can be determined by calculating the scour depths using both the clear-water and live-bed contraction scour equations and using the smaller of the two depths. Therefore, these calculations represent the clear-water calculation for contraction and abutment scour.

Note: Per HEC-18, abutment scour is considered condition "A" for abutments set within or adjacent to the channel.

Hydraulic Analysis Report

Project Data

Project Title: Bridge 0618 Lynch Rd-Dyer Creek Newcastle ME
Designer:
Project Date: Friday, September 29, 2023
Project Units: U.S. Customary Units
Notes:

Bridge Scour Analysis:Bridge Scour Analysis

Notes:

Scenario: Alt2_Q100

Contraction Scour Summary

Contraction & Long Term Scour is applied method due to greater scour.
Applied Contraction Scour Depth 2.82 ft
Contraction & Long Term Scour is applied method due to greater scour.
Pressure Scour Depth 2.82 ft
Clear Water Contraction Scour Depth 2.82 ft
Live Bed Contraction Scour Depth 14.10 ft

Local Scour at Abutments Summary

Left Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Right Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Main Channel Contraction Scour

Computation Type: Clear-Water and Live-Bed Scour

Input Parameters

Average Depth Upstream of Contraction: 6.45 ft
D50: 50.800000 mm
Average Velocity Upstream: 1.92 ft/s

Results of Scour Condition

Critical velocity above which bed material of size D and smaller will be transported: 8.39 ft/s
Contraction Scour Condition: Clear-Water
Live Bed and/or Clear Water Input Parameters
Flow in Contracted Section: 812.16 cfs

Bottom Width in Contracted Section: 14.00 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Temperature of Water: 60.00 ºF
Slope of Energy Grade Line at Approach Section: 0.0003 ft/ft
Flow in Contracted Section: 812.16 cfs
Flow Upstream that is Transporting Sediment: 576.36 cfs
Width in Contracted Section: 14.00 ft
Width Upstream that is Transporting Sediment: 46.64 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Unit Weight of Water: 62.40 lb/ft^3
Unit Weight of Sediment: 165.00 lb/ft^3
Results of Clear Water Method
Diameter of the smallest nontransportable particle in the bed material: 63.500000 mm
Average Depth in Contracted Section after Scour: 6.32 ft
Scour Depth: 2.82 ft

Results of Live Bed Method

Shear Velocity: 0.25 ft/s
Fall Velocity: 1.64 ft/s
Average Depth in Contracted Section after Scour: 17.60 ft
Scour Depth for Live Bed: 14.10 ft
Shear Applied to Bed by Live-Bed Scour: 0.5079 lb/ft^2
Shear Required for Movement of D50 Particle: 0.6669 lb/ft^2
Recommendations
Recommended Scour Depth: 2.82 ft

Left Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.76 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.83 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.45 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00

Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Right Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.45 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.92 ft/s
Critical Velocity above which Bed Material of Size D and Smaller will be Transported: 8.39 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Scenario: Alt2 Q500

Contraction Scour Summary

Contraction & Long Term Scour is applied method due to greater scour.
Applied Contraction Scour Depth 2.82 ft
Contraction & Long Term Scour is applied method due to greater scour.
Pressure Scour Depth 2.82 ft
Clear Water Contraction Scour Depth 2.82 ft
Live Bed Contraction Scour Depth 14.10 ft

Local Scour at Abutments Summary

Left Abutment

Abutment Scour Method: NCHRP Method

Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Right Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Main Channel Contraction Scour

Computation Type: Clear-Water and Live-Bed Scour

Input Parameters

Average Depth Upstream of Contraction: 6.45 ft
D50: 50.800000 mm
Average Velocity Upstream: 1.92 ft/s

Results of Scour Condition

Critical velocity above which bed material of size D and smaller will be transported: 8.39 ft/s
Contraction Scour Condition: Clear-Water
Live Bed and/or Clear Water Input Parameters
Flow in Contracted Section: 812.16 cfs
Bottom Width in Contracted Section: 14.00 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Temperature of Water: 60.00 ºF
Slope of Energy Grade Line at Approach Section: 0.0003 ft/ft
Flow in Contracted Section: 812.16 cfs
Flow Upstream that is Transporting Sediment: 576.36 cfs
Width in Contracted Section: 14.00 ft
Width Upstream that is Transporting Sediment: 46.64 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Unit Weight of Water: 62.40 lb/ft^3
Unit Weight of Sediment: 165.00 lb/ft^3
Results of Clear Water Method
Diameter of the smallest nontransportable particle in the bed material: 63.500000 mm
Average Depth in Contracted Section after Scour: 6.32 ft
Scour Depth: 2.82 ft

