Final Design Hydrology and Hydraulics Report

Southport- Thompson's Bridge #2848

By: Northstar Hydro, Inc.

For: Stantec and Maine Dept. of Transportation

February 13, 2019

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STATE OF MAINE
ELLEN
KNIGHT O'BRIEN
No. 7945
LICENSED
PROFESSIONAL ENGINEER

Ellen K O'Brien

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1.0 Introduction

Thompson's Bridge over Decker's Cove on Southport Island, # 2848, is slated for replacement. Northstar Hydro, Inc. was retained by Stantec to provide hydrologic, hydraulic and scour assessments for the preliminary and final design process. Results of that work are detailed in this report.

Figure 1 Thompson's Bridge looking north

The Bridge is located at the north end of Southport Island, carrying Route 238 over Decker's Cove from Route 27. The bridge location is shown in Figure 2.

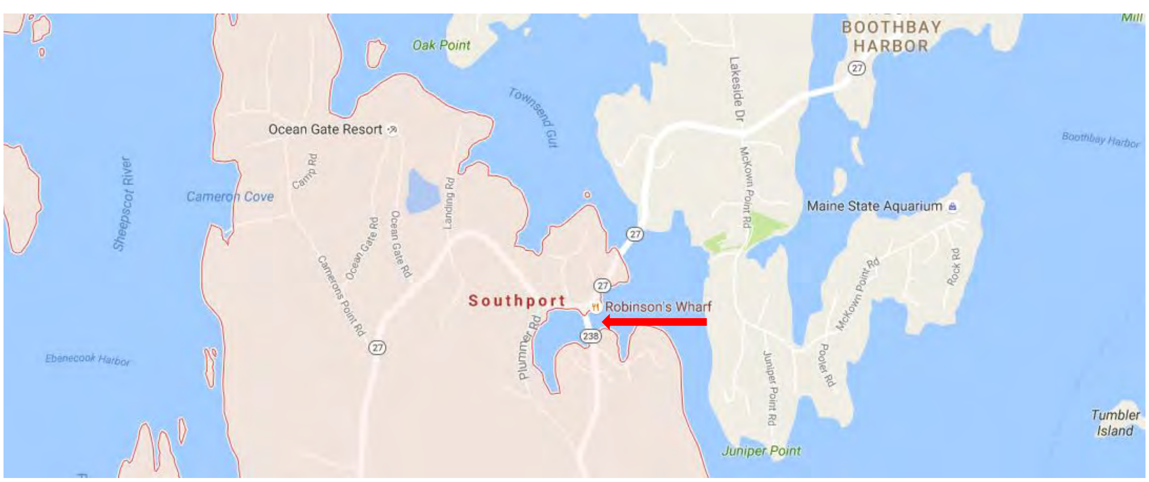


Figure 2 Thompsons Bridge in Southport, # 2848

Thompsons Bridge is located at the opening to Decker's Cove. The bridge opening is wide (total 192.5' span or 188' from abutment-to-abutment according to 1970 plans) and the cove is not large, resulting in gradual tidal interchange and flow through the bridge.

Figure 3. Looking upstream from Thompsons Bridge to Decker's Cove.

MaineDOT's Bridge Design Guide recommends the following for tidal bridges:

"Bridges on tidal rivers/streams should be designed to protect the bridge structure itself. Most of the surrounding land and the approach roadways may be inundated by relatively frequent tidal storm surges. The minimum design freeboard in these areas is 2 feet above Q10 (based upon MHW) including wave heights. The finished grade of the bridge will be set by considering this requirement, along with navigation clearance, the approach roadways, topography, and good engineering judgment".

Recently updated guidance by MaineDOT recommends additional consideration of potential sea level rise over the life of the bridge. Detailed analysis related to sea level rise and potential impacts for this project is included in section 4.2.

This report summarizes data collected and analyses conducted to characterize expected tide levels on either side of the bridge and rates of tidal flow through the bridge. Analyses were conducted to:

- Identify normal and annual high and low tide levels on either side of the bridge

- Identify storm tide levels
- Evaluate rates and direction of flow through the bridge under normal tide and storm tide conditions
- Evaluate impacts of bridge on water levels
- Evaluate potential impacts from future sea level rise
- Evaluate potential wave impacts
- Evaluate potential scour impacts

The Bridge was built in 1933, with repairs being done in 1970, 1988 and 1990. The Bridge is shown in aerial view in Figure 4.

Figure 4 Thompsons Bridge and Decker Cove to west of bridge.

Figures 5 and 6 are site photographs of the bridge and surrounding area.

Figure 5. Thompsons Bridge from the northeast

Figure 6. This figure shows three pile bents for the four span bridge. Photo taken looking southeast.

The proposed bridge will be a 2 span bridge with dimensions very similar to the existing bridge, but with only one center pier, slightly lower low chord and slightly wider abutments. The proposed bridge plans are included in the Appendix.

2.0 Existing Data Review, Project Survey and GIS Database

2.1 Data Review

Prior studies related to tidal flood elevations include a July, 2015 FEMA Flood Insurance Study, and the U.S. Army Corps of Engineers Tidal Flood Profiles, published in 2012. Existing tidal flood information is summarized in table 1.

Source of Data	Datum	1.1-year	10-year	50-year	100-year	100-year plus waves	500-year	Storm-11/30/1963 - Boothbay	Storm-1/9/1978 - Boothbay	Storm-2/7/1978-Boothbay
FEMA Effective Study, July, 2015	NAVD 88		8.2	9.2	9.7	10.2	11.1	8.0	8.7	8.4
US Army Corps of Engineers Tidal Flood Elevations, 2012	NAVD 88	7.8	8.2	9.2	9.7		11.1			
Flood of Record, Georgetown	NAVD 88									7.4-12.1

Table 1. Summary of existing data, flood elevations at or near Southport

FEMA analyzed potential wave effects. FEMA FIS transects are shown on the map below, excerpted from the FIS study. Transect 20 is the closest to the project site but wave action at the project site is very different from what would occur at Transect 20. Exposure to open water fetch for development of waves at the project site is very small.

Figure 7. Extracted from FEMA FIS, July 2015

Other available data include NOAA tide gages and tidal prediction stations. NOAA maintains four recording tidal gages in Maine, including Portland, Bar Harbor, Cutler and Eastport and a number of tidal prediction locations. Figure 8 shows subordinate tide prediction stations in the vicinity of the project. The nearest stations are Townsend Gut and Boothbay Harbor.

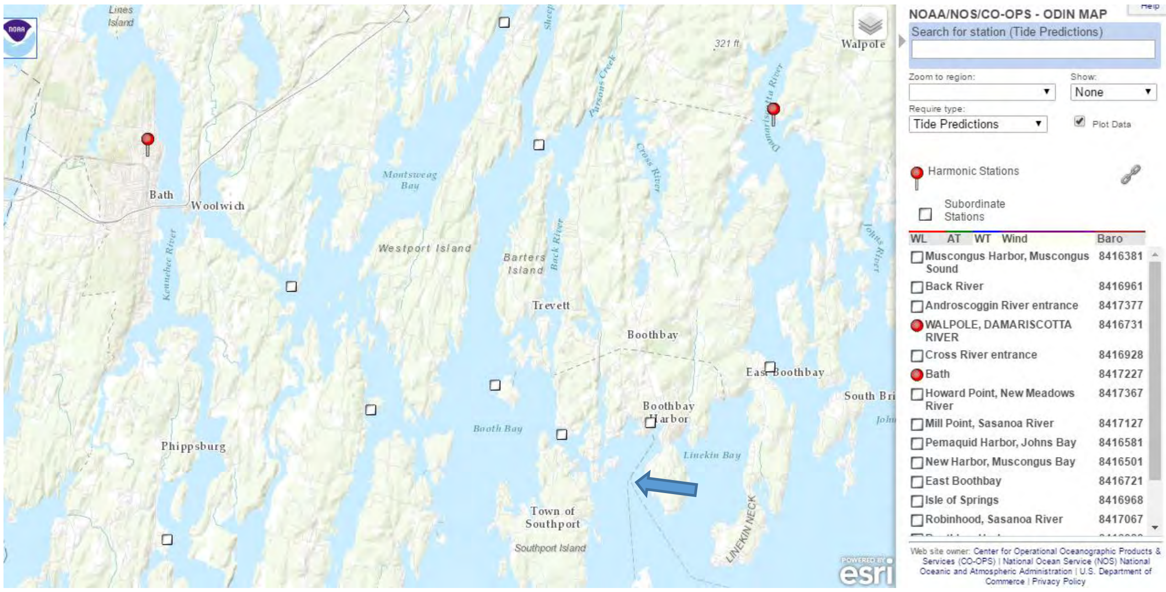


Figure 8. NOAA Tide Prediction Stations in project vicinity. Blue arrow is project site.

Tide elevations at Southport and in relation to the Portland recording gage are shown in table 2.

	Townsend Gut, Station 8416908	**Portland, Station 8418150**
Elevation	NAVD 88	NAVD 88
HOWL – 2/7/1978	8.7	8.87
HAT – 5/17/1999	6.6	
HAT 2016, 5/8/2016	6.55	6.64
MHHW	4.56	5.05
MHW	4.13	4.21
NAVD 88	0.00	0.00
DTL	-0.30	
MSL	-0.32	
MTL	-0.34	
MLW	-4.81	-4.91
MLLW	-5.15	-5.26
LAT -7.23 1/21/1996	-7.23	
LOWL - 11/30/1955	-8.54	

Table 2. Summary of NOAA tidal data.

2.2 Project Survey:

Bottom elevations of the tidal basins on either side of the Thompsons' Bridge, as well as bottom elevations within the bridge were field surveyed to provide a basis for hydraulic modeling. Figure 9 shows relative depths (blue is deepest) based on project survey. Survey extended downstream to Robinson's Wharf and upstream about 600'.

Figure 9. Bottom contours based on project survey

2.3 DEM and GIS database

A GIS database was assembled containing a triangulated terrain model of the survey, survey points, 2-meter digital elevation model of Southport from Maine GIS and aerial photography. The GIS database was used to develop cross sections for the hydraulic model. Where cross sections extended onto land but were not included in the survey, the 2-meter DEM values were used. Upstream of project survey, depths were estimated in Decker's Cove based on air photos and field observation.

3.0 Field Data 5/13 and 7/6

Site visits were conducted by the Northstar Hydro team on May 13, and July 6, 2016. The second site visit was planned to collect at least one half of a tide cycle of data in daylight hours when tides were close to highest monthly values. Data collection date was selected based on daylight hours, weather, and high lunar tides. A rising tide was observed and recorded.

For the Boothbay tide prediction station, MHHW to MLLW is 4.56 to -5.15. Highest annual tide predicted for 2016 would have occurred on May 8 at 6.56'. Tides on the selected field day (7/6) ranged from 4.45' to -6.25' NAVD and data was collected from low to high tide.

Data detail is included in the Appendix. Water level readings on each side of the bridge were taken approximately every 15 minutes by measuring from top of through girder on the east and west sides of the bridge. Velocity was estimated through observation of time of travel through the bridge in the center of the channel. Observations were noted on direction of flow. Figure 10 shows location of water level measurements on the east side of the bridge.

Figure 10. Water level measurements from "x".

Measurements were collected at up- and down-stream locations at the 10th post on the bridge, counting from the south side of the bridge.

The following observations summarize daily tide fluctuation at the site.

- The bridge site is wide, perpendicular to flow and deep. The site does not dewater at low tide.
- Tide flow is very slow, filling Decker Cove at approximately the same rate as the tide changes outside of the bridge.
- The bridge offers little to no restriction to tidal flow.
- Water level drops as much as 3’ in an hour, which is about an inch every two minutes. While measurements were taken on each side of the bridge, the time difference from east measurement to west measurement was about 2 minutes. Data has been adjusted for this time difference.
- Note also that top of rail elevations on the bridge are 16.75 to 17.0’.
- Estimated velocities as measured on July 6 ranged up to 0.4 fps.
- Measured tide levels vs. predicted tide levels at Boothbay and Townsend Gut are shown in Figure 11 below. Measured tides at Thompson’s Bridge were as much as 0.7’ higher than predicted tides at the Boothbay and Townsend Gut tide stations.

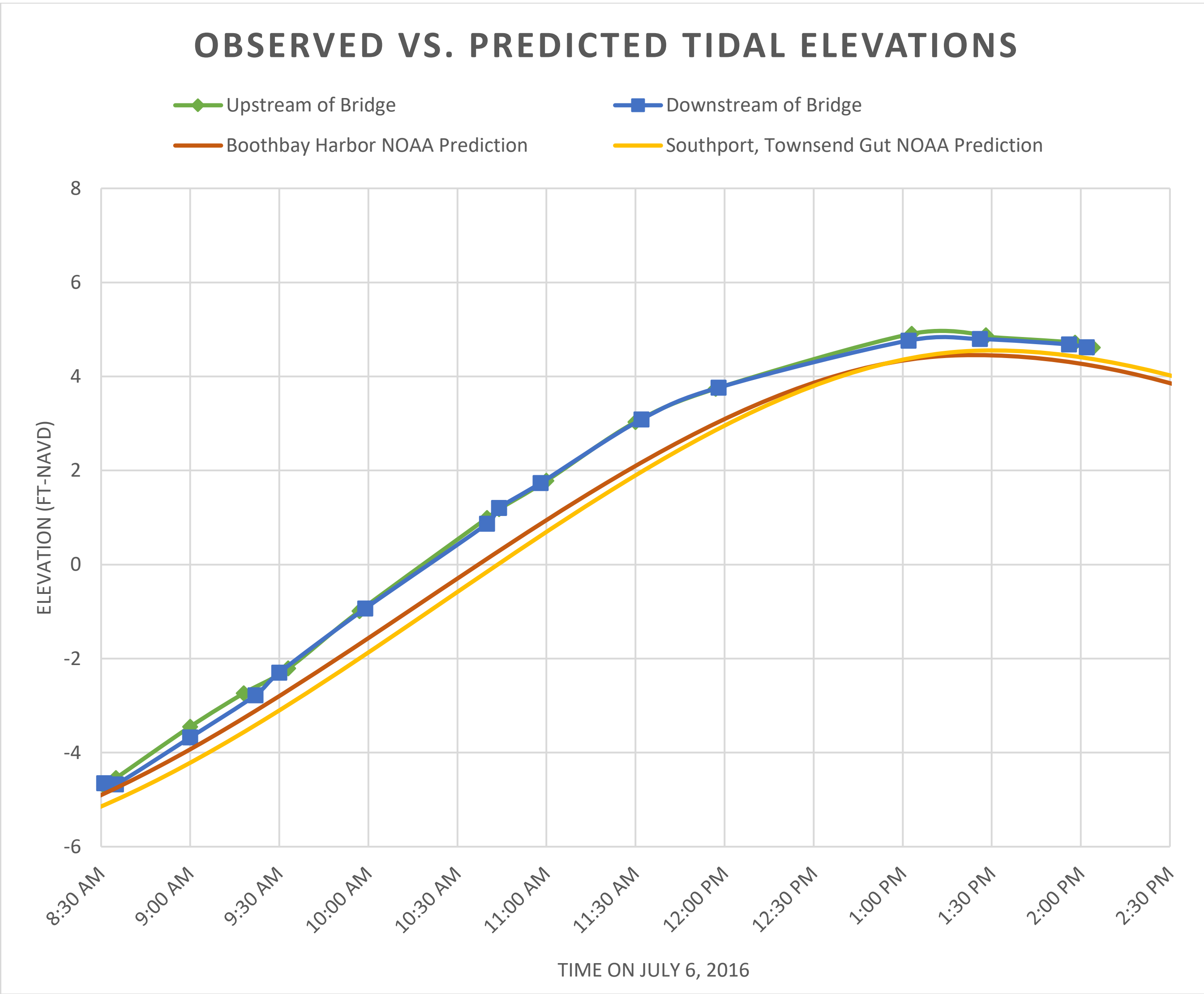


Figure 11. Measured vs predicted tides, Thompson’s Bridge

4.0 Hydrology and Sea Level Rise

4.1 Hydrology:

The project site is a wide bridge that forms the entrance to a relatively small cove. Tidal fluctuation at and through this bridge is slow and the bridge appears to offer little resistance to flow. Tidal elevations vary little from one side of the bridge to the other, but tidal elevations vary greatly over time. It is recommended that the following tidal elevations be adopted for the purposes of bridge design:

- 10-year storm surge elevation based on the FEMA Preliminary level study of 8.2'.
- 50-, 100- and 500-year storm surge levels from FEMA Flood Study of 9.2', 9.7' and 11.1' NAVD.
- MHHW 4.56, MLLW -5.15.

Minimal freshwater flow impacts this bridge site. A drainage basin of 0.2 square miles (128.0 acres) provides runoff to Decker Cove. Flood flows from this basin are listed below.

Return Interval	Flow, cfs
1.1-year	7.1
10-year	28.7
25-year	37.3
50-year	43.6
100-year	50.9
500-year	68.5

Table 3. Summary of Upland Flows

4.2 Sea Level Rise:

This final design report considers sea level rise of up to 4' for the project. At the time the PDR Hydrology and Hydraulics Report was issued, MaineDOT's Bridge Design Guide Recommended using the following reference for Sea Level Rise resulting in a projected rise of 0.6' in 100-years.

http://www.co-ops.nos.noaa.gov/sltrends/sltrends.html

The mean sea level trend is 1.87 mm/year with a 95% confidence interval of +/- 0.15 mm/year based on monthly mean sea level data from 1912 to 2015 which is equivalent to a change of 0.61 feet in 100 years.

The May 2018 update to Maine DOT's Bridge Design Guide includes the following:

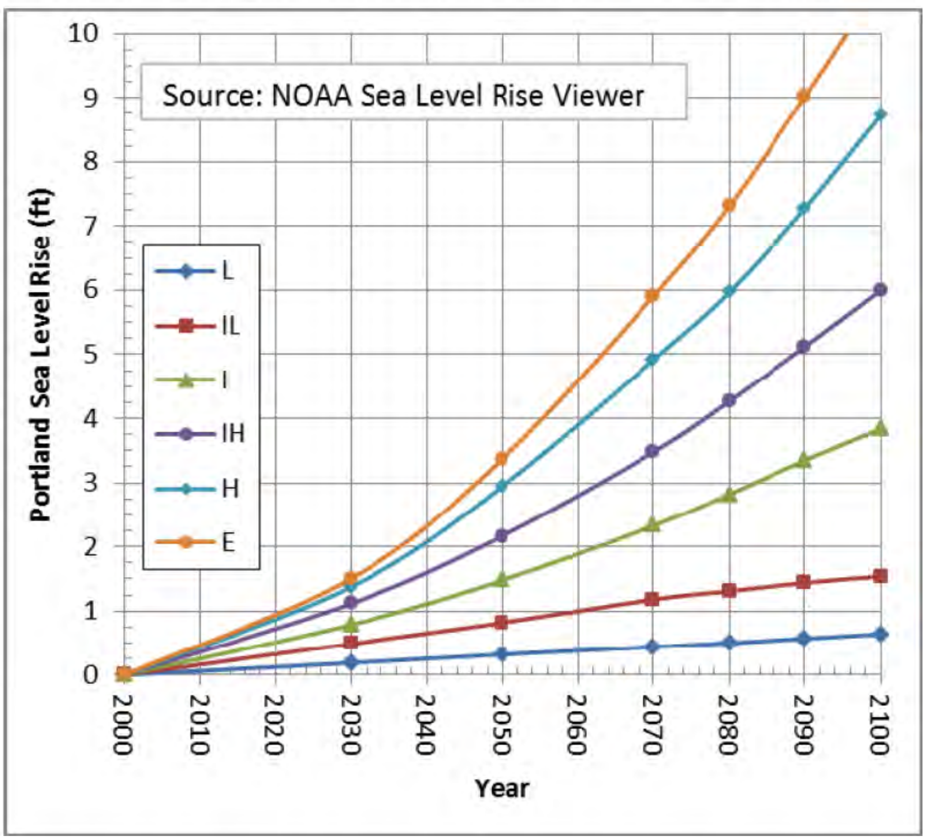
> "2*.3.7 Changes in Sea Level*
> *Historical data from NOAA shows that the sea level along the Maine coast over the past 80-100 years has risen between 0.5 and 0.75 feet per 100 years relative to local datums. More detailed information is available from the NOAA Tides and Currents website in the Sea Level Trends section. Based on this historical data and NOAA projections, the proposed design should assume 4 feet of sea level rise per 100 years."*

MaineDOT's Bridge Design Guide recommends the following for tidal bridges:

> *"Bridges in tidal area - Bridges on tidal rivers/streams should be designed to protect the bridge structure itself. Most of the surrounding land and the approach roadways may be inundated by relatively frequent tidal storm surges. The minimum design freeboard in these areas is 2 feet above Q10 (based on MHW with sea level rise), including wave heights." (page 2-31)*

Maine DOT provided updated guidance on Sea Level Rise in a recent memorandum. The graphic showing potential sea level rise scenarios is shown in Figure 1 below and was included in the following document: Memorandum from Charles Hebson, Maine DOT to Jim Wentworth, Kleinfelder Assoc, July 09, 2017. 21677 Brooklin-Sedgwick River Bridge #3216, Sea Level Rise. The "Intermediate or I" trend yields 4' in 100-years.

