# WIN 23657.00 TRACY BRIDGE (ROUTE 125/PINKHAM BROOK ROAD) OVER MEADOW BROOK, DURHAM, ANDROSCOGGIN COUNTY, MAINE

## HYDROLOGIC AND HYDRAULIC REPORT

July 2021

PREPARED FOR

**MAINEDOT**
16 State House Station
Augusta, ME 04333

PREPARED BY

**HNTB Corporation**
82 Running Hill Road
Suite 201
South Portland, ME 04106
Phone: (207) 775-5155

HNTB

## Table of Contents

## 1.0 Introduction

The existing Tracy Bridge carries Route 125 (Pinkham Brook Road) over Meadow Brook and is to be replaced and a portion of Meadow Brook is to be realigned. The existing bridge deck is located approximately 27' upstream of the confluence between Meadow Brook and the Androscoggin River. Figure 1 shows the bridge in aerial view.


**Figure 1: Existing Bridge**

The existing bridge spans over Meadow Brook with a total length of approximately 18' from abutment to abutment and has an out-to-out width of 25.50'. The existing structure features concrete abutments that are parallel to the streamflow. The low chord of elevation of the existing bridge is 81.17', and the existing structure has a hydraulic opening of 251.31 square feet.

The centerline of the roadway will be shifted approximately 16' upstream and will be widened compared to the existing structure, as a result the upstream fascia will extend approximately 35' further upstream. The proposed structure will have a total length of 75', a clear span of 62.48' perpendicular to streamflow and an out-to-out width of 35.40'. The structure will consist of 36" F-beams, topped with 8" Structural concrete and 1" of integral wearing surface. The low chord will be 82.91', approximately 1.74' higher than the existing bridge. The hydraulic opening will increase to 366.15 square feet. The proposed design also includes an upstream stream

realignment and surrounding bank regrade which was accounted for in the proposed model and is reflected in the cross sections presented in the Appendix.

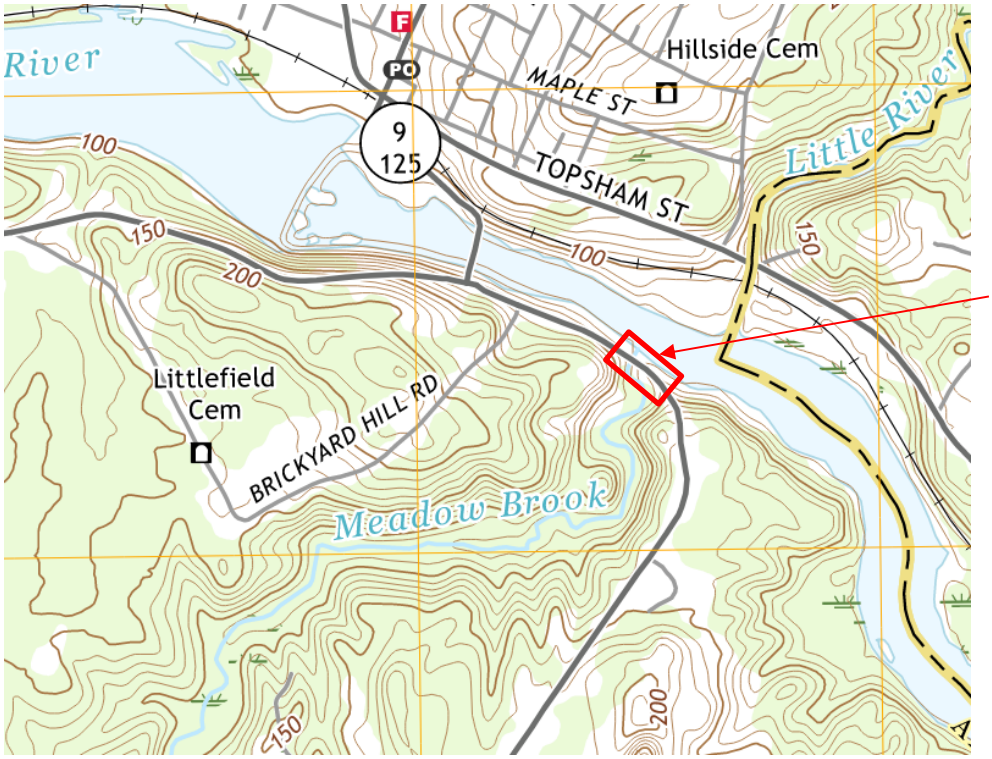



**Figure 2: Project Location**

The closest upstream structure is located approximately 1.78 miles upstream of the existing bridge. The Androscoggin River is located immediately downstream, and the water surface of the Androscoggin River directly impacts the water surface elevations at the existing bridge.

This report details hydrologic, hydraulic and scour elevations associated with the design of a replacement bridge for Tracy Bridge (Route 125/Pinkham Brook Road) over Meadow Brook. This design report specifically compares the proposed bridge's hydraulic conditions to the existing bridge's hydraulic conditions.

## 2.0 Review of Existing Data

Existing data was reviewed, including but not limited to:

- Androscoggin Flood Insurance Study by FEMA
- Historical Flood data published by USGS
- Topographic maps
- Existing bridge as-built plans

The low chord of the existing bridge was confirmed to be 81.17' using site photos and surveyed seat elevations. The flood profiles for the confluence between Meadow Brook and the Androscoggin River were taken from the most recent FEMA Flood Insurance Study (FIS) for Androscoggin County, Volume 2 of 3 (23001CV002A). The Flood profiles from said study showed the 100-year and 500-year events at water surface elevations of 83.50' and 89.80' respectively. This profile is included in the Appendix.

## 3.0 Hydrology

Flows for Meadow Brook were calculated using USGS Regression equations, and the drainage area for this project was determined to be 3.80 $mi^2$. The peak flow calculation sheets can be found in the Appendix D. The peak flow data used is summarized below in Table 1. Flows taken from the previously referenced FIS can also be found in Table 1 for comparison.

| Return Interval, years | Peak Flow (cfs) | FIS Flow (cfs) |
|---|---|---|
| 1.1 | 55.5 | --- |
| 10 | 216.9 | 197 |
| 25 | 284.5 | --- |
| 50 | 327.6 | 300 |
| 100 | 383.6 | 349 |
| 500 | 510.2 | 497 |

Table 1: Summary of Peak Flows

## 4.0 Hydraulics

U.S. Army Corps of Engineers' software HEC-RAS version 5.0.7 was used for the hydraulic modeling and analysis of both the existing Tracy Bridge and Meadow Brook, along with the proposed realigned Meadow Brook and redesigned Tracy Bridge. The boundary condition employed the use of known downstream water surface elevations, and the resultant data is displayed in Table 2. Due to no known water surface elevations for the 1.1 year design storm, the boundary conditions for this storm event were set to the normal depth boundary condition. The model was run in the sub-critical flow regime as it is necessary to run in subcritical for the known water surface elevation boundary condition. Ineffective flow areas were modeled due to the contraction and expansion of the bridge opening. Manning's coefficients of 0.04 and 0.075 were used for the channel and the overbanks respectively. These values were taken from the FEMA FIS 23001CV001A and the values can be found in Appendix C. For the bridge modeling approach, the energy method was used for the low flow condition and the pressure and/or weir method was used for the high flow condition. Please note that due to the redesign, the cross sections had to be cut twice for the model. Once along the existing stream alignment and once along the proposed realignment. Due to this the cross section labeled 112.72 in the existing model is homogenous with the cross section labeled 131.70 in the proposed model. It should also be noted that the Androscoggin River was not modeled during this analysis.

| **Summary of Hydraulic Data-Tracy Bridge over the Meadow Brook in Durham, Maine** | Existing Conditions (RS 112.72) | Proposed Conditions (RS 131.70) |
|---|---|---|
| Low Chord | 81.17 | 82.91 |
| Floodplain width at Q100, ft | 91.99 | 235.58 |
| Floodplain width at Q500, ft | 146.93 | 461.54 |
| Width at Banks, ft | 21.35 | 28.27 |
| Headwater Q10, ft | 77.72 | 77.72 |
| Headwater Q50, ft | 81.53 | 81.52 |
| Headwater Q100, ft | 83.54 | 83.52 |
| Headwater Q500, ft | 89.82 | 89.81 |
| Discharge Velocity Q10, fps | 0.83 | 0.69 |
| Discharge Velocity Q50, fps | 0.92 | 0.70 |
| Discharge Velocity Q100, fps | 0.94 | 0.65 |
| Discharge Velocity Q500, fps | 0.61 | 0.42 |
| Ordinary High-Water Elevation (Q1.1), ft | 68.10 | 68.45 |
| Discharge Velocity Q1.1, fps | 2.06 | 1.72 |
| Clearance at Q10, ft | 3.45 | 5.19 |
| Clearance at Q50, ft | 0.00 | 1.39 |
| Clearance at Q100, ft | 0.00 | 0.00 |
| Clearance at Q500, ft | 0.00 | 0.00 |
| Bridge Opening Area, $ft^2$ | 251.31 | 366.15 |
| Flow area at Q100, $ft^2$ | 409.69 | 1132.44 |
| Flow area at Q500, $ft^2$ | 1548.14 | 3057.99 |

Table 2: Hydraulic Analysis Summary with FEMA FIS Water Surface Elevations

Known water surface elevations of the Androscoggin River during storm events taken from the aforementioned FEMA FIS (23001CV002A) were used to examine the backwater effects which are the controlling water surface factor due to the proximity of the confluence between the Androscoggin River and Meadow Brook. The known water surface elevations are provided in Table 3. As can be seen in Table 2, the resultant water surface elevations from our model are nearly identical to the known water surface elevations presented in the FIS.

| Return Interval, years | Water Surface Elevation (ft) |
|---|---|
| 10 | 77.70 |
| 50 | 81.50 |
| 100 | 83.50 |
| 500 | 89.80 |

Table 3: Summary of Water Surface Elevations

## 5.0 Scour

A scour analysis was conducted using the resultant hydraulic data from the FEMA FIS Water surface elevation model. The $D_{50}$ of the streambed material was assumed to be approximately 0.03936 feet. The $D_{50}$ will be updated as soon as the geotechnical analysis is completed. It was determined that for the 100-year storm the near abutment had 5.78 feet of total scour and the far abutment had 3.13 feet of scour. For the 500-year storm the near abutment had 3.38 feet of scour and the far abutment had 8.65 feet of scour.

| | **100 - year storm** | |
|---|---|---|
| | Abutment 1 | Abutment 2 |
| Aggradation/ Degradation (ft) | 0.00 | 0.00 |
| Contraction/Expansion Scour (ft) | 0.00 | 0.00 |
| Local Scour (ft) | 5.78 | 3.13 |
| Pressure Flow Scour (ft) | 7.16 | 7.16 |
| ***TOTAL SCOUR (ft)*** | ***12.94*** | ***10.29*** |

| | **500-year storm** | |
|---|---|---|
| | Abutment 1 | Abutment 2 |
| Aggradation/ Degradation (ft) | 0.00 | 0.00 |
| Contraction/Expansion Scour (ft) | 0.00 | 0.00 |
| Local Scour (ft) | 3.38 | 8.65 |
| Pressure Flow Scour (ft) | 6.18 | 6.18 |
| ***TOTAL SCOUR (ft)*** | ***9.56*** | ***14.83*** |

Table 4: Scour Executive Summary Table

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

## 6.0 Summary

The existing Tracy bridge carrying Pinkham Brook Road over Meadow Brook is to be replaced and a portion of Meadow Brook is to be realigned. The existing bridge deck is located 27' upstream of the confluence between Meadow Brook and the Androscoggin River. The proposed bridge provides a greater hydraulic opening while maintaining the existing water surface elevations. The proposed bridge also provides greater clearance.

# Appendix A
## HEC-RAS Analysis

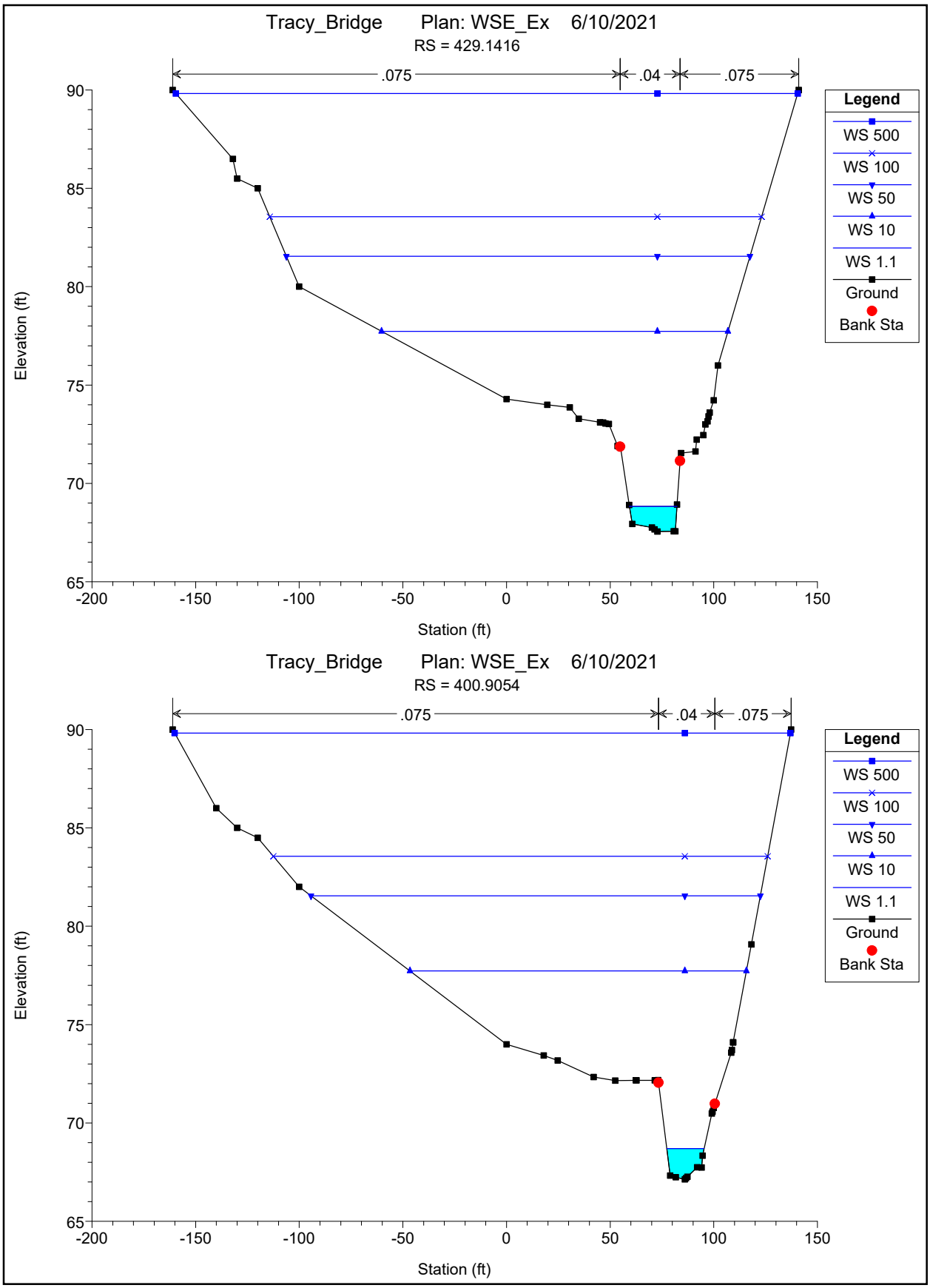
# Existing HEC-RAS

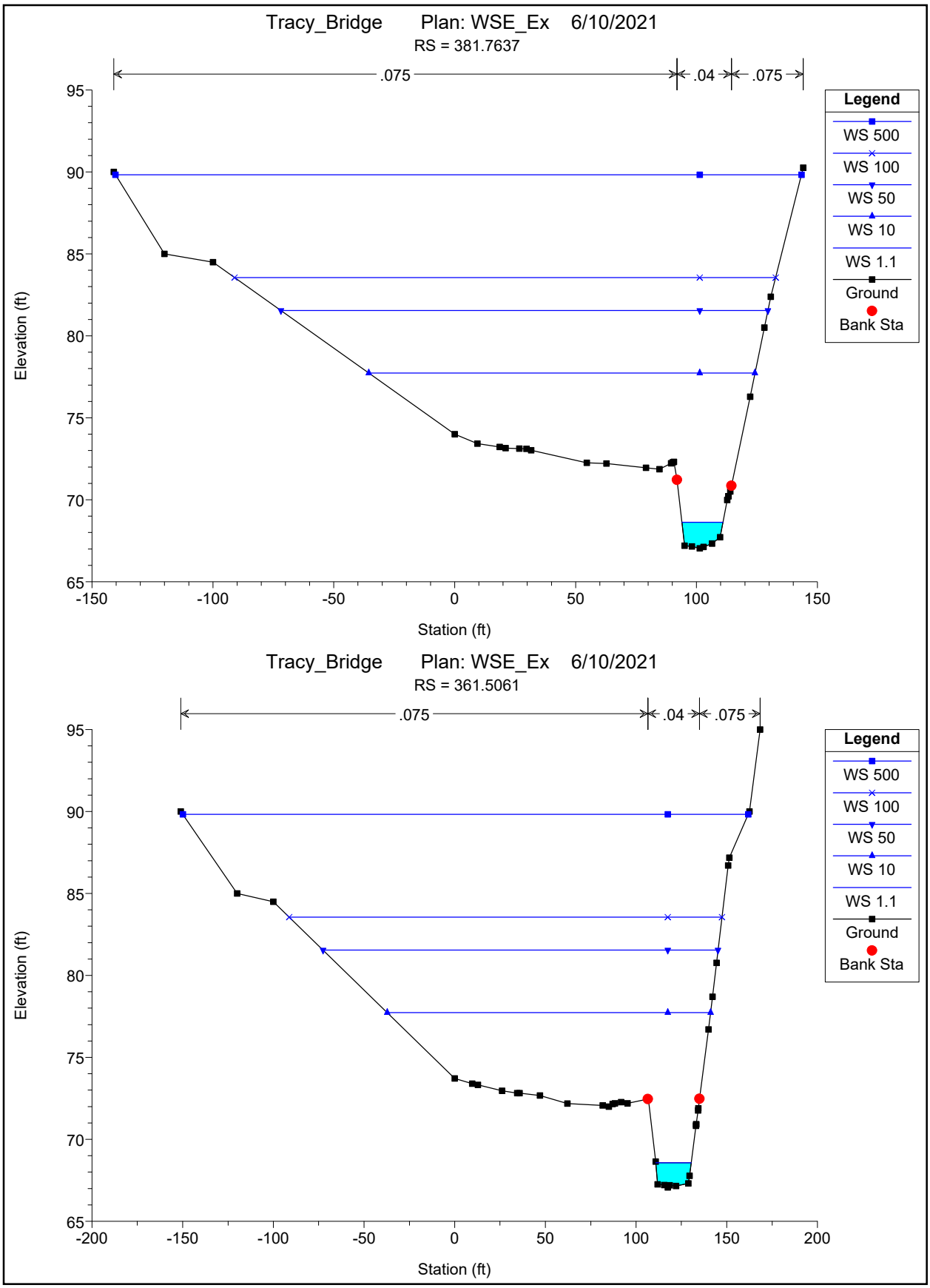
HEC-RAS Plan: WSE-EX River: Meadow_Brook Reach: Meadow_Brook