Results of Live Bed Method

Shear Velocity: 0.25 ft/s
Fall Velocity: 1.64 ft/s
Average Depth in Contracted Section after Scour: 17.60 ft
Scour Depth for Live Bed: 14.10 ft
Shear Applied to Bed by Live-Bed Scour: 0.5079 lb/ft^2
Shear Required for Movement of D50 Particle: 0.6669 lb/ft^2
Recommendations
Recommended Scour Depth: 2.82 ft

Left Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.76 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.83 ft/s
Critical Velocity above which Bed Material of Size D and Smaller will be Transported: 8.45 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Right Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.45 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69

Average Velocity Upstream: 1.92 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.39 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Scenario: Alt1_Q100

Contraction Scour Summary

Contraction & Long Term Scour is applied method due to greater scour.
Applied Contraction Scour Depth 2.82 ft
Contraction & Long Term Scour is applied method due to greater scour.
Pressure Scour Depth 2.82 ft
Clear Water Contraction Scour Depth 2.82 ft
Live Bed Contraction Scour Depth 14.10 ft

Local Scour at Abutments Summary

Left Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Right Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Main Channel Contraction Scour

Computation Type: Clear-Water and Live-Bed Scour

Input Parameters

Average Depth Upstream of Contraction: 6.45 ft
D50: 50.800000 mm
Average Velocity Upstream: 1.92 ft/s

Results of Scour Condition

Critical velocity above which bed material of size D and smaller will be transported: 8.39 ft/s
Contraction Scour Condition: Clear-Water
Live Bed and/or Clear Water Input Parameters
Flow in Contracted Section: 812.16 cfs
Bottom Width in Contracted Section: 14.00 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Temperature of Water: 60.00 ºF
Slope of Energy Grade Line at Approach Section: 0.0003 ft/ft
Flow in Contracted Section: 812.16 cfs

Flow Upstream that is Transporting Sediment: 576.36 cfs
Width in Contracted Section: 14.00 ft
Width Upstream that is Transporting Sediment: 46.64 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Unit Weight of Water: 62.40 lb/ft^3
Unit Weight of Sediment: 165.00 lb/ft^3
Results of Clear Water Method
Diameter of the smallest nontransportable particle in the bed material: 63.500000 mm
Average Depth in Contracted Section after Scour: 6.32 ft
Scour Depth: 2.82 ft

Results of Live Bed Method

Shear Velocity: 0.25 ft/s
Fall Velocity: 1.64 ft/s
Average Depth in Contracted Section after Scour: 17.60 ft
Scour Depth for Live Bed: 14.10 ft
Shear Applied to Bed by Live-Bed Scour: 0.5079 lb/ft^2
Shear Required for Movement of D50 Particle: 0.6669 lb/ft^2
Recommendations
Recommended Scour Depth: 2.82 ft

Left Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.76 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.83 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.45 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Right Abutment Details

Abutment Scour
Computation Type: NCHRP
Input Parameters

NCHRP Method
Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.45 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters
q2/q1: 4.69
Average Velocity Upstream: 1.92 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.39 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Scenario: Alt1_Q500

Contraction Scour Summary
Contraction & Long Term Scour is applied method due to greater scour.
Applied Contraction Scour Depth 2.82 ft
Contraction & Long Term Scour is applied method due to greater scour.
Pressure Scour Depth 2.82 ft
Clear Water Contraction Scour Depth 2.82 ft
Live Bed Contraction Scour Depth 14.10 ft

Local Scour at Abutments Summary

Left Abutment
Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Right Abutment
Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft

Total Scour at Abutment 4.05 ft

Main Channel Contraction Scour

Computation Type: Clear-Water and Live-Bed Scour

Input Parameters

Average Depth Upstream of Contraction: 6.45 ft
D50: 50.800000 mm
Average Velocity Upstream: 1.92 ft/s

Results of Scour Condition

Critical velocity above which bed material of size D and smaller will be transported: 8.39 ft/s
Contraction Scour Condition: Clear-Water
Live Bed and/or Clear Water Input Parameters
Flow in Contracted Section: 812.16 cfs
Bottom Width in Contracted Section: 14.00 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Temperature of Water: 60.00 ºF
Slope of Energy Grade Line at Approach Section: 0.0003 ft/ft
Flow in Contracted Section: 812.16 cfs
Flow Upstream that is Transporting Sediment: 576.36 cfs
Width in Contracted Section: 14.00 ft
Width Upstream that is Transporting Sediment: 46.64 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Unit Weight of Water: 62.40 lb/ft^3
Unit Weight of Sediment: 165.00 lb/ft^3
Results of Clear Water Method
Diameter of the smallest nontransportable particle in the bed material: 63.500000 mm
Average Depth in Contracted Section after Scour: 6.32 ft
Scour Depth: 2.82 ft