Figure 1: Sea Level Rise Projections for Portland (from NOAA Sea Level Rise Viewer)



Additional DOT guidance includes: The finished grade of the bridge will be set by considering this requirement, along with navigation clearance, the approach roadways, topography, and good engineering judgment.

The following lists key storm elevations (NAVD).

- 10-year storm surge elevation based on the FEMA Preliminary FIS - 8.2'.
- HOWL- 8.7' based on extrapolation of Townsend Gut Tide Station predictive data, or 7.4-12.1' based on recorded high water marks in Georgetown and surrounding area (some with wave heights included).
- HAT 6.99
- 50-, 100- and 500-year storm surge levels from FEMA Flood Study of 9.2', 9.7' and 11.1' NAVD.
- MHHW 4.56
- MHW 4.1
- MHW plus 4' SLR = 8.1' (approximately same as current 10-year storm surge).

Description	**Elevation, NAVD**
HOWL Boothbay	8.7
HOWL, surrounding area (Georgetown)	7.4-12.1
HAT, 2016 (based on Townsend Gut Tide Station)	6.99
MHHW	4.56
MHW	4.13
MHW plus 4' of SLR	8.1
MSL	-.32
NAVD 1988	0.00
MLW	-4.8
MLLW	-5.15
LAT	-7.23
LOWL	-8.58
10-year storm surge	8.2
10-year storm surge with sea level rise	8.8
HECRAS Normal Highest Annual Tide (HAT)	6.99
50-year storm surge	9.2
100-year storm surge	9.7
500-year storm surge	11.1

Table 4. Summary of Water Level Elevations/Hydrology

5.0 Hydraulics

The hydraulic analysis was designed to identify flow characteristics at the bridge site that may impact aspects of the bridge design. For tidal bridges, goals include:

- Evaluate tide elevations on either side of the bridge
- Evaluate the potential impact of changes to bridge geometry on tidal flow and tidal elevations
- Evaluate velocity of flow through the bridge for purposes of scour evaluation
- Evaluate potential wave impacts

The site is shown in Figure 12 below.

Figure 12. Thompsons Bridge site and Decker Cove

The bridge spans the opening to Decker's Cove and connects to a secondary bay that then connects to a branch of Linekin Bay. The site is well protected from wave action, but is subject to full tidal fluctuation as well as storm surge.   The coastline surrounding the site, and site photos are shown below.

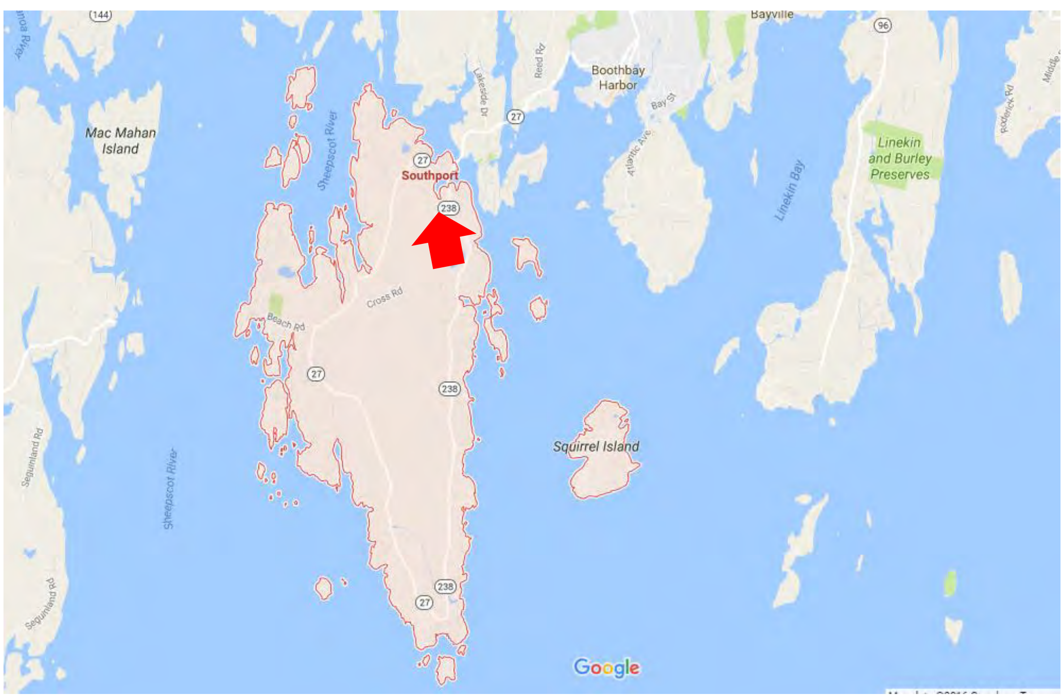


Figure 13. Southport Island and Thompson's Bridge.

Figure 14. Looking northeast from bridge

Figure 15. Looking west from bridge towards Deckers Cove.

Figure 16. Looking at western face (upstream) of bridge

5.1 HECRAS Hydraulic Model:

Several methods were considered to evaluate flow at the bridge, including measuring flow on site, and using the HECRAS hydraulic model in unsteady flow mode to attempt to simulate flow during storm events. Inputs for the unsteady flow model include a geometric model and a tidal hydrograph.

The HECRAS geometry model was compiled using project survey and the GIS database described above. Model cross sections were laid out as shown in Figure 17 below.

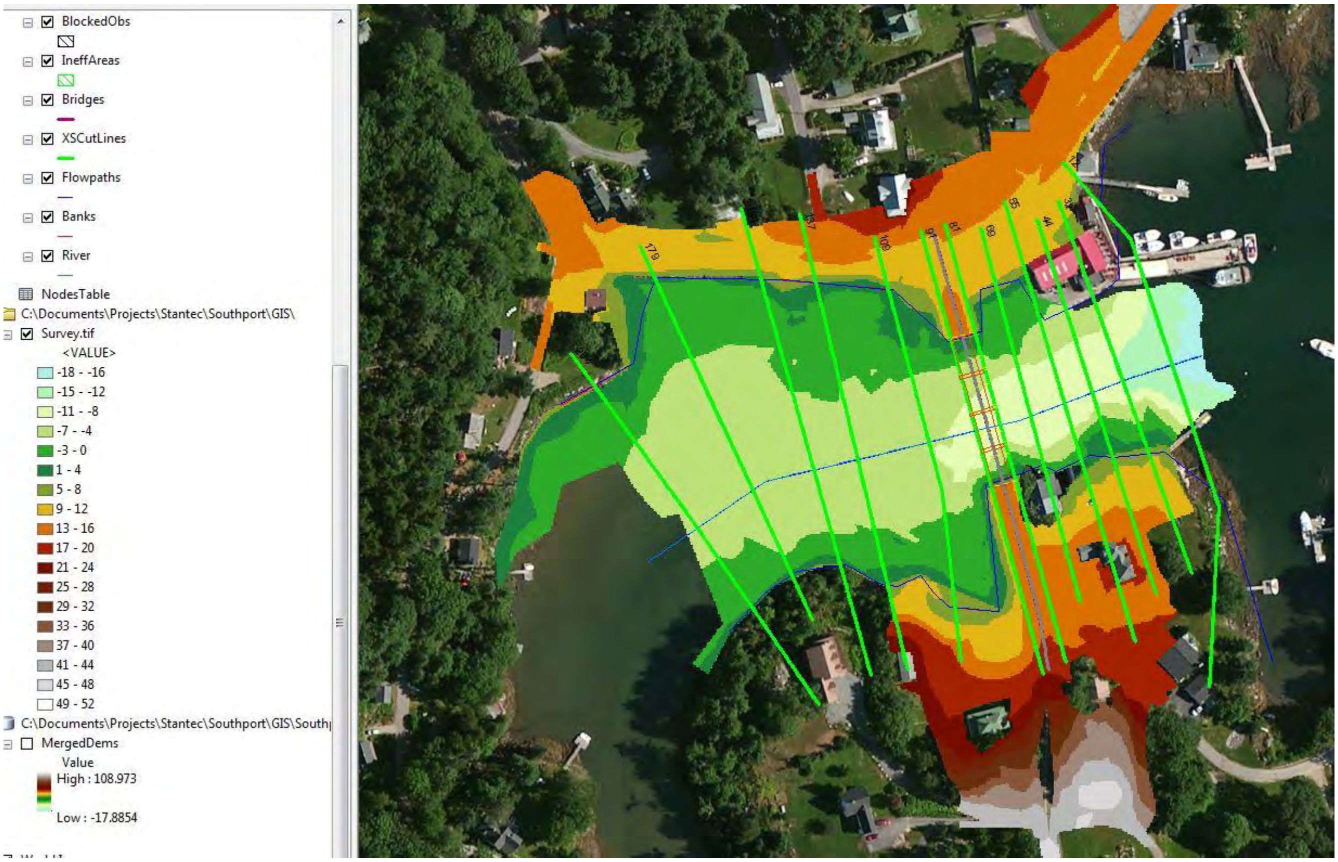


Figure 17. HECRAS model setup- depth range is shown in the legend to left.

The profile of minimum bottom elevation through the bridge is shown below, from the HECRAS model. Note that the inner reaches of Decker's Cove dewater at very low tides.

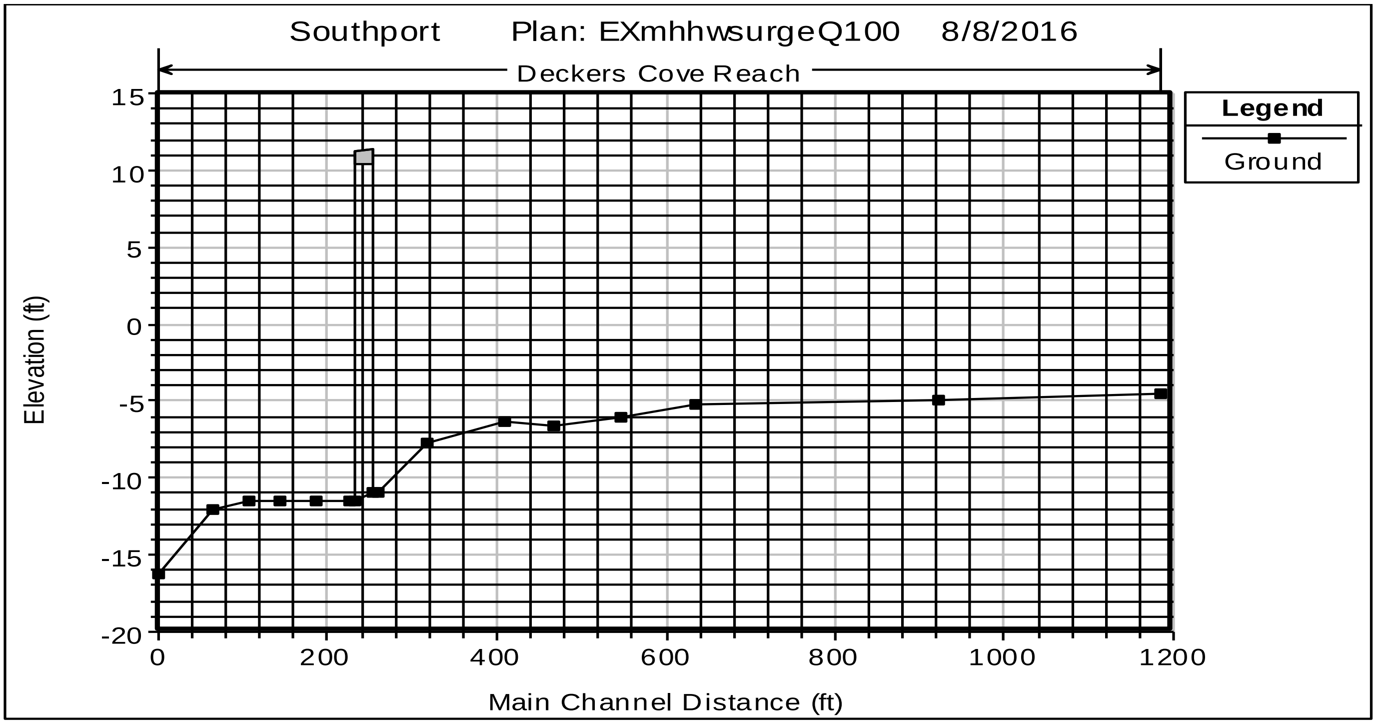


Figure 18. Profile through existing bridge and Decker's Cove

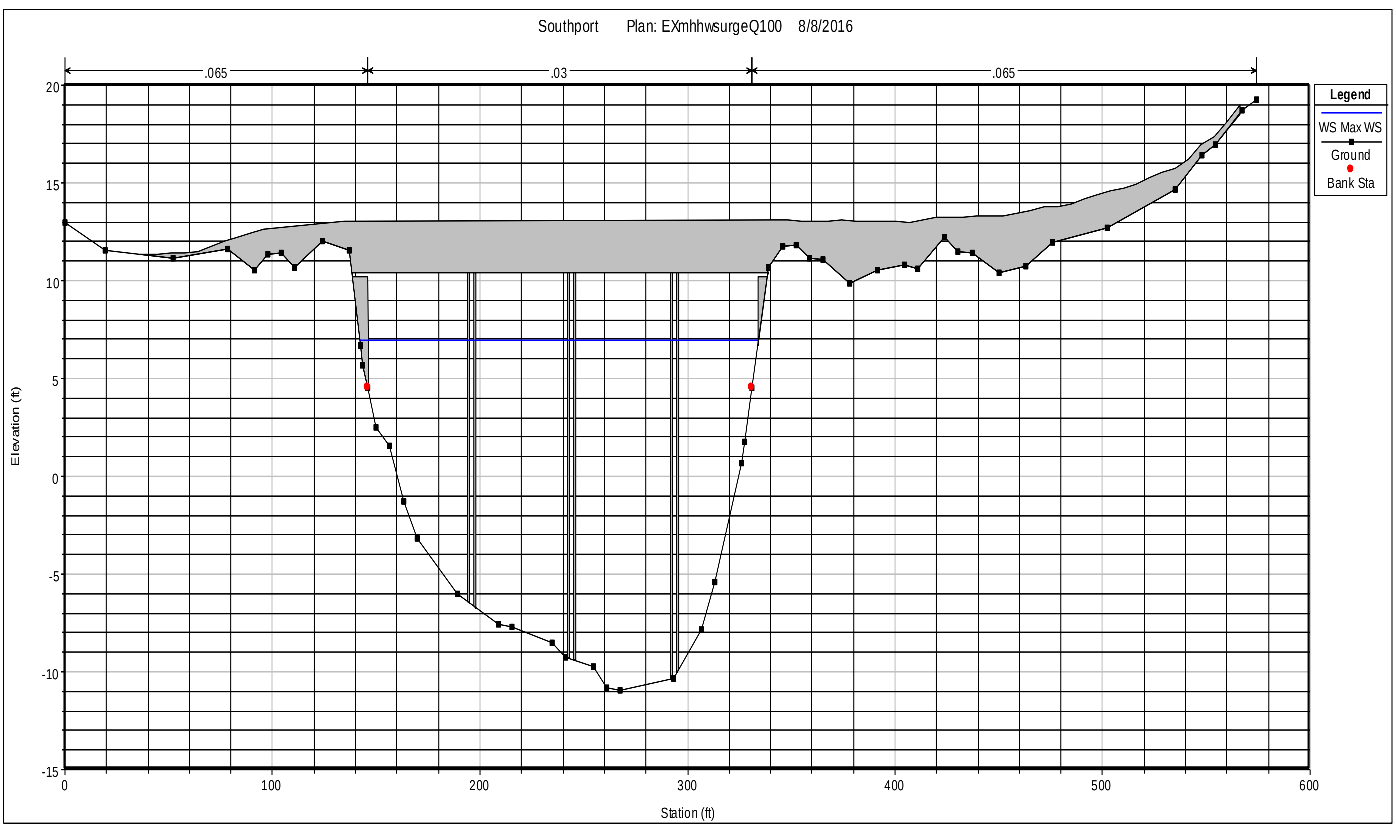


Figure 19. HECRAS model section of existing bridge.

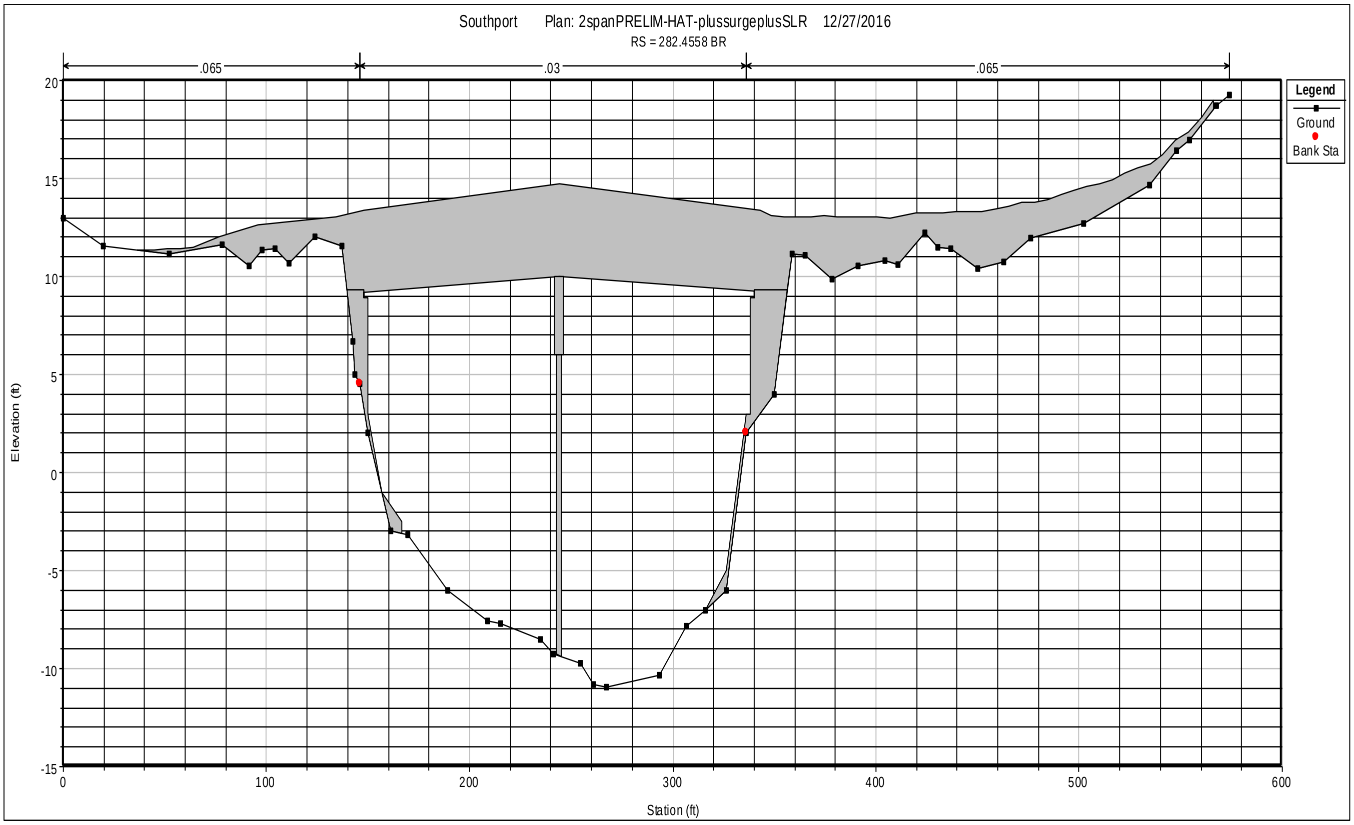


Figure 20. Proposed two span bridge, HECRAS model

The second portion of the hydraulic model is tidal hydrographs that simulate typical tidal elevations for the site. Tidal hydrographs were used as the boundary condition for the eastern/northern side of the model, the area nearest to the ocean. Because inland flows are so small, a steady state flow boundary was applied on the upstream end of the model, at 50 cfs or the Q100. Unsteady flow models tend to require a minimum flow for stability, so the steady state flow rate was used.

Field data was collected to measure a typical incoming tide on July 6, 2016. Tidal hydrographs at Townsend Gut were compared to field measured data and found to coincide well. The field day had little wind and no storms in the vicinity so actual tides and predicted tides were quite close. However, no direct observations of storm surge and/or wave impacts are available for the project site.

Estimated storm surge hydrographs for the project site were compiled as follows:

1. The HAT for Townsend Gut which occurred on May 8, 2016 was used for the base hydrograph for analyses.
2. MaineDOT provided a suggested method for calculation of storm surge. Surge levels were then added to the May 8 representative tide cycle.
3. Storm surge plus typical tide hydrographs were routed through the model as the downstream boundary condition, including the 10-, 100- and 500-year tide levels of 8.2’, 9.7’, and 11.1’. The typical highest annual tide (6.99’) was also run as a boundary condition.

4. These surge levels may be compared to the estimated HOWL of 8.7’ of February 7, 1978. This is based on the Portland gage recording 8.9’.
5. Velocity estimates were prepared to evaluate potential scour. For tidal systems, fastest velocities occur when tides are changing most rapidly, such as during a surge event and when water levels are low, usually mid-tide. Peak velocities were selected from modeled hydrographs at the proposed bridge at times of highest flow rates.
6. A total of 4 tide hydrographs were modeled. Due to the small upland flow, all tide hydrographs were combined with the 100-year inland runoff peak flow.

