Dewberry

MEMORANDUM

To: Tim Timberman

From: Josephine Schuster, P.E.

Date: December 15, 2016

Re: Preliminary Hydraulic Findings and Qualitative Scour Assessment
Replacement of Bridge No. 04575, Main Street Bridge over the Tankerhoosen River, Vernon, Connecticut
State Project No. 146-199

Introduction

Dewberry Engineers Inc. has been selected to prepare the design plans for the replacement of Bridge No. 04575 carrying Main Street over the Tankerhoosen River in the Town of Vernon, CT. The existing bridge, which provides access to approximately three residents as well as the Hop River State Park Trail, is being replaced because it is both structurally deficient and functionally obsolete.

Water surface profiles for the subject reach of the Tankerhoosen River were revised by the Federal Emergency Management Agency on August 9, 1999, for the Town of Vernon, Tolland County Flood Insurance Study (FIS). In order to evaluate the impacts the proposed work will have on the water surface elevations in the vicinity of Main Street, a hydraulic model of the river was developed by Dewberry. This memorandum describes the development and results of the model and provides a qualitative assessment of potential scour conditions at the bridge.

The effective model (HEC-2) of the Tankerhoosen River was obtained from FEMA. That effective model was imported into HEC-RAS and is the Duplicate Effective Model (DEM). The DEM was then adjusted to create the Corrected Effective Model (CEM). The CEM was run with the FEMA 100 year flow so that it matched the 100 year water surface elevations at the FEMA cross sections. The Existing Condition Model (ECM) was created by incorporating the surveyed bridge cross sections into the CEM. The Proposed Condition Model (PCM) was developed by replacing the existing bridge in the ECM with the proposed bridge. Lastly, the natural conditions were run to evaluate the effects of the proposed bridge alternative relative to the natural conditions without any channel obstructions.

Hydrologic Summary

The HEC-RAS 4.1.0 computer program was used to develop the hydraulic model. In accordance with the scope of work, the 2, 10, 25, 50, 100, and 500-year storms were modeled using the peak flows listed in the approved *Hydrologic Report*, dated June 2016, and approved by ConnDOT on June 21, 2016. The following tables summarize the recommended design flows, which were used in the ECM and PCM models, as well as the Flood Insurance Study (FIS) flows, which were used in the regulatory floodway analysis.

Table 1: Approved Design Flows at the Main Street Bridge

Storm (year)	Design Flow (cfs)
2	741
10	1,394
25	1,771
50	2,122
100	2,505
500	4,025

Table 2: FEMA FIS Flows

Storm (year)	Flow (cfs)
10	1,394
100	2,505

Hydraulic Boundary Conditions

At an average slope of approximately 0.62%, the main channel of the Tankerhoosen River within the study reach is very flat. Therefore, the hydraulic analysis was limited to the subcritical flow regime. In accordance with the approved scope of work, the downstream limit of the study begins just above the dam approximately 130 feet downstream from the Main Street Bridge. This location corresponds to a rating curve in the HEC-2 model at cross section 8.1 which reflects the impact of the downstream dam on the hydraulics. Although hydraulic models typically start at a lettered FEMA cross section, the models need to be started at the section where the rating curve is present. The closest FEMA lettered section (D) in the HEC-2 model is at cross section 8.0 which is downstream of the dam. Starting the model at FEMA lettered section D and using normal depth as the boundary condition for the design flows would effectively ignore the rating curve and the presence of the dam. Although the design flows differ from the FIS flows, the rating curve is still applicable, since the upper end of the curve is still higher than the maximum design flow. The upstream study limit is 2,230 feet upstream of the downstream study limit and corresponds to FEMA lettered section G in accordance with the scope of work.

DEM and CEM

The cross section geometry and Mannings roughness coefficients for the DEM and CEM were from the FEMA Effective model (HEC-2 model obtained from FEMA). Roughness coefficients between 0.035 and 0.020 were used throughout the study reach for the main channel, which is generally free of vegetation. The floodplains surrounding the study reach consist of a variety of land cover, ranging from forested areas with mature trees to open lawns. The associated roughness coefficients therefore ranged from 0.090 to 0.040.