Results of Live Bed Method

Shear Velocity: 0.25 ft/s
Fall Velocity: 1.64 ft/s
Average Depth in Contracted Section after Scour: 17.60 ft
Scour Depth for Live Bed: 14.10 ft
Shear Applied to Bed by Live-Bed Scour: 0.5079 lb/ft^2
Shear Required for Movement of D50 Particle: 0.6669 lb/ft^2
Recommendations
Recommended Scour Depth: 2.82 ft

Left Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees

Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.76 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.83 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.45 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Right Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.45 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.92 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.39 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Scenario: Alt3_Q100

Contraction Scour Summary

Contraction & Long Term Scour is applied method due to greater scour.
Applied Contraction Scour Depth 2.82 ft
Contraction & Long Term Scour is applied method due to greater scour.
Pressure Scour Depth 2.82 ft
Clear Water Contraction Scour Depth 2.82 ft
Live Bed Contraction Scour Depth 14.10 ft

Local Scour at Abutments Summary

Left Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Right Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Main Channel Contraction Scour

Computation Type: Clear-Water and Live-Bed Scour

Input Parameters

Average Depth Upstream of Contraction: 6.45 ft
D50: 50.800000 mm
Average Velocity Upstream: 1.92 ft/s

Results of Scour Condition

Critical velocity above which bed material of size D and smaller will be transported: 8.39 ft/s
Contraction Scour Condition: Clear-Water
Live Bed and/or Clear Water Input Parameters
Flow in Contracted Section: 812.16 cfs
Bottom Width in Contracted Section: 14.00 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Temperature of Water: 60.00 ºF
Slope of Energy Grade Line at Approach Section: 0.0003 ft/ft
Flow in Contracted Section: 812.16 cfs
Flow Upstream that is Transporting Sediment: 576.36 cfs
Width in Contracted Section: 14.00 ft
Width Upstream that is Transporting Sediment: 46.64 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Unit Weight of Water: 62.40 lb/ft^3
Unit Weight of Sediment: 165.00 lb/ft^3
Results of Clear Water Method
Diameter of the smallest nontransportable particle in the bed material: 63.500000 mm
Average Depth in Contracted Section after Scour: 6.32 ft
Scour Depth: 2.82 ft

Results of Live Bed Method
Shear Velocity: 0.25 ft/s
Fall Velocity: 1.64 ft/s
Average Depth in Contracted Section after Scour: 17.60 ft
Scour Depth for Live Bed: 14.10 ft
Shear Applied to Bed by Live-Bed Scour: 0.5079 lb/ft^2
Shear Required for Movement of D50 Particle: 0.6669 lb/ft^2
Recommendations
Recommended Scour Depth: 2.82 ft

Left Abutment Details

Abutment Scour
Computation Type: NCHRP
Input Parameters

NCHRP Method
Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.76 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters
q2/q1: 4.69
Average Velocity Upstream: 1.83 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.45 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Right Abutment Details

Abutment Scour
Computation Type: NCHRP
Input Parameters

NCHRP Method
Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft

Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.45 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.92 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.39 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Scenario: Alt3_Q500

Contraction Scour Summary

Contraction & Long Term Scour is applied method due to greater scour.
Applied Contraction Scour Depth 2.82 ft
Contraction & Long Term Scour is applied method due to greater scour.
Pressure Scour Depth 2.82 ft
Clear Water Contraction Scour Depth 2.82 ft
Live Bed Contraction Scour Depth 14.10 ft

Local Scour at Abutments Summary

Left Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Right Abutment

Abutment Scour Method: NCHRP Method
Abutment Scour Depth 4.05 ft
Total Scour at Abutment 4.05 ft

Main Channel Contraction Scour

Computation Type: Clear-Water and Live-Bed Scour

Input Parameters

Average Depth Upstream of Contraction: 6.45 ft
D50: 50.800000 mm
Average Velocity Upstream: 1.92 ft/s

Results of Scour Condition

Critical velocity above which bed material of size D and smaller will be transported: 8.39 ft/s
Contraction Scour Condition: Clear-Water
Live Bed and/or Clear Water Input Parameters
Flow in Contracted Section: 812.16 cfs
Bottom Width in Contracted Section: 14.00 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Temperature of Water: 60.00 ºF
Slope of Energy Grade Line at Approach Section: 0.0003 ft/ft
Flow in Contracted Section: 812.16 cfs
Flow Upstream that is Transporting Sediment: 576.36 cfs
Width in Contracted Section: 14.00 ft
Width Upstream that is Transporting Sediment: 46.64 ft
Depth Prior to Scour in Contracted Section: 3.50 ft
Unit Weight of Water: 62.40 lb/ft^3
Unit Weight of Sediment: 165.00 lb/ft^3
Results of Clear Water Method
Diameter of the smallest nontransportable particle in the bed material: 63.500000 mm
Average Depth in Contracted Section after Scour: 6.32 ft
Scour Depth: 2.82 ft