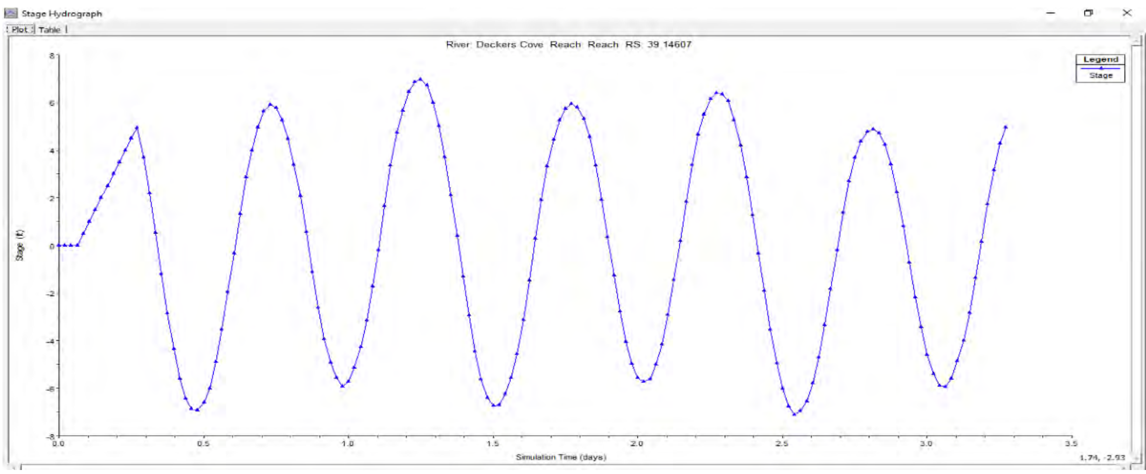


Figure 21. May 6-8 Tide Hydrograph, Townsend Gut. Note that first quarter day is for model stabilization.

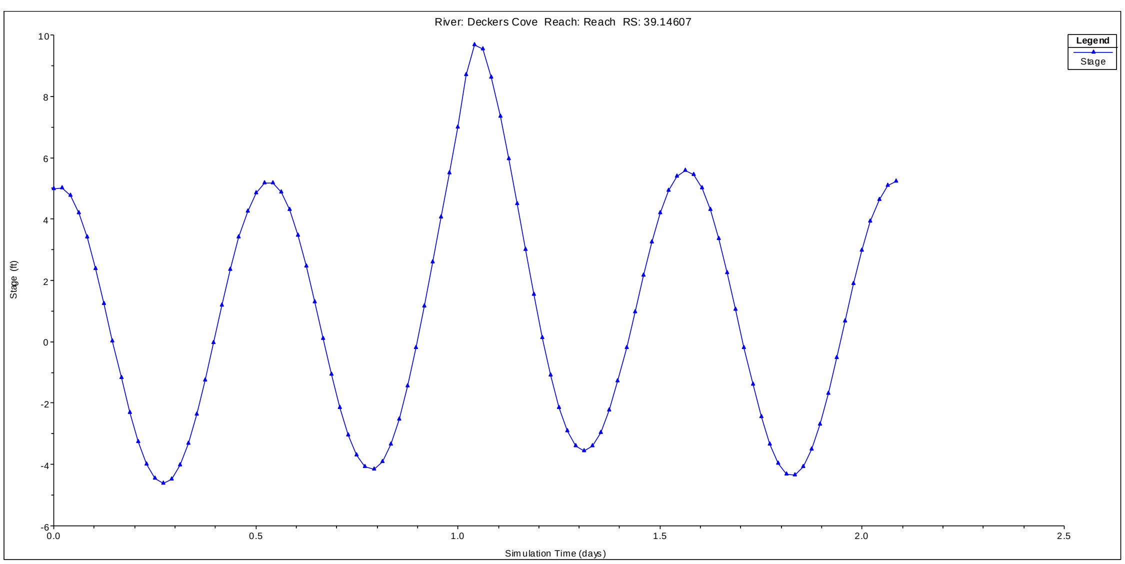


Figure 22. Surge hydrograph, 100-year storm surge.

5.2 Wave Heights

FEMA Flood Insurance Study data indicates that damaging waves (greater than 3’ high) are not likely at this site due to limited fetch length. The site was reviewed for potential wave heights using methodology described in the U.S. Army Corps of Engineers Shore Protection Manual, Chapter 3. Both deep water and shallow water potential waves were calculated using SPM charts 3-24 and 3-10. Maximum fetch length was estimated at 1400' using google earth air photos and NOAA Nautical Charts. Figure 23 below shows offshore areas and depths. Potential wave height is dependent on available fetch for wind generation of waves, wind speeds, and offshore depths. The deepwater and 20 feet depth charts were used.

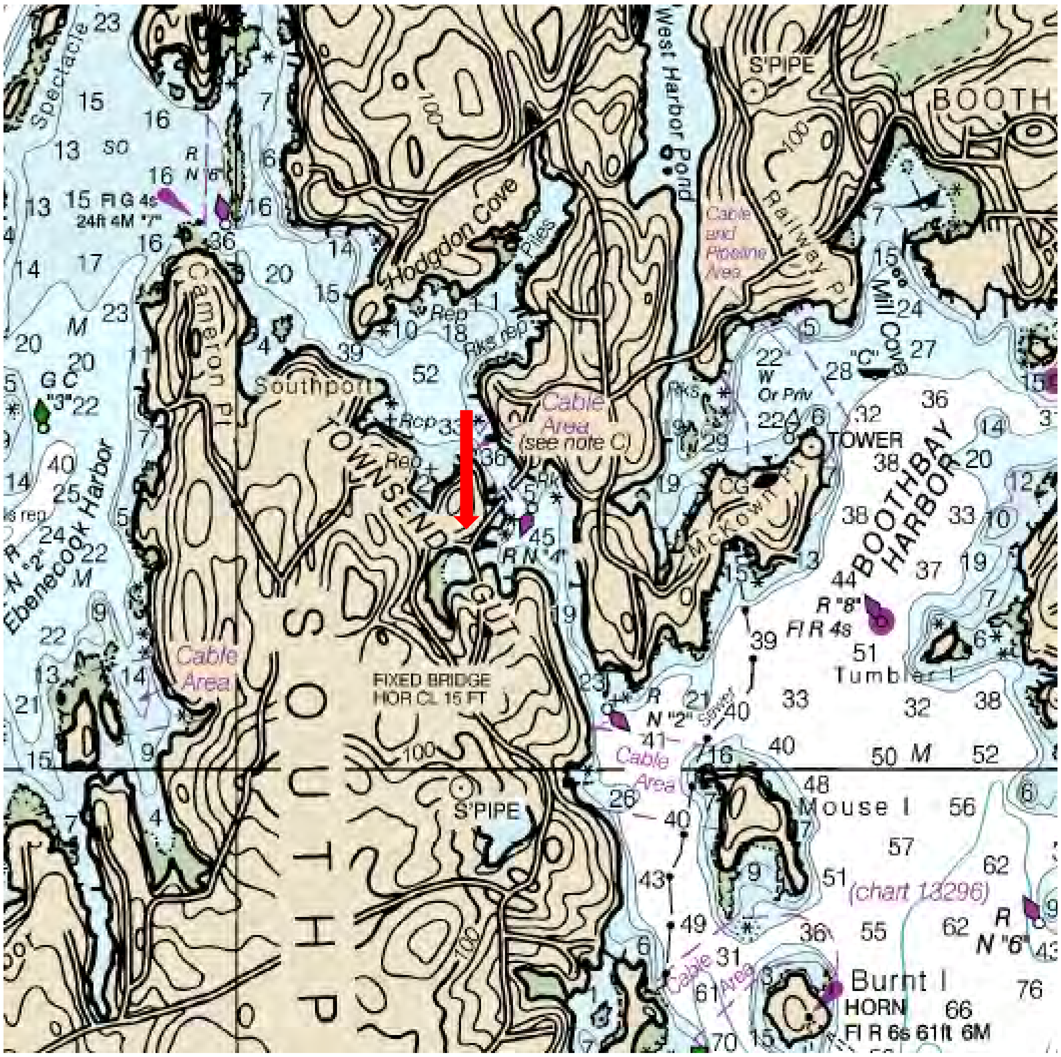


Figure 23. NOAA Nautical Chart showing limited fetch to Thompson's Point Bridge. Red arrow points to Thompson's Bridge.

Potential 100-year 1 minute windspeed is 70 mph from the east and southeast. Potential deepwater maximum wave height is estimated at 1.2' for the one minute wind and 0.85' for the 1 hour wind of 53 mph. 10-year wave heights maximum are estimated at 0.8' for the 1 minute wind, and 0.7' for the 60 minute wind. All waves are high frequency, small amplitude, small wavelength waves. In other words, these waves do not have significant power for damage.

Using the shallow water, 20' charts, maximum waves are forecast to be less than 0.5' for all conditions at this site, with wave period less than 1 second. Shallow water wave forecast curves are more representative for this location.

5.3 Selected Geometry: Considering site conditions, storm potentials, bridge hydraulics and sea level rise potential, final design low chord is set at 8.8'(min. at abutments)-to-10.2'(max. at pier) NAVD. For the Southport Bridge, minimum proposed top of road for final design is 13.5'. Note that approach roadways show low points of 11.3' under existing conditions and proposed conditions.

Potential hydraulic scenarios compared to *minimum* proposed low chord (EL. 8.8) at this site include:

- 10-year tide surge (8.2') coupled with 1-year upland runoff, with 0.6' of sea level rise = no freeboard.
- **MHW (4.1') with 10-year runoff plus 4' of sea level rise = 0.7' of freeboard at the abutments.**
- MHHW (4.6') plus 4' of sea level rise = 0.2' of freeboard.

Comparing to minimum top of road and *maximum* low chord (EL. 10.2), the following freeboard results for various storm conditions:

- 10-year tide surge (8.2') coupled with 1-year upland runoff, with 2' of sea level rise = no freeboard.
- **MHW (4.1') with 10-year runoff plus 4' of sea level rise = 2.1' of freeboard at the pier.**
- MHHW (4.6') plus 4' of sea level rise = 1.6' of freeboard.
- The proposed roadway minimum is 1' above a 100-year storm surge assuming no wave action at current sea levels.

Tide Frequency	Tide EL.	Upland Flow Frequency	Freeboard at Min. Low Chord EL. 8.8 (Abutments)	Freeboard at Max Low Chord EL. 10.2 (Pier)
10-year storm surge	8.2	1-year	0.6	2
MHW	**4.1**	**10-year**	**4.7**	**6.1**
MHHW	4.6	10-year	4.2	5.6
100-year storm surge	9.7	1-year	-0.9	0.5

Table 5. Summary of Freeboard at Proposed Bridge.

Summary of Hydraulic Data Thompsons Bridge # 2848, Southport, Maine	Existing Bridge NAVD	Proposed Bridge
Low Chord, ft	10.4	8.8-10.2
Abutment to abutment width	188’	188’
Total width of piers	6’	2.8’
Minimum Elevation of Road Profile – East/West Approaches, ft	11.2	11.3
10-year surge, no SLR	8.2	8.2
50-year surge, no SLR	9.2	9.2
100-year storm surge, no SLR	9.7	9.7
Approximate Discharge Velocity 100-year tide	0.35	0.2
Ordinary High Water Elevation (1.1-yr tide), ft (HAT 2016)	6.99	6.99
Discharge Velocity for typical tides (close to HAT)	0.4	0.45
Clearance @ Q10, ft (current levels)	2.2	0.6-2.0
Clearance @ 50-year tide (current levels)	1.2	-0.4-1.0
Clearance @ 100-year tide (current levels)	0.7	-0.9-0.5
Bridge Opening Area, ft^2	2920	3019

Table 6. Summary of Hydraulic Data

6.0 Scour

Scour related data includes:

- CHA Bridge Scour Assesment Report to Maine Dept of Transportation prepared in 2011.
- Geotechnical report for this bridge, prepared by GZA. Borings were taken at the bridge site in May of 2016 at the location of each existing pier.
- Bottom profiles from project survey and original bridge plans.

CHA concluded the following related to scour:
“The scour analysis (HEC RAS model) completed by Ayres Associates indicated that the peak velocities for the 100yr and 500yr discharges were below the calculated transport velocity for the bed material observed in the field. Furthermore even though there is a significant tide range of over 10’ this channel (and corresponding flow) is relatively small compared to other tidal areas and results in a very small flow and low velocities. Based on this information and the extensive flood history of this bridge (over 75 years) CHA recommends a non scour critical rating for this bridge.”

The geotechnical report includes a geological cross section of the bridge site and boring logs. Deepest layers of unconsolidated material are found in the center of the channel, with about 40’ of various materials above bedrock. The data indicates about 8’ of “river bottom deposit” or dark brown/dark grey very soft organic silt with a little sand and a trace of gravel. This layer extends from elevation -12 to -20. Below that layer is a layer of marine clay, extending approximately 9’ to elevation -29. Till lies below the clay to elevation -37’ +/- and below that till with granite cobbles and boulders. Hard, fresh granite bedrock was encountered at elevation -53’ +/-. The geological profile is included in the Appendix.

Stantec plotted the recent bottom profile on the 1933 bridge plans. The overlaid bed profiles indicate potential aggradation in the silt layer of approximately 4-6'. This layer is very soft and may move with the tides.

The new bridge will have one center pier, with piles extending into bedrock.

Highest measured velocity in the field was approximately 0.4 fps. Highest modeled velocity was also approximately 0.4 fps. To be conservative, a value of 0.5 fps was assumed for scour estimates. Scour components, including contraction, local and long term were considered in evaluating potential future scour.

D50 values from geotechnical samples are summarized below in Table 5.

Table 5. Summary of Geologic Data

Boring Number	Depth, ft Below Ground Surface	Sample Number	Geologic formation	D50, mm
102 (Right, south channel)	0 -2	1D	silt	0.58
102	17 -18	7D	Marine clay	0.25
104 (Left, north channel)	5-7	2D	silt	0.25
104	10-12	3D	till	0.78
104	15-17	4D	till	0.30

Contraction scour: Contraction scour was evaluated in the top layer of silt. D50 values of 0.25 to 0.58 mm were reported in samples. Using the lower value, critical velocity for incipient motion of this material was calculated where

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

Where: Ku = 11.17

Y = 3.1' at low tide, 12.1' at high tide in a surge event.

D = 0.00082 ft

And

Vc = 1.2 to 1.6 fps.

Therefore, Clearwater scour equations prevail.

$Y_2 = ((Ku * Q^2)/(Dm^{2/3}\ W^2))^{3/7}$

Ku = 0.0077

Q = 300 cfs

Dm = 1.25 X D50

W = 188 (width of contracted section)

$Y_2 = 1.3$'.
Ys = Y2-Y0.
Y0= average existing depth in contracted section
Y2= Average equilibrium depth in the contracted section
Ys= scour depth

Since Y0 is 3.1' at low tide, equilibrium scour depth is less than existing. Therefore contraction scour is not likely.

Aggradation/Degradation: approximately 5-7' of aggradation is noted from the 1933 bridge plan bottom profile to the current profile. Assume 0' of this type of scour to be conservative.

Pier Scour:

Check at lowest depth, highest potential velocity, using 500-year tide.

$Y_s/Y_1 = 2.0\ K_1\ K_2\ K_3\ (a/y_1)^{0.65}\ Fr^{0.43}$

$Y^1 = 4.7$
$K_1 = 1$
$K_2 = 1$
$K_3 = 1.1$
a = 2.8'
Fr = .04

$Y_s = 8.8$

Per HEC-18, maximum potential scour at a pier = 2.4 X Diameter or 2.4 X 2.8' = 6.7'.

With no contraction scour, maximum potential scour is 6.7, or approximately the depth of the upper silt layer.

6.0 Summary and Conclusions

1. Thompson's Bridge crosses the opening of Decker's Cove with a long span of nearly 200'. The cove area is small compared to the bridge opening, so tides generally equilibrate up- and down-stream of the bridge at the same rate as the tide changes in open water. Flow velocities through the bridge are low, but as with tides in this area, water level changes by as much as 2' per hour or one inch in 2-3 minutes.
2. Wave action is limited by available fetch length. Maximum possible wave is 1.2' assuming the wave is generated by the 1 minute 100-year wind of 70 mph. This type of condition would be intermittent and infrequent. A sustained storm wind of 53 mph has the capability to generate waves up to 0.9'. Wave setup is not expected to be a factor at this location.
3. Flow is generally perpendicular to the bridge span.

4. Maximum flow velocity measured in the field was about 0.4 fps, and modeling with HECRAS generated similar results.
5. The existing low chord is 10.4 above NAVD. Proposed low chord will vary from 8.8’ to 10.2’ above NAVD.
6. The new bridge will replace the existing 4 span bridge with a 2 span bridge with a single center channel pier.
7. 10-year, 100-year and 500-year storm tide elevations are 8.2’, 97’ and 11.1’.
8. Highest predicted annual tide for 2016 was 6.99’ NAVD.

Based on information gathered to date, design recommendations include:

1. Construction of a bridge that would meet the BDG guideline would require a bottom of bridge elevation of 2’ above 8.2’. 2’ of freeboard yields 10.2’.
2. The existing span length does not impact water levels. Based on water levels, the existing span is adequate.
3. Scour is projected to be minimal but it is recommended to assume that the organic silt river deposit can be scoured, with possible 1-2’ of additional scour into the till layer at the pier.
4. Stantec and MaineDOT analyzed the site for a potential design exception to the freeboard requirement. Stantec and MaineDOT concur that designing for a two span bridge with low chord ranging from 8.8’ to 10.2’ will best serve this site due to multiple site limitations and nature of flooding at the site. Stantec submitted a request for Design Exception on June 20, 2016 and MaineDOT concurred on August 2, 2016.

7.0 References

- Stantec. Memorandum June 20, 2016. Reference Southport WIN 18748.00 – Hydraulic
- MaineDOT via email to Stantec. Southport 18748.00 – Hydraulic Freeboard Design Exception. August 02, 2016 9:12:25 am.
- ESRI ArcMap, ArcGIS Desktop, Version 9.3.1, 2009. Arcview license. Data added from MEGIS website, project plans and ESRI
- Federal Emergency Management Agency. Flood Insurance Study and Flood Hazard Boundary Maps, XX
- Federal Emergency Management Agency, Flood Insurance Study and Flood Hazard Boundary Maps. XX
- Maine Dept. of Transportation. Bridge Design Manual. August 2003
- Maine DOT, Bridge Plans, XX
- Maine GIS website was used for download of 2' contour data for Southport. http://www.maine.gov/megis/catalog/
- NOAA tide data: NOAA maintains subordinate stations at XX
- NOAA tide data: Portland:
- NOAA coastal charts. Navigation Chart XX
- NOAA Sea Level Trends http://www.co-ops.nos.noaa.gov/sltrends/sltrends.html
- U.S. Army Corps of Engineers, Hydrologic Engineering Center. HEC-RAS River Analysis System. Version 5.0. 2016 Davis, CA
- U.S. Army Corps of Engineers, Updated Tidal Flood Profiles, New England Coastline, March, 2012.
- U.S. Department of Transportation. Federal Highway Administration. Evaluating Scour at Bridges, 5th edition. HEC-18. April 2012 , Publication No. FHWA-HIF-12-003
- U.S. Department of Transportation. Federal Highway Administration. Bridge Scour and Stream Instability Countermeasures. HEC-23. Volume 2. September, 2009. FHWA-NHI-09-112 . DG 14, Rock Riprap at Bridge Abutments and DG 4, Riprap Revetment
- U.S. Dept. of Transportation. Design of Riprap Revetment. HEC No. 11. FHWA IP-89-016, March 1989
- Maryland DOT, Office of Structures. Manual on Hydrologic and Hydraulic Design. Chapter 10, Appendix A. Hydraulics of Tidal Bridges. September, 2011
- U. S. Army Corps of Engineers. Coastal Engineering Research Center. Waterways Experiment Station. Vicksburgh, MI 1984 and 2002

APPENDIX MATERIAL

Project Name:	Southport Thompson's Bridge	**PIN:**	18748
Stream Name:		**Town:**	Southport
Bridge Name:	Thompson's Bridge	**Bridge No.**	
Route No.	ME 238	**USGS Quad:**	
Analysis by:	CSH	**Date:**	5/13/2015

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

Enter data in blue cells only!

	km^2	mi^2	ac	
				Enter data in [mi^2]
A	0.52	0.20	128.0	Watershed Area
W	0.03	0.01	7.2	Wetlands area (by NWI)
P_c	447004	4853942		watershed centroid (E, N; UTM 19N; meters)
County	Lincoln			*choose county from drop-down menu*
pptA	46.1			mean annual precipitation (inches; by look-up)
SG	0.00			sand & gravel aquifer as decimal fraction of watershed A

A (km^2)	0.52
W (%)	5.59

Conf Lvl 0.67

Worksheet prepared by:

Charles S. Hebson, PE
Environmental Office
Maine Dept. Transportation
Augusta, ME 04333-0016
207-557-1052
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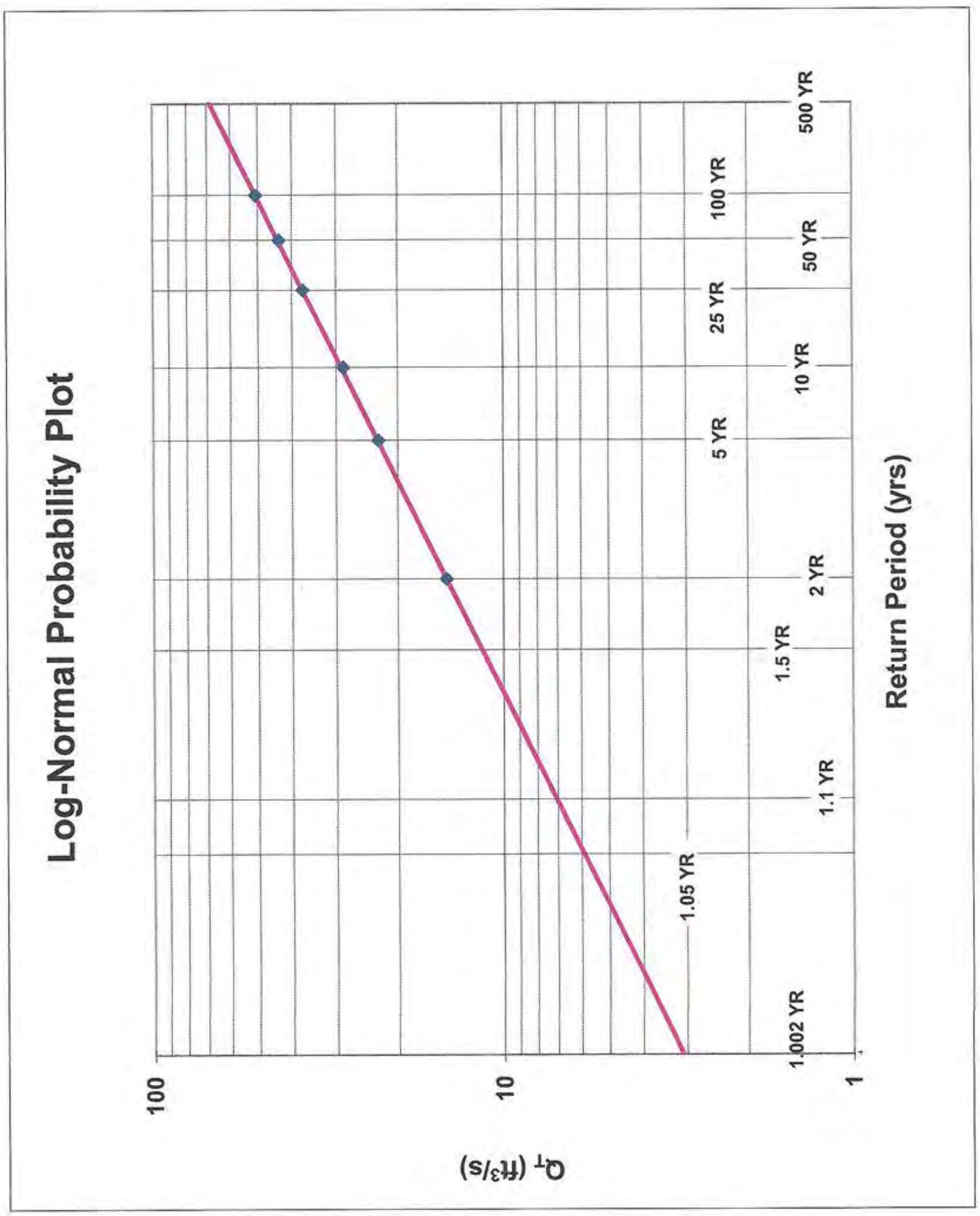
Ret Pd T (yr)	**Peak Flow Estimate Lower**	**Q_T (m^3/s)**	**Upper**	**Q_T (ft^3/s)**
1.1		0.20		7.1
2		0.41		14.5
5		0.64		22.7
10		0.81		28.7
25		1.06		37.3
50		1.23		43.6
100		1.44		50.9
500		1.94		68.5

Reference:

Hodgkins, G., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
Water-Resources Investigations Report 99-4008
US Geological Survey, Augusta, Maine

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


Log-Normal Probability Plot
Q_T (ft³/s)
100
10
1
1.002 YR
1.05 YR
1.1 YR
1.5 YR
2 YR
5 YR
10 YR
25 YR
50 YR
100 YR
500 YR
Return Period (yrs)

Project Name:	Southport Thompson's Bridge		**PIN:**	18748
Stream Name:	0		**Town:**	Southport
Bridge Name:	Thompson's Bridge		**Bridge No.**	0
Route No.	ME 238		**USGS Quad:**	0
Analysis by:	CSH		**Date:**	5/13/2015

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

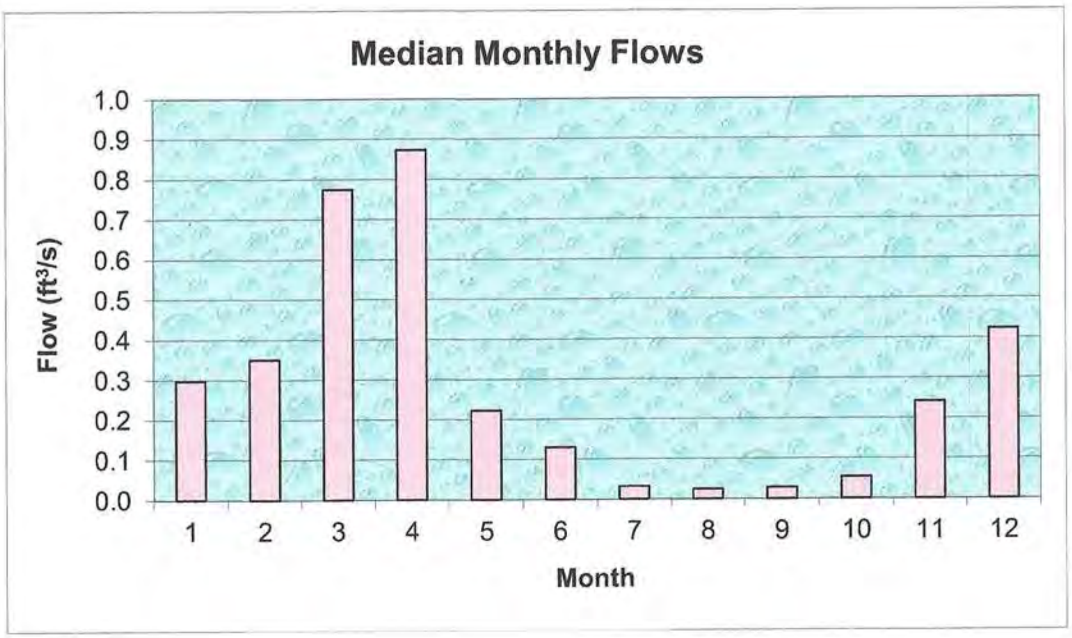
MAINE MONTHLY MEDIAN FLOWS BY USGS REGRESSION EQUATIONS (2004)

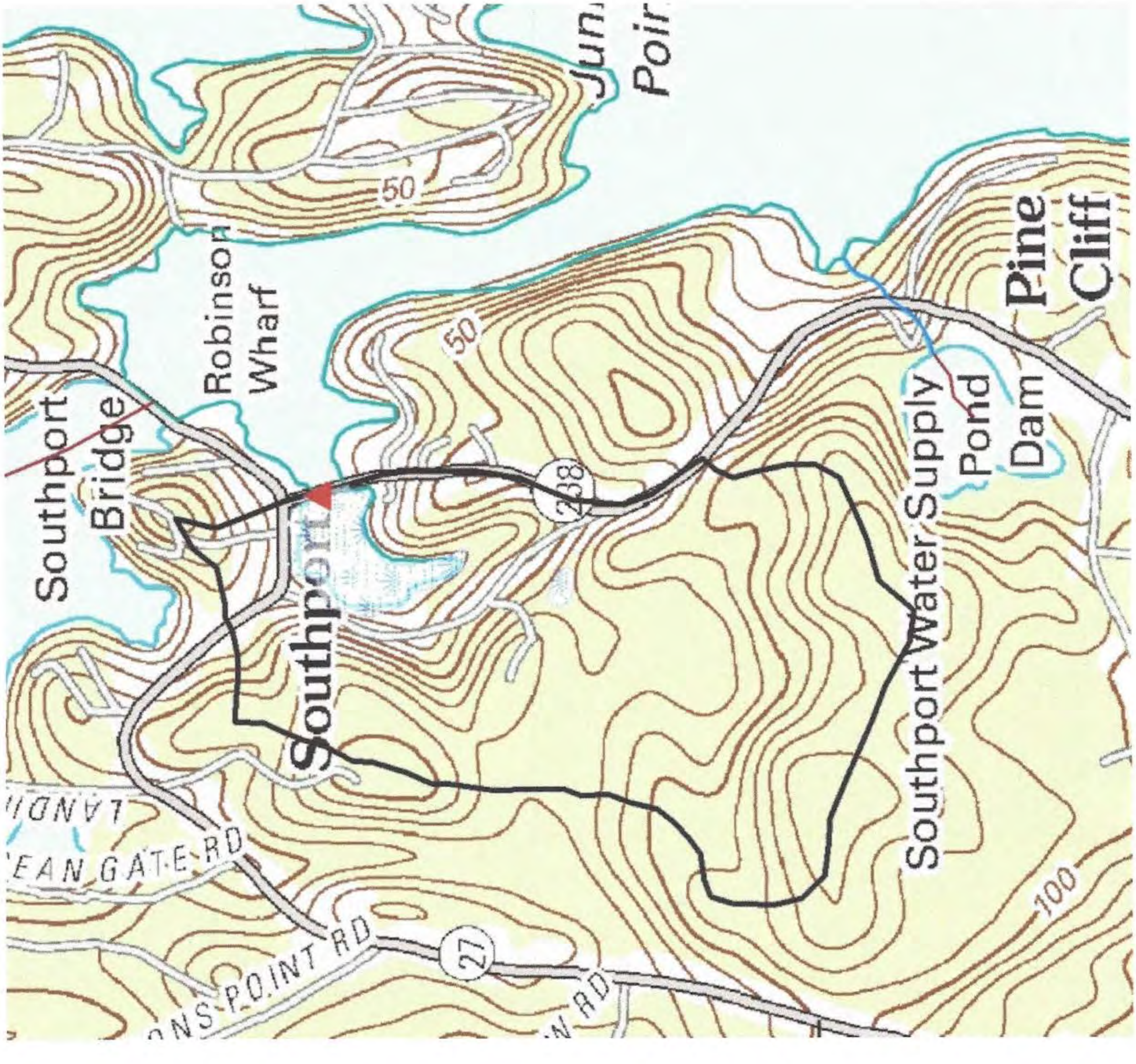
Worksheet prepared by:
Charles S. Hebson, PE
Chief Hydrologist
Maine Dept. Transportation
Augusta, ME 04333-0016
207-624-3073
Charles.Hebson@maine.gov

	Value	Variable	Explanation
	0.200	*A*	Area (mi²)
447004	4853942	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	29.40	*DIST*	Distance from Coastal reference line (mi)
	46.1	*pptA*	Mean Annual Precipitation (inches)
	0.00	*SG*	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft3/s)	(m^3/s)
Jan	**0.30**	0.0084
Feb	**0.35**	0.0099
Mar	**0.77**	0.0219
Apr	**0.87**	0.0247
May	**0.22**	0.0063
Jun	**0.13**	0.0037
Jul	**0.03**	0.0009
Aug	**0.03**	0.0007
Sep	**0.03**	0.0008
Oct	**0.05**	0.0015
Nov	**0.24**	0.0069
Dec	**0.42**	0.0120

Q_{bf}	**1.0**	
ann avg	**0.4**	
ann med	**0.2**	
$Q_{1.002}$	**3.1**	
$Q_{1.01}$	4.1	
$Q_{1.05}$	5.9	
W_{bf}	3.3	estimated bankfull width
d_{bf}	0.3	
Q_{bf}	3.4	assume v = 4ft/s




Southport Bridge
Robinson Wharf
Southport
Southport Water Supply Pond Dam
Pine Cliff
238
27
50
50
100
RD
POINT RD

Environmental Office – Hydrology Section
16 State House Station
Augusta ME 04333-0016
207.557.1052
Charles.Hebson@maine.gov

Maine Department of Transportation

Memo

To: Janet Damren

From: Charles Hebson

CC:

Date: 03 June 2015

Re: 18748 Southport Thompson's Bridge Tidal Datums

Tidal datums for Thompson's Bridge are reported below. They were derived from the Southport (Townsend Gut) Subordinate Station 8416908 (subordinate station nearest project) and the corresponding primary reference station, Portland 8418150. The high and low tide values at Portland were multiplied by the corresponding height offset multipliers (0.98 and 0.98, respectively) to get the values reported below.

Datum	**Value** (ft NAVD88)	**Notes**
HOWL	8.69	2/7/1978 10:30 Highest Observed Water Level
HAT	6.56	5/17/1999 4:42 Highest Astronomical Tide
HAT 2015	6.45	10/28/2015 12:03 HAT in 2015
MHHW	4.56	Mean Higher High Water
MHW	4.13	Mean High Water
NAVD88	0.00	
DTL	-0.30	Diurnal Tide Level
MSL	-0.32	Mean Sea Level
MTL	-0.34	Mean Tide Level
MLW	-4.81	Mean Low Water
MLLW	-5.15	Mean Lower Low Water
LAT	-7.23	1/21/1996 22:36 Lowest Astronomical Tide
LOWL	-8.54	11/30/1955 17:18 Lowest Observed Water Level

Southport Tide Measurements
Water Level Measurements - 15-30 minute intervals
BOOTHBAY

July 6 2016 By: EOB
By: MC

-5.15 MLLW = 0.0 NAVD

Time		MLLW		NAVD
7:02 AM		-1.1	-5.15	-6.25
1:19 PM		9.6		4.45
7:13 PM		0.1		-5.05

Top of Rail		West side S-N	East Side S-N
US (West)	DS (East)=	16.82	16.75
16.99	16.91	16.92	16.91
LOW chord approx 10.4' navd		16.99	16.91
per email from Dan Taylor 7-7/1(		17	16.95
		16.94	16.89
		16.94	16.84
		16.85	16.81

Bridge Width 22

Feet 0.85 Add 10.25" to all measurements for length of weighted chain
10.25"

Time	US tape ft	US tape inches	DS tape ft	DS tape inches	US total length	DS total length	DS minus US		US elev	DS Elev	EST Boothbay Tide, MLLW	EST Boothbay Tide, NAVD	Townsend gut MLLW	NAVD	notes	travel across bridge		AVE	velocity, fps
8:31 AM	20.00	10.125			21.70		ft	in	-4.71		0.5	-4.65	0.2	-4.95	5th post,				
8:31 AM			20.00	8.50		21.56	-0.14	-1.63		-4.65	0.50	-4.65	0.2	-4.95	10th post-	for all others			
8:35 AM	20.00	8.13			21.53				-4.54		0.60	-4.55	0.3	-4.85					
8:35 AM			20.00	8.75		21.58	0.05	0.63		-4.67	0.60	-4.55	0.3	-4.85					
8:51 AM											0.60	-4.55	0.6	-4.55	DS to US	1 min 42 sec		102	0.215686
9:00 AM	19.00	7.00			20.44				-3.45		1.00	-4.15	1	-4.15					
9:00 AM			19.00	8.80		20.59	0.15	1.80		-3.68	1.30	-3.85	1	-4.15					
9:22 AM			18.00	10.00		19.69	-0.04	-0.50		-2.78	2.40	-2.75	2.2	-2.95	slack tide				
9:18 AM	18.00	10.50			19.73				-2.74		2.40	-2.75	2.2	-2.95					
9:30 AM			18.00	4.25		19.21	0.01	0.13		-2.30	2.90	-2.25	2.3	-2.85					
9:33	18.00	4.13			19.20				-2.21		2.90	-2.25	2.35	-2.8	pictures				
9:50											3.60	-1.55	3	-2.15		75.00	50.00	49	0.37931
9:57	17.00	1.50			17.98				-0.99		4.10	-1.05	3.2	-1.95					
9:59			16.00	11.88		17.84	-0.14	-1.63		-0.93	4.10	-1.05	3.2	-1.95					
10:40	15.00	1.75			16.00				0.99		5.60	0.45	5.5	0.35					
10:40			15.00	2.25		16.04	0.04	0.50		0.87	5.60	0.45	5.5	0.35					
10:44	14.00	11.50			15.81				1.18		5.70	0.55	5.8	0.65					
10:44			14.00	10.25		15.71	-0.10	-1.25		1.20	5.70	0.55	5.8	0.65					
10:48											5.80	0.65	5.8	0.65		82.00	68.00	130	0.235714
10:58			14.00	3.88		15.18	-0.03	-0.38		1.73	6.30	1.15	5.9	0.75					
11:00 AM	14.00	4.25			15.21				1.78		6.30	1.15	5.9	0.75					
11:30 AM	13.00	1.25			13.96				3.03		7.50	2.35	7.8	2.65	pictures				
11:32 AM			12	11.63		13.82	-0.14	-1.62		3.09	7.50	2.35	7.8	2.65					
11:57 AM	12.00	4.75			13.25				3.74		8.30	3.15	8.2	3.05					
11:58 AM			12.00	3.50		13.15	-0.10	-1.25		3.76	8.30	3.15	8.2	3.05	pictures				
1:02 PM			11.00	3.50		12.15				4.76	9.20	4.05	9.3	4.15					
1:03 PM	11.00	2.75			12.08		0.06	0.75	4.91		9.20	4.05	9.3	4.15					
1:26 PM			11.00	3.13		12.11				4.80	9.60	4.45	9.3	4.15					
1:28 PM	11.00	3.13			12.11		0.00	0.00	4.88		9.50	4.35	9.5	4.35					
1:28 PM	11.00	3.50			12.15		-0.03	-0.38	4.84		9.50	4.35	9.5	4.35					
1:56 PM			11.00	4.50		12.23				4.68	9.00	3.85	9.5	4.35					
1:58 PM	11.00	5.00			12.27		-0.04	-0.50	4.72		9.00	3.85	9.3	4.15					
2:02 PM			11.00	5.25		12.29				4.62	9.00	3.85	9.3	4.15					
2:04 PM	11.00	6.25			12.38		-0.08	-1.00	4.62		9.00	3.85	9.3	4.15					

may have read wrong side of tape measure.. Use readings with caution

Southport Final Hydrographs

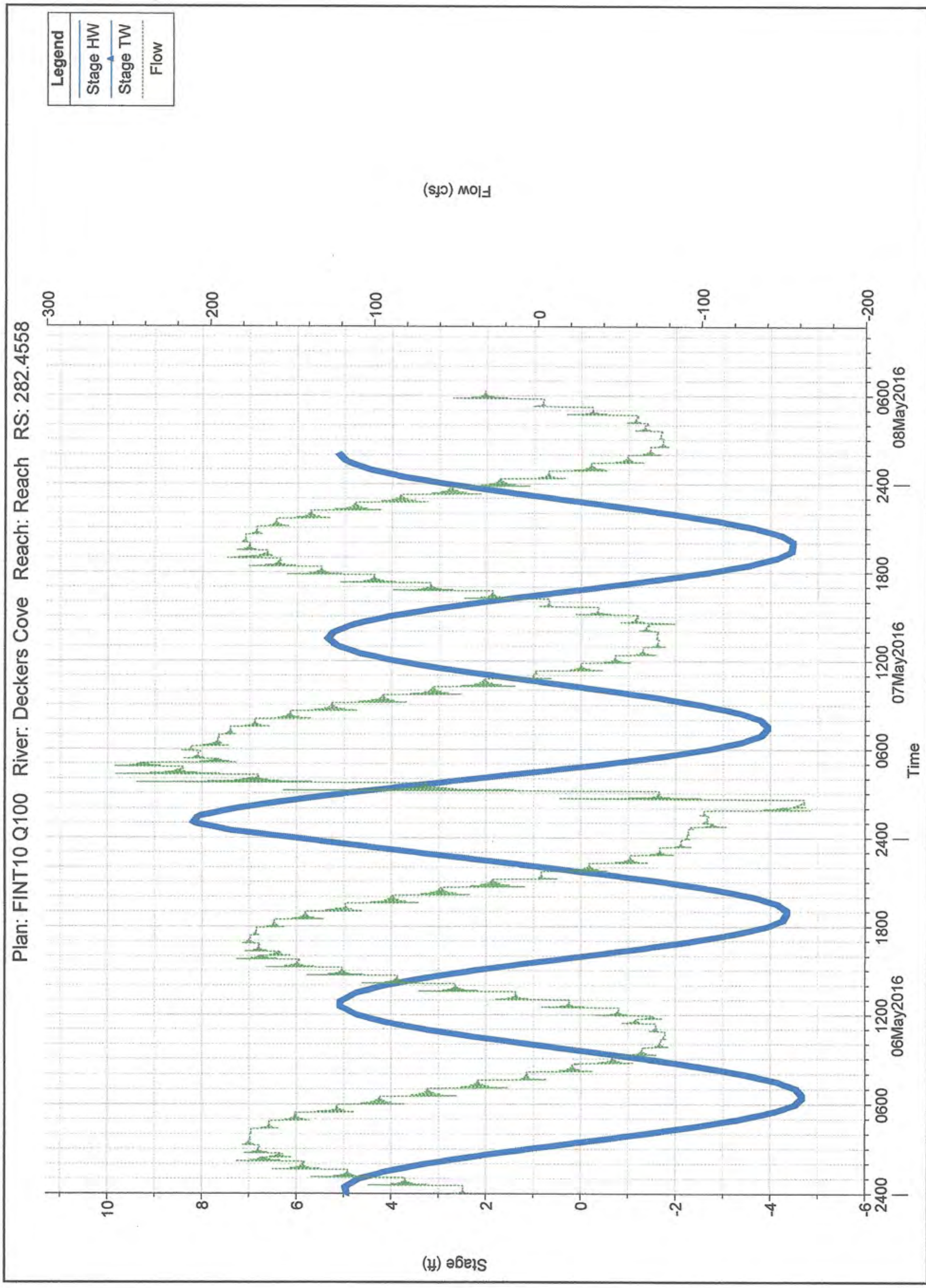
10-year	8.20												
100-year	9.70												
500-year	11.10												
SLR	4.00	2	3										
waves	0.50												
Enter historical hydrograph in column B				NOAA	ADCIRC	semi-	NWS 38		MHW -		4.13		
MHHW =	4.56			Ht/2-ft	sp	diurnal	D=R/f		MLW		-4.81		
MLLW =	-5.15			4.855	2.1	2	0.94						
				10yrsurge	3.35								
NAVD-NGV	0.65		MHW-MLW	8.94			hr						
				100-yr surge	4.845								
NAVD				500-year sur	6.245								