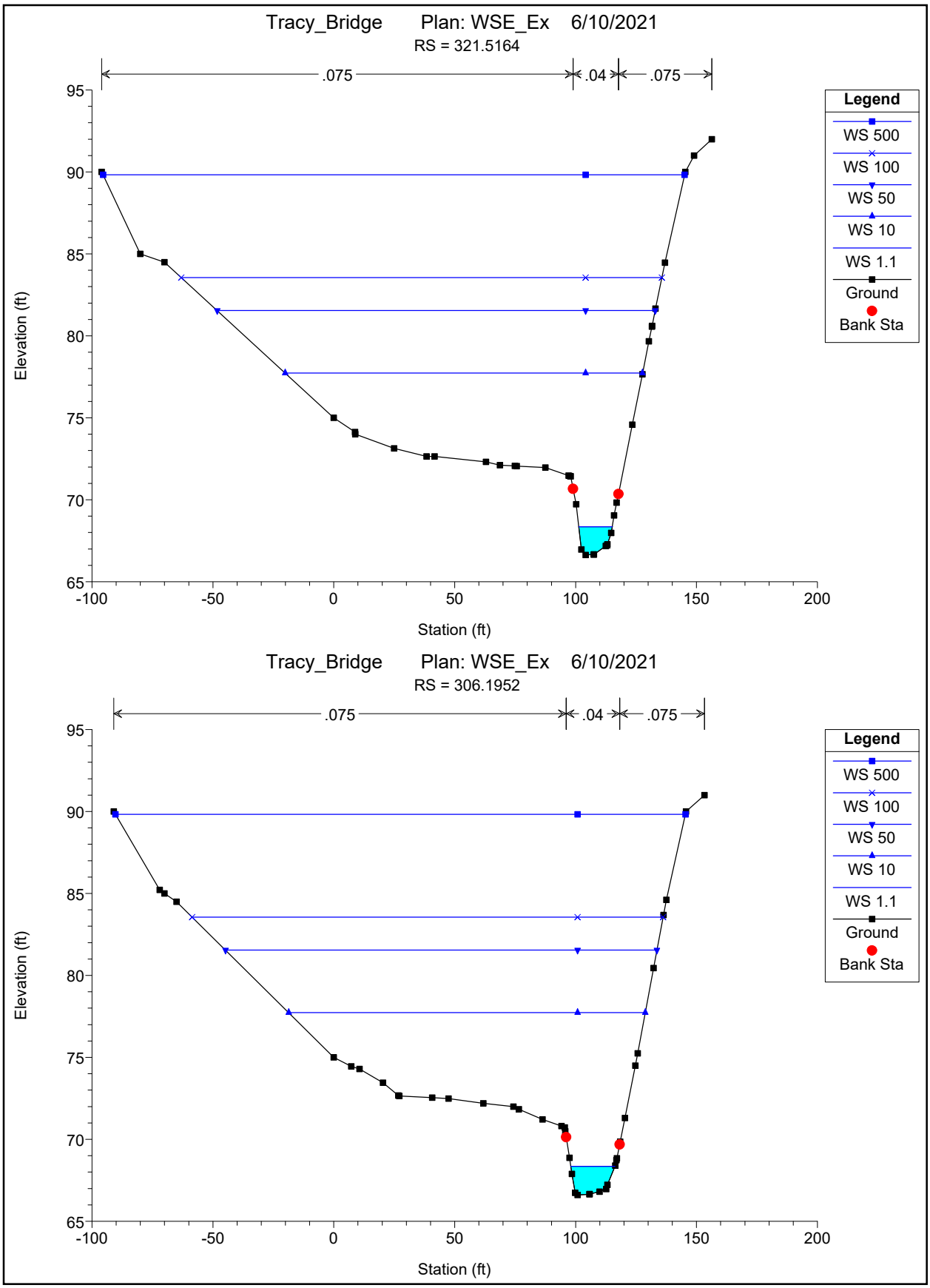
| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Meadow_Brook | 429.1416 | 1.1 | 55.50 | 67.55 | 68.83 | | 68.91 | 0.003623 | 2.27 | 24.44 | 22.90 | 0.39 |
| Meadow_Brook | 429.1416 | 10 | 216.90 | 67.55 | 77.73 | | 77.73 | 0.000013 | 0.56 | 700.38 | 167.12 | 0.03 |
| Meadow_Brook | 429.1416 | 50 | 327.60 | 67.55 | 81.54 | | 81.55 | 0.000005 | 0.45 | 1469.28 | 223.62 | 0.02 |
| Meadow_Brook | 429.1416 | 100 | 383.60 | 67.55 | 83.56 | | 83.56 | 0.000004 | 0.40 | 1933.75 | 237.30 | 0.02 |
| Meadow_Brook | 429.1416 | 500 | 510.20 | 67.55 | 89.83 | | 89.83 | 0.000001 | 0.30 | 3606.46 | 300.06 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 400.9054 | 1.1 | 55.50 | 67.13 | 68.70 | | 68.80 | 0.004038 | 2.57 | 21.58 | 18.03 | 0.41 |
| Meadow_Brook | 400.9054 | 10 | 216.90 | 67.13 | 77.73 | | 77.73 | 0.000012 | 0.53 | 761.13 | 162.35 | 0.03 |
| Meadow_Brook | 400.9054 | 50 | 327.60 | 67.13 | 81.54 | | 81.55 | 0.000005 | 0.45 | 1484.13 | 216.74 | 0.02 |
| Meadow_Brook | 400.9054 | 100 | 383.60 | 67.13 | 83.56 | | 83.56 | 0.000004 | 0.41 | 1944.43 | 238.46 | 0.02 |
| Meadow_Brook | 400.9054 | 500 | 510.20 | 67.13 | 89.83 | | 89.83 | 0.000001 | 0.30 | 3649.17 | 297.09 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 381.7637 | 1.1 | 55.50 | 67.04 | 68.62 | | 68.72 | 0.003788 | 2.58 | 21.51 | 16.92 | 0.40 |
| Meadow_Brook | 381.7637 | 10 | 216.90 | 67.04 | 77.73 | | 77.73 | 0.000012 | 0.54 | 785.65 | 159.69 | 0.03 |
| Meadow_Brook | 381.7637 | 50 | 327.60 | 67.04 | 81.54 | | 81.55 | 0.000005 | 0.46 | 1474.32 | 201.39 | 0.02 |
| Meadow_Brook | 381.7637 | 100 | 383.60 | 67.04 | 83.56 | | 83.56 | 0.000004 | 0.42 | 1902.59 | 223.77 | 0.02 |
| Meadow_Brook | 381.7637 | 500 | 510.20 | 67.04 | 89.83 | | 89.83 | 0.000001 | 0.31 | 3540.54 | 283.69 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 361.5061 | 1.1 | 55.50 | 67.07 | 68.57 | | 68.65 | 0.002807 | 2.23 | 24.89 | 19.56 | 0.35 |
| Meadow_Brook | 361.5061 | 10 | 216.90 | 67.07 | 77.73 | | 77.73 | 0.000009 | 0.45 | 903.43 | 178.34 | 0.03 |
| Meadow_Brook | 361.5061 | 50 | 327.60 | 67.07 | 81.54 | | 81.55 | 0.000004 | 0.38 | 1658.91 | 217.80 | 0.02 |
| Meadow_Brook | 361.5061 | 100 | 383.60 | 67.07 | 83.56 | | 83.56 | 0.000003 | 0.36 | 2118.88 | 238.66 | 0.02 |
| Meadow_Brook | 361.5061 | 500 | 510.20 | 67.07 | 89.83 | | 89.83 | 0.000001 | 0.27 | 3870.08 | 311.78 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 321.5164 | 1.1 | 55.50 | 66.64 | 68.36 | | 68.50 | 0.004978 | 3.01 | 18.41 | 13.87 | 0.46 |
| Meadow_Brook | 321.5164 | 10 | 216.90 | 66.64 | 77.73 | | 77.73 | 0.000013 | 0.58 | 749.58 | 147.80 | 0.03 |
| Meadow_Brook | 321.5164 | 50 | 327.60 | 66.64 | 81.54 | | 81.55 | 0.000006 | 0.49 | 1376.93 | 181.11 | 0.02 |
| Meadow_Brook | 321.5164 | 100 | 383.60 | 66.64 | 83.56 | | 83.56 | 0.000005 | 0.46 | 1759.75 | 198.76 | 0.02 |
| Meadow_Brook | 321.5164 | 500 | 510.20 | 66.64 | 89.82 | | 89.83 | 0.000002 | 0.34 | 3162.48 | 240.52 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 306.1952 | 1.1 | 55.50 | 66.61 | 68.35 | | 68.42 | 0.002594 | 2.24 | 24.75 | 18.30 | 0.34 |
| Meadow_Brook | 306.1952 | 10 | 216.90 | 66.61 | 77.73 | | 77.73 | 0.000010 | 0.53 | 793.08 | 147.47 | 0.03 |
| Meadow_Brook | 306.1952 | 50 | 327.60 | 66.61 | 81.54 | | 81.54 | 0.000005 | 0.47 | 1414.71 | 178.42 | 0.02 |
| Meadow_Brook | 306.1952 | 100 | 383.60 | 66.61 | 83.56 | | 83.56 | 0.000004 | 0.44 | 1790.78 | 194.77 | 0.02 |
| Meadow_Brook | 306.1952 | 500 | 510.20 | 66.61 | 89.82 | | 89.83 | 0.000001 | 0.34 | 3153.84 | 235.73 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 286.9647 | 1.1 | 55.50 | 66.23 | 68.36 | | 68.39 | 0.000540 | 1.22 | 45.52 | 25.66 | 0.16 |
| Meadow_Brook | 286.9647 | 10 | 216.90 | 66.23 | 77.73 | | 77.73 | 0.000008 | 0.46 | 807.23 | 144.14 | 0.02 |
| Meadow_Brook | 286.9647 | 50 | 327.60 | 66.23 | 81.54 | | 81.54 | 0.000004 | 0.43 | 1419.88 | 177.05 | 0.02 |
| Meadow_Brook | 286.9647 | 100 | 383.60 | 66.23 | 83.56 | | 83.56 | 0.000003 | 0.41 | 1794.25 | 194.44 | 0.02 |
| Meadow_Brook | 286.9647 | 500 | 510.20 | 66.23 | 89.82 | | 89.83 | 0.000001 | 0.32 | 3186.36 | 253.43 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 265.7286 | 1.1 | 55.50 | 66.07 | 68.32 | | 68.37 | 0.001089 | 1.71 | 32.49 | 18.11 | 0.22 |
| Meadow_Brook | 265.7286 | 10 | 216.90 | 66.07 | 77.73 | | 77.73 | 0.000012 | 0.57 | 708.31 | 134.05 | 0.03 |
| Meadow_Brook | 265.7286 | 50 | 327.60 | 66.07 | 81.54 | | 81.54 | 0.000006 | 0.50 | 1280.87 | 166.08 | 0.02 |
| Meadow_Brook | 265.7286 | 100 | 383.60 | 66.07 | 83.56 | | 83.56 | 0.000005 | 0.47 | 1632.69 | 183.10 | 0.02 |
| Meadow_Brook | 265.7286 | 500 | 510.20 | 66.07 | 89.82 | | 89.83 | 0.000002 | 0.36 | 2936.45 | 222.67 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 225.3258 | 1.1 | 55.50 | 66.55 | 68.24 | | 68.31 | 0.002118 | 2.06 | 26.95 | 19.26 | 0.31 |
| Meadow_Brook | 225.3258 | 10 | 216.90 | 66.55 | 77.73 | | 77.73 | 0.000013 | 0.57 | 642.76 | 119.92 | 0.03 |
| Meadow_Brook | 225.3258 | 50 | 327.60 | 66.55 | 81.54 | | 81.54 | 0.000007 | 0.52 | 1165.13 | 153.65 | 0.02 |
| Meadow_Brook | 225.3258 | 100 | 383.60 | 66.55 | 83.56 | | 83.56 | 0.000005 | 0.49 | 1494.42 | 173.25 | 0.02 |
| Meadow_Brook | 225.3258 | 500 | 510.20 | 66.55 | 89.82 | | 89.83 | 0.000002 | 0.37 | 2690.86 | 208.84 | 0.01 |
| | | | | | | | | | | | | |
| Meadow_Brook | 195.1151 | 1.1 | 55.50 | 66.12 | 68.22 | | 68.26 | 0.000918 | 1.53 | 36.33 | 21.99 | 0.21 |
| Meadow_Brook | 195.1151 | 10 | 216.90 | 66.12 | 77.73 | | 77.73 | 0.000010 | 0.55 | 614.85 | 96.69 | 0.03 |
| Meadow_Brook | 195.1151 | 50 | 327.60 | 66.12 | 81.54 | | 81.54 | 0.000007 | 0.54 | 1032.04 | 123.39 | 0.03 |
| Meadow_Brook | 195.1151 | 100 | 383.60 | 66.12 | 83.56 | | 83.56 | 0.000006 | 0.54 | 1303.02 | 149.80 | 0.02 |
| Meadow_Brook | 195.1151 | 500 | 510.20 | 66.12 | 89.82 | | 89.83 | 0.000002 | 0.42 | 2460.54 | 208.73 | 0.02 |
| | | | | | | | | | | | | |
| Meadow_Brook | 171.7323 | 1.1 | 55.50 | 65.30 | 68.22 | | 68.24 | 0.000358 | 1.07 | 51.89 | 26.29 | 0.13 |
| Meadow_Brook | 171.7323 | 10 | 216.90 | 65.30 | 77.72 | | 77.73 | 0.000011 | 0.58 | 493.55 | 72.81 | 0.03 |
| Meadow_Brook | 171.7323 | 50 | 327.60 | 65.30 | 81.54 | | 81.54 | 0.000008 | 0.59 | 814.47 | 94.55 | 0.03 |
| Meadow_Brook | 171.7323 | 100 | 383.60 | 65.30 | 83.56 | | 83.56 | 0.000007 | 0.59 | 1016.76 | 109.86 | 0.03 |
| Meadow_Brook | 171.7323 | 500 | 510.20 | 65.30 | 89.82 | | 89.83 | 0.000003 | 0.49 | 1877.70 | 160.29 | 0.02 |
| | | | | | | | | | | | | |
| Meadow_Brook | 151.9101 | 1.1 | 55.50 | 65.39 | 68.19 | 66.89 | 68.23 | 0.001037 | 1.67 | 33.14 | 18.86 | 0.22 |
| Meadow_Brook | 151.9101 | 10 | 216.90 | 65.39 | 77.72 | 68.01 | 77.73 | 0.000021 | 0.78 | 320.14 | 69.19 | 0.04 |
| Meadow_Brook | 151.9101 | 50 | 327.60 | 65.39 | 81.53 | 68.56 | 81.54 | 0.000016 | 0.84 | 455.18 | 87.72 | 0.04 |
| Meadow_Brook | 151.9101 | 100 | 383.60 | 65.39 | 83.55 | 68.82 | 83.56 | 0.000014 | 0.85 | 526.53 | 94.78 | 0.04 |
| Meadow_Brook | 151.9101 | 500 | 510.20 | 65.39 | 89.82 | 69.30 | 89.83 | 0.000004 | 0.56 | 1737.17 | 164.22 | 0.02 |
| | | | | | | | | | | | | |
| Meadow_Brook | 112.7206 | 1.1 | 55.50 | 66.32 | 68.10 | 67.32 | 68.17 | 0.002209 | 2.06 | 26.95 | 20.19 | 0.31 |
| Meadow_Brook | 112.7206 | 10 | 216.90 | 66.32 | 77.72 | 68.32 | 77.73 | 0.000025 | 0.83 | 262.79 | 55.25 | 0.05 |
| Meadow_Brook | 112.7206 | 50 | 327.60 | 66.32 | 81.53 | 68.82 | 81.54 | 0.000020 | 0.92 | 358.90 | 71.31 | 0.04 |
| Meadow_Brook | 112.7206 | 100 | 383.60 | 66.32 | 83.54 | 69.03 | 83.56 | 0.000018 | 0.94 | 409.69 | 91.99 | 0.04 |
| Meadow_Brook | 112.7206 | 500 | 510.20 | 66.32 | 89.82 | 69.48 | 89.82 | 0.000005 | 0.61 | 1548.14 | 146.93 | 0.02 |
| | | | | | | | | | | | | |
| Meadow_Brook | 80.1124 | 1.1 | 55.50 | 66.13 | 67.87 | 67.43 | 68.04 | 0.006942 | 3.32 | 16.74 | 14.33 | 0.54 |
| Meadow_Brook | 80.1124 | 10 | 216.90 | 66.13 | 77.71 | 68.66 | 77.73 | 0.000040 | 1.07 | 203.47 | 48.38 | 0.06 |
| Meadow_Brook | 80.1124 | 50 | 327.60 | 66.13 | 81.52 | 69.24 | 81.54 | 0.000033 | 1.18 | 277.47 | 59.53 | 0.06 |

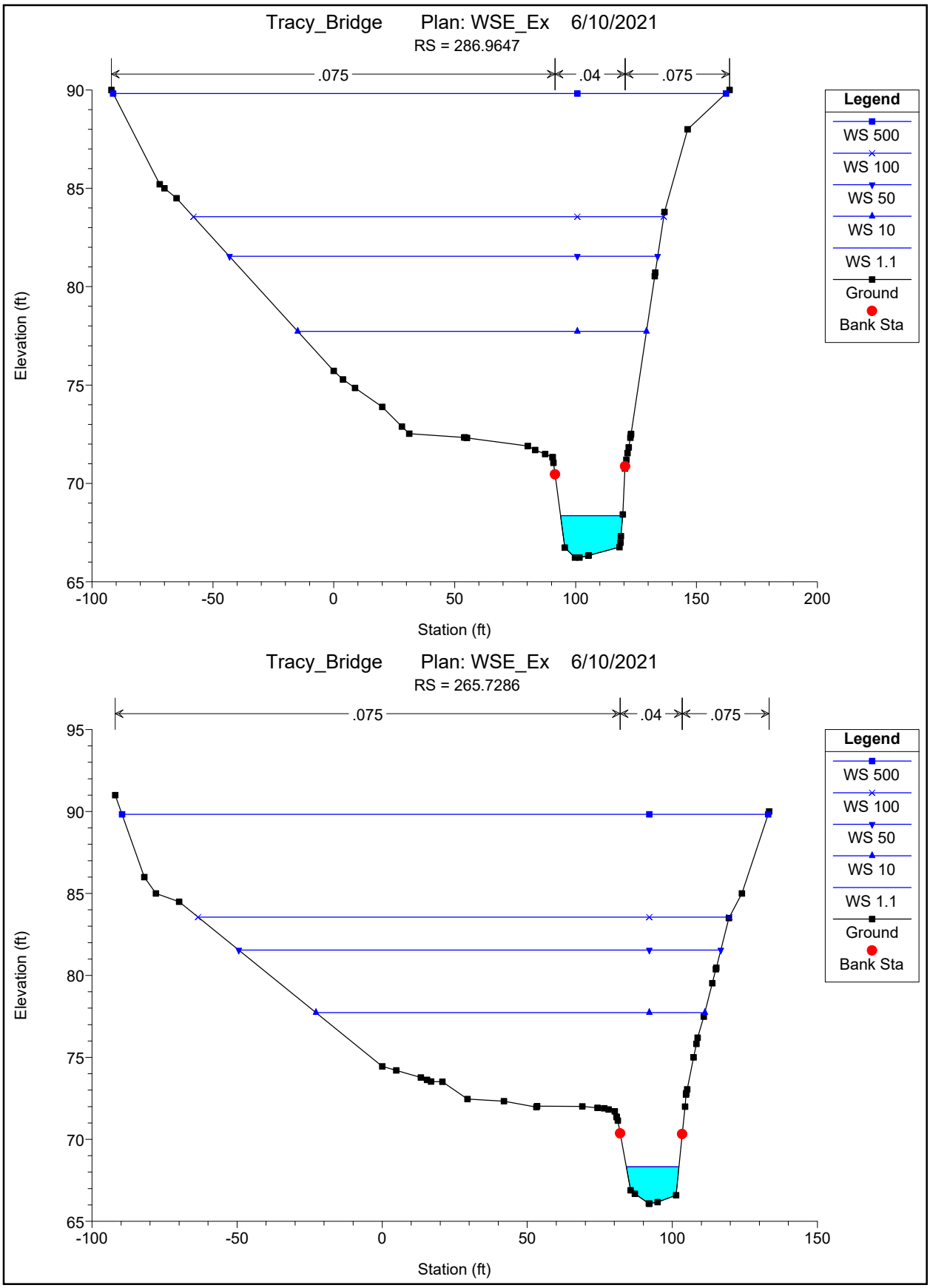
HEC-RAS Plan: WSE-EX River: Meadow_Brook Reach: Meadow_Brook (Continued)

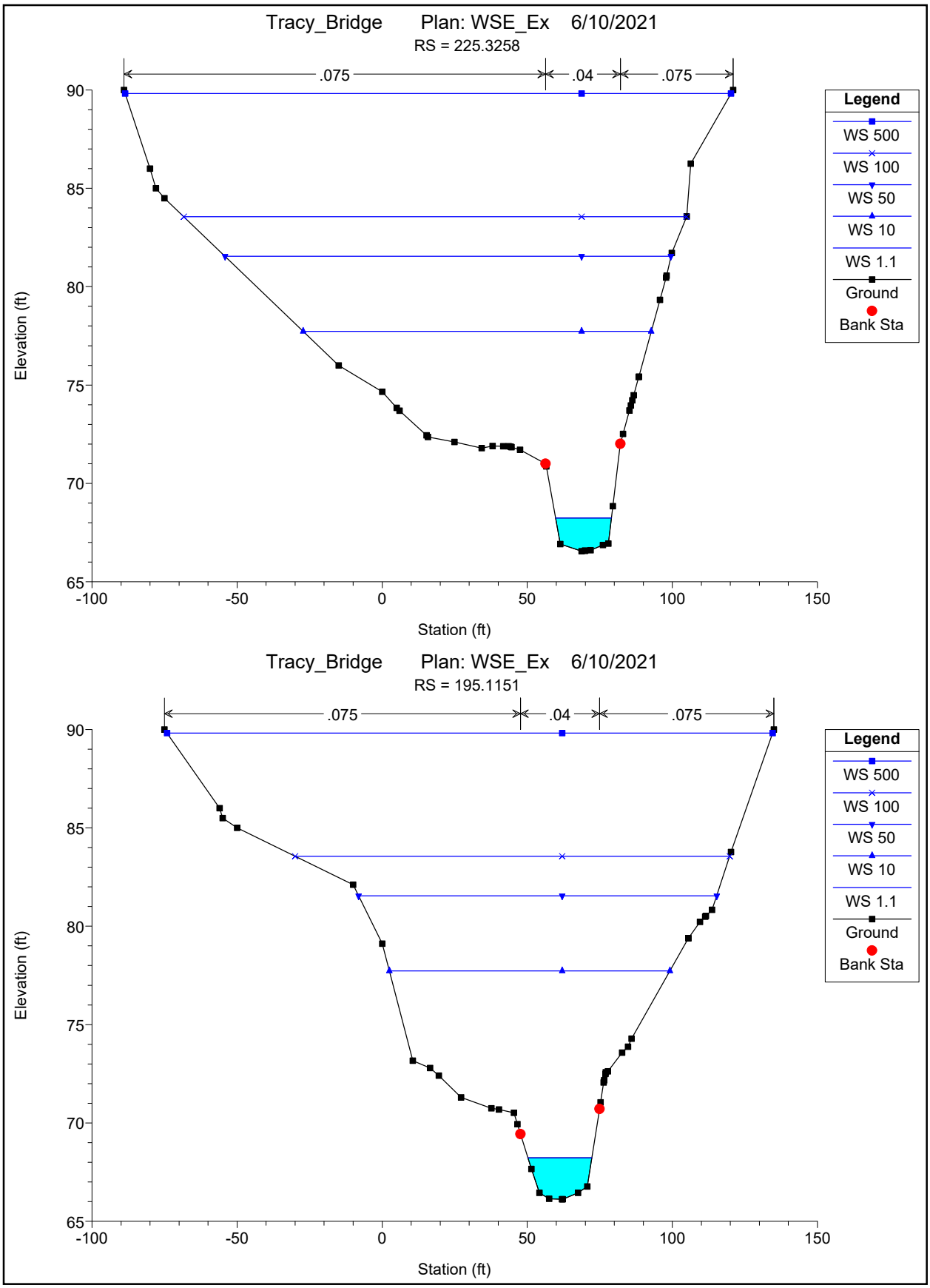
| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Meadow_Brook | 80.1124 | 100 | 383.60 | 66.13 | 83.53 | 69.49 | 83.56 | 0.000029 | 1.21 | 316.59 | 79.26 | 0.05 |
| Meadow_Brook | 80.1124 | 500 | 510.20 | 66.13 | 89.82 | 70.01 | 89.82 | 0.000006 | 0.69 | 1642.33 | 232.97 | 0.03 |
| | | | | | | | | | | | | |
| Meadow_Brook | 68.2341 | 1.1 | 55.50 | 65.93 | 67.81 | 67.25 | 67.96 | 0.005000 | 3.07 | 18.08 | 15.61 | 0.48 |
| Meadow_Brook | 68.2341 | 10 | 216.90 | 65.93 | 77.70 | 68.50 | 77.72 | 0.000045 | 1.18 | 195.28 | 41.48 | 0.06 |
| Meadow_Brook | 68.2341 | 50 | 327.60 | 65.93 | 81.51 | 69.10 | 81.54 | 0.000038 | 1.31 | 267.36 | 50.31 | 0.06 |
| Meadow_Brook | 68.2341 | 100 | 383.60 | 65.93 | 83.53 | 69.38 | 83.55 | 0.000033 | 1.34 | 305.47 | 70.46 | 0.06 |
| Meadow_Brook | 68.2341 | 500 | 510.20 | 65.93 | 89.82 | 69.93 | 89.82 | 0.000006 | 0.69 | 1582.34 | 239.39 | 0.03 |
| | | | | | | | | | | | | |
| Meadow_Brook | 35.30 | | Bridge | | | | | | | | | |
| | | | | | | | | | | | | |
| Meadow_Brook | 14.2816 | 1.1 | 55.50 | 64.89 | 66.41 | 66.26 | 66.73 | 0.016656 | 4.49 | 12.35 | 12.69 | 0.80 |
| Meadow_Brook | 14.2816 | 10 | 216.90 | 64.89 | 77.70 | 67.53 | 77.72 | 0.000075 | 1.19 | 191.26 | 23.98 | 0.06 |
| Meadow_Brook | 14.2816 | 50 | 327.60 | 64.89 | 81.50 | 68.14 | 81.52 | 0.000065 | 1.34 | 263.08 | 40.62 | 0.06 |
| Meadow_Brook | 14.2816 | 100 | 383.60 | 64.89 | 83.50 | 68.41 | 83.53 | 0.000059 | 1.38 | 300.88 | 64.93 | 0.06 |
| Meadow_Brook | 14.2816 | 500 | 510.20 | 64.89 | 89.81 | 69.00 | 89.82 | 0.000017 | 0.90 | 1038.57 | 104.26 | 0.03 |
| | | | | | | | | | | | | |
| Meadow_Brook | 6.9889 | 1.1 | 55.50 | 64.55 | 66.40 | 66.06 | 66.57 | 0.008207 | 3.35 | 16.58 | 17.41 | 0.59 |
| Meadow_Brook | 6.9889 | 10 | 216.90 | 64.55 | 77.70 | 67.16 | 77.72 | 0.000029 | 1.03 | 209.90 | 27.63 | 0.05 |
| Meadow_Brook | 6.9889 | 50 | 327.60 | 64.55 | 81.50 | 67.71 | 81.52 | 0.000027 | 1.19 | 275.07 | 27.63 | 0.05 |
| Meadow_Brook | 6.9889 | 100 | 383.60 | 64.55 | 83.50 | 67.96 | 83.52 | 0.000025 | 1.24 | 309.37 | 27.63 | 0.05 |
| Meadow_Brook | 6.9889 | 500 | 510.20 | 64.55 | 89.80 | 68.48 | 89.82 | 0.000013 | 1.08 | 642.52 | 27.63 | 0.04 |