Results of Live Bed Method

Shear Velocity: 0.25 ft/s
Fall Velocity: 1.64 ft/s
Average Depth in Contracted Section after Scour: 17.60 ft
Scour Depth for Live Bed: 14.10 ft
Shear Applied to Bed by Live-Bed Scour: 0.5079 lb/ft^2
Shear Required for Movement of D50 Particle: 0.6669 lb/ft^2
Recommendations
Recommended Scour Depth: 2.82 ft

Left Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.76 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.83 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.45 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Right Abutment Details

Abutment Scour

Computation Type: NCHRP
Input Parameters

NCHRP Method

Abutment Type: Vertical-wall abutment
Angle of Embankment to Flow: 0.00 Degrees
Centerline Length of Embankment: 0.00 ft
Projected Length of Embankment: 0.00 ft
Width of Flood Plain: 0.00 ft
Unit Discharge, Upstream in Main Channel (q1): 12.36 cfs
Unit Discharge in the Constricted Area (q2): 58.01 cfs/ft
D50: 50.800000 mm
Upstream Flow Depth: 6.45 ft
Flow Depth Prior to Scour: 3.50 ft

Result Parameters

q2/q1: 4.69
Average Velocity Upstream: 1.92 ft/s
Critical Velocity above which Bed Materal of Size D and Smaller will be Transported: 8.39 ft/s
Scour Condition: Clear Water
Embankment Length/Floodplain Width Ratio: 0.00
Scour Condition: a (Main Channel)
Amplification Factor: 1.10
Flow Depth including Contraction Scour: 6.85 ft
Maximum Flow Depth including Abutment Scour: 7.55 ft
Scour Hole Depth from NCHRP Method: 4.05 ft

Scour Summary Table

Long Term Degradation

Contraction Scour

Parameter	Alt2_Q100	Alt2 Q500	Alt1_Q100	Alt1_Q500	Alt3_Q100	Alt3_Q500	Units	Notes
Selected Contraction Computation Method	Clear-Water and Live-Bed Scour	Clear-Water and Live-Bed Scour	Clear-Water and Live-Bed Scour	Clear-Water and Live-Bed Scour	Clear-Water and Live-Bed Scour	Clear-Water and Live-Bed Scour		
Applied Contraction Scour Depth	0.43	0.79	0.62	1.11	1.86	2.82	ft	Clear-Water and Live-Bed Scour
Clear Water Contraction Scour Depth	0.43	0.79	0.62	1.11	1.86	2.82	ft	
Live Bed Contraction Scour Depth	2.50	3.05	2.71	3.47	12.61	14.10	ft	

Local Scour at Piers

Local Scour at Abutments

Parameter	Alt2_Q100	Alt2 Q500	Alt1_Q100	Alt1_Q500	Alt3_Q100	Alt3_Q500	Units	Notes
Left Abutment								
Abutment Scour Depth	1.96	2.88	2.73	3.38	2.80	4.05	ft	NCHRP Method: Scour Condition A (includes LTD)
Max Flow Depth including Abutment Scour	3.61	4.53	4.13	5.29	5.81	7.55	ft	Including the long-term scour depth
Total Scour at Abutment	1.96	2.88	2.73	3.38	2.80	4.05	ft	
Right Abutment								
	2.15	2.59	2.73	3.38	2.80	4.05	ft	NCHRP

Abutment Scour Depth								Method: Scour Condition A (includes LTD)
Max Flow Depth including Abutment Scour	3.61	4.53	4.13	5.29	5.81	7.55	ft	Including the long-term scour depth
Total Scour at Abutment	2.15	2.59	2.73	3.38	2.80	4.05	ft	

Riprap Sizing Worksheet

Project:	**#0618 Dyer Brook at Lynch Rd**	**Project #**	**55718.00**
Location:	**Newcastle, ME**	**Sheet**	**1**
Calculated by:	**DWC**	**Date:**	**10/2/2023**
Checked by:		**Date:**	
Title:	**Riprap Sizing - HEC-23 DG 14 (Bridge Alternative)**		

Notes:

1) Calculations based on methodology outlined in HEC-23 3rd Edition (FHWA-NHI-09-112, 2009), Design Guide 14
2) Scour Countermeasure Design Check Storm = 500 year

A) Determine Set-Back Ratio (SBR)

	Q100	Q500	
Setback Length	2	2	ft
Avg. Chan. Flow Depth	2.72	3.22	ft
SBR	0.73410026		