Time	ADCIRC Surge only	1/2 MHHW-MLLW tide	MHHW plus 4' SLR	0	MHHW plus 3' SLR	10-yr no SLR	10yrplus 1ft SLR	10- yr plus 2 ft SLR	10-year plus 3 ft SLR	10-year plus 4' SLR	surge = 2.1 Surge at High tide	100 yr no waves (9.7)	500 yr no waves (11.1)
0	0.08	4.79	8.79	6.79	7.79	4.92	5.92	6.92	7.92	8.92	4.87	4.97	5.02
0.5	0.08	4.83	8.83	6.83	7.83	4.96	5.96	6.96	7.96	8.96	4.91	5.02	5.07
1	0.08	4.57	8.57	6.57	7.57	4.70	5.70	6.70	7.70	8.70	4.65	4.76	4.81
1.5	0.08	4.01	8.01	6.01	7.01	4.14	5.14	6.14	7.14	8.14	4.10	4.20	4.26
2	0.08	3.20	7.20	5.20	6.20	3.34	4.34	5.34	6.34	7.34	3.29	3.40	3.45
2.5	0.09	2.19	6.19	4.19	5.19	2.32	3.32	4.32	5.32	6.32	2.27	2.39	2.44
3	0.09	1.03	5.03	3.03	4.03	1.17	2.17	3.17	4.17	5.17	1.12	1.24	1.29
3.5	0.09	-0.19	3.81	1.81	2.81	-0.04	0.96	1.96	2.96	3.96	-0.10	0.02	0.08
4	0.09	-1.40	2.60	0.60	1.60	-1.25	-0.25	0.75	1.75	2.75	-1.30	-1.18	-1.12
4.5	0.09	-2.51	1.49	-0.51	0.49	-2.36	-1.36	-0.36	0.64	1.64	-2.42	-2.30	-2.24
5	0.10	-3.47	0.53	-1.47	-0.47	-3.32	-2.32	-1.32	-0.32	0.68	-3.38	-3.25	-3.19
5.5	0.10	-4.21	-0.21	-2.21	-1.21	-4.05	-3.05	-2.05	-1.05	-0.05	-4.11	-3.98	-3.92
6	0.10	-4.68	-0.68	-2.68	-1.68	-4.52	-3.52	-2.52	-1.52	-0.52	-4.58	-4.45	-4.38
6.5	0.10	-4.85	-0.85	-2.85	-1.85	-4.69	-3.69	-2.69	-1.69	-0.69	-4.75	-4.61	-4.55
7	0.11	-4.72	-0.72	-2.72	-1.72	-4.55	-3.55	-2.55	-1.55	-0.55	-4.61	-4.47	-4.40
7.5	0.11	-4.28	-0.28	-2.28	-1.28	-4.11	-3.11	-2.11	-1.11	-0.11	-4.17	-4.03	-3.95
8	0.11	-3.57	0.43	-1.57	-0.57	-3.39	-2.39	-1.39	-0.39	0.61	-3.46	-3.31	-3.24
8.5	0.12	-2.63	1.37	-0.63	0.37	-2.45	-1.45	-0.45	0.55	1.55	-2.52	-2.37	-2.29
9	0.12	-1.53	2.47	0.47	1.47	-1.34	-0.34	0.66	1.66	2.66	-1.41	-1.25	-1.17
9.5	0.12	-0.33	3.67	1.67	2.67	-0.13	0.87	1.87	2.87	3.87	-0.20	-0.04	0.04
10	0.13	0.89	4.89	2.89	3.89	1.10	2.10	3.10	4.10	5.10	1.02	1.19	1.27
10.5	0.13	2.06	6.06	4.06	5.06	2.27	3.27	4.27	5.27	6.27	2.19	2.36	2.45
11	0.14	3.09	7.09	5.09	6.09	3.31	4.31	5.31	6.31	7.31	3.23	3.41	3.50
11.5	0.14	3.93	7.93	5.93	6.93	4.16	5.16	6.16	7.16	8.16	4.07	4.26	4.35
12	0.15	4.52	8.52	6.52	7.52	4.75	5.75	6.75	7.75	8.75	4.67	4.86	4.96
12.5	0.15	4.82	8.82	6.82	7.82	5.06	6.06	7.06	8.06	9.06	4.97	5.17	5.27
13	0.16	4.81	8.81	6.81	7.81	5.06	6.06	7.06	8.06	9.06	4.97	5.18	5.28
13.5	0.16	4.50	8.50	6.50	7.50	4.76	5.76	6.76	7.76	8.76	4.66	4.88	4.99
14	0.17	3.90	7.90	5.90	6.90	4.17	5.17	6.17	7.17	8.17	4.07	4.30	4.41
14.5	0.18	3.05	7.05	5.05	6.05	3.34	4.34	5.34	6.34	7.34	3.23	3.47	3.59
15	0.19	2.01	6.01	4.01	5.01	2.31	3.31	4.31	5.31	6.31	2.20	2.45	2.57
15.5	0.20	0.84	4.84	2.84	3.84	1.16	2.16	3.16	4.16	5.16	1.04	1.30	1.43
16	0.21	-0.38	3.62	1.62	2.62	-0.05	0.95	1.95	2.95	3.95	-0.17	0.10	0.24
16.5	0.22	-1.58	2.42	0.42	1.42	-1.23	-0.23	0.77	1.77	2.77	-1.36	-1.07	-0.93
17	0.23	-2.68	1.32	-0.68	0.32	-2.31	-1.31	-0.31	0.69	1.69	-2.45	-2.14	-1.99
17.5	0.25	-3.61	0.39	-1.61	-0.61	-3.21	-2.21	-1.21	-0.21	0.79	-3.36	-3.04	-2.87
18	0.26	-4.31	-0.31	-2.31	-1.31	-3.89	-2.89	-1.89	-0.89	0.11	-4.04	-3.70	-3.52
18.5	0.28	-4.73	-0.73	-2.73	-1.73	-4.28	-3.28	-2.28	-1.28	-0.28	-4.45	-4.08	-3.89
19	0.30	-4.85	-0.85	-2.85	-1.85	-4.37	-3.37	-2.37	-1.37	-0.37	-4.55	-4.15	-3.95
19.5	0.33	-4.67	-0.67	-2.67	-1.67	-4.14	-3.14	-2.14	-1.14	-0.14	-4.34	-3.91	-3.69
20	0.36	-4.18	-0.18	-2.18	-1.18	-3.61	-2.61	-1.61	-0.61	0.39	-3.83	-3.35	-3.11
20.5	0.40	-3.44	0.56	-1.44	-0.44	-2.81	-1.81	-0.81	0.19	1.19	-3.04	-2.52	-2.26
21	0.44	-2.47	1.53	-0.47	0.53	-1.77	-0.77	0.23	1.23	2.23	-2.03	-1.45	-1.16
21.5	0.49	-1.34	2.66	0.66	1.66	-0.56	0.44	1.44	2.44	3.44	-0.85	-0.20	0.13
22	0.56	-0.13	3.87	1.87	2.87	0.77	1.77	2.77	3.77	4.77	0.43	1.17	1.55
22.5	0.66	1.09	5.09	3.09	4.09	2.13	3.13	4.13	5.13	6.13	1.74	2.60	3.04
23	0.79	2.24	6.24	4.24	5.24	3.49	4.49	5.49	6.49	7.49	3.02	4.05	4.58
23.5	0.98	3.24	7.24	5.24	6.24	4.80	5.80	6.80	7.80	8.80	4.22	5.50	6.15
24	1.28	4.04	8.04	6.04	7.04	6.08	7.08	8.08	9.08	10.08	5.32	7.00	7.85
24.5	1.78	4.59	8.59	6.59	7.59	7.42	8.42	9.42	10.42	11.42	6.37	8.69	9.88
25	**2.10**	4.84	8.84	6.84	7.84	8.18	9.18	10.18	11.18	12.18	6.94	9.68	11.08
25.5	2.06	4.78	8.78	6.78	7.78	8.07	9.07	10.07	11.07	12.07	6.84	9.54	10.91
26	1.82	4.42	8.42	6.42	7.42	7.31	8.31	9.31	10.31	11.31	6.24	8.61	9.82
26.5	1.55	3.78	7.78	5.78	6.78	6.24	7.24	8.24	9.24	10.24	5.33	7.35	8.38
27	1.33	2.90	6.90	4.90	5.90	5.01	6.01	7.01	8.01	9.01	4.23	5.96	6.85
27.5	1.16	1.83	5.83	3.83	4.83	3.67	4.67	5.67	6.67	7.67	2.99	4.50	5.27
28	1.02	0.65	4.65	2.65	3.65	2.27	3.27	4.27	5.27	6.27	1.67	3.00	3.69
28.5	0.91	-0.58	3.42	1.42	2.42	0.88	1.88	2.88	3.88	4.88	0.34	1.53	2.14
29	0.83	-1.77	2.23	0.23	1.23	-0.45	0.55	1.55	2.55	3.55	-0.94	0.14	0.69
29.5	0.75	-2.84	1.16	-0.84	0.16	-1.64	-0.64	0.36	1.36	2.36	-2.09	-1.10	-0.60
30	0.69	-3.74	0.26	-1.74	-0.74	-2.63	-1.63	-0.63	0.37	1.37	-3.04	-2.14	-1.68
30.5	0.64	-4.39	-0.39	-2.39	-1.39	-3.37	-2.37	-1.37	-0.37	0.63	-3.75	-2.92	-2.49
31	0.60	-4.77	-0.77	-2.77	-1.77	-3.82	-2.82	-1.82	-0.82	0.18	-4.18	-3.40	-3.00
31.5	0.56	-4.84	-0.84	-2.84	-1.84	-3.96	-2.96	-1.96	-0.96	0.04	-4.29	-3.56	-3.19
32	0.52	-4.61	-0.61	-2.61	-1.61	-3.78	-2.78	-1.78	-0.78	0.22	-4.09	-3.41	-3.06
32.5	0.49	-4.08	-0.08	-2.08	-1.08	-3.30	-2.30	-1.30	-0.30	0.70	-3.59	-2.95	-2.62
33	0.46	-3.29	0.71	-1.29	-0.29	-2.55	-1.55	-0.55	0.45	1.45	-2.83	-2.22	-1.91
33.5	0.44	-2.30	1.70	-0.30	0.70	-1.60	-0.60	0.40	1.40	2.40	-1.86	-1.28	-0.99
34	0.42	-1.15	2.85	0.85	1.85	-0.49	0.51	1.51	2.51	3.51	-0.74	-0.19	0.09
34.5	0.40	0.06	4.06	2.06	3.06	0.70	1.70	2.70	3.70	4.70	0.46	0.98	1.25
35	0.38	1.28	5.28	3.28	4.28	1.88	2.88	3.88	4.88	5.88	1.66	2.15	2.41
35.5	0.36	2.41	6.41	4.41	5.41	2.99	3.99	4.99	5.99	6.99	2.77	3.25	3.49
36	0.35	3.39	7.39	5.39	6.39	3.94	4.94	5.94	6.94	7.94	3.73	4.19	4.42
36.5	0.34	4.15	8.15	6.15	7.15	4.68	5.68	6.68	7.68	8.68	4.48	4.92	5.15
37	0.32	4.65	8.65	6.65	7.65	5.16	6.16	7.16	8.16	9.16	4.97	5.39	5.61
37.5	0.31	4.85	8.85	6.85	7.85	5.35	6.35	7.35	8.35	9.35	5.16	5.57	5.77
38	0.30	4.75	8.75	6.75	7.75	5.22	6.22	7.22	8.22	9.22	5.05	5.44	5.64
38.5	0.29	4.34	8.34	6.34	7.34	4.80	5.80	6.80	7.80	8.80	4.63	5.01	5.20
39	0.28	3.65	7.65	5.65	6.65	4.10	5.10	6.10	7.10	8.10	3.93	4.30	4.49
39.5	0.27	2.74	6.74	4.74	5.74	3.17	4.17	5.17	6.17	7.17	3.01	3.36	3.54
40	0.26	1.65	5.65	3.65	4.65	2.07	3.07	4.07	5.07	6.07	1.91	2.25	2.43
40.5	0.25	0.45	4.45	2.45	3.45	0.86	1.86	2.86	3.86	4.86	0.71	1.04	1.21
41	0.25	-0.77	3.23	1.23	2.23	-0.38	0.62	1.62	2.62	3.62	-0.52	-0.20	-0.04
41.5	0.24	-1.95	2.05	0.05	1.05	-1.56	-0.56	0.44	1.44	2.44	-1.71	-1.39	-1.23
42	0.23	-3.00	1.00	-1.00	0.00	-2.63	-1.63	-0.63	0.37	1.37	-2.76	-2.46	-2.30
42.5	0.23	-3.86	0.14	-1.86	-0.86	-3.50	-2.50	-1.50	-0.50	0.50	-3.63	-3.33	-3.18
43	0.22	-4.47	-0.47	-2.47	-1.47	-4.12	-3.12	-2.12	-1.12	-0.12	-4.25	-3.96	-3.82
43.5	0.22	-4.80	-0.80	-2.80	-1.80	-4.46	-3.46	-2.46	-1.46	-0.46	-4.59	-4.31	-4.16
44	0.21	-4.83	-0.83	-2.83	-1.83	-4.49	-3.49	-2.49	-1.49	-0.49	-4.62	-4.34	-4.20
44.5	0.20	-4.55	-0.55	-2.55	-1.55	-4.22	-3.22	-2.22	-1.22	-0.22	-4.34	-4.07	-3.94
45	0.20	-3.97	0.03	-1.97	-0.97	-3.65	-2.65	-1.65	-0.65	0.35	-3.77	-3.51	-3.38
45.5	0.20	-3.15	0.85	-1.15	-0.15	-2.84	-1.84	-0.84	0.16	1.16	-2.95	-2.70	-2.57
46	0.19	-2.12	1.88	-0.12	0.88	-1.82	-0.82	0.18	1.18	2.18	-1.93	-1.68	-1.56
46.5	0.19	-0.96	3.04	1.04	2.04	-0.67	0.33	1.33	2.33	3.33	-0.78	-0.53	-0.41
47	0.18	0.26	4.26	2.26	3.26	0.55	1.55	2.55	3.55	4.55	0.44	0.68	0.80
47.5	0.18	1.46	5.46	3.46	4.46	1.75	2.75	3.75	4.75	5.75	1.64	1.88	1.99
48	0.17	2.57	6.57	4.57	5.57	2.85	3.85	4.85	5.85	6.85	2.75	2.98	3.10
48.5	0.17	3.52	7.52	5.52	6.52	3.80	4.80	5.80	6.80	7.80	3.69	3.92	4.03
49	0.17	4.25	8.25	6.25	7.25	4.51	5.51	6.51	7.51	8.51	4.41	4.63	4.75
49.5	0.16	4.70	8.70	6.70	7.70	4.96	5.96	6.96	7.96	8.96	4.87	5.08	5.19
50	0.16	4.86	8.86	6.86	7.86	5.11	6.11	7.11	8.11	9.11	5.02	5.23	5.34

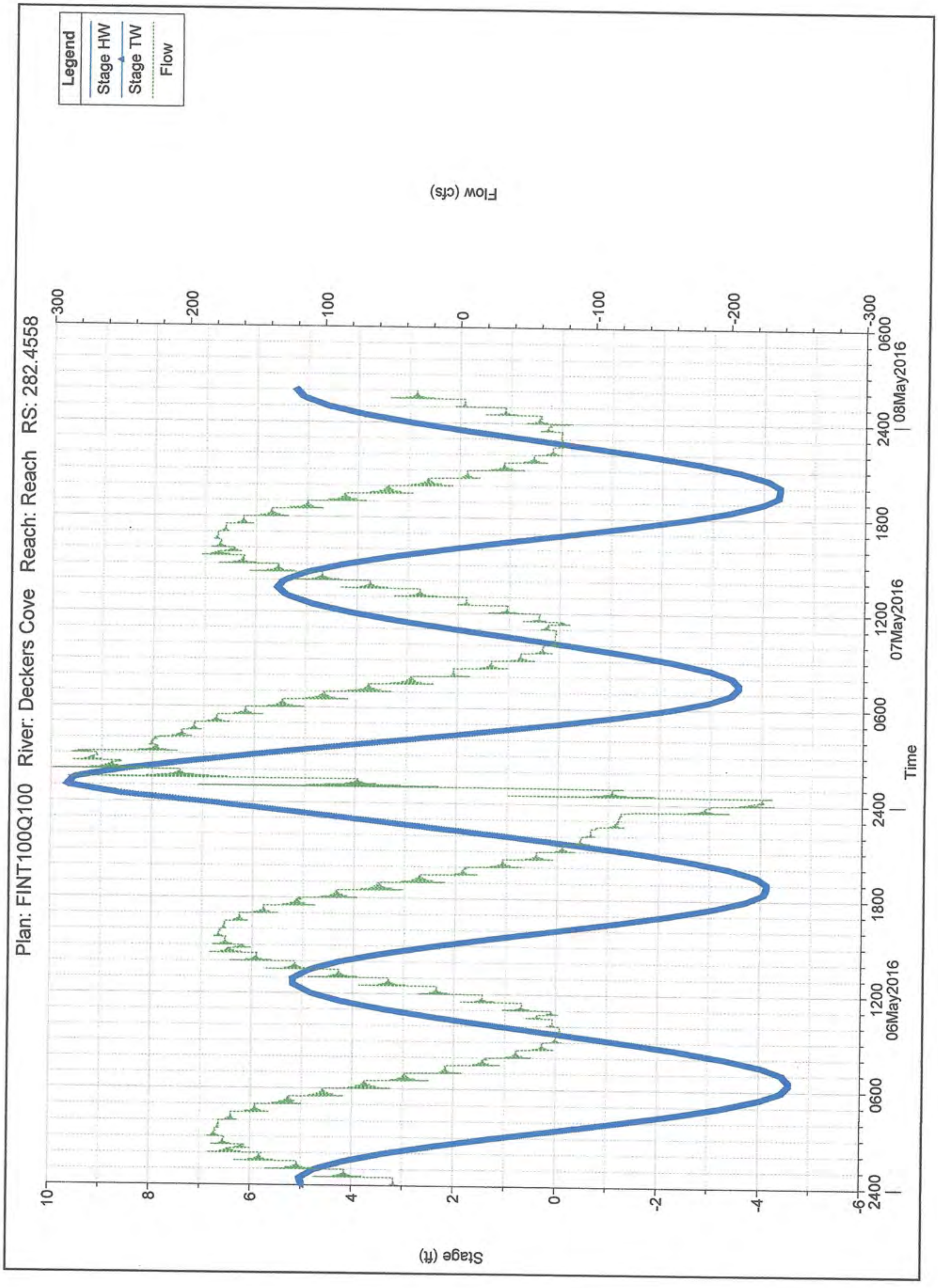
Theoretical hydrograph			southport- Townsend Gut based on Portland * .98										
MHHW	4.56									ADCIRC Penobscot Bay			
MLLW	-5.15		NOAA	ADCIRC	semi-	NWS 38					50	1.7	R95 = 50
MHW	4.13		5/8/16 tides	Sp	diurnal	D=R/f					100	2.1	F95=53
MLW	-4.81		7.0125	2.1	2	0.943396226					500	3.1	
predicted hig	6.55		ft	ft		hr							
predicted low	-7.05												
measured hig	7.125	5/8/2016			7.125								
measured low	-6.9				-6.9								
HAT	6.99												
HAT 2016	6.99												
HOWL ptld	8.69												