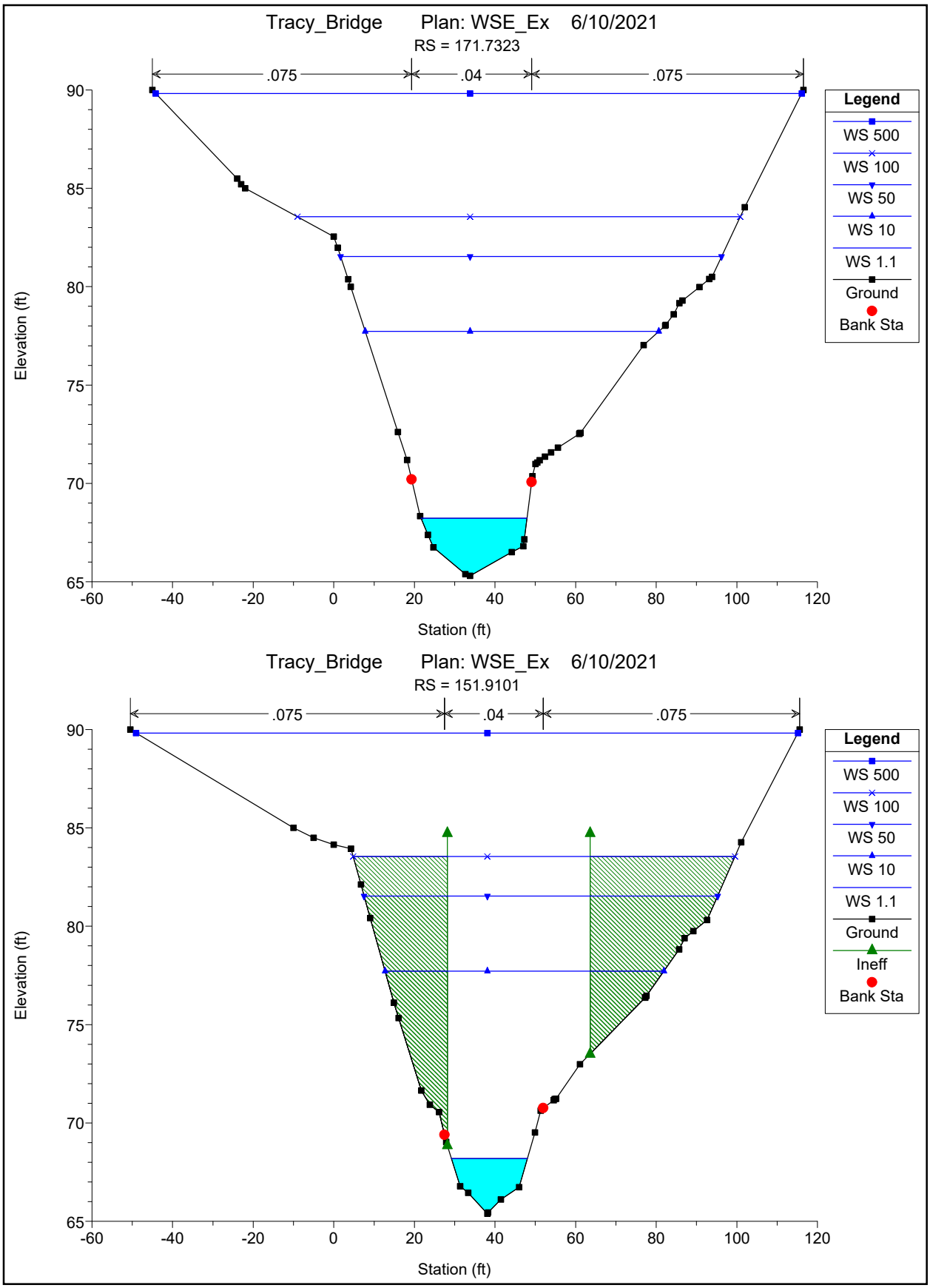

Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 429.1416
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
90
85
80
75
70
65
-200
-150
-100
-50
0
50
100
150
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 400.9054
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)

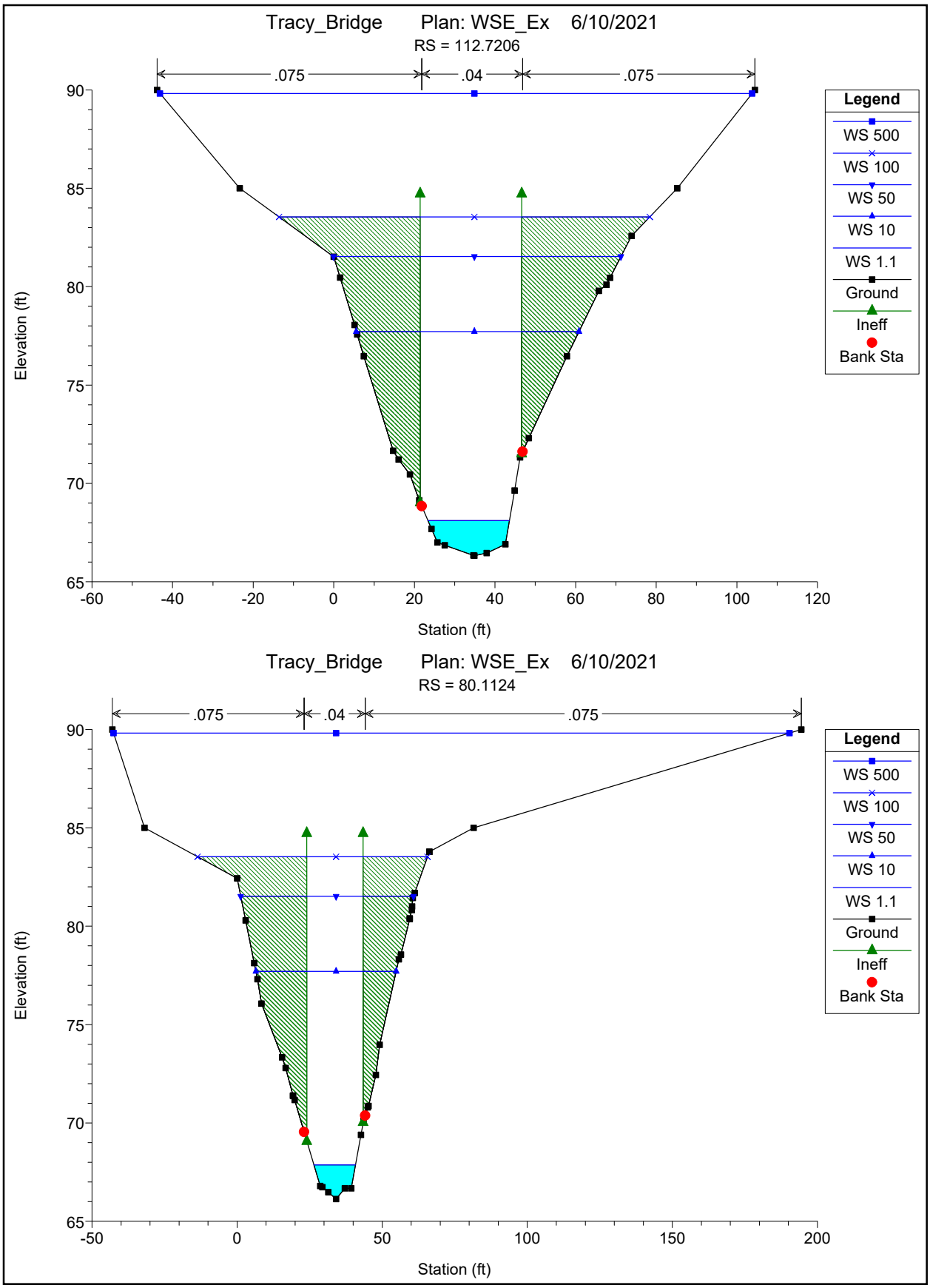

Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 381.7637
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-150
-100
-50
0
50
100
150
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 361.5061
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-200
-150
-100
-50
0
50
100
150
200

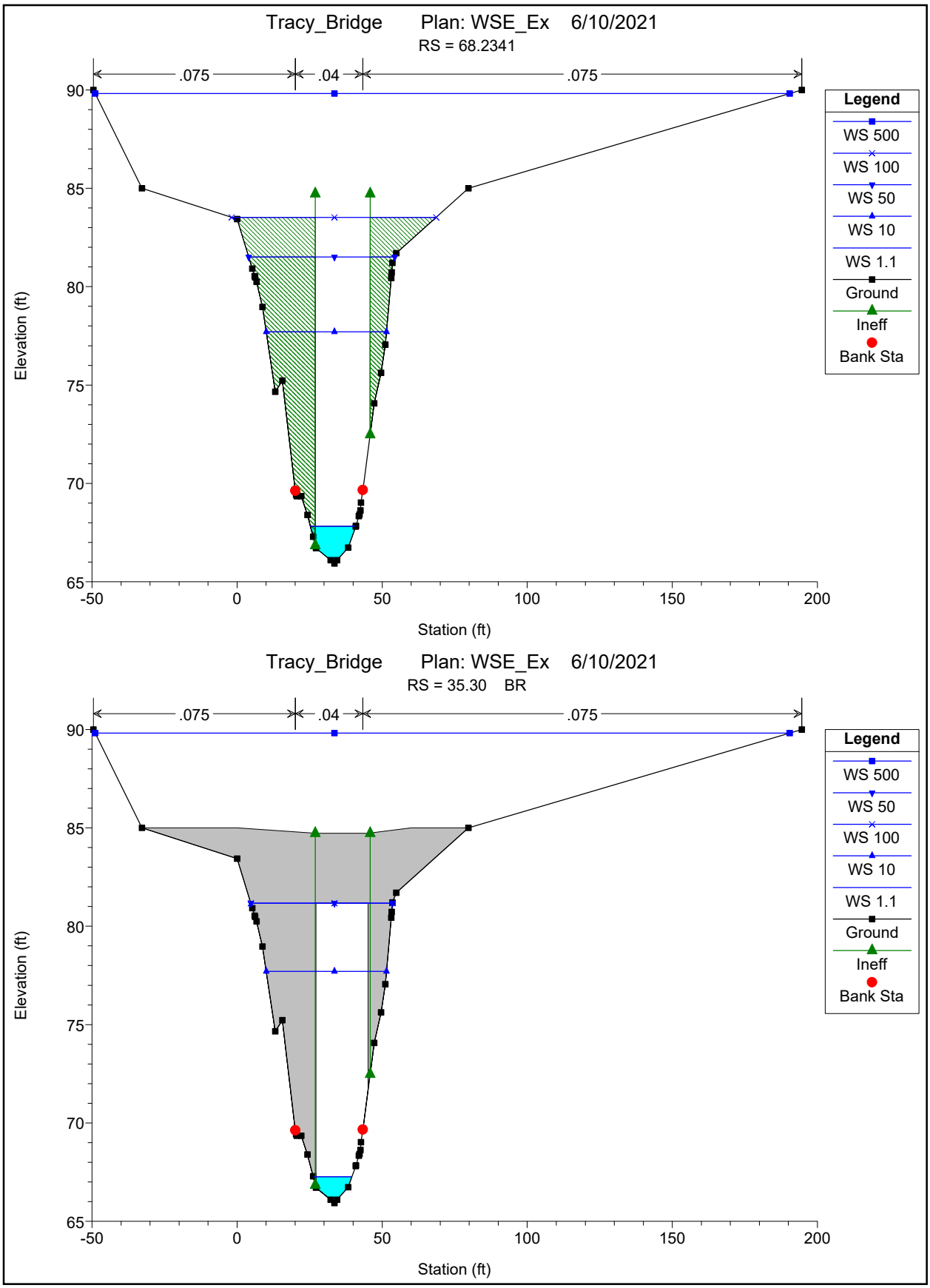

Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 321.5164
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-100
-50
0
50
100
150
200
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 306.1952
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)

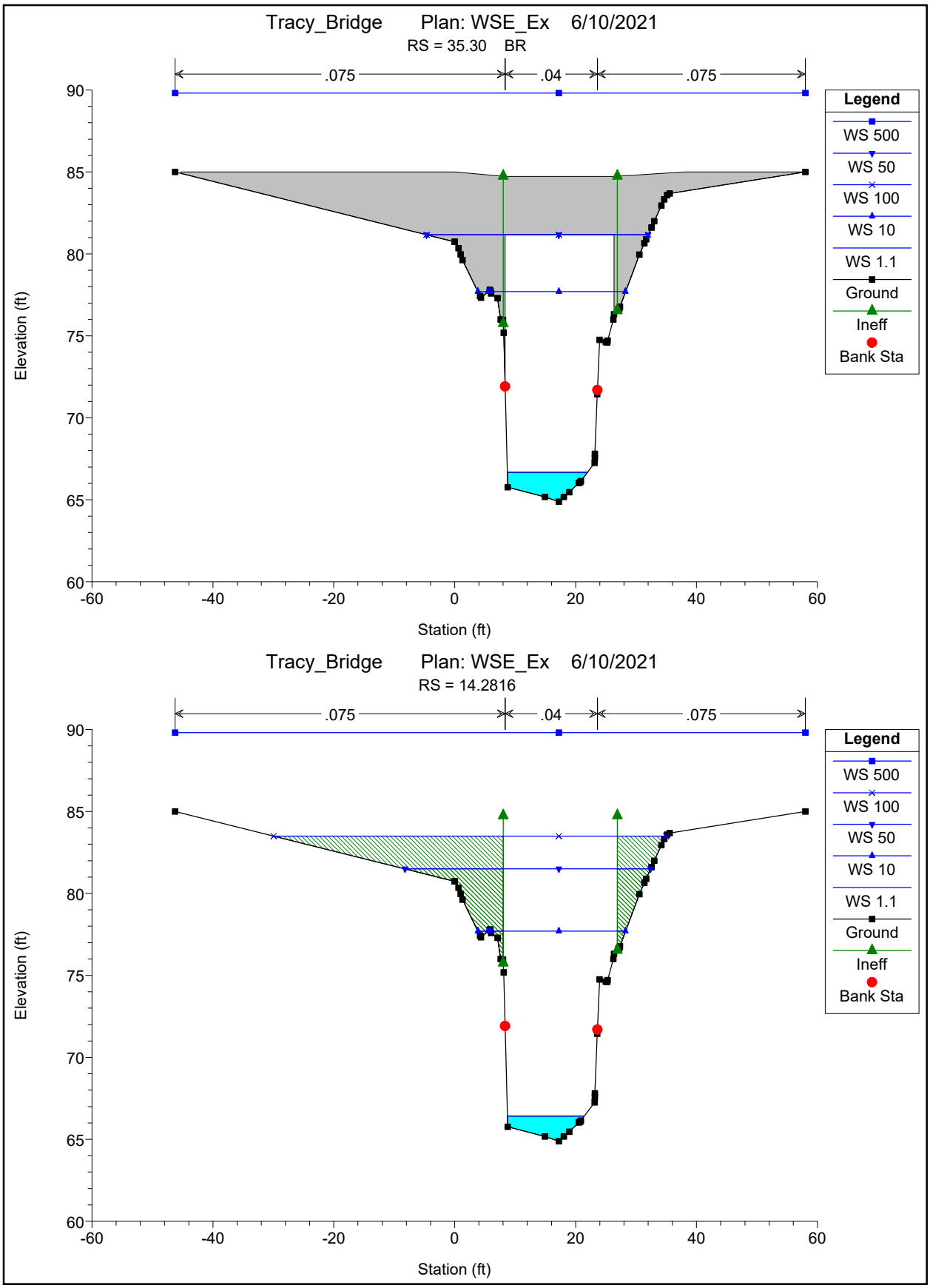

Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 286.9647
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
90
85
80
75
70
65
-100
-50
0
50
100
150
200
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 265.7286
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-100
-50
0
50
100
150

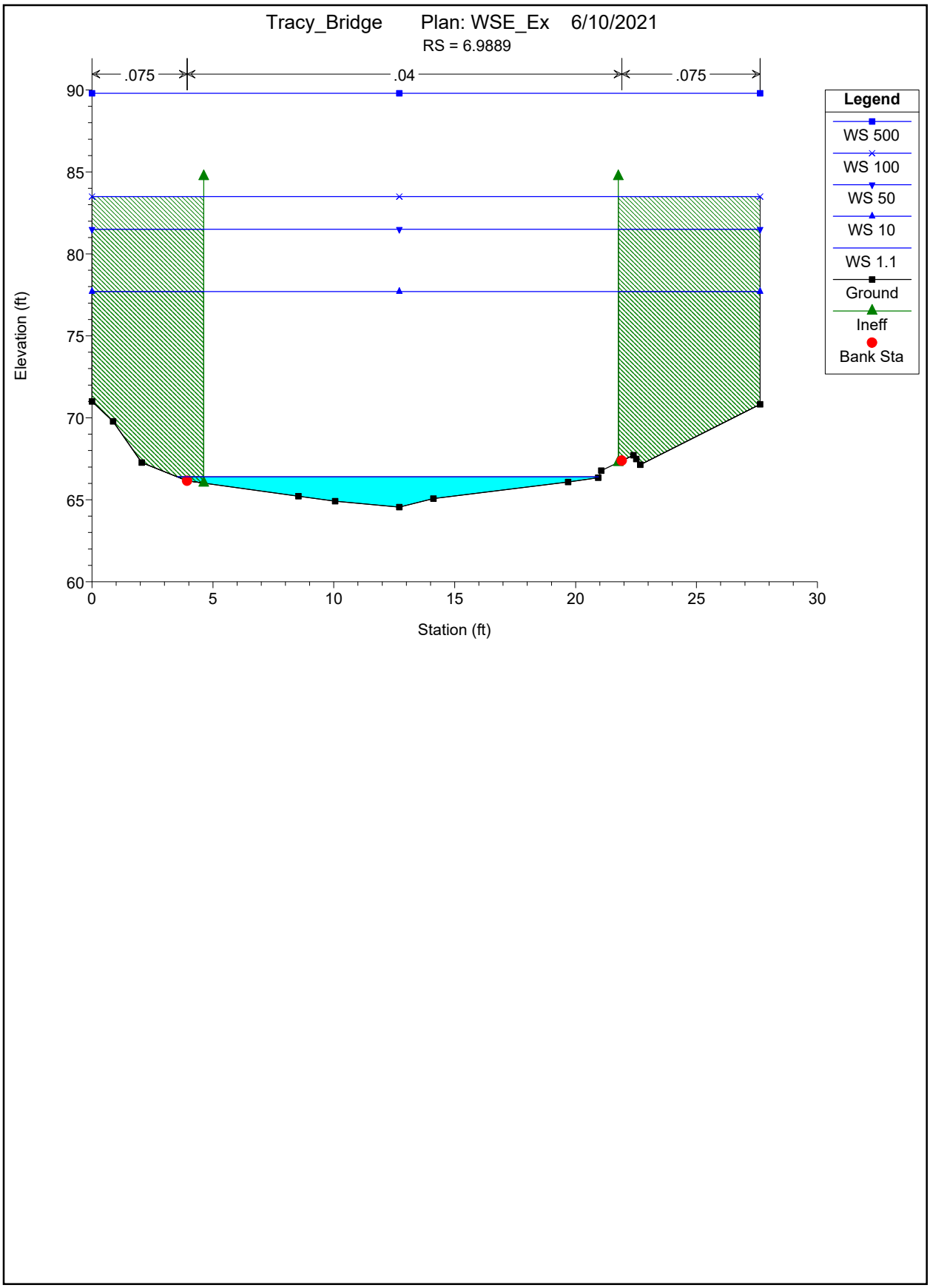

Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 225.3258
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
90
85
80
75
70
65
-100
-50
0
50
100
150
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 195.1151
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
90
85
80
75
70
65
-100
-50
0
50
100
150

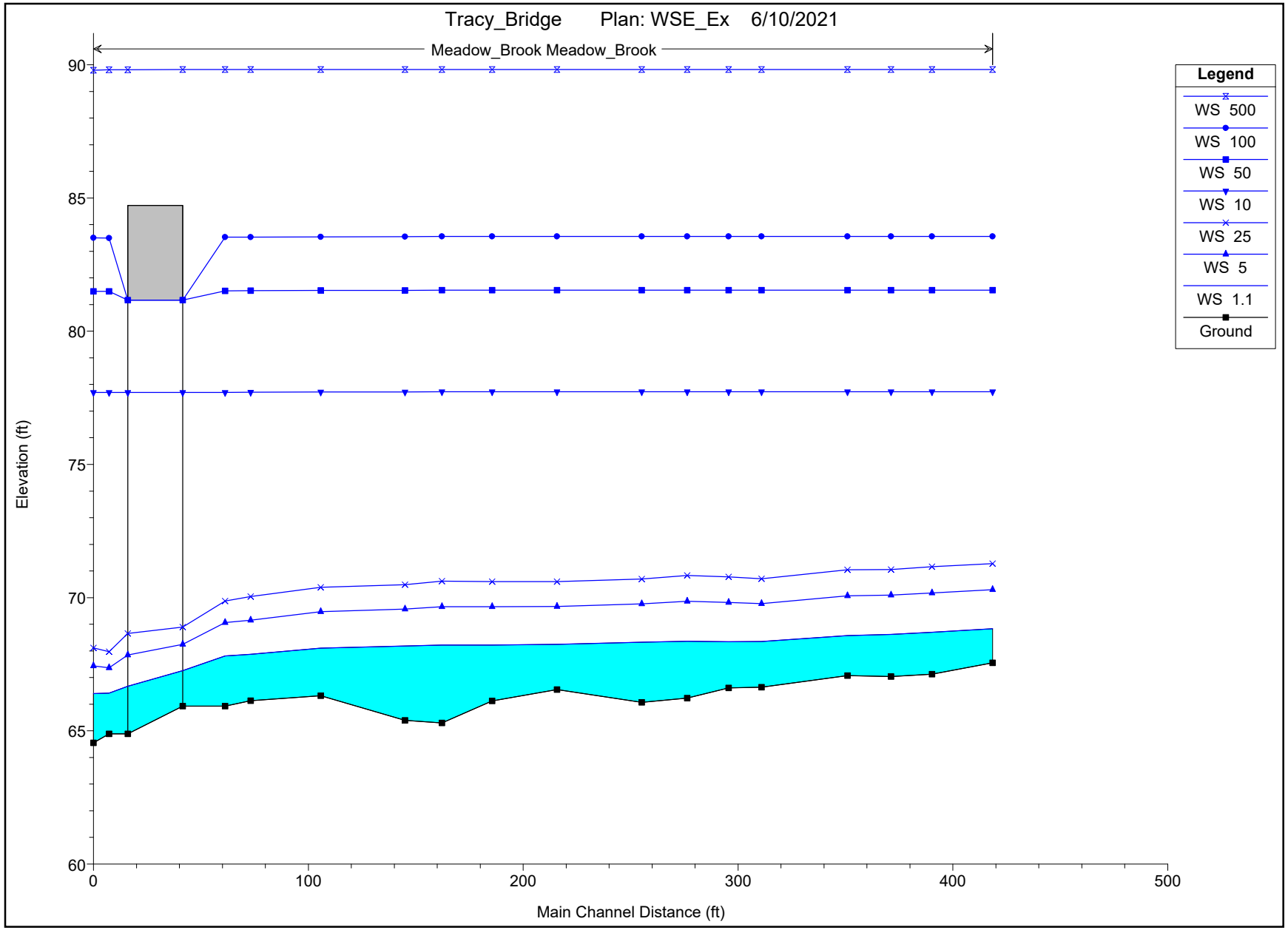

Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 171.7323
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 151.9101
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 112.7206
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Ineff
Bank Sta
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 80.1124
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Ineff
Bank Sta


Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 68.2341
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Ineff
Bank Sta
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 35.30 BR
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
WS 500
WS 50
WS 100
WS 10
WS 1.1
Ground
Ineff
Bank Sta


Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 35.30 BR
.075
.04
.075
Legend
WS 500
WS 50
WS 100
WS 10
WS 1.1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
90
85
80
75
70
65
60
-60
-40
-20
0
20
40
60
Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 14.2816
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Tracy_Bridge Plan: WSE_Ex 6/10/2021
RS = 6.9889
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
WS 1.1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
90
85
80
75
70
65
60
0
5
10
15
20
25
30


Tracy_Bridge Plan: WSE_Ex 6/10/2021
Meadow_Brook Meadow_Brook
Legend
WS 500
WS 100
WS 50
WS 10
WS 25
WS 5
WS 1.1
Ground
Elevation (ft)
Main Channel Distance (ft)
90
85
80
75
70
65
60
0
100
200
300
400
500

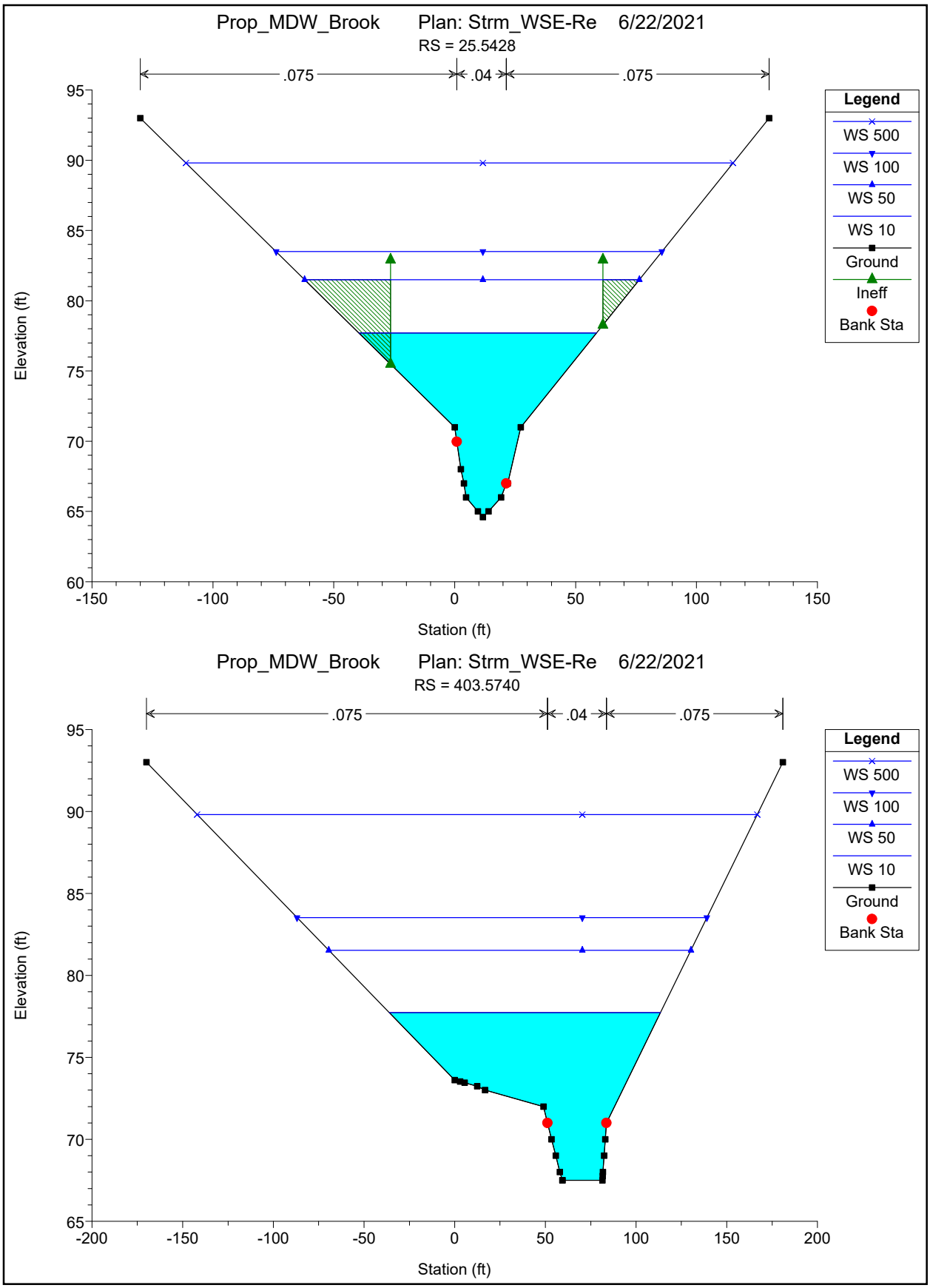
# Proposed HEC-RAS

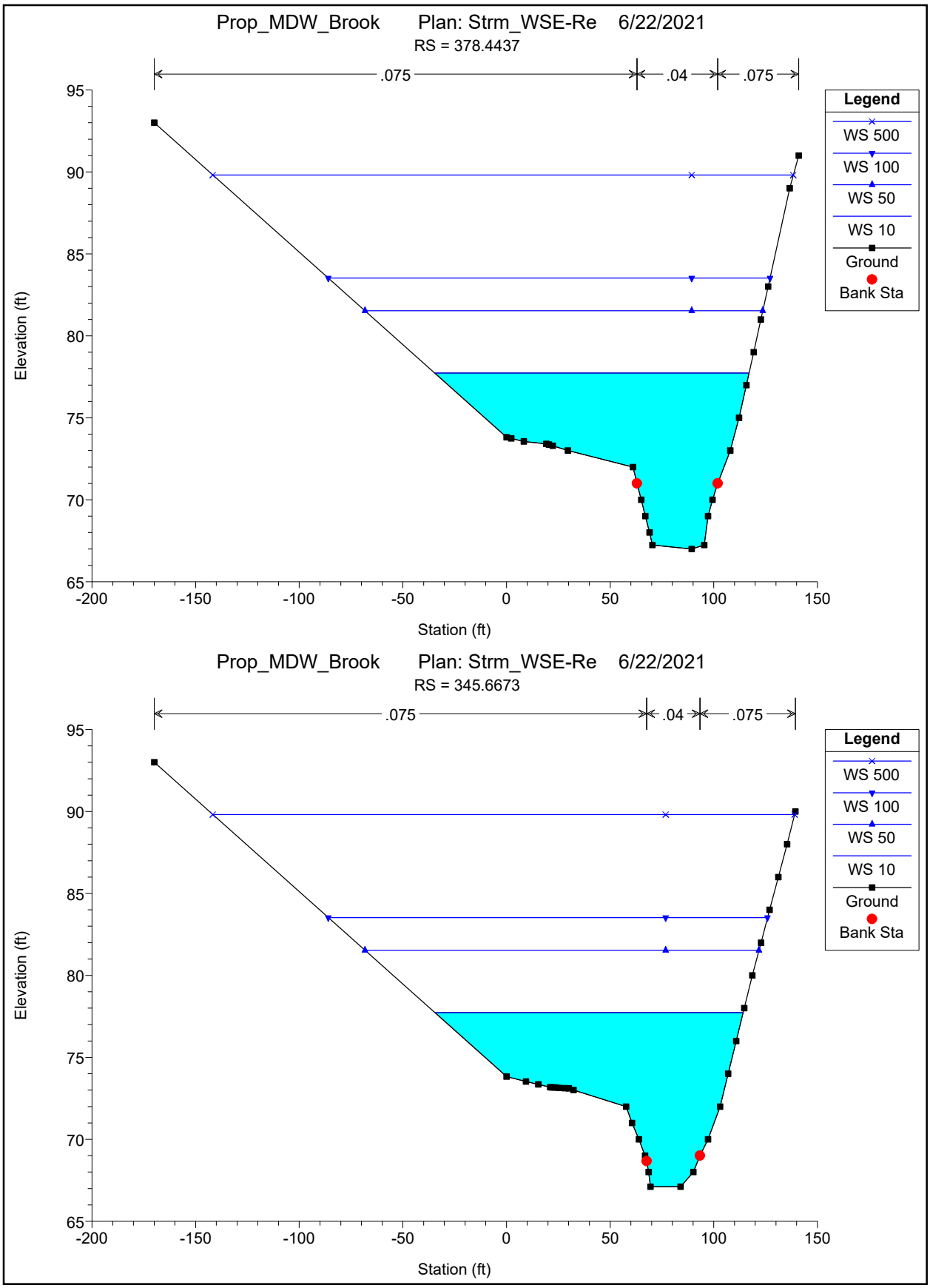
HEC-RAS Plan: Strm_WSE River: MeadowBrook Reach: Reach

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach | 403.5740 | 1.1 | 55.50 | 67.50 | 68.78 | | 68.83 | 0.001914 | 1.91 | 30.81 | 26.01 | 0.30 |
| Reach | 403.5740 | 10 | 216.90 | 67.50 | 77.72 | | 77.73 | 0.000011 | 0.58 | 743.94 | 149.50 | 0.03 |
| Reach | 403.5740 | 50 | 327.60 | 67.50 | 81.53 | | 81.53 | 0.000006 | 0.51 | 1407.56 | 199.65 | 0.02 |
| Reach | 403.5740 | 100 | 383.60 | 67.50 | 83.52 | | 83.53 | 0.000004 | 0.47 | 1832.96 | 226.01 | 0.02 |
| Reach | 403.5740 | 500 | 510.20 | 67.50 | 89.81 | | 89.81 | 0.000001 | 0.35 | 3513.42 | 308.89 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 378.4437 | 1.1 | 55.50 | 67.00 | 68.77 | | 68.80 | 0.000638 | 1.31 | 44.78 | 29.58 | 0.18 |
| Reach | 378.4437 | 10 | 216.90 | 67.00 | 77.72 | | 77.73 | 0.000008 | 0.51 | 810.00 | 151.61 | 0.03 |
| Reach | 378.4437 | 50 | 327.60 | 67.00 | 81.53 | | 81.53 | 0.000004 | 0.47 | 1463.01 | 191.95 | 0.02 |
| Reach | 378.4437 | 100 | 383.60 | 67.00 | 83.52 | | 83.53 | 0.000003 | 0.44 | 1867.81 | 213.12 | 0.02 |
| Reach | 378.4437 | 500 | 510.20 | 67.00 | 89.81 | | 89.81 | 0.000001 | 0.34 | 3416.34 | 280.10 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 345.6673 | 1.1 | 55.50 | 67.11 | 68.73 | | 68.78 | 0.001442 | 1.68 | 33.12 | 25.00 | 0.26 |
| Reach | 345.6673 | 10 | 216.90 | 67.11 | 77.72 | | 77.73 | 0.000009 | 0.52 | 780.99 | 148.70 | 0.03 |
| Reach | 345.6673 | 50 | 327.60 | 67.11 | 81.53 | | 81.53 | 0.000005 | 0.47 | 1424.48 | 190.01 | 0.02 |
| Reach | 345.6673 | 100 | 383.60 | 67.11 | 83.52 | | 83.53 | 0.000004 | 0.44 | 1826.17 | 211.92 | 0.02 |
| Reach | 345.6673 | 500 | 510.20 | 67.11 | 89.81 | | 89.81 | 0.000001 | 0.34 | 3374.08 | 280.71 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 326.8960 | 1.1 | 55.50 | 66.99 | 68.66 | | 68.73 | 0.002749 | 2.10 | 26.52 | 23.71 | 0.35 |
| Reach | 326.8960 | 10 | 216.90 | 66.99 | 77.72 | | 77.73 | 0.000010 | 0.52 | 759.70 | 145.55 | 0.03 |
| Reach | 326.8960 | 50 | 327.60 | 66.99 | 81.53 | | 81.53 | 0.000005 | 0.46 | 1390.58 | 186.35 | 0.02 |
| Reach | 326.8960 | 100 | 383.60 | 66.99 | 83.52 | | 83.53 | 0.000004 | 0.44 | 1784.15 | 207.35 | 0.02 |
| Reach | 326.8960 | 500 | 510.20 | 66.99 | 89.81 | | 89.81 | 0.000001 | 0.34 | 3264.76 | 263.20 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 308.9771 | 1.1 | 55.50 | 66.88 | 68.62 | | 68.66 | 0.000944 | 1.54 | 36.92 | 25.43 | 0.21 |
| Reach | 308.9771 | 10 | 216.90 | 66.88 | 77.72 | | 77.73 | 0.000011 | 0.58 | 698.15 | 129.20 | 0.03 |
| Reach | 308.9771 | 50 | 327.60 | 66.88 | 81.52 | | 81.53 | 0.000006 | 0.53 | 1258.52 | 165.60 | 0.02 |
| Reach | 308.9771 | 100 | 383.60 | 66.88 | 83.52 | | 83.53 | 0.000004 | 0.50 | 1608.68 | 184.74 | 0.02 |
| Reach | 308.9771 | 500 | 510.20 | 66.88 | 89.81 | | 89.81 | 0.000002 | 0.39 | 2958.61 | 244.93 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 297.6656 | 1.1 | 55.50 | 66.82 | 68.60 | | 68.64 | 0.000953 | 1.62 | 37.03 | 25.24 | 0.22 |
| Reach | 297.6656 | 10 | 216.90 | 66.82 | 77.72 | | 77.73 | 0.000012 | 0.62 | 683.72 | 128.00 | 0.03 |
| Reach | 297.6656 | 50 | 327.60 | 66.82 | 81.52 | | 81.53 | 0.000007 | 0.56 | 1240.47 | 164.87 | 0.03 |
| Reach | 297.6656 | 100 | 383.60 | 66.82 | 83.52 | | 83.53 | 0.000005 | 0.53 | 1589.44 | 184.26 | 0.02 |
| Reach | 297.6656 | 500 | 510.20 | 66.82 | 89.81 | | 89.81 | 0.000002 | 0.41 | 2939.54 | 246.09 | 0.02 |
| | | | | | | | | | | | | |
| Reach | 287.5170 | 1.1 | 55.50 | 66.74 | 68.58 | | 68.62 | 0.000941 | 1.60 | 36.78 | 24.66 | 0.22 |
| Reach | 287.5170 | 10 | 216.90 | 66.74 | 77.72 | | 77.73 | 0.000012 | 0.64 | 660.16 | 126.71 | 0.03 |
| Reach | 287.5170 | 50 | 327.60 | 66.74 | 81.52 | | 81.53 | 0.000007 | 0.57 | 1214.12 | 164.67 | 0.03 |
| Reach | 287.5170 | 100 | 383.60 | 66.74 | 83.52 | | 83.53 | 0.000005 | 0.54 | 1563.27 | 184.63 | 0.02 |
| Reach | 287.5170 | 500 | 510.20 | 66.74 | 89.81 | | 89.81 | 0.000002 | 0.41 | 2920.57 | 247.37 | 0.02 |
| | | | | | | | | | | | | |
| Reach | 279.2907 | 1.1 | 55.50 | 66.70 | 68.57 | | 68.60 | 0.000877 | 1.47 | 38.26 | 26.07 | 0.21 |
| Reach | 279.2907 | 10 | 216.90 | 66.70 | 77.72 | | 77.73 | 0.000010 | 0.56 | 707.82 | 129.69 | 0.03 |
| Reach | 279.2907 | 50 | 327.60 | 66.70 | 81.52 | | 81.53 | 0.000006 | 0.52 | 1269.26 | 165.93 | 0.02 |
| Reach | 279.2907 | 100 | 383.60 | 66.70 | 83.52 | | 83.53 | 0.000004 | 0.49 | 1619.11 | 183.68 | 0.02 |
| Reach | 279.2907 | 500 | 510.20 | 66.70 | 89.81 | | 89.81 | 0.000002 | 0.38 | 2970.93 | 247.29 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 241.5227 | 1.1 | 55.50 | 66.61 | 68.54 | | 68.58 | 0.001069 | 1.57 | 35.25 | 22.77 | 0.22 |
| Reach | 241.5227 | 10 | 216.90 | 66.61 | 77.72 | | 77.73 | 0.000011 | 0.55 | 658.14 | 116.39 | 0.03 |
| Reach | 241.5227 | 50 | 327.60 | 66.61 | 81.52 | | 81.53 | 0.000006 | 0.52 | 1163.27 | 148.27 | 0.02 |
| Reach | 241.5227 | 100 | 383.60 | 66.61 | 83.52 | | 83.53 | 0.000005 | 0.49 | 1474.77 | 163.38 | 0.02 |
| Reach | 241.5227 | 500 | 510.20 | 66.61 | 89.81 | | 89.81 | 0.000002 | 0.39 | 2650.62 | 210.87 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 211.3500 | 1.1 | 55.50 | 66.21 | 68.51 | | 68.55 | 0.000804 | 1.53 | 38.06 | 22.92 | 0.20 |
| Reach | 211.3500 | 10 | 216.90 | 66.21 | 77.72 | | 77.72 | 0.000012 | 0.57 | 658.25 | 114.30 | 0.03 |
| Reach | 211.3500 | 50 | 327.60 | 66.21 | 81.52 | | 81.53 | 0.000007 | 0.53 | 1166.55 | 152.56 | 0.02 |
| Reach | 211.3500 | 100 | 383.60 | 66.21 | 83.52 | | 83.53 | 0.000005 | 0.51 | 1486.54 | 167.13 | 0.02 |
| Reach | 211.3500 | 500 | 510.20 | 66.21 | 89.81 | | 89.81 | 0.000002 | 0.40 | 2676.08 | 211.47 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 189.8691 | 1.1 | 55.50 | 65.25 | 68.52 | 66.54 | 68.53 | 0.000229 | 0.98 | 59.15 | 26.76 | 0.11 |
| Reach | 189.8691 | 10 | 216.90 | 65.25 | 77.72 | 67.49 | 77.72 | 0.000012 | 0.60 | 509.02 | 75.54 | 0.03 |
| Reach | 189.8691 | 50 | 327.60 | 65.25 | 81.52 | 67.94 | 81.53 | 0.000008 | 0.60 | 830.75 | 97.38 | 0.03 |
| Reach | 189.8691 | 100 | 383.60 | 65.25 | 83.52 | 68.14 | 83.52 | 0.000007 | 0.61 | 1052.95 | 120.57 | 0.03 |
| Reach | 189.8691 | 500 | 510.20 | 65.25 | 89.81 | 68.58 | 89.81 | 0.000003 | 0.49 | 2059.56 | 199.75 | 0.02 |
| | | | | | | | | | | | | |
| Reach | 170.8144 | 1.1 | 55.50 | 65.75 | 68.51 | 66.69 | 68.53 | 0.000333 | 1.09 | 51.10 | 24.84 | 0.13 |
| Reach | 170.8144 | 10 | 216.90 | 65.75 | 77.72 | 67.68 | 77.72 | 0.000014 | 0.66 | 393.13 | 77.56 | 0.04 |
| Reach | 170.8144 | 50 | 327.60 | 65.75 | 81.52 | 68.16 | 81.53 | 0.000011 | 0.71 | 571.71 | 105.34 | 0.03 |
| Reach | 170.8144 | 100 | 383.60 | 65.75 | 83.52 | 68.38 | 83.52 | 0.000007 | 0.60 | 1086.19 | 125.71 | 0.03 |
| Reach | 170.8144 | 500 | 510.20 | 65.75 | 89.81 | 68.82 | 89.81 | 0.000003 | 0.48 | 2054.01 | 182.26 | 0.02 |
| | | | | | | | | | | | | |
| Reach | 131.6994 | 1.1 | 55.50 | 66.51 | 68.45 | 67.44 | 68.50 | 0.001321 | 1.72 | 32.24 | 21.34 | 0.25 |
| Reach | 131.6994 | 10 | 216.90 | 66.51 | 77.72 | 68.42 | 77.72 | 0.000017 | 0.69 | 399.64 | 58.61 | 0.04 |
| Reach | 131.6994 | 50 | 327.60 | 66.51 | 81.52 | 68.91 | 81.52 | 0.000012 | 0.70 | 648.89 | 157.66 | 0.03 |
| Reach | 131.6994 | 100 | 383.60 | 66.51 | 83.52 | 69.13 | 83.52 | 0.000009 | 0.65 | 1132.44 | 235.58 | 0.03 |

HEC-RAS Plan: Strm_WSE River: MeadowBrook Reach: Reach (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach | 131.6994 | 500 | 510.20 | 66.51 | 89.81 | 69.59 | 89.81 | 0.000002 | 0.42 | 3057.99 | 461.54 | 0.02 |
| | | | | | | | | | | | | |
| Reach | 60.71 | | Bridge | | | | | | | | | |
| | | | | | | | | | | | | |
| Reach | 32.5927 | 1.1 | 55.50 | 64.80 | 67.36 | 67.36 | 68.09 | 0.031757 | 6.85 | 8.11 | 5.54 | 1.00 |
| Reach | 32.5927 | 10 | 216.90 | 64.80 | 77.69 | 69.56 | 77.72 | 0.000094 | 1.34 | 210.51 | 39.32 | 0.07 |
| Reach | 32.5927 | 50 | 327.60 | 64.80 | 81.49 | 70.42 | 81.52 | 0.000067 | 1.40 | 304.98 | 207.09 | 0.07 |
| Reach | 32.5927 | 100 | 383.60 | 64.80 | 83.50 | 70.75 | 83.51 | 0.000032 | 1.05 | 1119.15 | 367.87 | 0.05 |
| Reach | 32.5927 | 500 | 510.20 | 64.80 | 89.80 | 71.39 | 89.80 | 0.000002 | 0.35 | 4041.59 | 555.76 | 0.01 |
| | | | | | | | | | | | | |
| Reach | 25.5428 | 1.1 | 55.50 | 64.60 | 66.06 | 66.06 | 66.44 | 0.026335 | 4.96 | 11.19 | 14.70 | 1.00 |
| Reach | 25.5428 | 10 | 216.90 | 64.60 | 77.70 | 67.19 | 77.71 | 0.000021 | 0.82 | 297.26 | 98.21 | 0.04 |
| Reach | 25.5428 | 50 | 327.60 | 64.60 | 81.50 | 67.75 | 81.51 | 0.000018 | 0.93 | 399.45 | 138.39 | 0.04 |
| Reach | 25.5428 | 100 | 383.60 | 64.60 | 83.50 | 67.99 | 83.50 | 0.000007 | 0.61 | 1286.19 | 159.54 | 0.03 |
| Reach | 25.5428 | 500 | 510.20 | 64.60 | 89.80 | 68.49 | 89.80 | 0.000003 | 0.46 | 2501.16 | 226.16 | 0.02 |


Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 25.5428
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 403.5740
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)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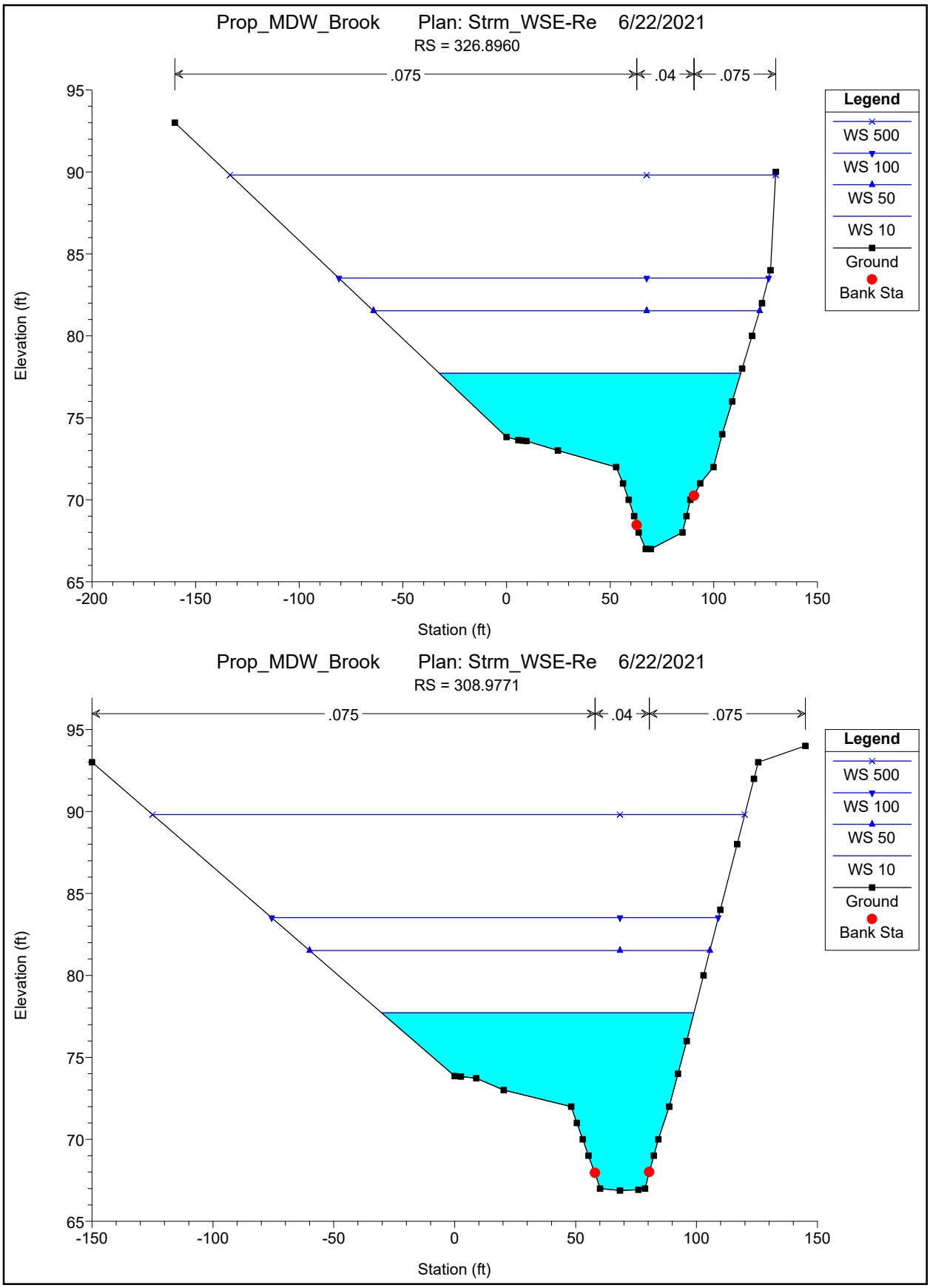
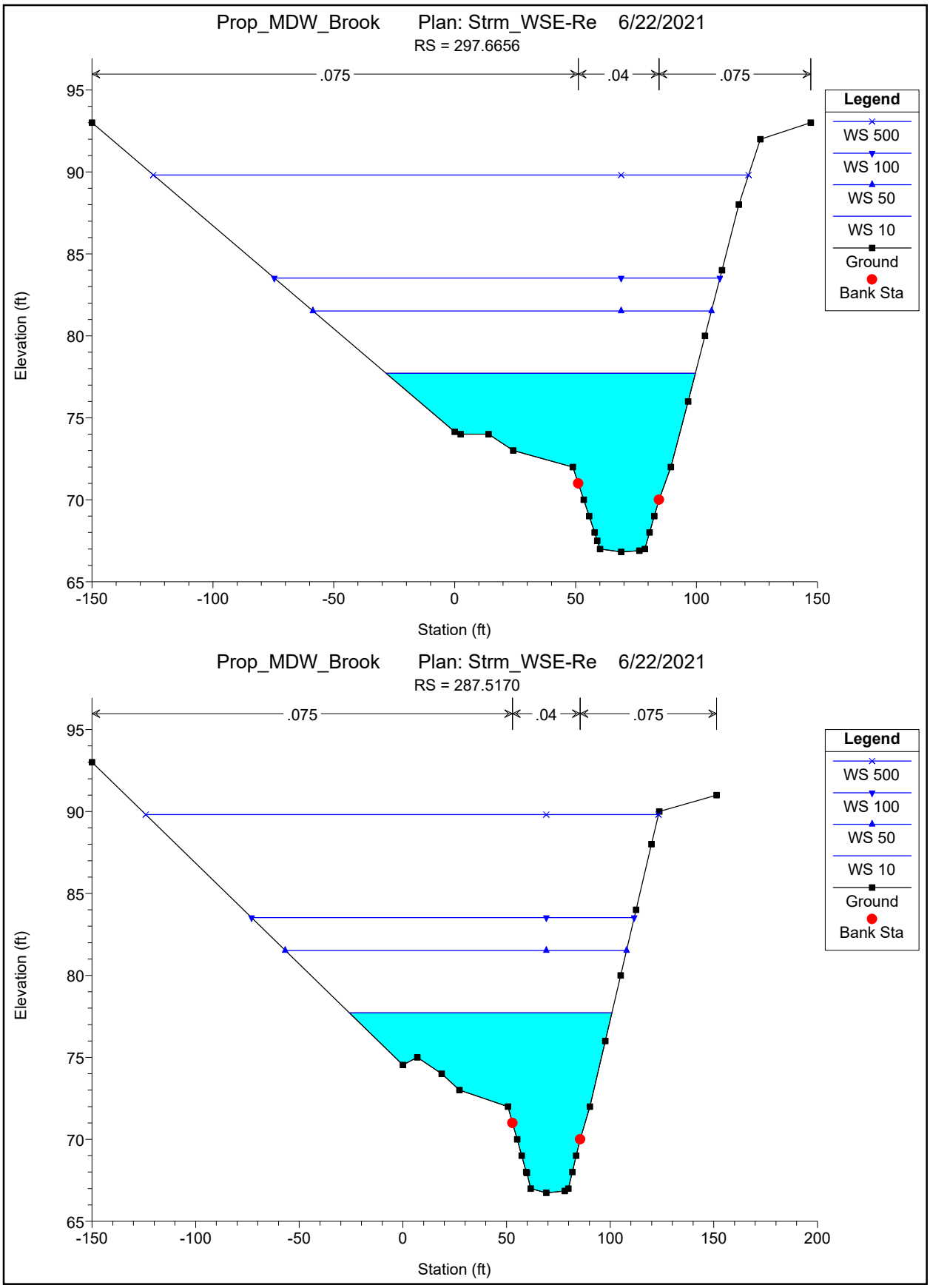
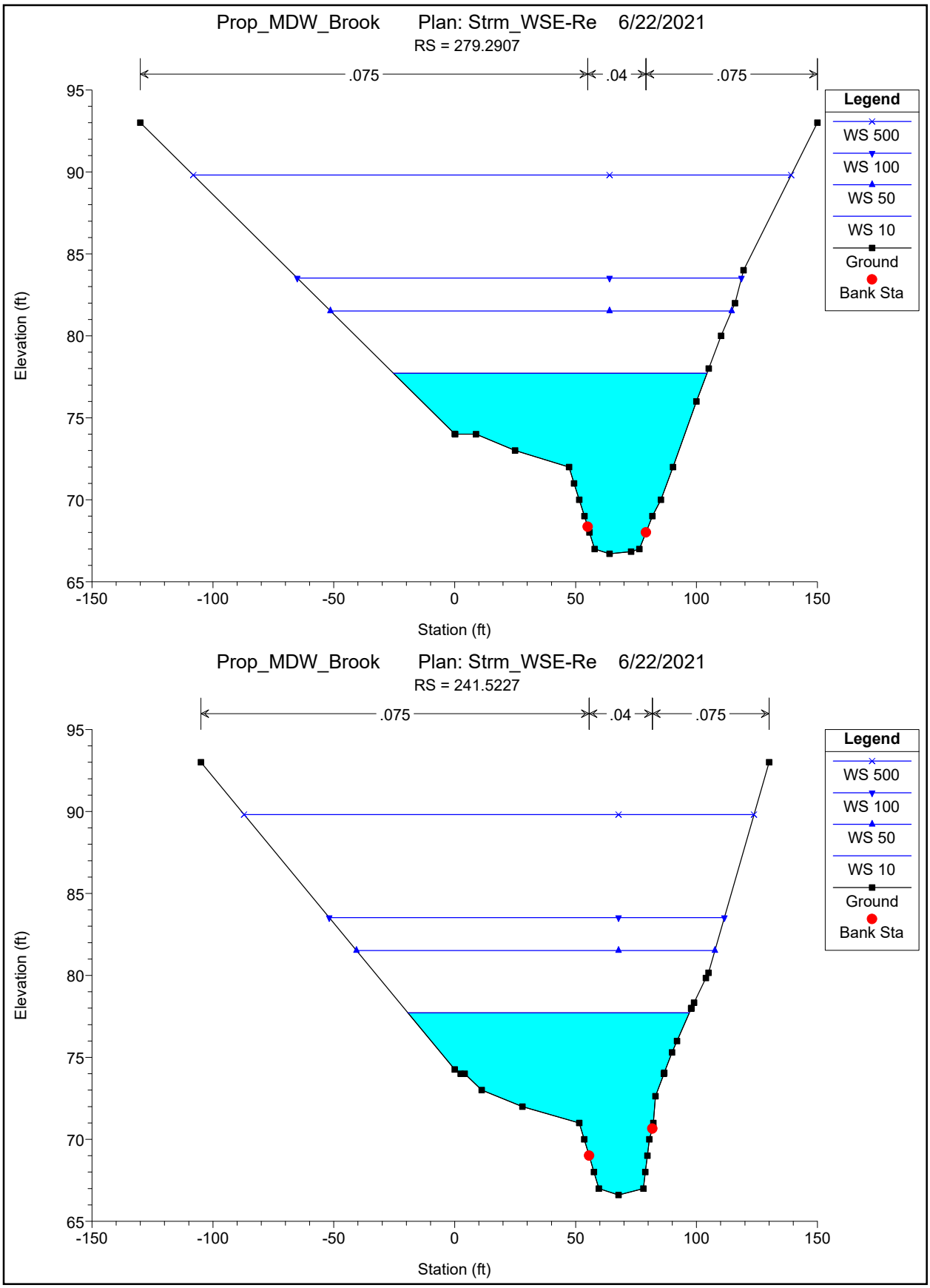
RS = 378.4437
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-200
-150
-100
-50
0
50
100
150
Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 345.6673
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)


Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 326.8960
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-200
-150
-100
-50
0
50
100
150
Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 308.9771
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-150
-100
-50
0
50
100
150


Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 297.6656
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 287.5170
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)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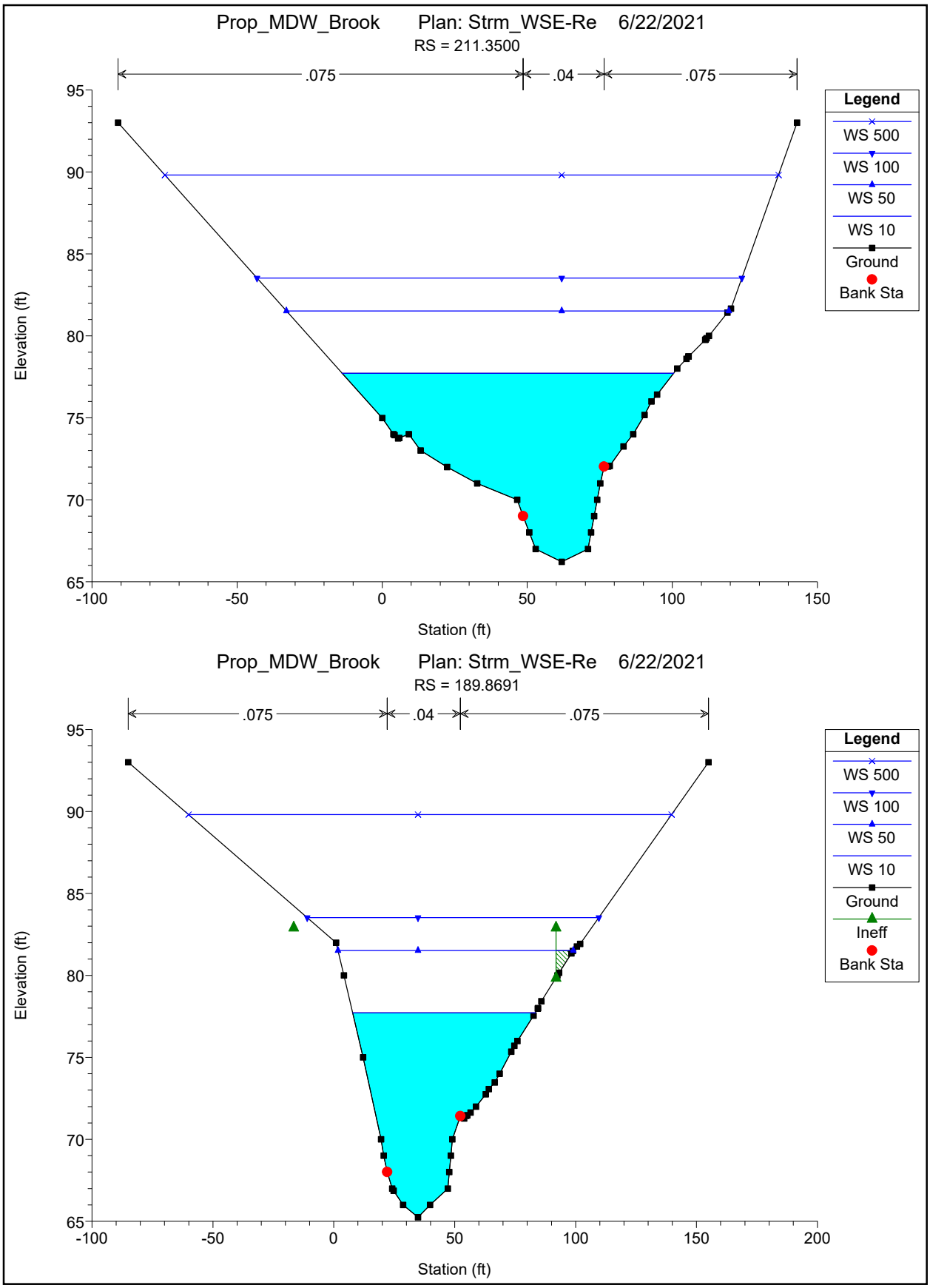
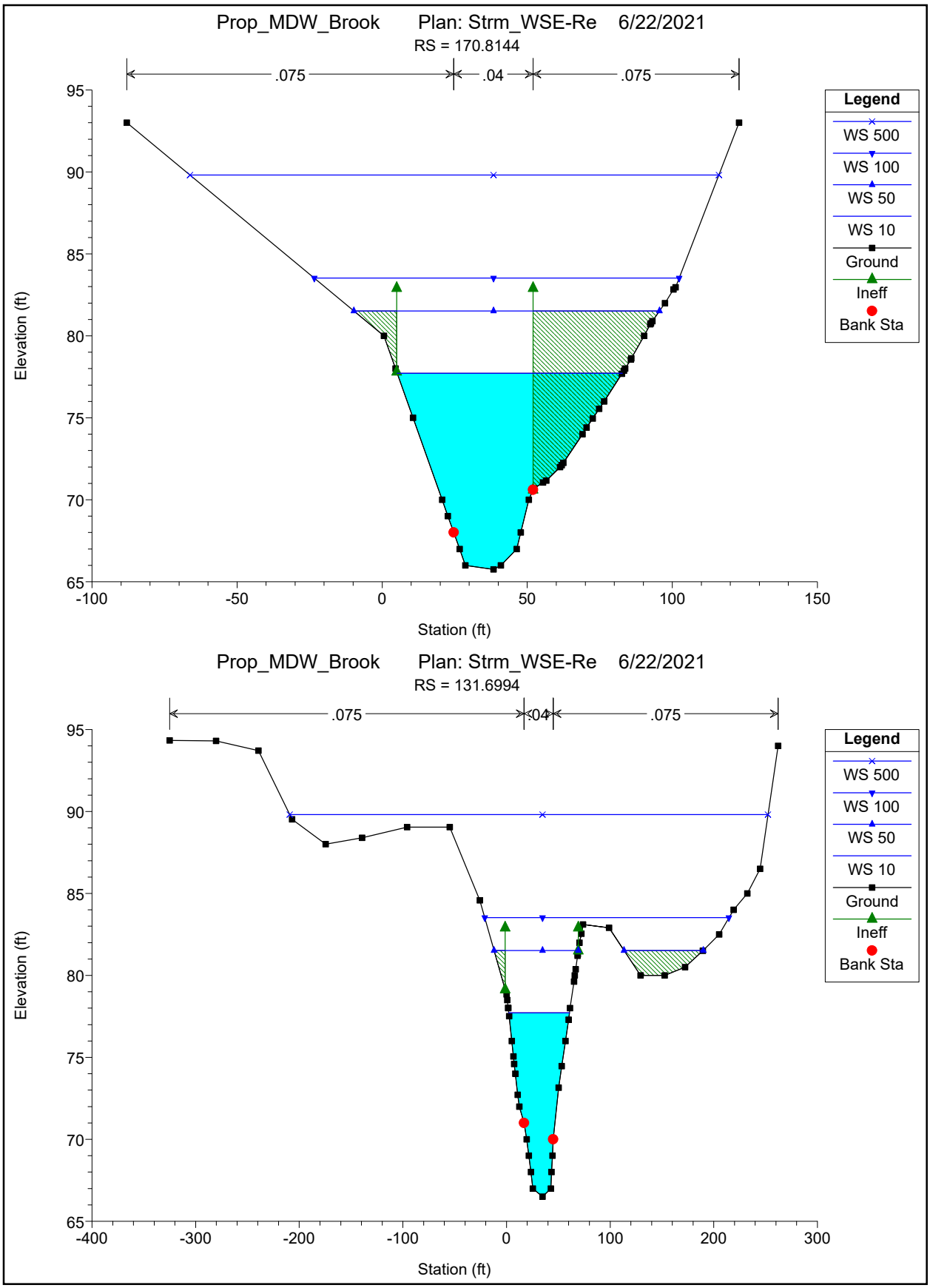
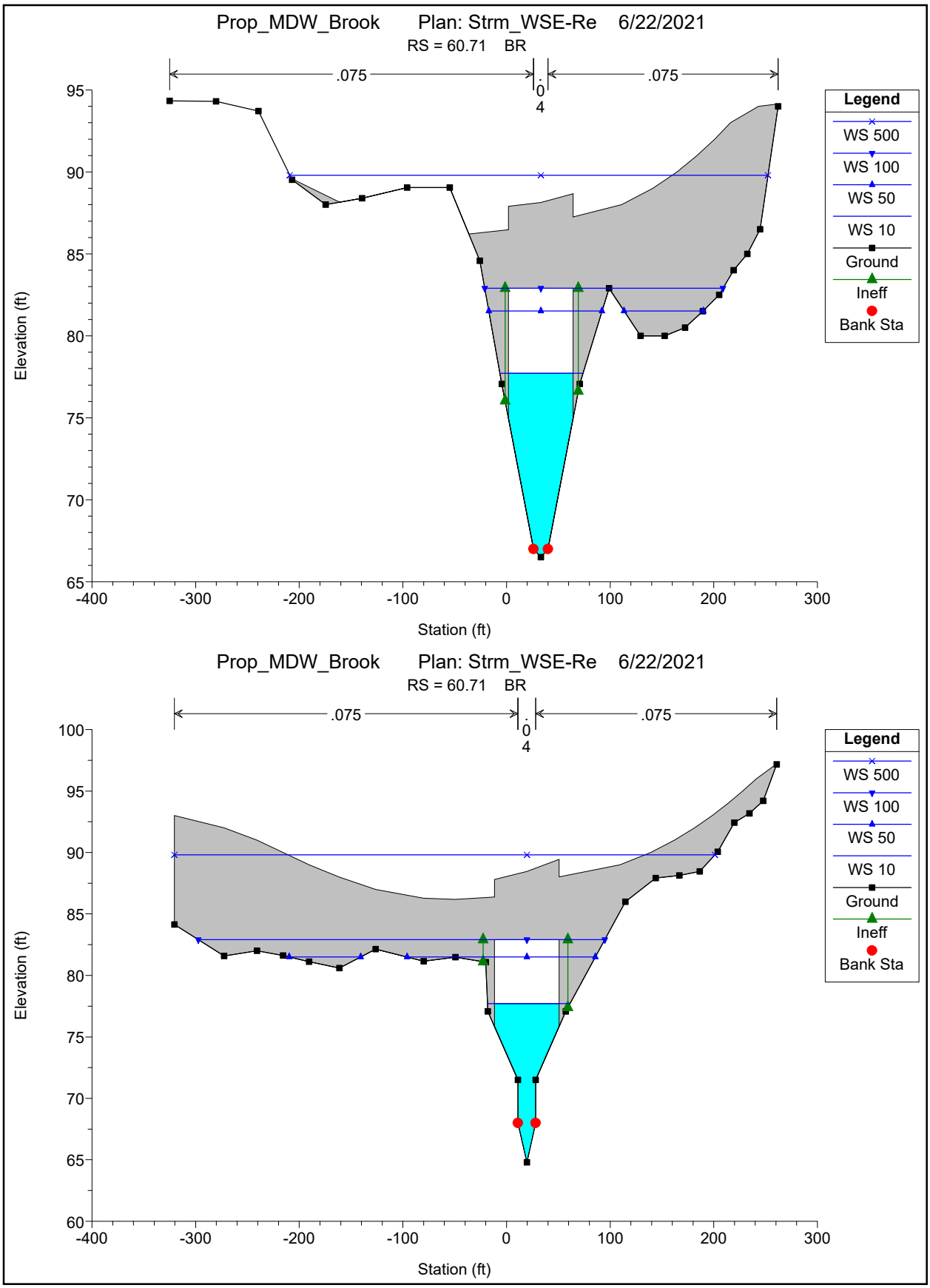
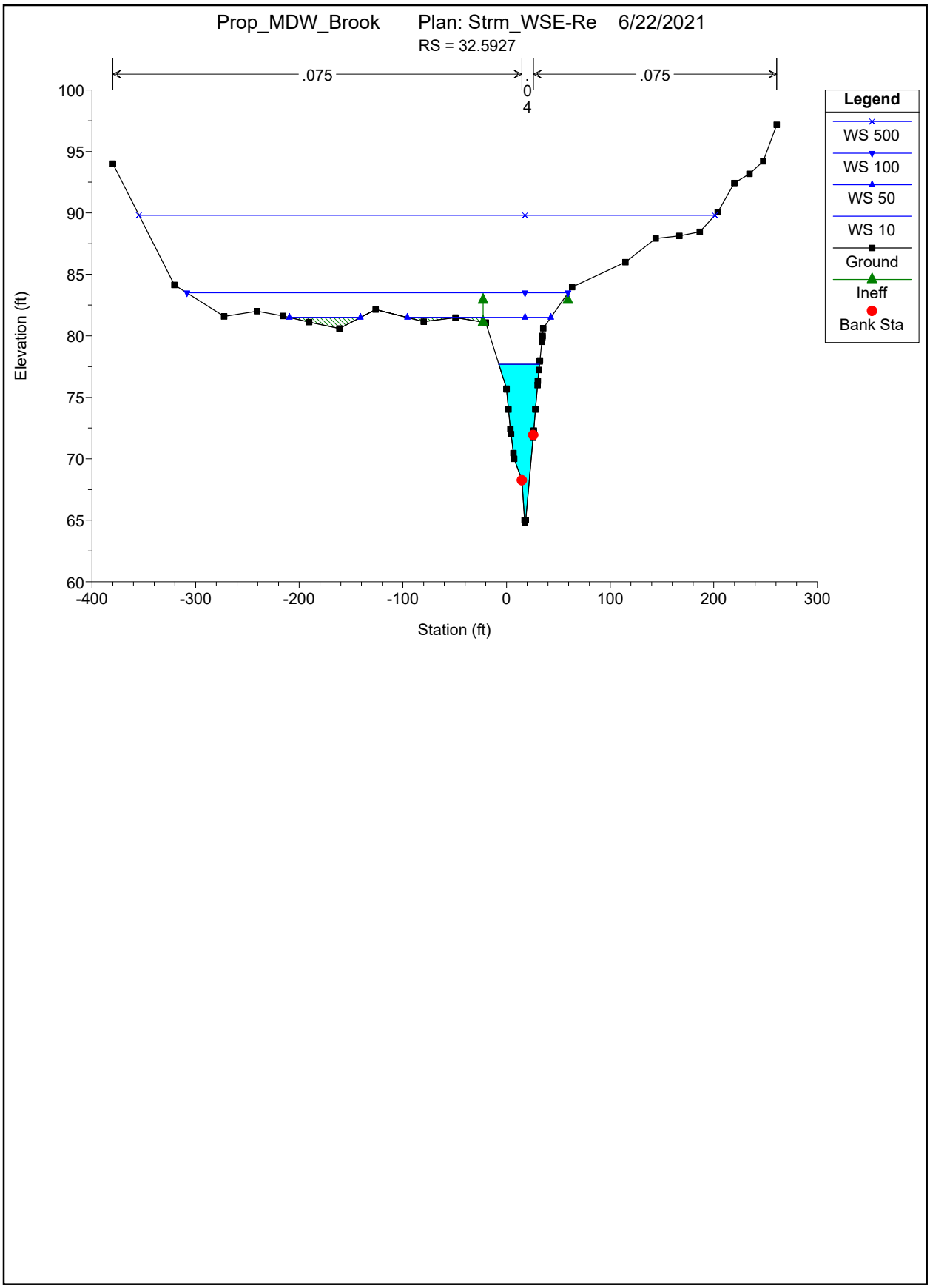
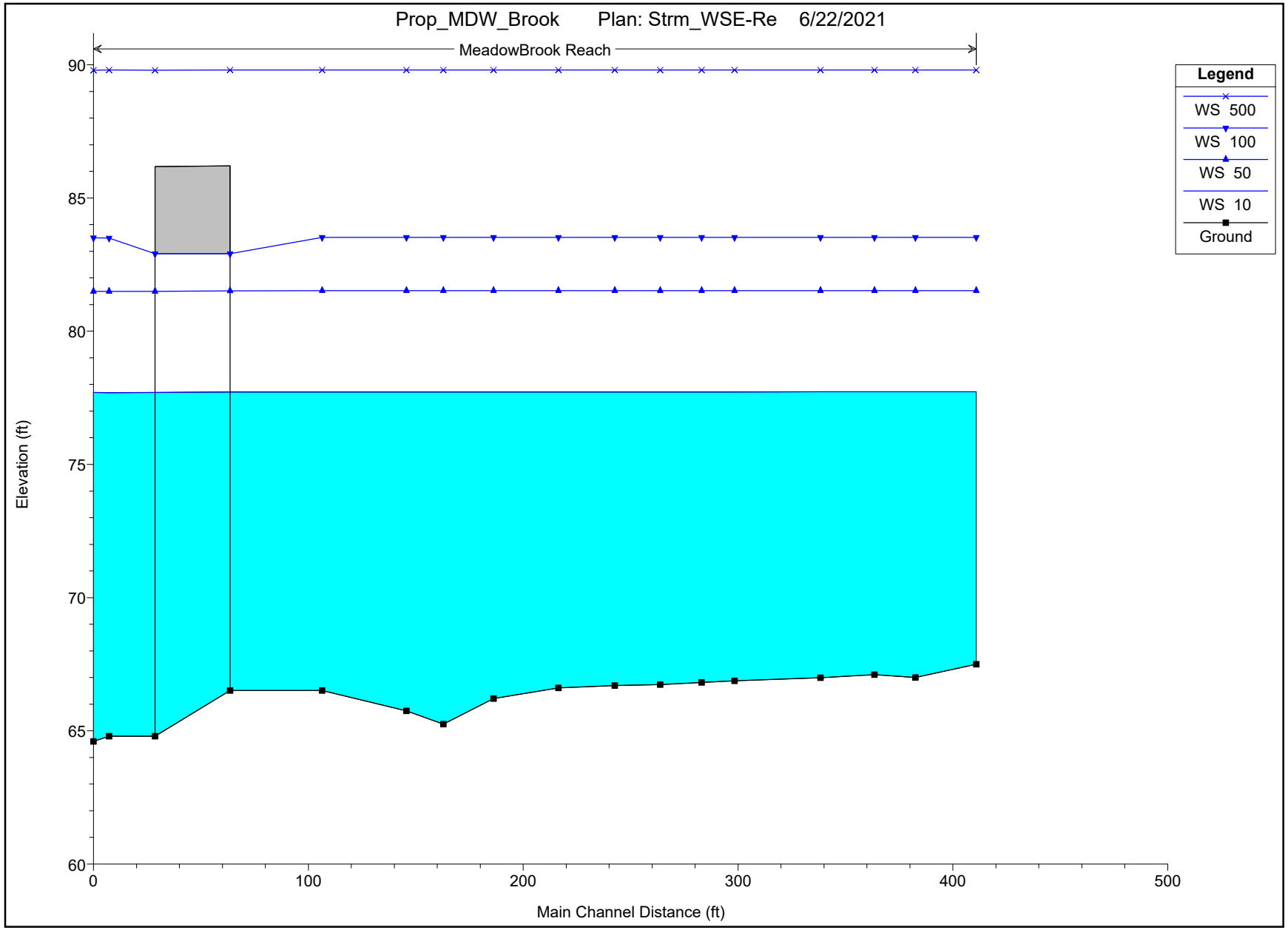
RS = 279.2907
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-150
-100
-50
0
50
100
150
Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 241.5227
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)


Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 211.3500
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-100
-50
0
50
100
150
Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 189.8691
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-100
-50
0
50
100
150
200


Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 170.8144
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 131.6994
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 60.71 BR
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
95
90
85
80
75
70
65
-400
-300
-200
-100
0
100
200
300
Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 60.71 BR
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
100
95
90
85
80
75
70
65
60
-400
-300
-200
-100
0
100
200
300


Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
RS = 32.5927
.075
.04
.075
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
100
95
90
85
80
75
70
65
60
-400
-300
-200
-100
0
100
200
300


Prop_MDW_Brook Plan: Strm_WSE-Re 6/22/2021
MeadowBrook Reach
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Elevation (ft)
90
85
80
75
70
65
60
0
100
200
300
400
500
Main Channel Distance (ft)

# Appendix B
## Scour Analysis

| | | | |
|---|---|---|---|
| Proj. Tracy Bridge | Job No. 63738 | Sheet No. 1 OF 7 | |
| Made by HHG | Checked by SPA | Backchecked by SPA | |
| Date 6-09-2021 | Date 6-10-2021 | Date 6-10-2021 | |

HNTB

## ***Scour Analysis: 100-year storm U/S face of Tracy Bridge over Meadow Brook***

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

**Live Bed Vs. Clear Water**

| | | |
|---|---|---|
| Depth of flow, y1 | 16.72 | ft |
| Particle size in a mix of which 50% are smaller, D50 (m) | 0.01200 | m |
| Particle size in a mix of which 50% are smaller, D50 (ft) | 0.03936 | ft |
| Velocity of main Channel, V | 0.6 | ft/s |
| Critical Velocity, Vc | 6.08 | ft/s |

$$V_c = K_u y^{1/6} D^{1/3}$$
Ku = 11.17

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

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

**Clear Water Scour**

| | | |
|---|---|---|
| Discharge through the bridge, Q | 383.60 | ft^3/s |
| Median diameter of bed material, D50 | 0.03936 | ft |
| Diameter of smallest nontrasportable particle, Dm | 0.04920 | ft |
| Bottom width of the contracted section, W | 28.27 | ft |
| Existing depth in the contracted Section, yo | 15.90 | ft |

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

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

| | | |
|---|---|---|
| Avg depth in contracted section, y2 | 2.75 | |
| ***Scour depth, ys*** | -13.15 | ***ft*** |

$$y_s = y_2 - y_0$$

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

| Proj. Tracy Bridge | Job No. 63738 | Sheet No. 2 OF 7 |
|---|---|---|
| Made by HHG | Checked by SPA | Backchecked by SPA |
| Date 6-09-2021 | Date 6-10-2021 | Date 6-10-2021 |

HNTB

## *Scour Analysis: 100-year storm U/S face of Tracy Bridge over Meadow Brook*

**Pressure Flow Scour**

| | | |
|---|---|---|
| Vertical size of the bridge opening prior to scour, hb | 15.61 | ft |
| Distance from the water surface to the lower face of bridge, ht | 0.61 | ft |
| Weir flow height, hw= ht - T for ht>T, hw = 0 for ht<T | 0.00 | ft |
| Upstream Channel flow depth, hu | 15.9 | ft |
| Separation Zone Thickness, t | 4.05 | ft |

$$t = 0.5\left(\frac{h_b \cdot h_t}{{h_u}^2}\right)\left(1 - \frac{h_w}{h_t}\right)$$

(HEC-18, 5th Edition, April 2012, Eqn. 6.16)

| | | |
|---|---|---|
| Y1 = hb + T (T = Obstruction height = 3.49 ft) | 19.10 | ft |
| Q1 | 383.60 | $ft^3/s$ |
| Q2 = Flow through bridge opening | 383.60 | $ft^3/s$ |
| Top width of U/S main channel, W1 | 27.33 | ft |
| Top width of the main channel in the contracted section, W2 | 28.27 | ft |
| Exponent, k1 | 0.59 | |
| Avg depth in contracted section, y2 | 18.72 | ft |
| Separation Zone Thickness, t | 4.05 | ft |
| Vertical size of the bridge prior to scour, hb | 15.61 | ft |

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

| | | |
|---|---|---|
| **Pressure Flow Scour Depth, ys** | 7.16 | ft |

$$y_s = y_2 + t - h_b$$

(HEC-18, April 2012, Eqn. 6.14)

| | | |
|---|---|---|
| Proj. Tracy Bridge | Job No. 63738 | Sheet No. 3 OF 7 |
| Made by HHG | Checked by SPA | Backchecked by SPA |
| Date 6-09-2021 | Date 6-10-2021 | Date 6-10-2021 |

HNTB

## ***Scour Analysis: 100-year storm U/S face of Tracy Bridge over Meadow Brook***

**Local Scour at Abutments**
**Near Abutment**

| | | |
|---|---|---|
| Coefficient for Abutment Shape, K1 | 0.55 | |
| Coefficient for angle of embankment to flow, K2 | 1.00 | |
| Length of active flow obstructed by embankment, L' | 3.16 | ft |
| Average depth of flow on embankment, ya | 5.40 | ft |
| Velocity on embankment, Ve | 0.17 | ft/s |
| Froude Number of approach flow = $V_e/(gy_a)^{1/2}$ | 0.013 | |
| Length of embankment projected to normal flow, L | | ft |

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

***Near Abutment Scour Depth, ys*** 5.78 ***ft***

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

**Far Abutment**

| | | |
|---|---|---|
| Coefficient for Abutment Shape, K1 | 0.55 | |
| Coefficient for angle of embankment to flow, K2 | 1.00 | |
| Length of active flow obstructed by embankment, L' | 5.13 | ft |
| Average depth of flow on embankment, ya | 2.83 | ft |
| Velocity on embankment, Ve | 0.11 | ft/s |
| Froude Number of approach flow = $V_e/(gy_a)^{1/2}$ | 0.012 | |
| Length of embankment projected to normal flow, L | | ft |

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

***Far Abutment Scour Depth, ys*** 3.13 ***ft***

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

| Proj. Tracy Bridge | Job No. 63738 | Sheet No. 4 OF 7 |
|---|---|---|
| Made by HHG | Checked by SPA | Backchecked by SPA |
| Date 6-09-2021 | Date 6-10-2021 | Date 6-10-2021 |

HNTB

## *Scour Analysis: 500-year storm U/S face of Tracy Bridge over Meadow Brook*

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

**Live Bed Vs. Clear Water**

| | | |
|---|---|---|
| Depth of flow, y1 | 23.01 | ft |
| Particle size in a mix of which 50% are smaller, D50 (m) | 0.01200 | m |
| Particle size in a mix of which 50% are smaller, D50 (ft) | 0.03936 | ft |
| Velocity of main Channel, V | 0.48 | ft/s |
| Critical Velocity, Vc | 6.41 | ft/s |

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

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

**Clear Water Scour**

| | | |
|---|---|---|
| Discharge through the bridge, Q | 413.26 | ft^3/s |
| Median diameter of bed material, D50 | 0.03936 | ft |
| Diameter of smallest nontrasportable particle, Dm | 0.04920 | ft |
| Bottom width of the contracted section, W | 28.27 | ft |
| Existing depth in the contracted Section, yo | 15.90 | ft |

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

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

Avg depth in contracted section, y2 2.93

***Scour depth, ys*** -12.97 ***ft***

$$y_s = y_2 - y_0$$

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

| Proj. Tracy Bridge | Job No. 63738 | Sheet No. 5 OF 7 |
|---|---|---|
| Made by HHG | Checked by SPA | Backchecked by SPA |
| Date 6-09-2021 | Date 6-10-2021 | Date 6-10-2021 |

HNTB

## *Scour Analysis: 500-year storm U/S face of Tracy Bridge over Meadow Brook*

**Pressure Flow Scour**

| | | |
|---|---|---|
| Vertical size of the bridge opening prior to scour, hb | 15.61 | ft |
| Distance from the water surface to the lower face of bridge, ht | 6.9 | ft |
| Weir flow height, hw= ht - T for ht>T, hw = 0 for ht<T | 3.41 | ft |
| Upstream Channel flow depth, hu | 22.19 | ft |
| Separation Zone Thickness, t | 6.17 | ft |

$$t = 0.5\left(\frac{h_b \cdot h_t}{h_u^{\,2}}\right)\left(1 - \frac{h_w}{h_t}\right)$$

(HEC-18, 5th Edition, April 2012, Eqn. 6.16)

| | | |
|---|---|---|
| Y1 = hb + T (T = Obstruction height = 3.49 ft) | 19.10 | ft |
| Q1 | 510.20 | $ft^3/s$ |
| Q2 = Flow through bridge opening | 413.26 | $ft^3/s$ |
| Top width of U/S main channel, W1 | 27.33 | ft |
| Top width of the main channel in the contracted section, W2 | 28.27 | ft |
| Exponent, k1 | 0.59 | |
| Avg depth in contracted section, y2 | 15.63 | ft |
| Separation Zone Thickness, t | 6.17 | ft |
| Vertical size of the bridge prior to scour, hb | 15.61 | ft |

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

| | | |
|---|---|---|
| **Pressure Flow Scour Depth, ys** | **6.18** | ft |

$$y_s = y_2 + t - h_b$$

(HEC-18, April 2012, Eqn. 6.14)

| | | |
|---|---|---|
| Proj. Tracy Bridge | Job No. 63738 | Sheet No. 6 OF 7 |
| Made by HHG | Checked by SPA | Backchecked by SPA |
| Date 6-09-2021 | Date 6-10-2021 | Date 6-10-2021 |

HNTB

## ***Scour Analysis: 500-year storm U/S face of Tracy Bridge over Meadow Brook***

**Local Scour at Abutments**
**Near Abutment**

| | | |
|---|---|---|
| Coefficient for Abutment Shape, K1 | 0.55 | |
| Coefficient for angle of embankment to flow, K2 | 1.00 | |
| Length of active flow obstructed by embankment, L' | 3.16 | ft |
| Average depth of flow on embankment, ya | 3.21 | ft |
| Velocity on embankment, Ve | 0.06 | ft/s |
| Froude Number of approach flow = $V_e/(gy_a)^{1/2}$ | 0.006 | |
| Length of embankment projected to normal flow, L | | ft |

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

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

***Near Abutment Scour Depth, ys*** 3.38 ***ft***

**Far Abutment**

| | | |
|---|---|---|
| Coefficient for Abutment Shape, K1 | 0.55 | |
| Coefficient for angle of embankment to flow, K2 | 1.00 | |
| Length of active flow obstructed by embankment, L' | 5.13 | ft |
| Average depth of flow on embankment, ya | 8.23 | ft |
| Velocity on embankment, Ve | 0.12 | ft/s |
| Froude Number of approach flow = $V_e/(gy_a)^{1/2}$ | 0.007 | |
| Length of embankment projected to normal flow, L | | ft |

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

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

***Far Abutment Scour Depth, ys*** 8.65 ***ft***

| | | | |
|---|---|---|---|
| Proj. Tracy Bridge | Job No. 63738 | Sheet No. 7 OF 7 | HNTB |
| Made by HHG | Checked by SPA | Backchecked by SPA | |
| Date 6-9-2021 | Date 6-10-2021 | Date 6-10-2021 | |

# Scour Summary

| | 100 - year storm | |
|---|---|---|
| | Near Abutment | Far Abutment |
| Aggradation/ Degradation (ft) | 0.00 | 0.00 |
| Contraction/Expansion Scour (ft) | 0.00 | 0.00 |
| Local Scour (ft) | 5.78 | 3.13 |
| Pressure Flow Scour (ft) | 7.16 | 7.16 |
| ***TOTAL SCOUR (ft)*** | ***12.94*** | ***10.29*** |

| | 500-year storm | |
|---|---|---|
| | Near Abutment | Far Abutment |
| Aggradation/ Degradation (ft) | 0.00 | 0.00 |
| Contraction/Expansion Scour (ft) | 0.00 | 0.00 |
| Local Scour (ft) | 3.38 | 8.65 |
| Pressure Flow Scour (ft) | 6.18 | 6.18 |
| ***TOTAL SCOUR (ft)*** | ***9.56*** | ***14.83*** |

Plan: Strm_WSE MeadowBrook Reach RS: 170.8144 Profile: 100

| E.G. Elev (ft) | 83.52 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.00 | Wt. n-Val. | 0.075 | 0.040 | 0.075 |
| W.S. Elev (ft) | 83.52 | Reach Len. (ft) | 43.00 | 39.24 | 17.77 |
| Crit W.S. (ft) | 68.38 | Flow Area (sq ft) | 271.46 | 456.97 | 357.76 |
| E.G. Slope (ft/ft) | 0.000007 | Area (sq ft) | 271.46 | 456.97 | 357.76 |
| Q Total (cfs) | 383.60 | Flow (cfs) | 42.21 | 275.28 | 66.10 |
| Top Width (ft) | 125.71 | Top Width (ft) | 48.06 | 27.33 | 50.32 |
| Vel Total (ft/s) | 0.35 | Avg. Vel. (ft/s) | 0.16 | 0.60 | 0.18 |
| Max Chl Dpth (ft) | 17.77 | Hydr. Depth (ft) | 5.65 | 16.72 | 7.11 |
| Conv. Total (cfs) | 148700.5 | Conv. (cfs) | 16364.3 | 106712.7 | 25623.6 |
| Length Wtd. (ft) | 36.23 | Wetted Per. (ft) | 51.14 | 28.99 | 52.05 |
| Min Ch El (ft) | 65.75 | Shear (lb/sq ft) | 0.00 | 0.01 | 0.00 |
| Alpha | 2.16 | Stream Power (lb/ft s) | 0.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | 0.00 | Cum Volume (acre-ft) | 1.05 | 1.10 | 0.88 |
| C & E Loss (ft) | 0.00 | Cum SA (acres) | 0.19 | 0.06 | 0.16 |

**UNCONTRACTED SECTION**

Plan: Strm_WSE MeadowBrook Reach RS: 170.8144 Profile: 500

| E.G. Elev (ft) | 89.81 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.00 | Wt. n-Val. | 0.075 | 0.040 | 0.075 |
| W.S. Elev (ft) | 89.81 | Reach Len. (ft) | 43.00 | 39.24 | 17.77 |
| Crit W.S. (ft) | 68.82 | Flow Area (sq ft) | 708.14 | 628.75 | 717.12 |
| E.G. Slope (ft/ft) | 0.000003 | Area (sq ft) | 708.14 | 628.75 | 717.12 |
| Q Total (cfs) | 510.20 | Flow (cfs) | 90.12 | 304.53 | 115.55 |
| Top Width (ft) | 182.26 | Top Width (ft) | 90.90 | 27.33 | 64.03 |
| Vel Total (ft/s) | 0.25 | Avg. Vel. (ft/s) | 0.13 | 0.48 | 0.16 |
| Max Chl Dpth (ft) | 24.06 | Hydr. Depth (ft) | 7.79 | 23.01 | 11.20 |
| Conv. Total (cfs) | 304292.6 | Conv. (cfs) | 53748.8 | 181630.0 | 68913.8 |
| Length Wtd. (ft) | 33.04 | Wetted Per. (ft) | 94.44 | 28.99 | 67.13 |
| Min Ch El (ft) | 65.75 | Shear (lb/sq ft) | 0.00 | 0.00 | 0.00 |
| Alpha | 2.41 | Stream Power (lb/ft s) | 0.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | 0.00 | Cum Volume (acre-ft) | 3.27 | 1.42 | 2.30 |
| C & E Loss (ft) | 0.00 | Cum SA (acres) | 0.76 | 0.07 | 0.40 |