SBR < 5: V based on entire contracted area through bridge

B) Determine Minimum Riprap Size At Abutments (Eq. 14.1 or 14.2)

For Fr <0.80: *(Eq 14.1)*

$$\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left[\frac{V^2}{gy}\right]$$

K = 0.89 for a spill-through abutment
1.02 for a vertical wall abutment

For Fr >=0.80: *(Eq 14.2)*

$$\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left[\frac{V^2}{gy}\right]^{0.14}$$

K = 0.61 for spill-through abutments
K = 0.69 for vertical wall abutments

Q	602	816	cfs	Flow Through Bridge Opening
A	59.50	70.40	sf	Contracted Area thru Bridge
V	10.12	11.59	ft/s	Contracted Velocity
S_g	2.65	2.65	pcf	Specific Gravity of Rip Rap
g	32.2	32.2	ft/s2	Gravitational Acceleration
y	2.72	3.22	ft	Average Flow Depth
K	0.69	0.69	ft	Vertical Wall Abutment, Fr>.80
Fr	1.08	1.14		Froude Number

D_{50}	1.2	1.4	median stone diameter, ft
D_{50}	**14.0**	**16.8**	median stone diameter, inches

Recommendation: Use Heavy Riprap, MaineDOT Item 703.28 (D50 = 24")

Riprap Sizing Worksheet

Project:	#0618 Dyer Brook at Lynch Rd	Project #	55718.00
Location:	Newcastle, ME	Sheet	2
Calculated by:	DWC	Date:	10/4/2023
Checked by:		Date:	
Title:	Riprap Sizing - HEC-23 DG 14 (Bridge Alternative)		

Notes:

1) Calculations based on methodology outlined in HEC-23 3rd Edition (FHWA-NHI-09-112, 2009), Design Guide 14
2) Scour Countermeasure Design Check Storm = 500 year

A) Determine Set-Back Ratio (SBR)

	Q100	Q500	
Setback Length	2	2	ft
Avg. Chan. Flow Depth	2.40	2.76	ft
SBR	0.83253886		

SBR < 5: V based on entire contracted area through bridge

B) Determine Minimum Riprap Size At Abutments (Eq. 14.1 or 14.2)

For Fr <0.80: *(Eq 14.1)*

$$\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left[\frac{V^2}{gy}\right]$$

K = 0.89 for a spill-through abutment
1.02 for a vertical wall abutment

For Fr >=0.80: *(Eq 14.2)*

$$\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left[\frac{V^2}{gy}\right]^{0.14}$$

K = 0.61 for spill-through abutments
K = 0.69 for vertical wall abutments

Q	602	816	cfs	Flow Through Bridge Opening
A	63.68	76.09	sf	Contracted Area thru Bridge
V	9.45	10.72	ft/s	Contracted Velocity
S_g	2.65	2.65	pcf	Specific Gravity of Rip Rap
g	32.2	32.2	ft/s2	Gravitational Acceleration
y	2.40	2.76	ft	Average Flow Depth
K	0.61	0.61	ft	Spill-Through Abutment, Fr>.80
Fr	1.07	1.14		Froude Number

D_{50}	0.9	1.1	median stone diameter, ft
D_{50}	**10.9**	**12.7**	median stone diameter, inches

Recommendation: Use Heavy Riprap, MaineDOT Item 703.28 (D50 = 24")

Riprap Sizing Worksheet

Project:	**#0618 Dyer Brook at Lynch Rd**	**Project #**	**55718.00**
Location:	**Newcastle, ME**	**Sheet**	**3**
Calculated by:	**DWC**	**Date:**	**10/4/2023**
Checked by:		**Date:**	
Title:	**Riprap Sizing - HEC-23 DG 14 (Alt 3)**		

Notes:

1) Calculations based on methodology outlined in HEC-23 3rd Edition (FHWA-NHI-09-112, 2009), Design Guide 14
2) Scour Countermeasure Design Check Storm = 500 year

A) Determine Set-Back Ratio (SBR)

	Q100	Q500	
Setback Length	0	0	ft
Avg. Chan. Flow Depth	3.01	3.50	ft
SBR	0		

SBR < 5: V based on entire contracted area through bridge

B) Determine Minimum Riprap Size At Abutments (Eq. 14.1 or 14.2)

For Fr <0.80: *(Eq 14.1)*

$$\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left[\frac{V^2}{gy}\right]$$

K = 0.89 for a spill-through abutment
1.02 for a vertical wall abutment

For Fr >=0.80: *(Eq 14.2)*

$$\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left[\frac{V^2}{gy}\right]^{0.14}$$