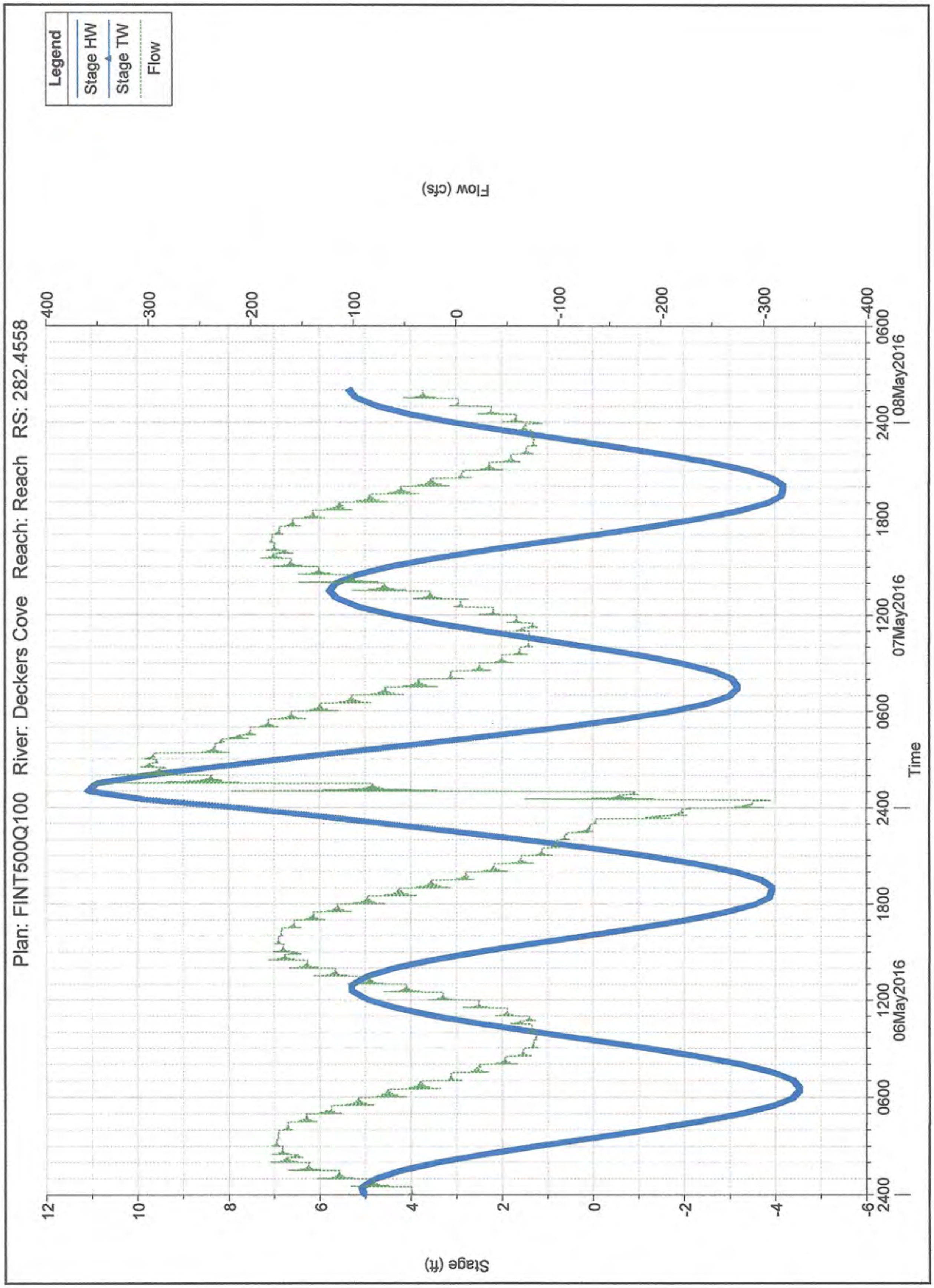
FEMA

10-year	8.2
50-year	9.2
100-year	9.7
500-year	11.1
MHW plus	8.1

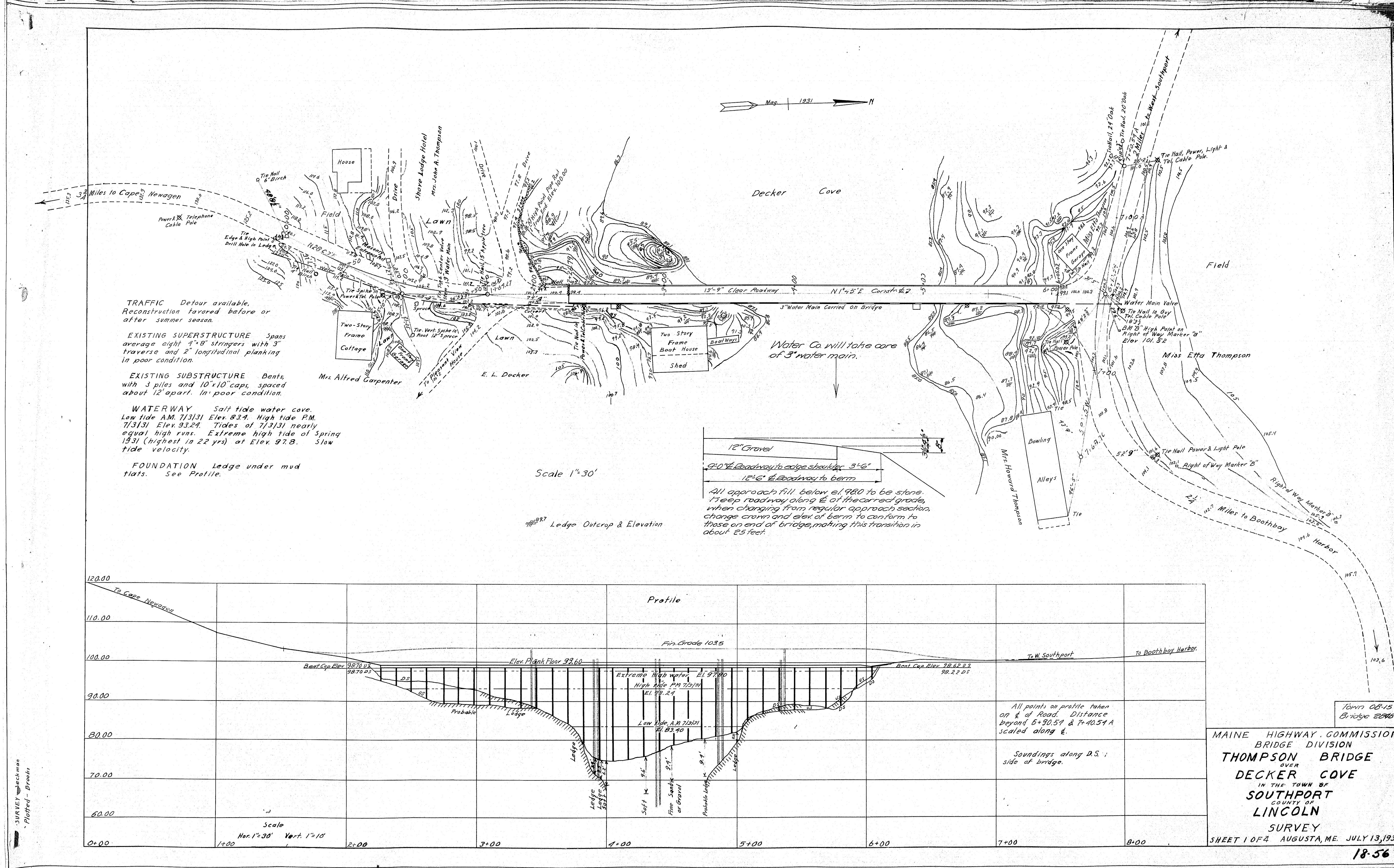


Plan: FINT10 Q100 River: Deckers Cove Reach: Reach RS: 282.4558
Legend
Stage HW
Stage TW
Flow
Stage (ft)
Flow (cfs)
Time
2400
0600
1200
06May2016
1800
2400
0600
1200
07May2016
1800
2400
0600
08May2016
1 in Horiz. = 0.4 1 in Vert. = 3 ft

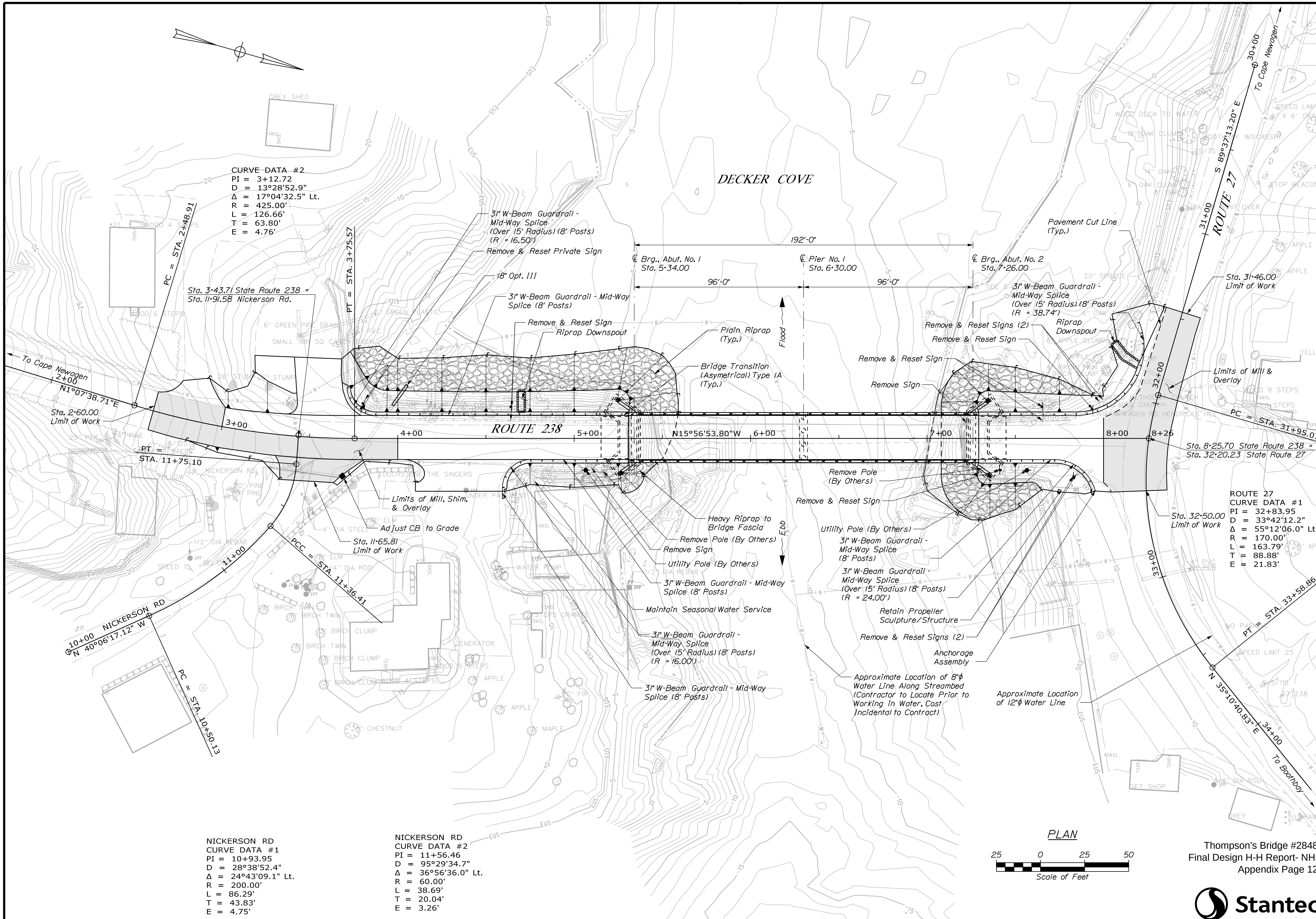

Plan: FINT100Q100 River: Deckers Cove Reach: Reach RS: 282.4558
Legend
Stage HW
Stage TW
Flow
Stage (ft)
Flow (cfs)
Time
06May2016
07May2016
08May2016



Plan: FINT500Q100 River: Deckers Cove Reach: Reach RS: 282.4558
Legend
Stage HW
Stage TW
Flow
Stage (ft)
Flow (cfs)
Time
2400
0600
1200
06May2016
1800
2400
0600
1200
07May2016
1800
2400
0600
08May2016


TRAFFIC Detour available. Reconstruction favored before or after summer season.
EXISTING SUPERSTRUCTURE Spans average eight 4"×8" stringers with 3" traverse and 2" longitudinal planking in poor condition.
EXISTING SUBSTRUCTURE Bents, with 3 piles and 10"×10" caps, spaced about 12' apart. In poor condition.
WATERWAY Salt tide water cove. Low tide A.M. 7/3/31 Elev. 83.4. High tide P.M. 7/3/31 Elev. 93.24. Tides of 7/3/31 nearly equal high runs. Extreme high tide of Spring 1931 (highest in 22 yrs) at Elev. 97.8. Slow tide velocity.
FOUNDATION Ledge under mud flats. See Profile.
Scale 1"=30'
Ledge Outcrop & Elevation
Decker Cove
Water Co. will take care of 3" water main.
3" Water Main Carried on Bridge
13'-9" Clear Roadway
N 1°45' E Constr. ℄
12" Gravel
9'-0" ℄ Roadway to edge shoulder 3'-6"
12'-6" ℄ Roadway to berm
All approach fill below el. 98.0 to be stone. Keep roadway along ℄ of the corrected grade, when changing from regular approach section, change crown and elev. of berm to conform to those on end of bridge, making this transition in about 25 feet.
Mag. 1931 N
3/4 Miles to Cape Newagen
2 1/4 Miles to Boothbay Harbor
2 Miles to West Southport
Field
Lawn
House
Two-Story Frame Cottage
Two Story Frame Boat House
Shed
Boat Ways
Bowling Alleys
Mrs. Alfred Carpenter
E. L. Decker
Shore Lodge Hotel
Mrs. John A. Thompson
Mrs. Howard Thompson
Miss Etta Thompson
To Pleasant View House
Water Main Valve
Right of Way Marker "B"
Protile
Fin. Grade 103.5
Elev. Plank Floor 99.60
Extreme High water El. 97.80
High tide P.M. 7/3/31 El. 93.24
Low tide A.M. 7/3/31 El. 83.40
Bent Cap Elev. 98.70 U.S. 98.70 D.S.
Bent Cap Elev. 98.62 U.S. 98.22 D.S.
To Cape Newagen
To W. Southport
To Boothbay Harbor
Probable Ledge
Ledge
Soft
Fine Sand or Gravel
All points on profile taken on ℄ of Road. Distance beyond 5+90.51 & 7+40.54 A scaled along ℄.
Soundings along D.S. side of bridge.
Scale Hor. 1"=30' Vert. 1"=10'
120.00
110.00
100.00
90.00
80.00
70.00
60.00
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
Form 08-15
Bridge 2848
MAINE HIGHWAY COMMISSION
BRIDGE DIVISION
THOMPSON BRIDGE
OVER
DECKER COVE
IN THE TOWN OF
SOUTHPORT
COUNTY OF
LINCOLN
SURVEY
SHEET 1 OF 4 AUGUSTA, ME. JULY 13, 1931
18-56
SURVEY – Beckman
Plotted – Brooks

Filename: ...\MSTA\004_GeneralPlan.dgn   Division: BRIDGE   Username: lflanders   Date:2/27/2019



Thompson's Bridge #2848
Final Design H-H Report- NHI
Appendix Page 12

Stantec

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-1874(800)

WIN 18748.00

BRIDGE NO. 2848

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER	L. TIMBERLAKE	
DESIGN-DETAILED	DDT	FEB 2019
CHECKED-REVIEWED	LEM/TWM	FEB 2019
DESIGN2-DETAILED2	PLP	FEB 2019
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

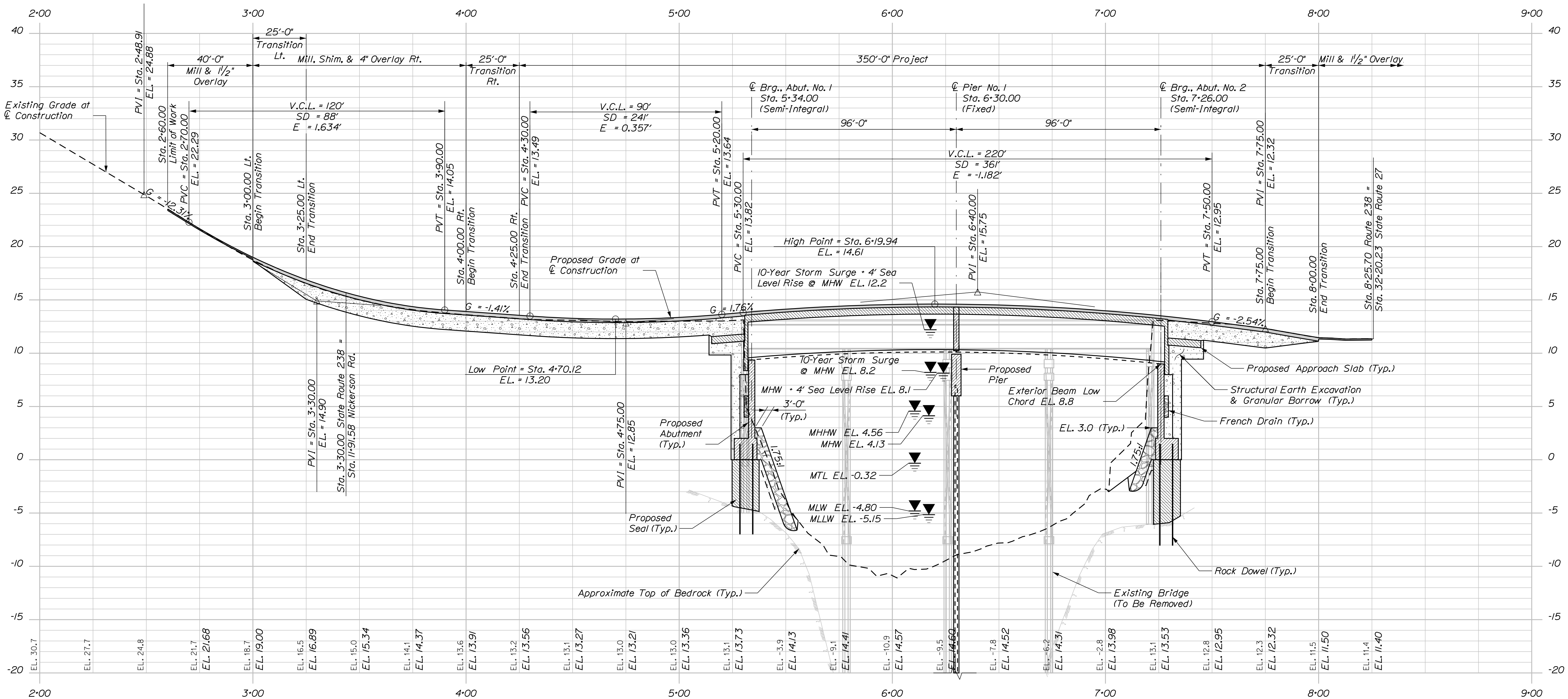
DATE

THOMPSONS BRIDGE
DECKER COVE
SOUTHPORT LINCOLN COUNTY

GENERAL PLAN

SHEET NUMBER
4
OF 43

Filename: ...\00\BRIDGE\MSTA\005_Profile.dgn Division: BRIDGE Username: lflanders Date:2/27/2019



PROFILE - ROUTE 238

Horiz. 25 0 25 50

Vert. 5 0 5 10

Scale of Feet

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-1874(800)

BRIDGE NO. 2848

WIN 18748.00

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER	L. TIMBERLAKE	
DESIGN-DETAILED	DDT	DDT	FEB 2019
CHECKED-REVIEWED	LSF	LEM/TWM	FEB 2019
DESIGN2-DETAILED2	PLP	PLP	FEB 2019
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

THOMPSONS BRIDGE
DECKER COVE
SOUTHPORT LINCOLN COUNTY

PROFILE

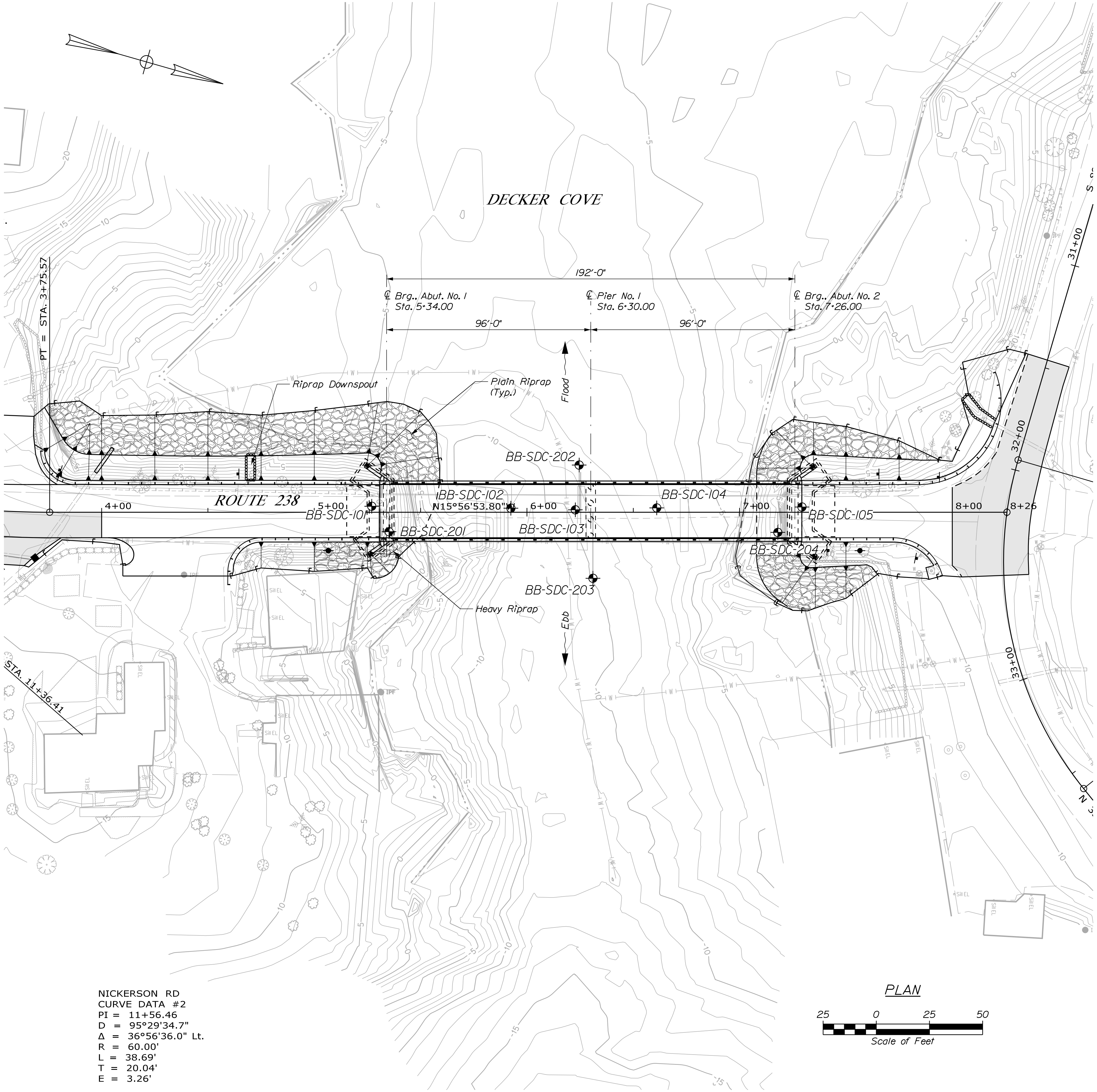
SHEET NUMBER

5

OF 43

Stantec

Filename: ...\00\BRIDGE\MSTA\006_BLP.DGN Division: BRIDGE Username: lflanders Date:2/27/2019



NOTES

1) Base map developed from electronic files provided by Stantec on August 16, 2016 (Files included 002_GeneralPlan.dgn, BDPLAN.dgn, contours.dgn, and 3DTopo_10aug16.dgn) and on January 24, 2019 (bridge.dgn).