**UNCONTRACTED SECTION**

Plan: Strm_WSE MeadowBrook Reach RS: 131.6994 Profile: 100

| E.G. Elev (ft) | 83.52 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.01 | Wt. n-Val. | 0.075 | 0.040 | 0.075 |
| W.S. Elev (ft) | 83.52 | Reach Len. (ft) | 42.77 | 42.77 | 42.77 |
| Crit W.S. (ft) | 69.13 | Flow Area (sq ft) | 204.04 | 449.52 | 478.87 |
| E.G. Slope (ft/ft) | 0.000009 | Area (sq ft) | 204.04 | 449.52 | 478.87 |
| Q Total (cfs) | 383.60 | Flow (cfs) | 35.00 | 293.70 | 54.91 |
| Top Width (ft) | 235.58 | Top Width (ft) | 37.81 | 28.27 | 169.50 |
| Vel Total (ft/s) | 0.34 | Avg. Vel. (ft/s) | 0.17 | 0.65 | 0.11 |
| Max Chl Dpth (ft) | 17.01 | Hydr. Depth (ft) | 5.40 | 15.90 | 2.83 |
| Conv. Total (cfs) | 130833.7 | Conv. (cfs) | 11935.8 | 100170.7 | 18727.3 |
| Length Wtd. (ft) | 42.77 | Wetted Per. (ft) | 40.22 | 30.60 | 172.68 |
| Min Ch El (ft) | 66.51 | Shear (lb/sq ft) | 0.00 | 0.01 | 0.00 |
| Alpha | 2.89 | Stream Power (lb/ft s) | 0.00 | 0.01 | 0.00 |
| Frctn Loss (ft) | | Cum Volume (acre-ft) | 0.82 | 0.69 | 0.71 |
| C & E Loss (ft) | | Cum SA (acres) | 0.15 | 0.03 | 0.12 |

**CONTRACTED SECTION**

Plan: Strm_WSE  MeadowBrook  Reach  RS: 131.6994  Profile: 500

| E.G. Elev (ft) | 89.81 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.00 | Wt. n-Val. | 0.075 | 0.040 | 0.075 |
| W.S. Elev (ft) | 89.81 | Reach Len. (ft) | 42.77 | 42.77 | 42.77 |
| Crit W.S. (ft) | 69.59 | Flow Area (sq ft) | 726.13 | 627.25 | 1704.61 |
| E.G. Slope (ft/ft) | 0.000002 | Area (sq ft) | 726.13 | 627.25 | 1704.61 |
| Q Total (cfs) | 510.20 | Flow (cfs) | 46.39 | 260.79 | 203.02 |
| Top Width (ft) | 461.54 | Top Width (ft) | 226.07 | 28.27 | 207.20 |
| Vel Total (ft/s) | 0.17 | Avg. Vel. (ft/s) | 0.06 | 0.42 | 0.12 |
| Max Chl Dpth (ft) | 23.30 | Hydr. Depth (ft) | 3.21 | 22.19 | 8.23 |
| Conv. Total (cfs) | 341467.9 | Conv. (cfs) | 31051.1 | 174539.3 | 135877.5 |
| Length Wtd. (ft) | 42.77 | Wetted Per. (ft) | 228.99 | 30.60 | 211.22 |
| Min Ch El (ft) | 66.51 | Shear (lb/sq ft) | 0.00 | 0.00 | 0.00 |
| Alpha | 3.39 | Stream Power (lb/ft s) | 0.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | 0.00 | Cum Volume (acre-ft) | 2.56 | 0.85 | 1.80 |
| C & E Loss (ft) | 0.00 | Cum SA (acres) | 0.60 | 0.04 | 0.35 |

**CONTRACTED SECTION**

Plan: Strm_WSE MeadowBrook Reach RS: 60.71 Profile: 100

| E.G. US. (ft) | 83.52 | Element | Inside BR US | Inside BR DS |
|---|---|---|---|---|
| W.S. US. (ft) | 83.52 | E.G. Elev (ft) | 83.52 | 83.51 |
| Q Total (cfs) | 383.60 | W.S. Elev (ft) | 82.91 | 82.91 |
| Q Bridge (cfs) | 383.60 | Crit W.S. (ft) | 69.44 | 68.89 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 16.40 | 18.11 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 0.48 | 1.05 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 803.59 | 366.15 |
| Weir Submerg | | Froude # Chl | 0.03 | 0.05 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 5402.12 | 2807.35 |
| Min El Weir Flow (ft) | 86.22 | Hydr Depth (ft) | | 14.73 |
| Min El Prs (ft) | 82.91 | W.P. Total (ft) | 151.30 | 33.15 |
| Delta EG (ft) | 0.02 | Conv. Total (cfs) | 65898.2 | 71410.0 |
| Delta WS (ft) | 0.02 | Top Width (ft) | | 62.48 |
| BR Open Area (sq ft) | 366.15 | Frctn Loss (ft) | | |
| BR Open Vel (ft/s) | 1.05 | C & E Loss (ft) | | |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 0.01 | 0.02 |
| BR Sel Method | Press Only | Power Total (lb/ft s) | 0.01 | 0.02 |

Plan: Strm_WSE MeadowBrook Reach RS: 60.71 Profile: 500

| E.G. US. (ft) | 89.81 | Element | Inside BR US | Inside BR DS |
|---|---|---|---|---|
| W.S. US. (ft) | 89.81 | E.G. Elev (ft) | 89.81 | 89.80 |
| Q Total (cfs) | 510.20 | W.S. Elev (ft) | 89.80 | 89.80 |
| Q Bridge (cfs) | 413.26 | Crit W.S. (ft) | 69.94 | 69.41 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 23.29 | 25.00 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 0.37 | 0.37 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 1378.41 | 1381.05 |
| Weir Submerg | | Froude # Chl | 0.02 | 0.02 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 11527.19 | 10055.29 |
| Min El Weir Flow (ft) | 86.22 | Hydr Depth (ft) | 3.74 | 4.02 |
| Min El Prs (ft) | 82.91 | W.P. Total (ft) | 515.52 | 494.81 |
| Delta EG (ft) | 0.01 | Conv. Total (cfs) | 75446.6 | 77297.2 |
| Delta WS (ft) | 0.00 | Top Width (ft) | 368.99 | 343.83 |
| BR Open Area (sq ft) | 366.15 | Frctn Loss (ft) | 0.00 | 0.00 |
| BR Open Vel (ft/s) | 0.59 | C & E Loss (ft) | 0.00 | 0.00 |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 0.01 | 0.01 |
| BR Sel Method | Energy only | Power Total (lb/ft s) | 0.00 | 0.00 |

D50 Fall Velocity

correctly account for the increase in transport that will occur as the result of the bed planing out (which decreases resistance to flow, increases the velocity and the transport of bed material at the bridge). That is, Laursen's equation indicates a decrease in scour for this case, whereas in reality, there would be an increase in scour depth. In addition, at flood flows, a plane bedform will usually exist upstream and through the bridge waterway, and the values of Manning n will be equal. Consequently, the n value ratio is not recommended or presented in Equation 6.2.

4. $W_1$ and $W_2$ are not always easily defined. In some cases, it is acceptable to use the topwidth of the main channel to define these widths. Whether topwidth or bottom width is used, it is important to be consistent so that $W_1$ and $W_2$ refer to either bottom widths or top widths.

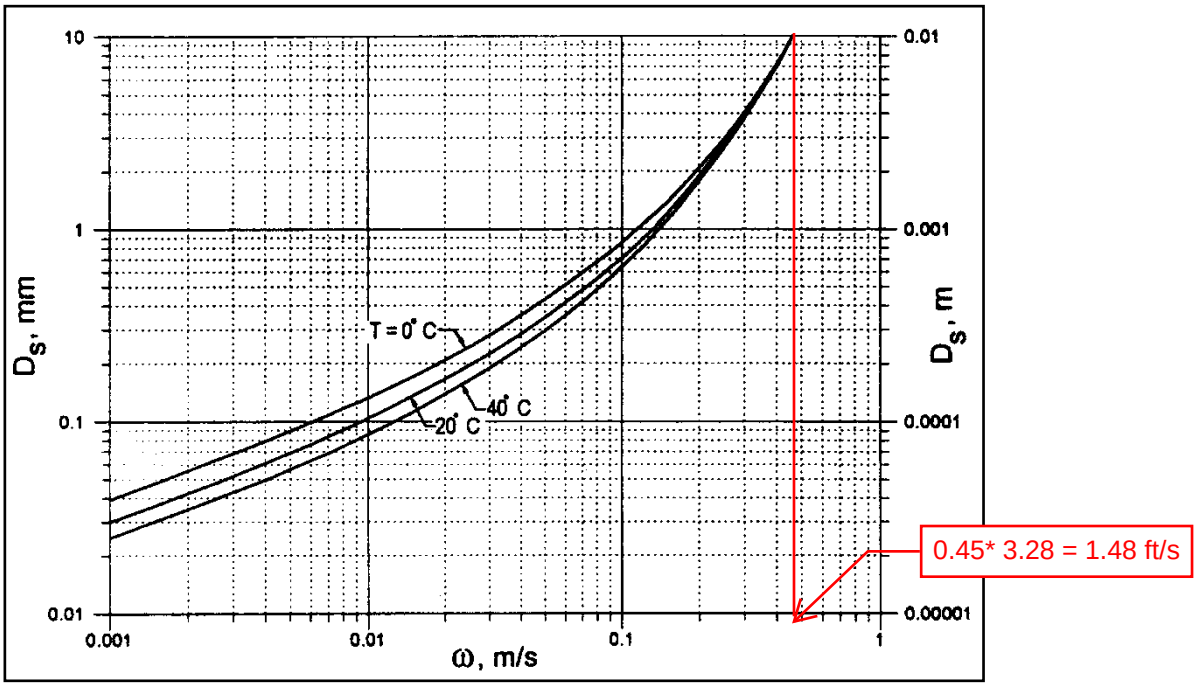



Figure 6.8. Fall velocity of sand-sized particles with specific gravity of 2.65 in metric units.

5. The average width of the bridge opening ($W_2$) is normally taken as the bottom width, with the width of the piers subtracted.

6. Laursen's equation will overestimate the depth of scour at the bridge if the bridge is located at the upstream end of a natural contraction or if the contraction is the result of the bridge abutments and piers. At this time, however, it is the best equation available.

7. In sand channel streams where the contraction scour hole is filled in on the falling stage, the $y_0$ depth may be approximated by $y_1$. Sketches or surveys through the bridge can help in determining the existing bed elevation.

8. **Scour depths with live-bed contraction scour may be limited by coarse sediments in the bed material armoring the bed. Where coarse sediments are present, it is recommended that scour depths be calculated for live-bed scour conditions using the clear-water scour equation (given in the next section) in addition to the live-bed equation, and that the smaller calculated scour depth be used.**

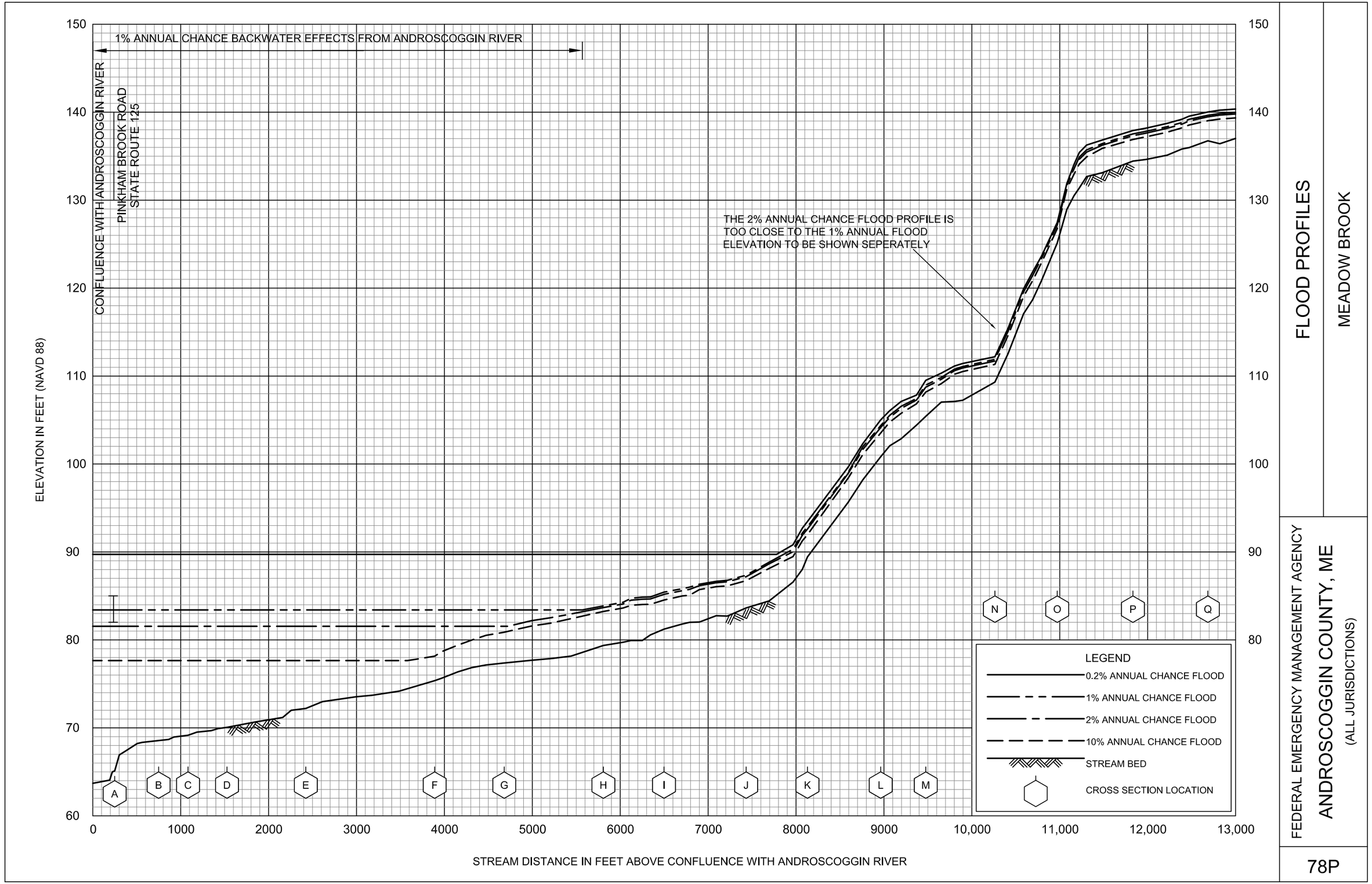
# Appendix C
## FEMA Flood Insurance Study

**Table 7 – Manning's "n" Values (Continued)**

| Stream | Channel | Overbank |
|---|---|---|
| Hart Brook | 0.045-0.060 | 0.040-0.120 |
| Hooper Brook | 0.040-0.065 | 0.078-0.095 |
| Hooper Brook Tributary 1 | 0.065-0.067 | 0.078-0.095 |
| House Brook | 0.045 | 0.045-0.150 |
| Jepson Brook | 0.013-0.050 | 0.032-0.120 |
| Lake Auburn | 0.032-0.040 | 0.032-0.120 |
| Lapham Brook | 0.035-0.045 | 0.035-0.090 |
| Little Androscoggin River | 0.050 | 0.035-0.110 |
| Lively Brook | * | * |
| Lower Range Pond | 0.032 | 0.032-0.090 |
| Martin Stream | * | * |
| Maxwell Brook | 0.060-0.075 | 0.080-0.085 |
| Meadow Brook | 0.045 | 0.035-0.150 |
| Moody Brook | 0.035-0.045 | 0.050-0.080 |
| Newell Brook | 0.050 | 0.032-0.130 |
| Nezinscot River | 0.040-0.052 | 0.060-0.080 |
| No Name Brook | 0.040-0.045 | 0.030-0.150 |
| No Name Brook Tributary A | 0.045-0.050 | 0.040-0.120 |
| Potash Brook | 0.032-0.055 | 0.032-0.150 |
| Range Brook | 0.032-0.060 | 0.035-0.090 |
| Redwater Brook | 0.032-0.055 | 0.032-0.150 |
| Sabattus River | 0.015-0.062 | 0.017-0.092 |
| Salmon Brook | 0.040 | 0.040-0.150 |
| Soper Mill Brook | 0.045 | 0.040-0.090 |
| Stetson Brook | 0.065 | 0.035-0.150 |
| Taylor Brook | 0.035-0.070 | 0.030-0.120 |
| Taylor Brook Tributary 1 | 0.050 | 0.100 |
| The Basin | 0.032 | 0.032-0.120 |
| Tributary A to Little Androscoggin River | 0.045 | 0.032-0.090 |
| Tributary A to Soper Mill Brook | 0.045 | 0.032-0.150 |
| Waterhouse Brook | 0.060 | 0.040-0.090 |
| Winter Brook | 0.035-0.060 | 0.060-0.105 |
| Worthley Brook | 0.055 | 0.035-0.150 |
| Worthley Pond | 0.032-0.055 | 0.055-0.120 |

*Data not available

All qualifying benchmarks within a given jurisdiction that are catalogued by the National Geodetic Survey (NGS) and entered into the National Spatial Reference System (NSRS) as First or Second Order Vertical and have a vertical stability classification of A, B or C are shown and labeled on the FIRM with their 6-character NSRS Permanent Identifier.




FLOOD PROFILES

MEADOW BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

ANDROSCOGGIN COUNTY, ME

(ALL JURISDICTIONS)

78P

# Appendix D
## Peak Flow Calculations

| | | | |
|---|---|---|---|
| **WIN:** | 23657.00 | **Project Name:** | Durham |
| **Town:** | Durham | **Stream Name:** | Meadow Brook |
| **Route No.** | 125 | **Bridge Name:** | Tracy Brook Bridge |
| **Asset ID:** | 2852 | **Analysis by:** | AWM |
| **Lat:** | 43.99095 **Long:** -70.0542 | **Date:** | 4/30/2018 |

# 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** | 9.84 | 3.80 | 2432.0 | Watershed Area *DRNAREA* |
| **W** | 1.47 | 0.6 | 362.1 | Wetlands area (by NWI) |

| | | |
|---|---|---|
| **$P_c$** | 413448 4868495 | watershed centroid (E, N; UTM 19N; meters) |
| **County** | Androscoggin | *choose county from drop-down menu* |
| **pptA** | 45.3 | mean annual precipitation (inches; by look-up) |
| **SG** | 0.00 | sand & gravel aquifer as decimal fraction of watershed A |

| | | | |
|---|---|---|---|
| **A (km$^2$)** | 9.84 | **Conf Lvl** | 0.67 |
| **W (%)** | 14.89 | NWI Wetlands % *STORNWI* | |

| **Ret Pd** | **Peak Flow Estimate** | | | |
|---|---|---|---|---|
| **T (yr)** | **Lower** | **$Q_T$ (m$^3$/s)** | **Upper** | **$Q_T$ (ft$^3$/s)** |
| 1.1 | | 1.57 | | 55.5 |
| 2 | | 3.17 | | 112.1 |
| 5 | | 4.95 | | 174.6 |
| 10 | | 6.14 | | 216.9 |
| 25 | | 8.06 | | 284.5 |
| 50 | | 9.28 | | 327.6 |
| 100 | | 10.87 | | 383.6 |
| 500 | | 14.45 | | 510.2 |

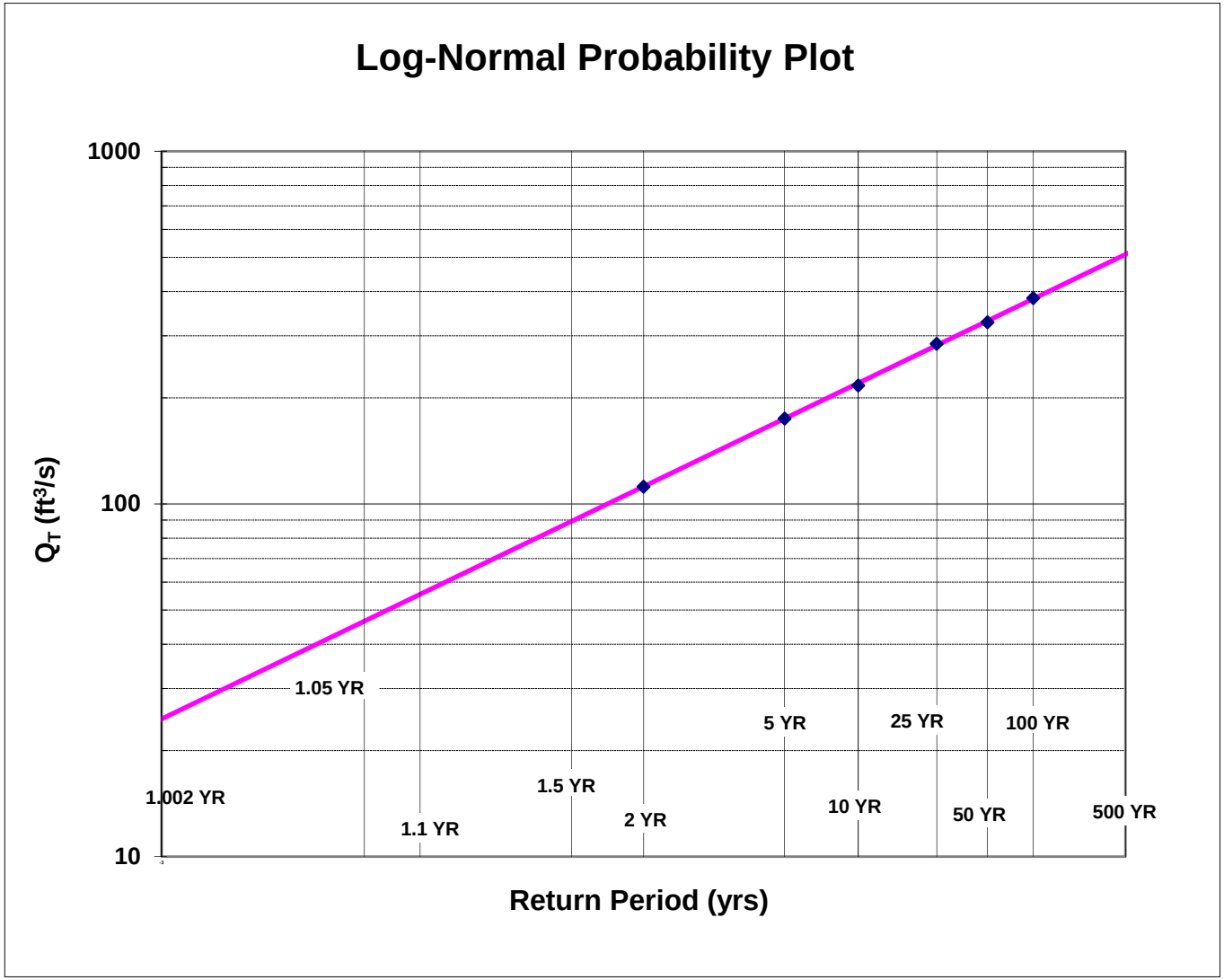
***Worksheet prepared by:***
Charles S. Hebson, PE
Environmental Office
Maine Dept. Transportation
Augusta, ME 04333-0016
207-557-1052
Charles.Hebson@maine.gov
*ver. 2017 Jun. 09*

***References:***

Hodgkins, G.A., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
*WRIR 99-4008,* USGS Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2015.
Peak flow regression equations for small, ungaged streams in Maine - Comparing map-based to field-based variables
*SIR 2015-4059,* USGS, Augusta, ME

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


Log-Normal Probability Plot
1000
100
10
$Q_T$ (ft³/s)
1.05 YR
5 YR
25 YR
100 YR
1.002 YR
1.5 YR
10 YR
1.1 YR
2 YR
50 YR
500 YR
Return Period (yrs)