K = 0.61 for spill-through abutments
K = 0.69 for vertical wall abutments

Q	602	816	cfs	Flow Through Bridge Opening
A	47.15	54.76	sf	Contracted Area thru Bridge
V	12.77	14.90	ft/s	Contracted Velocity
S_g	2.65	2.65	pcf	Specific Gravity of Rip Rap
g	32.2	32.2	ft/s2	Gravitational Acceleration
y	3.01	3.50	ft	Average Flow Depth
K	0.69	0.69	ft	Vertical Wall Abutment, Fr>.80
Fr	1.30	1.40		Froude Number

D_{50}	1.4	1.6	median stone diameter, ft
D_{50}	**16.3**	**19.3**	median stone diameter, inches

Recommendation: Use Heavy Riprap, MaineDOT Item 703.28 (D50 = 24")

Appendix D

Preliminary Cost Estimates

Construction Cost Estimate

Project:	Lynch Rd - Mill Bridge #0618	Project #:	55718.00
Location:	Newcastle, ME	Sheet:	
Calculated by:	BJR	Date:	10/13/2023
Checked by:	CTA	Date:	10/13/2023
Title:	3-sided Frame - 14' Span x 12' Rise		

Estimate

Item	Description	Quantity	Unit	Unit Cost	Total Cost
202.19	Removing Existing Bridge	1	LS	$ 50,000	$ 50,000
202.202	Removing Pavement Surface	195	SY	$ 18	$ 3,413
203.20	Common Excavation	450	CY	$ 25	$ 11,250
203.24	Common Borrow	50	CY	$ 30	$ 1,500
203.25	Granular Borrow	125	CY	$ 45	$ 5,625
203.33	Special Fill	25	CY	$ 91	$ 2,275
206.061	Structural Earth Excavation - Drainage and Minor Structures Below Grade	250	CY	$ 80	$ 20,000
206.07	Structural Rock Excavation - Drainage and Minor Structures	25	CY	$ 750	$ 18,750
304.10	Aggregate Subbase Course Gravel	125	CY	$ 50	$ 6,250
403.21	Hot Mix Asphalt, 9.5mm Nominal Maximum Size	30	T	$ 290	$ 8,700
403.213	Hot Mix Asphalt, 12.5mm Nominal Maximum Size (Base and Intermediate Base Course)	35	T	$ 290	$ 10,150
409.15	Bituminous Tack Coat, Applied	15	G	$ 20	$ 300
502.219	Structural Concrete, Abutments and Retaining Walls	30	CY	$ 1,600	$ 48,000
503.12	Reinforcing Steel, Placing	875	LB	$ 1.50	$ 1,313
503.13	Reinforcing Steel, Fabricated and Delivered	875	LB	$ 1.50	$ 1,313
508.13	Sheet Waterproofing Membrane (120 SY)	1	LS	$ 4,250	$ 4,250
511.07	Cofferdam: Upstream	1	LS	$ 30,000	$ 30,000
511.07	Cofferdam: Downstream	1	LS	$ 50,000	$ 50,000
515.21	Protective Coating for Concrete Surfaces (65 SY)	1	LS	$ 3,000	$ 3,000
534.71	Precast Concrete Box Culvert (65 CY)	1	LS	$ 150,000	$ 150,000
606.353	Reflectorized Flexible Guardrail Marker	8	EA	$ 100	$ 800
606.366	Guardrail, Removed and Reset, Type 3c	200	LF	$ 25	$ 5,000
610.08	Plain Riprap	35	CY	$ 90	$ 3,150
610.16	Heavy Riprap	125	CY	$ 100	$ 12,500
615.07	Loam	30	CY	$ 50	$ 1,500
618.14	Seeding Method Number 2	3	UN	$ 90	$ 270
619.12	Mulch	3	UN	$ 75	$ 225
620.54	Stabilization/Reinforcement Geotextile	135	SY	$ 8.50	$ 1,148
629.05	Hand Labor, Straight Time	20	HR	$ 50	$ 1,000
631.12	All Purpose Excavator (Including Operator)	20	HR	$ 150	$ 3,000
631.15	Roller, Earth and Base (Including Operator)	10	HR	$ 100	$ 1,000
631.172	Truck - Large (Including Operator)	10	HR	$ 105	$ 1,050
631.21	Road Broom (Including Operators and Hauler)	20	HR	$ 75	$ 1,500
639.19	Field Office, Type B	1	EA	$ 10,000	$ 10,000
652.312	Type III Barricades	9	EA	$ 300	$ 2,700
652.33	Drum	25	EA	$ 65	$ 1,625
652.34	Cones	25	EA	$ 25	$ 625
652.35	Construction Signs	250	SF	$ 20	$ 5,000
652.361	Maintenance of Traffic Control Devices	1	LS	$ 12,500	$ 12,500
656.75	Temporary Soil Erosion and Water Pollution Control	1	LS	$ 20,000	$ 20,000
659.10	Mobilization	1	LS	$ 70,000	$ 70,000
674.10	Precast Concrete Block Gravity Wall	560	SF	$ 300	$ 168,000