2) The as drilled locations of the test borings were estimated by taping to existing bridge structural elements and should be considered approximate.

3) BB-SDC-100 series bridge borings were performed by New England Boring Contractors and observed by GZA personnel between May 24 and May 27, 2016.

4) BB-SDC-200 series bridge borings were performed by New England Boring Contractors and observed by GZA personnel between November 13, 2018 and December 27, 2018.

LEGEND

BB-SDC-204 Location and designation of cased wash boring

PLAN

25 0 25 50

Scale

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-1874(800)

WIN 18748.00

BRIDGE NO. 2848

BRIDGE PLANS

STATE OF MAINE Andrew R. Blaisdell 10957 LICENSED PROFESSIONAL ENGINEER

SIGNATURE

P.E. NUMBER 10957

DATE 02/21/2019

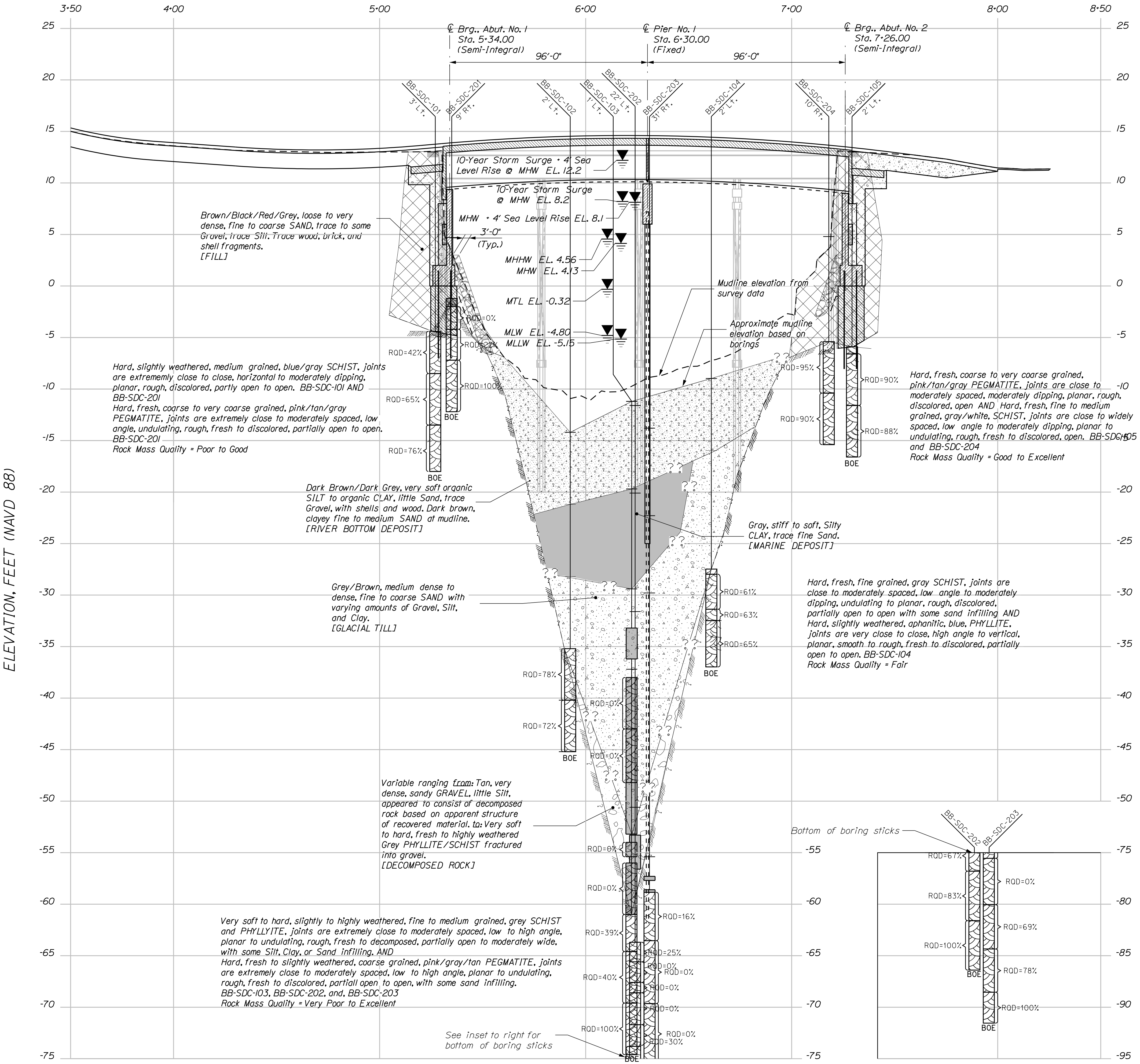
		BY	DATE
PROJ. MANAGER	L. TIMBERLAKE		
DESIGN-DETAILED		NVW	FEB 2019
CHECKED-REVIEWED		ARB	FEB 2019
DESIGN2-DETAILED2		NVW	
DESIGN3-DETAILED3		CLS	
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

THOMPSONS BRIDGE
DECKER COVE
SOUTHPORT LINCOLN COUNTY

BORING LOCATION PLAN

SHEET NUMBER 6 OF 43

PREPARED BY: GZA



NOTES

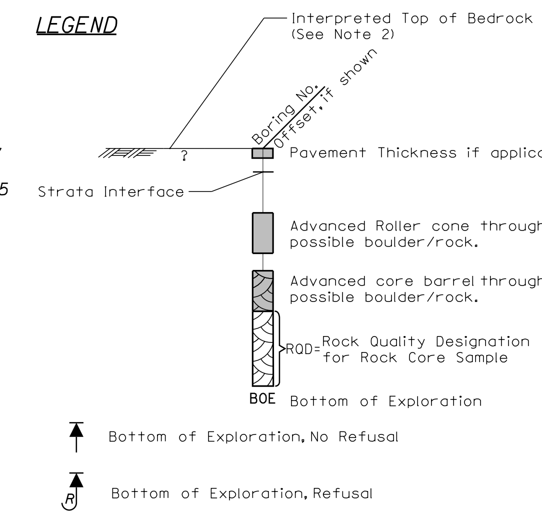
1) Base map developed from electronic files provided by Stantec on January 24, 2019 (Files included profiles.dgn).

2) The as drilled locations of the test borings were estimated by taping to existing bridge structural elements and should be considered approximate.

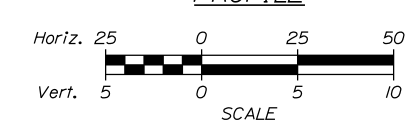
3) Interpreted top of rock considers general trend of ledge lines from 1933 plans between borings BB-SDC-101 and -102 and between borings BB-SDC-104 and -105.

4) This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

LEGEND



PROFILE



Thompson's Bridge #2848
Final Design H-H Report- NHI
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PREPARED BY: GZA

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-1874(800)

WIN 18748.00

BRIDGE PLANS

BRIDGE NO. 2848

STATE OF MAINE Andrew R. Blaisdell 10957 LICENSED PROFESSIONAL ENGINEER

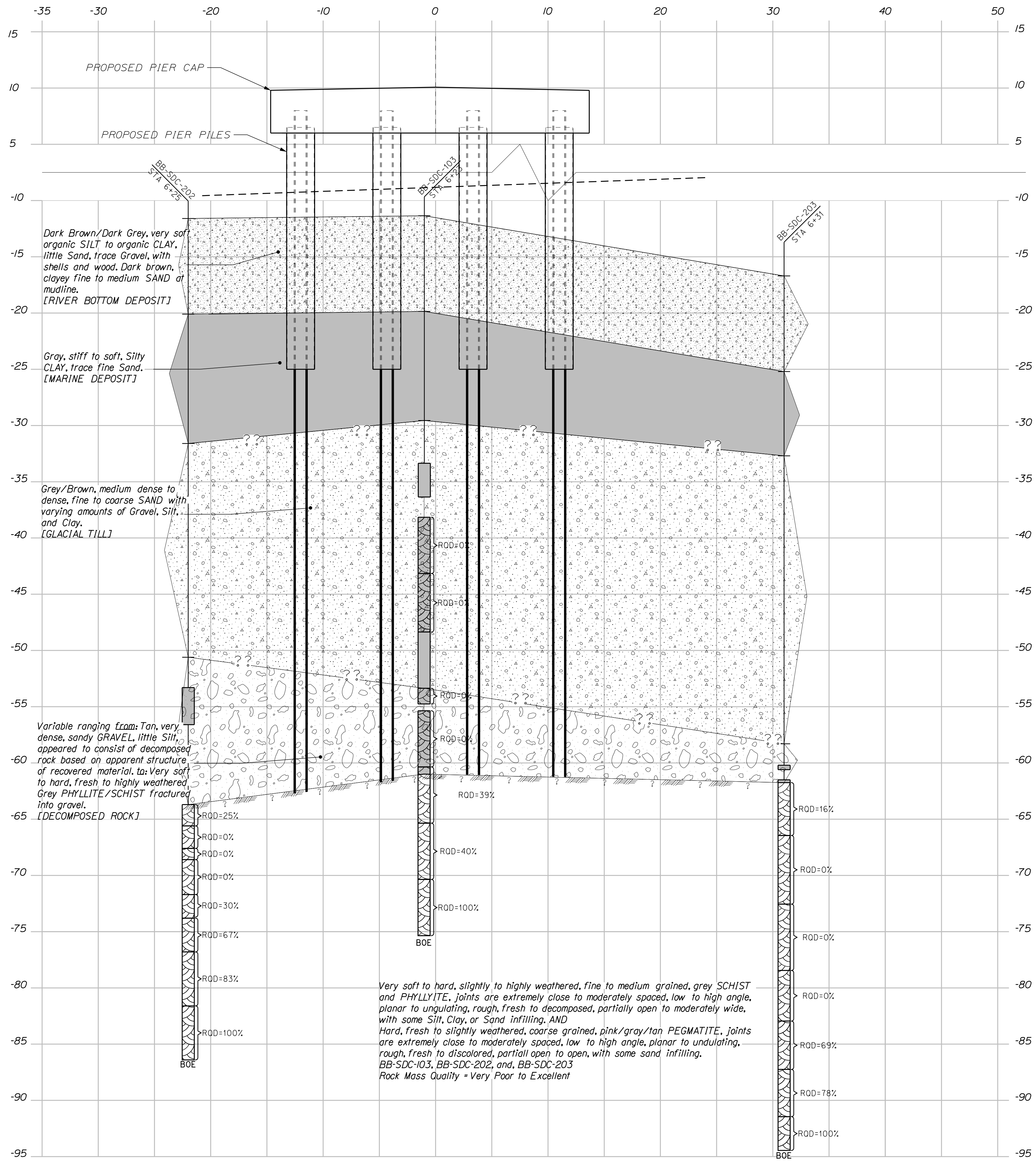
SIGNATURE 10957
P.E. NUMBER 02/21/2019
DATE

	BY	DATE
PROJ. MANAGER	L. TIMBERLAKE	
DESIGN-DETAILED	NVW	FEB 2019
CHECKED-REVIEWED	ARB	FEB 2019
DESIGN2-DETAILED2	CLS	FEB 2019
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

THOMPSONS BRIDGE
DECKER COVE
SOUTHPORT LINCOLN COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
7
OF 43

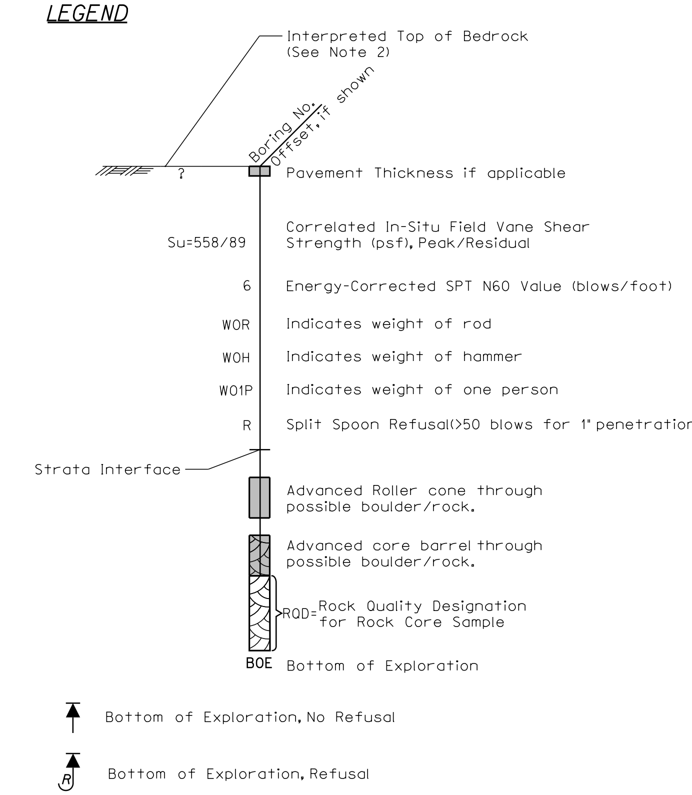


NOTES

1) The as drilled locations of the test borings were estimated by taping to existing bridge structural elements and should be considered approximate.

2) This generalized interpretive subsurface cross section is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

LEGEND



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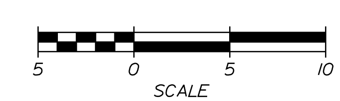


STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-1874(800)

WIN 18748.00

BRIDGE PLANS

BRIDGE NO. 2848

Andrew R. Blaisdell 10957 LICENSED PROFESSIONAL ENGINEER STATE OF MAINE

SIGNATURE

P.E. NUMBER 10957

DATE 02/21/2019

	BY	DATE
PROJ. MANAGER	L. TIMBERLAKE	
DESIGN-DETAILED	NVW	FEB 2019
CHECKED-REVIEWED	NVW	FEB 2019
DESIGN2-DETAILED2	ARB	
DESIGN3-DETAILED3	CLS	
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

THOMPSONS BRIDGE
DECKER COVE
SOUTHPORT LINCOLN COUNTY

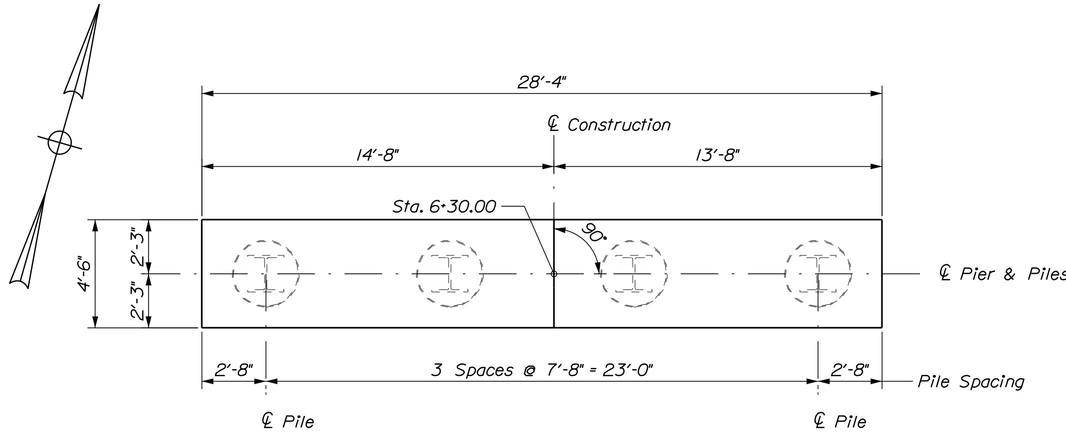
INTERPRETIVE SUBSURFACE CROSS SECTION

PREPARED BY: GZA

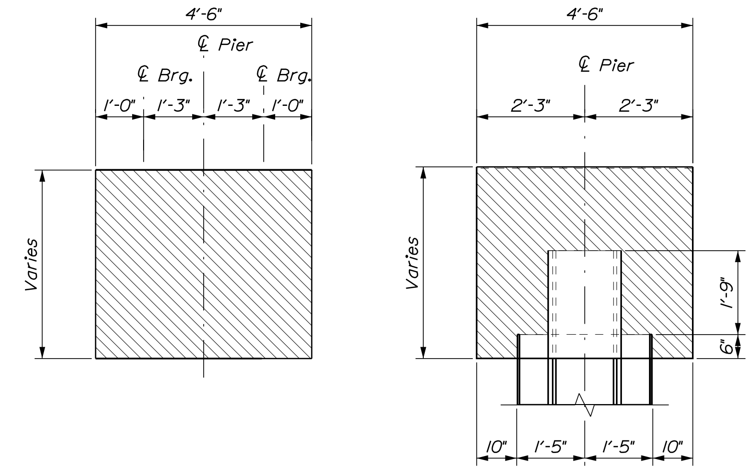
SHEET NUMBER 8 OF 43

Thompson's Bridge #2848
Final Design H-H Report- NHI
Appendix Page 16

Filename: ...\00\BRIDGE\MSTA\007_ISP.DGN Division: BRIDGE Username: lflanders Date:2/27/2019