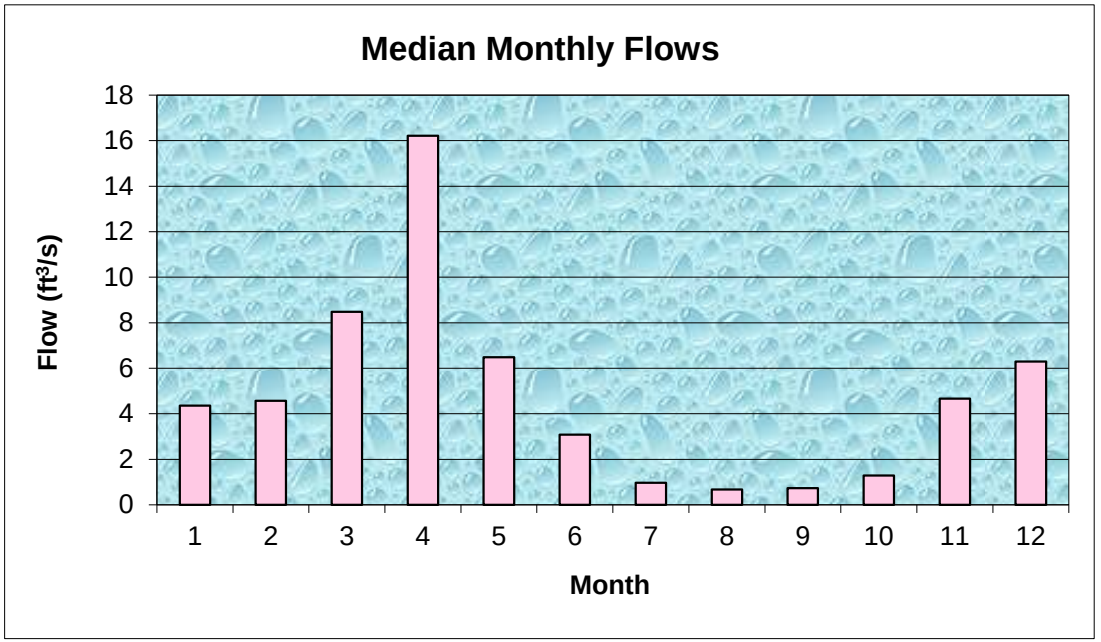
| | | | |
|---|---|---|---|
| **WIN:** | 23657.00 | **Project Name:** | Durham |
| **Town:** | Durham | **Stream Name:** | Meadow Brook |
| **Route No.** | 125 | **Bridge Name:** | Tracy Brook Bridge |
| **Asset ID:** | 2852 | **Analysis by:** | AWM |
| **Lat:** | 43.99095 **Long:** -70.05417 | **Date:** | 4/30/2018 |

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

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

| | Value | Variable | Explanation |
|---|---|---|---|
| | 3.80 | *A* | Area ($mi^2$) |
| 413448 | 4868495 | $P_c$ | Watershed centroid (E,N; UTM; Zone 19; meters) |
| | 47.54 | *DIST* | Distance from Coastal reference line (mi) |
| | 45.3 | *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 | **4.35** | 0.1234 |
| Feb | **4.57** | 0.1295 |
| Mar | **8.47** | 0.2401 |
| Apr | **16.22** | 0.4596 |
| May | **6.48** | 0.1837 |
| Jun | **3.09** | 0.0875 |
| Jul | **0.97** | 0.0276 |
| Aug | **0.68** | 0.0192 |
| Sep | **0.73** | 0.0206 |
| Oct | **1.29** | 0.0365 |
| Nov | **4.67** | 0.1323 |
| Dec | **6.29** | 0.1782 |



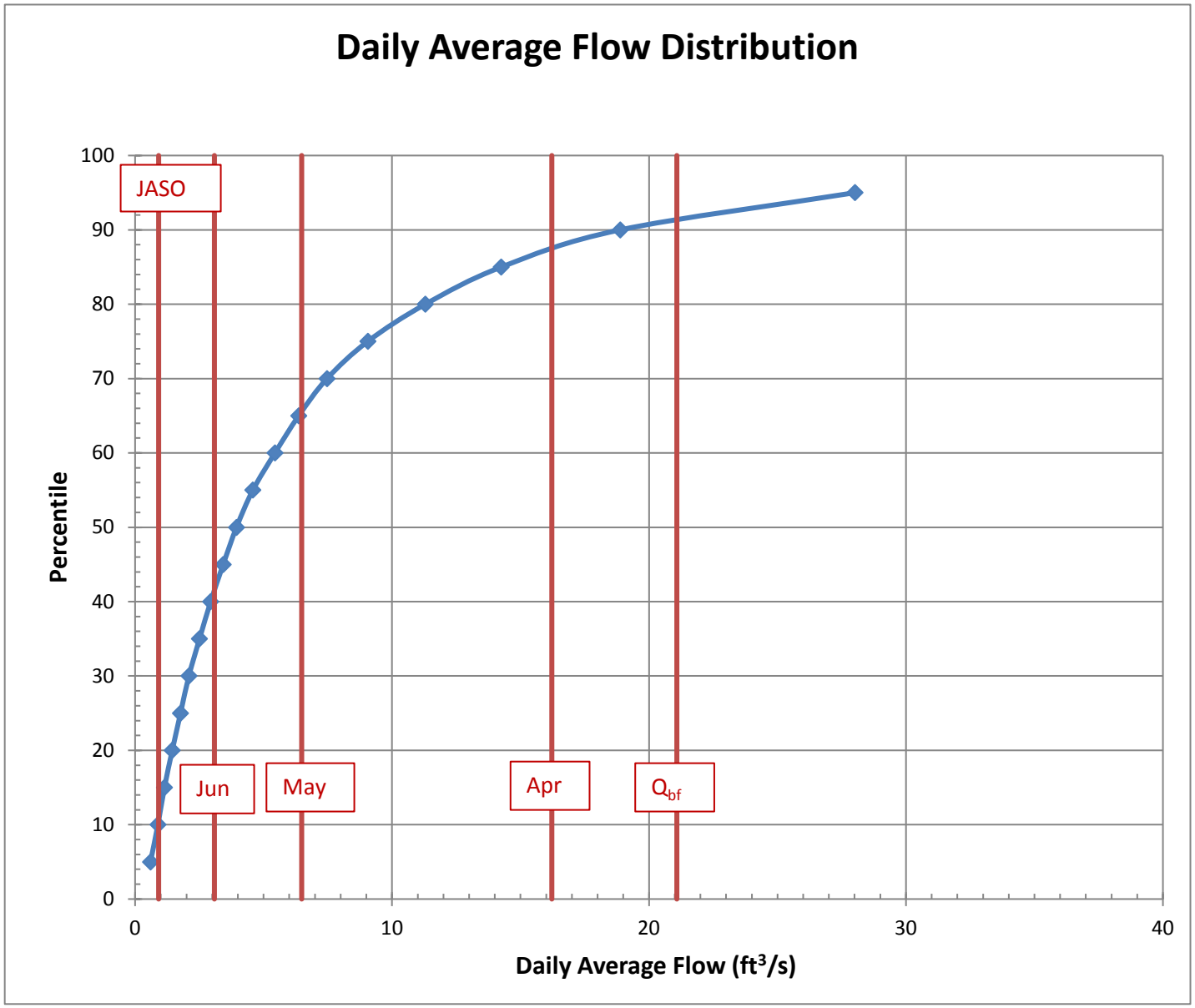

| | | |
|---|---|---|
| $Q_{bf}$ | **21.1** | |
| ann avg | **7.9** | |
| ann med | **4.0** | |
| $Q_{1.002}$ | **24.6** | |
| $Q_{1.01}$ | **32.8** | |
| $Q_{1.05}$ | **46.5** | |
| $Q_{bf}$ | **70.3** | assume v = 4ft/s |

| | | |
|---|---|---|
| $W_{bf}$ | **18.8** | estimated bankfull width (ft) |
| $d_{bf}$ | **0.9** | estimated bankfull depth (ft) |
| $A_{bf}$ | **14.3** | estimated bankfull flow area ($ft^2$) |

***References***

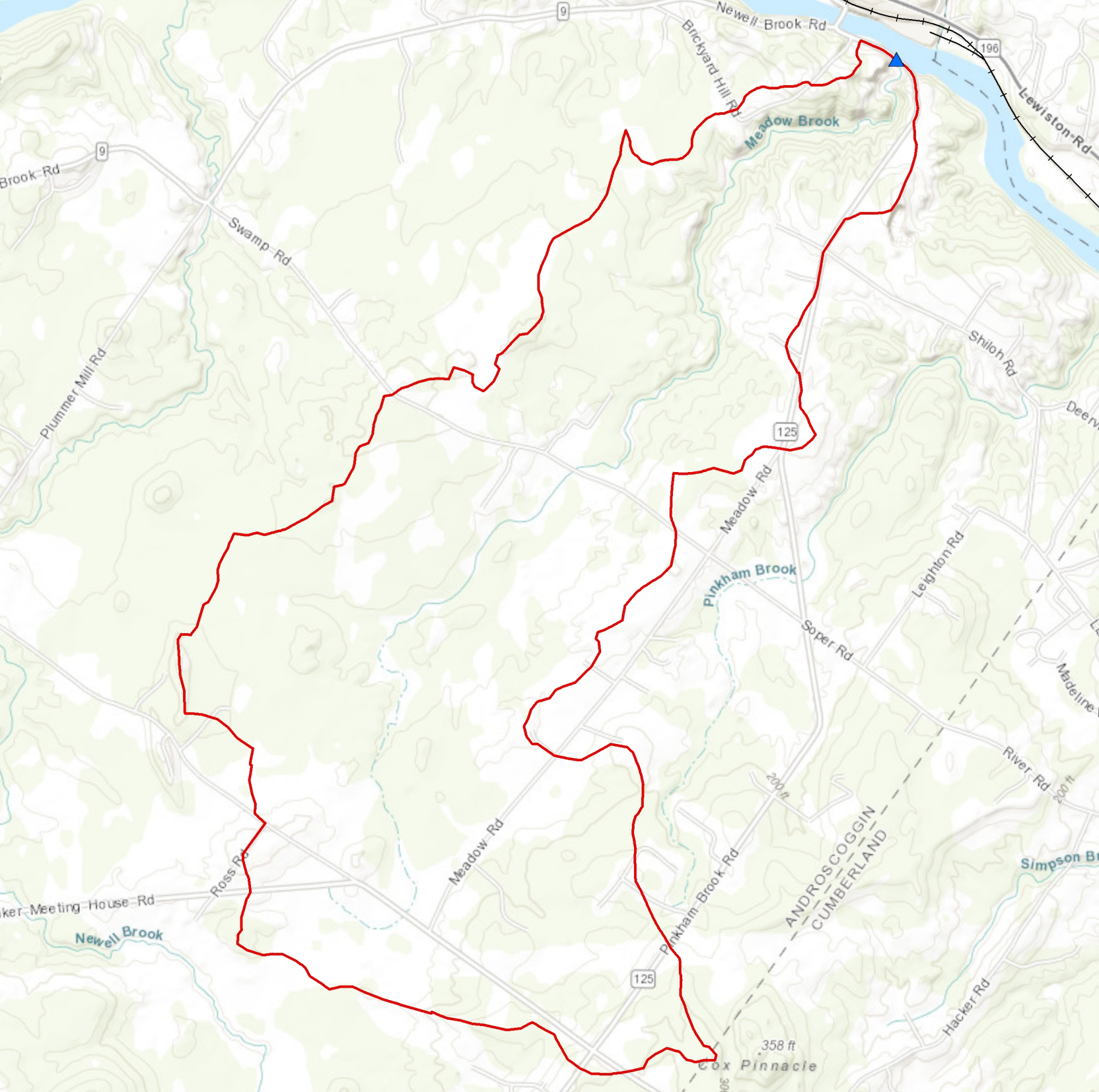

Dudley, R.W., 2013. FY2013 Progress Report - Phase 1 …, USFWS QRP Project

Dudley, R.W., 2004. Estimating Monthly Streamflows … , SIR 2004-5026



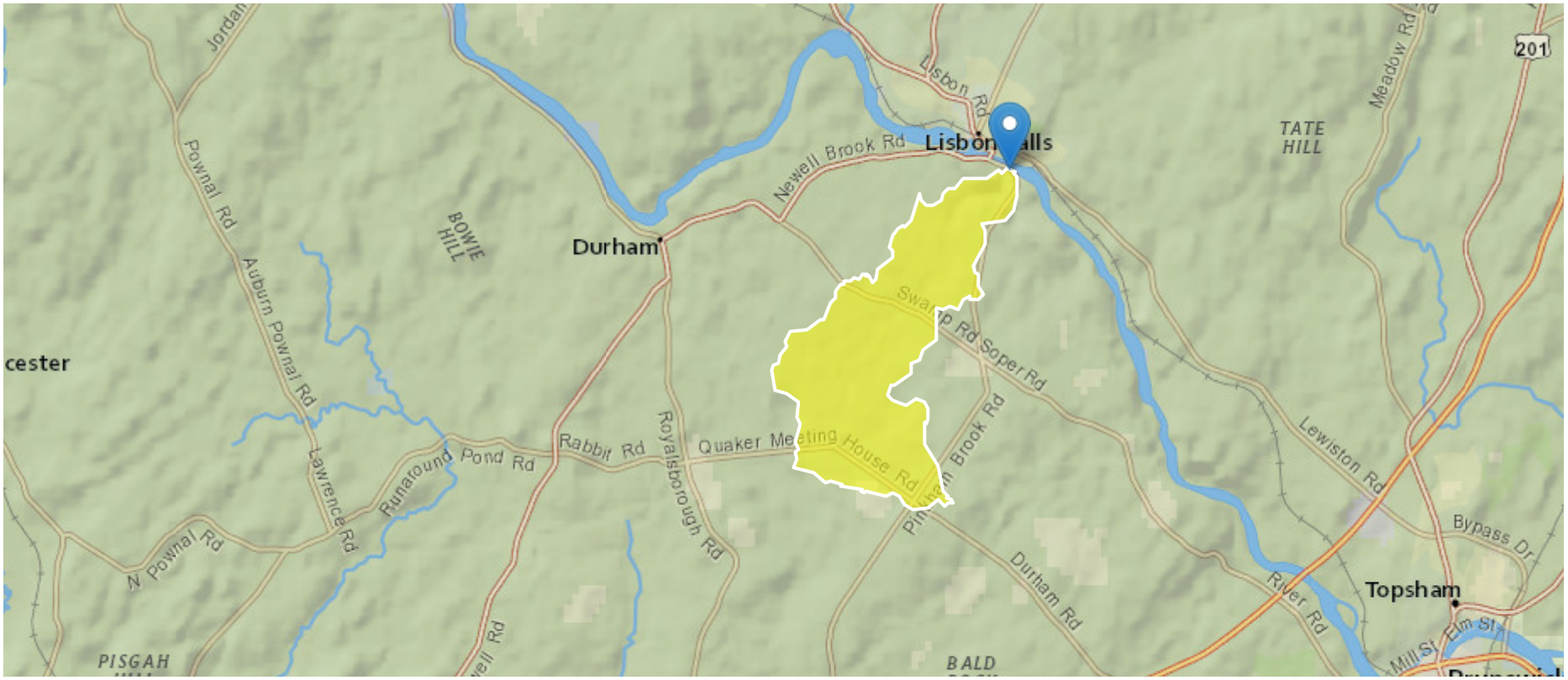

| Daily Avg Flow Dist | | |
|---|---|---|
| $A_{ws}$ = (mi$^2$) | | 3.8 |
| Q (ft$^3$/s) | | |
| **Pctl** | **Median** | **84$^{th}$ pctl** |
| 5 | 0.60 | 0.96 |
| 10 | 0.89 | 1.34 |
| 15 | 1.14 | 1.67 |
| 20 | 1.45 | 2.02 |
| 25 | 1.77 | 2.37 |
| 30 | 2.09 | 2.70 |
| 35 | 2.51 | 3.09 |
| 40 | 2.94 | 3.55 |
| 45 | 3.43 | 4.01 |
| 50 | 3.95 | 4.74 |
| 55 | 4.58 | 5.51 |
| 60 | 5.44 | 6.47 |
| 65 | 6.37 | 7.54 |
| 70 | 7.47 | 8.80 |
| 75 | 9.06 | 10.58 |
| 80 | 11.29 | 12.63 |
| 85 | 14.25 | 16.19 |
| 90 | 18.88 | 21.74 |
| 95 | 28.02 | 33.81 |

| | |
|---|---|
| $Q_{bf}$ | 21.1 |
| $Q_{1.002}$ | 24.6 |
| $Q_{1.1}$ | 55.5 |
| $Q_2$ | 112.1 |


Newell Brook Rd
Brickyard Hill Rd
Meadow Brook
Lewiston Rd
196
9
Brook Rd
Swamp Rd
Plummer Mill Rd
Shiloh Rd
125
Meadow Rd
Pinkham Brook
Leighton Rd
Soper Rd
River Rd
200 ft
ANDROSCOGGIN
CUMBERLAND
Simpson Br
Hacker Rd
Ross Rd
ker Meeting House Rd
Newell Brook
Pinkham Brook Rd
358 ft
Cox Pinnacle

# Durham 23657 Tracy Brook (Meadow Brk) at ME125 (Pinkham Brk Rd)

**Region ID:** ME
**Workspace ID:** ME20190620175639805000
**Clicked Point (Latitude, Longitude):** 43.99095, -70.05417
**Time:** 2019-06-20 13:57:00 -0400




Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| DRNAREA | Area that drains to a point on a stream | 3.8 | square miles |
| STORNWI | Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory | 14.94 | percent |
| SANDGRAVAF | Fraction of land surface underlain by sand and gravel aquifers | 0 | dimensionless |
| ELEV | Mean Basin Elevation | 175.7 | feet |
| BSLDEM10M | Mean basin slope computed from 10 m DEM | 4.36 | percent |
| CENTROIDX | Basin centroid horizontal (x) location in state plane coordinates | 413448.4 | feet |
| CENTROIDY | Basin centroid vertical (y) location in state plane units | 4868494.8 | feet |
| COASTDIST | Shortest distance from the coastline to the basin centroid | 48 | miles |
| ELEVMAX | Maximum basin elevation | 322.9 | feet |
| LC06WATER | Percent of open water, class 11, from NLCD 2006 | 0 | percent |
| LC11DEV | Percentage of developed (urban) land from NLCD 2011 classes 21-24 | 5.42 | percent |
| LC11IMP | Average percentage of impervious area determined from NLCD 2011 impervious dataset | 0.94 | percent |
| PRECIP | Mean Annual Precipitation | 45.5 | inches |
| SANDGRAVAP | Percentage of land surface underlain by sand and gravel aquifers | 0 | percent |
| STATSGOA | Percentage of area of Hydrologic Soil Type A from STATSGO | 10 | percent |

Bankfull Statistics Parameters[Central and Coastal Bankfull 2004 5042]

| Parameter Code | Parameter Name | Value | Units | Min Limit | Max Limit |
|---|---|---|---|---|---|
| DRNAREA | Drainage Area | 3.8 | square miles | 2.92 | 298 |

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

| Statistic | Value | Unit |
|---|---|---|
| Bankfull Streamflow | 21.1 | ft^3/s |
| Bankfull Width | 15.4 | ft |
| Bankfull Depth | 0.935 | ft |
| Bankfull Area | 14.3 | 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)**

Peak-Flow Statistics Parameters[Statewide Peak Flow DA LT 12sqmi 2015 5049]

| Parameter Code | Parameter Name | Value | Units | Min Limit | Max Limit |
|---|---|---|---|---|---|
| DRNAREA | Drainage Area | 3.8 | square miles | 0.31 | 12 |
| STORNWI | Percentage of Storage from NWI | 14.94 | percent | 0 | 22.2 |

Peak-Flow Statistics Flow Report[Statewide Peak Flow DA LT 12sqmi 2015 5049]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

| Statistic | Value | Unit | SEp |
|---|---|---|---|
| 1.01 Year Peak Flood | 33.7 | ft^3/s | 38 |
| 2 Year Peak Flood | 112 | ft^3/s | 34 |
| 5 Year Peak Flood | 174 | ft^3/s | 35 |
| 10 Year Peak Flood | 216 | ft^3/s | 37 |
| 25 Year Peak Flood | 284 | ft^3/s | 39 |

| Statistic | Value | Unit | SEp |
|---|---|---|---|
| 50 Year Peak Flood | 327 | ft^3/s | 41 |
| 100 Year Peak Flood | 383 | ft^3/s | 42 |
| 250 Year Peak Flood | 427 | ft^3/s | 44 |
| 500 Year Peak Flood | 509 | ft^3/s | 47 |

*Peak-Flow Statistics Citations*

**Lombard, P.J., and Hodgkins, G.A.,2015, Peak flow regression equations for small, ungaged streams in Maine— Comparing map-based to field-based variables: U.S. Geological Survey Scientific Investigations Report 2015–5049, 12 p. (http://dx.doi.org/10.3133/sir20155049)**

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

| Parameter Code | Parameter Name | Value | Units | Min Limit | Max Limit |
|---|---|---|---|---|---|
| DRNAREA | Drainage Area | 3.8 | square miles | 14.9 | 1419 |
| SANDGRAVAF | Fraction of Sand and Gravel Aquifers | 0 | dimensionless | 0 | 0.212 |
| ELEV | Mean Basin Elevation | 175.7 | feet | 239 | 2120 |

Flow-Duration Statistics Disclaimers[Statewide Annual SIR 2015 5151]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Flow-Duration Statistics Flow Report[Statewide Annual SIR 2015 5151]

| Statistic | Value | Unit |
|---|---|---|
| 1 Percent Duration | 0.0085 | ft^3/s |
| 5 Percent Duration | 0.0573 | ft^3/s |

| Statistic | Value | Unit |
|---|---|---|
| 10 Percent Duration | 0.167 | ft^3/s |
| 25 Percent Duration | 0.927 | ft^3/s |
| 50 Percent Duration | 3.34 | ft^3/s |
| 75 Percent Duration | 8.82 | ft^3/s |
| 90 Percent Duration | 20 | ft^3/s |
| 95 Percent Duration | 31.6 | ft^3/s |
| 99 Percent Duration | 79 | ft^3/s |

*Flow-Duration Statistics Citations*

**Dudley, R.W.,2015, Regression equations for monthly and annual mean and selected percentile streamflows for ungaged rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2015–5151, 35 p. (http://dx.doi.org/10.3133/sir20155151)**

Annual Flow Statistics Parameters[Statewide Annual SIR 2015 5151]

| Parameter Code | Parameter Name | Value | Units | Min Limit | Max Limit |
|---|---|---|---|---|---|
| DRNAREA | Drainage Area | 3.8 | square miles | 14.9 | 1419 |
| SANDGRAVAF | Fraction of Sand and Gravel Aquifers | 0 | dimensionless | 0 | 0.212 |
| ELEV | Mean Basin Elevation | 175.7 | feet | 239 | 2120 |

Annual Flow Statistics Disclaimers[Statewide Annual SIR 2015 5151]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Annual Flow Statistics Flow Report[Statewide Annual SIR 2015 5151]

| Statistic | Value | Unit |
|---|---|---|
| Mean Annual Flow | 8.14 | ft^3/s |

*Annual Flow Statistics Citations*

**Dudley, R.W.,2015, Regression equations for monthly and annual mean and selected percentile streamflows for ungaged rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2015–5151, 35 p. (http://dx.doi.org/10.3133/sir20155151)**



Application Version: 4.3.8