		Sub-Total =	$ 748,680
15%		Contingency =	$ 112,302
		Total =	***$ 870,000***

Construction Cost Estimate

Project:	**Lynch Rd - Mill Bridge #0618**	**Project #:**	**55718.00**
Location:	**Newcastle, ME**	**Sheet:**	
Calculated by:	**BJR**	**Date:**	**10/13/2023**
Checked by:	**CTA**	**Date:**	**10/13/2023**
Title:	**Box Culvert - 22' Span x 12' Rise**		

Estimate

Item	Description	Quantity	Unit	Unit Cost	Total Cost
202.19	Removing Existing Bridge	1	LS	$ 50,000	$ 50,000
202.202	Removing Pavement Surface	320	SY	$ 18	$ 5,600
203.20	Common Excavation	625	CY	$ 25	$ 15,625
203.24	Common Borrow	50	CY	$ 30	$ 1,500
203.25	Granular Borrow	200	CY	$ 45	$ 9,000
203.33	Special Fill	50	CY	$ 91	$ 4,550
203.55	Culvert Bedding Stone	75	CY	$ 80	$ 6,000
206.061	Structural Earth Excavation - Drainage and Minor Structures Below Grade	375	CY	$ 80	$ 30,000
206.07	Structural Rock Excavation - Drainage and Minor Structures	30	CY	$ 750	$ 22,500
304.10	Aggregate Subbase Course Gravel	125	CY	$ 50	$ 6,250
403.21	Hot Mix Asphalt, 9.5mm Nominal Maximum Size	30	T	$ 290	$ 8,700
403.213	Hot Mix Asphalt, 12.5mm Nominal Maximum Size (Base and Intermediate Base Course)	35	T	$ 290	$ 10,150
409.15	Bituminous Tack Coat, Applied	15	G	$ 20	$ 300
508.13	Sheet Waterproofing Membrane (155 SY)	1	LS	$ 5,500	$ 5,500
511.07	Cofferdam: Upstream	1	LS	$ 30,000	$ 30,000
511.07	Cofferdam: Downstream	1	LS	$ 50,000	$ 50,000
515.21	Protective Coating for Concrete Surfaces (75 SY)	1	LS	$ 3,375	$ 3,375
534.71	Precast Concrete Box Culvert (110 CY)	1	LS	$ 275,000	$ 275,000
606.353	Reflectorized Flexible Guardrail Marker	8	EA	$ 100	$ 800
606.366	Guardrail, Removed and Reset, Type 3c	200	LF	$ 25	$ 5,000
610.16	Heavy Riprap	125	CY	$ 100	$ 12,500
618.14	Seeding Method Number 2	3	UN	$ 90	$ 270
619.12	Mulch	3	UN	$ 75	$ 225
620.54	Stabilization/Reinforcement Geotextile	285	SY	$ 8.50	$ 2,423
631.12	All Purpose Excavator (Including Operator)	20	HR	$ 150	$ 3,000
631.15	Roller, Earth and Base (Including Operator)	10	HR	$ 100	$ 1,000
631.172	Truck - Large (Including Operator)	10	HR	$ 105	$ 1,050
631.21	Road Broom (Including Operators and Hauler)	20	HR	$ 75	$ 1,500
639.19	Field Office, Type B	1	EA	$ 10,000	$ 10,000
652.312	Type III Barricades	9	EA	$ 300	$ 2,700
652.33	Drum	25	EA	$ 65	$ 1,625
652.34	Cones	25	EA	$ 25	$ 625
652.35	Construction Signs	250	SF	$ 20	$ 5,000
652.361	Maintenance of Traffic Control Devices	1	LS	$ 12,500	$ 12,500
659.10	Mobilization	1	LS	$ 80,000	$ 80,000
674.10	Precast Concrete Block Gravity Wall	560	SF	$ 300	$ 168,000

	Sub-Total =	$ 867,918
15%	Contingency =	$ 130,188
	Total =	***$ 1,000,000***

Construction Cost Estimate

Project:	**Lynch Rd - Mill Bridge #0618**	**Project #:**	**55718.00**
Location:	**Newcastle, ME**	**Sheet:**	
Calculated by:	**BJR**	**Date:**	**10/13/2023**
Checked by:	**CTA**	**Date:**	**10/13/2023**
Title:	**50' Simple Span Steel**		