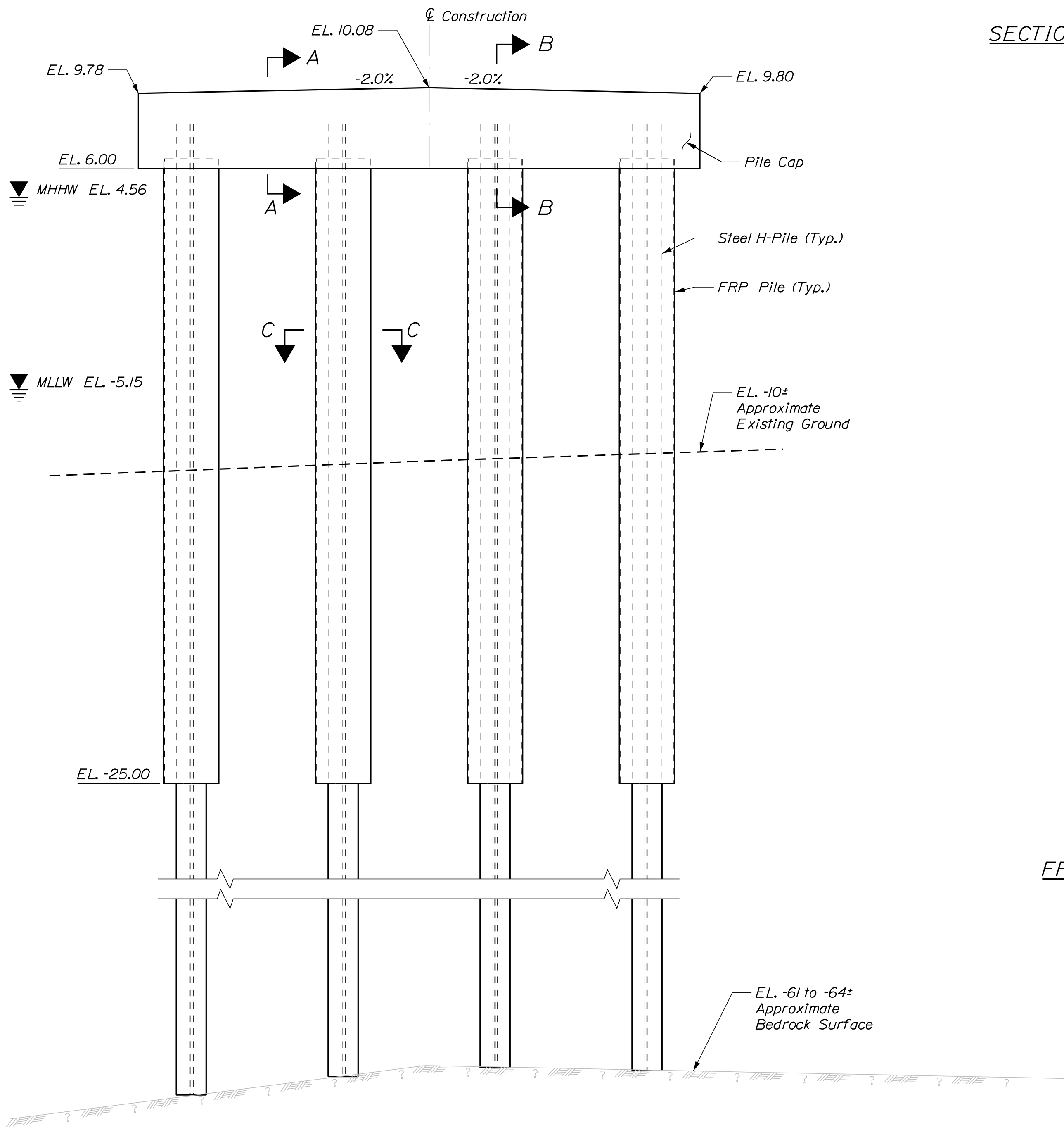


PLAN - PIER

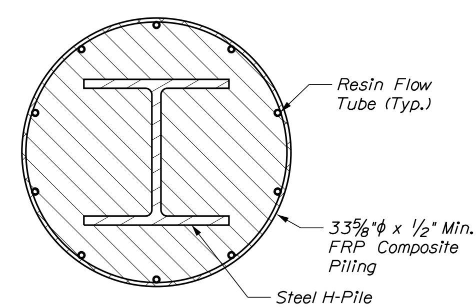


SECTION A-A

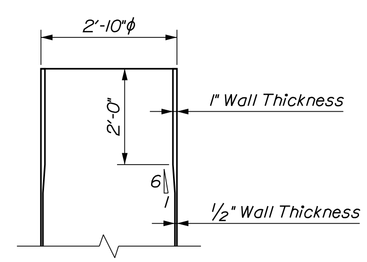
SECTION B-B



ELEVATION - PIER



SECTION C-C



FRP REINFORCED END DETAIL

(Typical top and bottom)

PIER NOTES

1. Reinforcing steel shall have a minimum concrete cover of 3 inches unless otherwise noted.

PILE NOTES

1. The maximum factored pile load is 600 kips.

2. H-pile material shall be ASTM A 572, Grade 50.

3. Estimate of piles required at the pier:
   4 ~ HP 18x204 @ 73 ft
   4 ~ 33⅝"φ (O.D.) x ½" FRP Casing @ 33.5 ft (Includes 2 ft sacrificial length at the top of the pile)

4. Piles shall not be out of position shown by more than 2 inches in any direction.

5. The order lengths of the piles shall include an additional 5 feet of length for the test pile to accommodate dynamic pile testing equipment. No additional payment will be made for additional pile length needed to accommodate dynamic pile testing equipment. The cost will be considered incidental to related Contract items.

6. The Contractor shall submit to the Department, for review and acceptance, their proposed pile driving equipment with a completed "Pile and Driving Equipment Data Form," Figure 1, of Standard Specification Section 501 - Foundation Piles. Approval of the proposed pile driving equipment by the Department will be based on Department-conducted wave equation analyses and the criteria specified in Section 501 and Subsection 501.042, Equipment for Driving Piles. If the Department-conducted wave equation analyses show that the proposed driving system(s) is unacceptable, the Contractor shall modify or replace the proposed driving equipment in an amendment of the QCP, at their own expense, until subsequent wave equation anlyses by the Department indicate that the pile can be driven to the required resistance, without damage or excessive blows.

7. The Contractor shall provide access for the agents of the Department to perform one (1) dynamic load test with signal matching and two (2) restrike tests as specified in Special Provision 501 - Dynamic Loading Test, to confirm the nominal geotechnical resistance of the H-piles. The dynamic pile load test will be completed on the first production pile driven and will include two (2) restrike tests: one (1) at 24-hour minimum and one (1) at 72-hour minimum. The required nominal resistance for the piles is the maximum factored axial pile load divided by a resistance factor equal to 0.65 per LRFD specifications. The Contractor may drive production piles to the preliminary driving criteria. However, pile cut-off will not be permitted until completion of restrike testing and establishment of final driving criteria.

8. The driving system shall be operating at efficiency greater than or equal to that used in the wave equation submittal. If the driving system is not operating at the required efficiency, as indicated by the approved wave equation analysis and/or dynamic load test result, the Contractor shall rebuild or replace driving system components in accordance with Standard Specification Section 501.

9. In preparation for dynamic H-pile tests, each test pile shall be installed with the tip elevation to approximately EL. -35.00 (into the Glacial Till layer). Dynamic pile test measurements shall be recorded for the remaining length of the driven test pile.

10. Holes shall be field-drilled in the top of the H-pile after installation to allow for placement of two reinforcing bars along the length of the pile cap. Payment shall be considered incidental to related Contract items.

Thompson's Bridge #2848
Final Design H-H Report- NHI
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Stantec

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-1874(800)

WIN
18748.00

BRIDGE PLANS

BRIDGE NO. 2848

PROJ. MANAGER	L. TIMBERLAKE	BY	DATE
DESIGN-DETAILED	LSF	KLW\LSF	FEB 2019
CHECKED-REVIEWED	DDT\PAG	DDT\WM	FEB 2019
DESIGN2-DETAILED2	PLP\LEM	PLP\LEM	FEB 2019
DESIGN3-DETAILED3			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

SIGNATURE

P.E. NUMBER

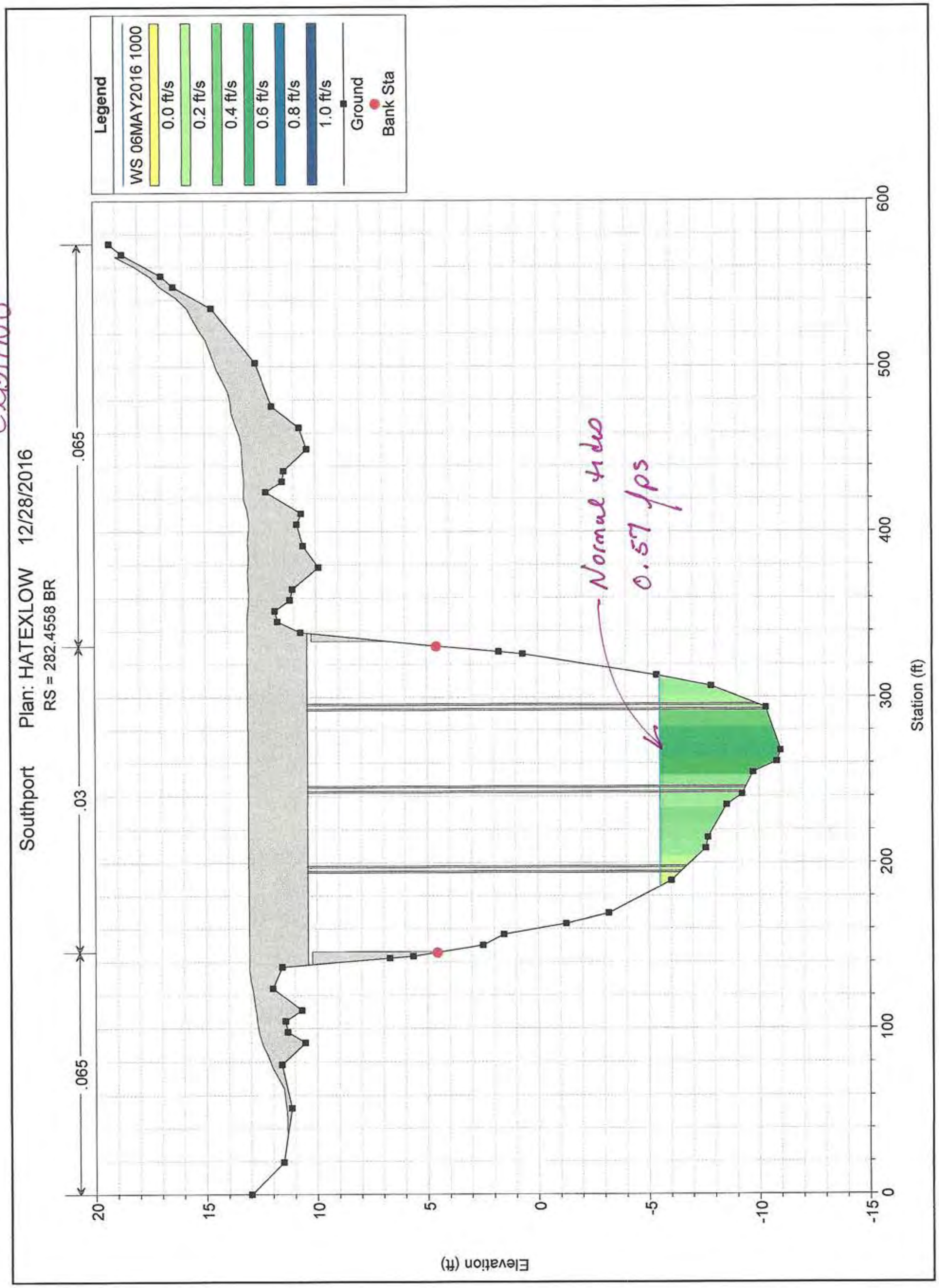
DATE

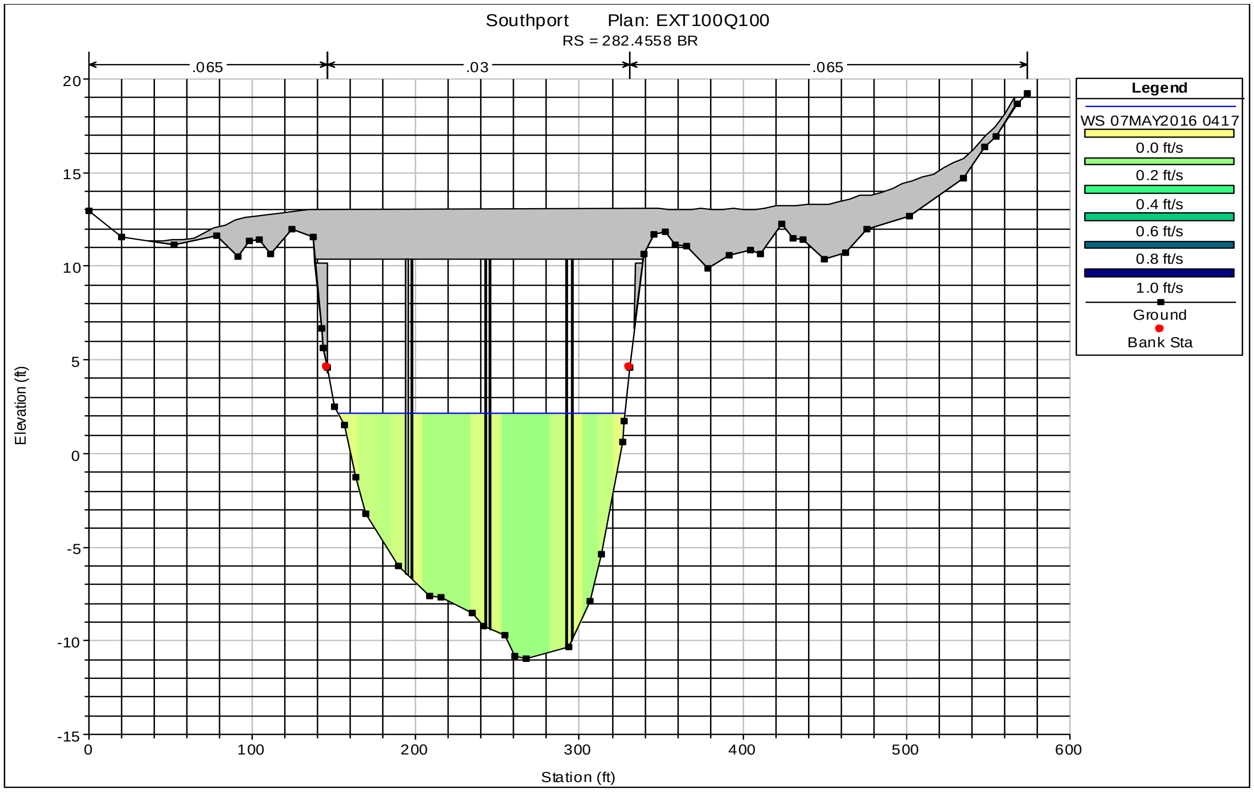
THOMPSONS BRIDGE
DECKER COVE
SOUTHPORT LINCOLN COUNTY

PIER PLAN & ELEVATION

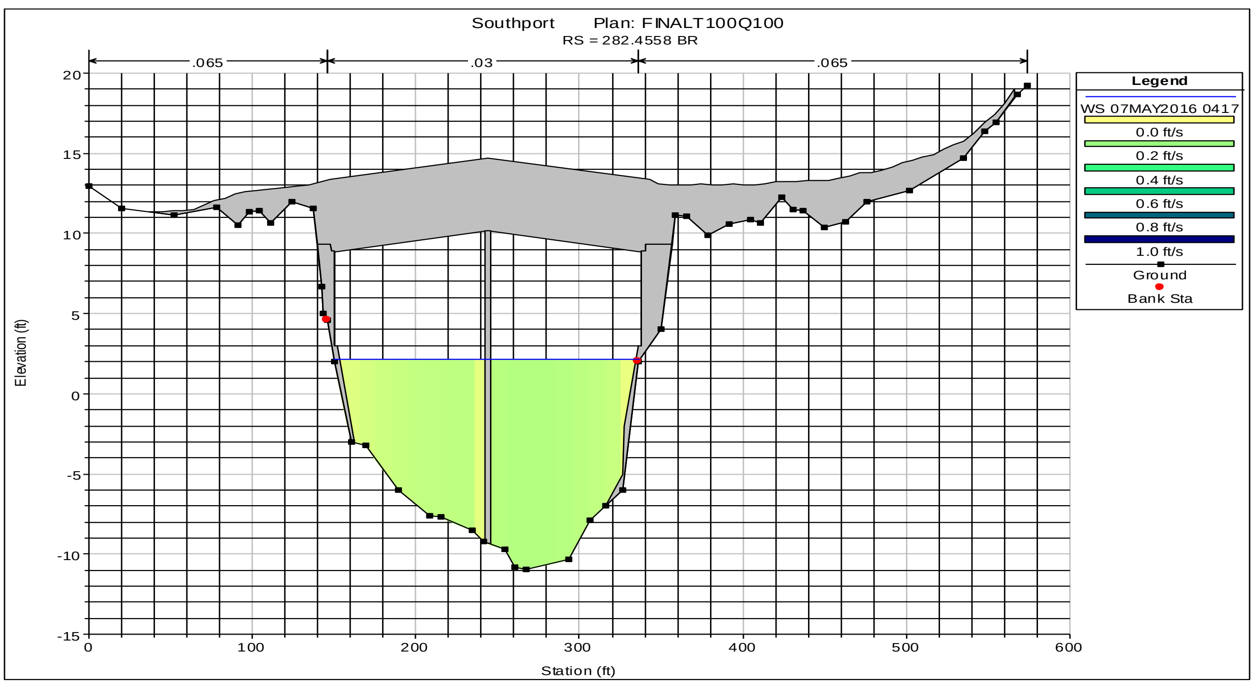
SHEET NUMBER
30
OF 43

Filename: ...\MSTA\030_pier_masonry.dgn
Division: BRIDGE
Username: lflanders
Date:2/27/2019

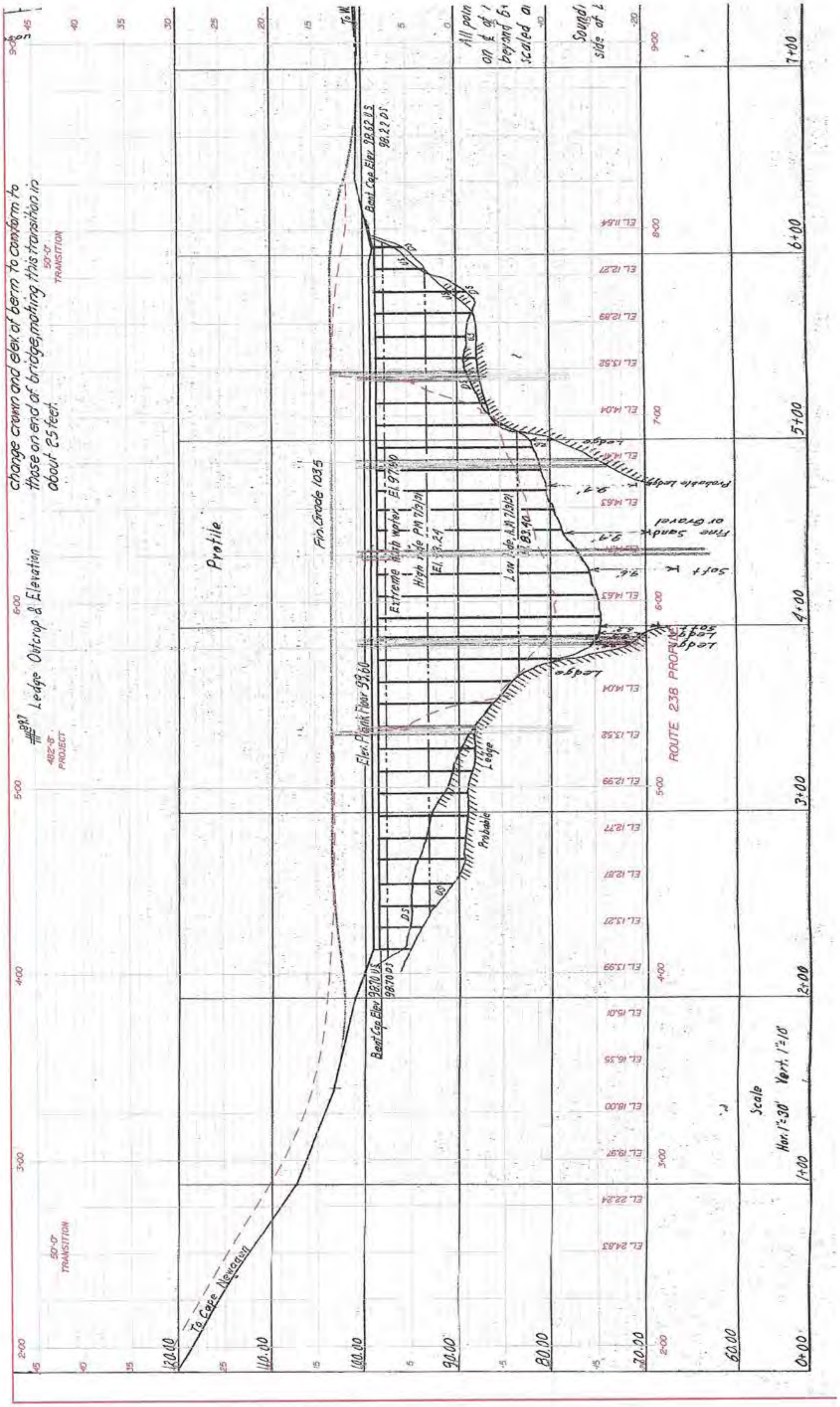

Existing
Southport Plan: HATEXLOW 12/28/2016
RS = 282.4558 BR
.065
.03
.065
Normal tide
0.57 fps
Legend
WS 06MAY2016 1000
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
20
15
10
5
0
-5
-10
-15
0
100
200
300
400
500
600



Existing Bridge, Velocity Distribution During falling limb of 100-year storm surge, Vmax = 0.2 fps



Proposed Bridge, Falling limb of 100-year tidal surge hydrograph, Maximum Velocity = 0.15 fps



change crown and elev of berm to conform to those on end of bridge, making this transition in about 25 feet.
Ledge Outcrop & Elevation
482-B PROJECT
50'-0" TRANSITION
Profile
Fin. Grade 103.5
Elev. Plank Floor 99.60
Extreme High water
Low Tide
Bent Cap Elev
To Cape Newagen
Probable Ledge
Ledge
Fine Sand or Gravel
Soft
ROUTE 238 PROFILE
Scale
Hor. 1"=30' Vert. 1"=10'
120.00
110.00
100.00
90.00
80.00
70.00
60.00
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00