Estimate

Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
202.19	Removing Existing Bridge	1	LS	$ 50,000	$ 50,000
202.202	Removing Pavement Surface	385	SY	$ 18	$ 6,738
203.20	Common Excavation	900	CY	$ 25	$ 22,500
203.24	Common Borrow	250	CY	$ 30	$ 7,500
203.25	Granular Borrow	375	CY	$ 45	$ 16,875
206.082	Structural Earth Excavation - Major Structures Plan Quantity	290	CY	$ 80	$ 23,200
206.092	Structural Rock Excavation - Major Structures	70	CY	$ 750	$ 52,500
304.10	Aggregate Subbase Course Gravel	125	CY	$ 50	$ 6,250
403.21	Hot Mix Asphalt, 9.5mm Nominal Maximum Size	35	T	$ 275	$ 9,625
403.213	Hot Mix Asphalt, 12.5mm Nominal Maximum Size (Base and Intermediate Base Course)	45	T	$ 290	$ 13,050
409.15	Bituminous Tack Coat, Applied	15	G	$ 20	$ 300
502.219	Structural Concrete, Abutments and Retaining Walls	230	CY	$ 1,600	$ 368,000
502.22	Structural Concrete, Abutments and Retaining Walls (placed underwater)	120	CY	$ 400	$ 48,000
502.26	Structural Concrete Roadway and Sidewalk Slabs on Steel Bridge	45	CY	$ 1,900	$ 85,500
503.12	Reinforcing Steel, Placing	15050	LB	$ 1.25	$ 18,813
503.13	Reinforcing Steel, Fabricated and Delivered	15050	LB	$ 1.25	$ 18,813
504.701	Structural Steel Fabricated and Delivered, Rolled	29800	LB	$ 3.25	$ 96,850
504.71	Structural Steel Erection	29800	LB	$ 1.25	$ 37,250
505.08	Shear Connectors	1	LS	$ 5,000	$ 5,000
506.9104	Thermal Spray Coating - Shop Applied	1	LS	$ 32,500	$ 32,500
507.0811	Steel Bridge Railing, 2 Bar (110 LF)	1	LS	$ 33,000	$ 33,000
507.0821	Steel Approach Railing, 2 Bar	4	EA	$ 9,000	$ 36,000
508.14	High Performance Waterproofing Membrane (155 SY)	1	LS	$ 7,800	$ 7,800
511.07	Cofferdam: Upstream	1	LS	$ 30,000	$ 30,000
511.07	Cofferdam: Downstream	1	LS	$ 50,000	$ 50,000
515.21	Protective Coating for Concrete Surfaces (115 SY)	1	LS	$ 1,750	$ 1,750
606.1721	Bridge Transition - Type 1	4	EA	$ 5,000	$ 20,000
606.265	Terminal End - Single rail - Galvanized Steel	4	EA	$ 80	$ 320
606.353	Reflectorized Flexible Guardrail Marker	8	EA	$ 100	$ 800
606.363	Guardrail Remove and Dispose	100	LF	$ 10	$ 1,000
606.366	Guardrail, Removed and Reset, Type 3c	150	LF	$ 25	$ 3,750
610.08	Plain Riprap	70	CY	$ 90	$ 6,300
610.16	Heavy Riprap	275	CY	$ 100	$ 27,500
615.07	Loam	45	CY	$ 50	$ 2,250
618.14	Seeding Method Number 2	4	UN	$ 90	$ 360
619.12	Mulch	4	UN	$ 75	$ 300
620.54	Stabilization/Reinforcement Geotextile	290	SY	$ 8.50	$ 2,465
629.05	Hand Labor, Straight Time	40	HR	$ 50	$ 2,000
631.12	All Purpose Excavator (Including Operator)	20	HR	$ 150	$ 3,000
631.15	Roller, Earth and Base (Including Operator)	10	HR	$ 100	$ 1,000
631.172	Truck - Large (Including Operator)	10	HR	$ 105	$ 1,050
631.21	Road Broom (Including Operators and Hauler)	20	HR	$ 75	$ 1,500
639.19	Field Office, Type B	1	EA	$ 10,000	$ 10,000
652.312	Type III Barricades	9	EA	$ 300	$ 2,700
652.33	Drum	25	EA	$ 65	$ 1,625
652.34	Cones	25	EA	$ 25	$ 625
652.35	Construction Signs	250	SF	$ 20	$ 5,000
652.361	Maintenance of Traffic Control Devices	1	LS	$ 25,000	$ 25,000
656.75	Temporary Soil Erosion and Water Pollution Control	1	LS	$ 20,000	$ 20,000
659.10	Mobilization	1	LS	$ 125,000	$ 125,000

	Sub-Total =	$ 1,341,358
15%	Contingency =	$ 201,204
	Total =	***$ 1,550,000***