The main channel geometry within the study reach varies significantly, with the presence of Talcottville Pond upstream of the bridge. The more abrupt changes to the channel geometry are reflected in the expansion/contraction coefficients, which were set to 0.5 and 0.3, respectively, at many of the upstream sections, which follows what was done in the HEC-2 model. Expansion/contraction coefficients at all other sections were set to 0.3 and 0.1, which are common loss coefficients associated with gradual transitions along a reach.

The water surface elevations from the DEM matched the water surface elevations from the FEMA Effective model at all sections within the study reach, therefore the only change made to the DEM to create the CEM was applying the datum conversion. The datum used in the FIS was the NGVD 29 (FIS page 7). The datum for the project is the NAVD 88. The associated datum conversion at the project site is 0.80 feet.

Existing Conditions

The boundary conditions and cross section geometry developed for the ECM are the same as the CEM with the exception of the following:

- Expansion/contraction coefficients assigned to the bridge's bounding cross sections. These values were increased at the first upstream section from 0.3/0.1 to 0.5/0.3 to account for the constriction occurring at the bridge.
- Upstream and downstream cross section data. The upstream and downstream sections from the HEC-2 model (Sections 1821 and 1766) used the same cross section geometry as the bridge section, when in reality, the channel at the bounding cross sections is significantly larger. Survey data was used to develop these sections. Additionally, ground elevations were changed in the first upstream section to reflect the remnant of an existing pier.
- Ineffective flow lines. The CEM did not include ineffective flow lines, which are necessary at the sections upstream and downstream of the bridge to reflect the expansion and contraction of water as it passes through the bridge.
- Blocked obstructions. Two blocked obstructions were added to the two cross sections just downstream of the bridge (Sections 1661 and 1766) to reflect the presence of buildings.
- Flows. The FIS flows in the CEM were change to the approved design flows in the ECM.

There were no other geometry changes for the other sections, because the HEC-2 geometry was within 0.5 ft of the survey data.

The existing Main Street Bridge over the Tankerhoosen River consists of a single-span steel beam superstructure, which supports a bituminous concrete deck. The structure has a normal clear span of 55.5 feet (measured between abutment front faces). This was changed from the DEM/CEM, which used a bridge opening of 57.5 feet. The deck/roadway width (measured in the direction of flow) is 26.75 feet out-to-out (including the attached gas line and railing). The existing lenticular truss is mounted to the bridge but is only aesthetic. The floor beams from this bridge extend below the low chord but are aligned with the direction of flow and present a limited reduction in the flow area, and were therefore not modeled. Since the guide rail posts are relatively wide and the existing truss is fairly open, no obstruction was modeled on top of the bridge. The low chord of the bridge is 207.66 feet (NAVD 88).

The water surface profiles from the ECM indicate that the 100-year event flows under the bridge without contacting the low chord. The 500-year event contacts the low chord, but does not overtop the road, therefore the pressure/weir flow method is included in the analysis to properly analyze this event.

Proposed Bridge Alternatives

The ECM was modified to create the PCM for the three steel multi-beam bridge replacement alternatives investigated. For all proposed conditions, an open steel rail system similar to the one that exists today is included in the design. As previously described for the Existing Conditions, this rail is not modeled as an obstruction. Additionally, all options involve the reuse of the existing lenticular truss as an aesthetic treatment, and like the existing condition, the floor beams from this truss are not included. All other geometric features, flows and boundary conditions from the ECM are the same for the PCM.

The following steel multi-beam bridge alternatives were investigated:

1. Alternative 1 – One 12' lane and 5'-6" shoulder.
2. Alternative 2 – Two 12' lanes and 5'-6" shoulder.
3. Alternative 3 – Two 12' lanes and 8'-0" pedestrian bridge.

Alternative 1 replaces the bridge at its existing location with the same normal clear span. Although the roadway is widened slightly, the length of the bridge in the direction of flow is reduced because the gas line on the downstream side is moved inside of the structure (mounted on the underside of the exterior diaphragm). This alternative increases the existing low chord elevation of 207.66-ft to the proposed low chord elevation of 207.78-ft (NAVD 88). The goal of this alternative is to provide a bridge that matches the existing span and therefore allows the existing trusses to be placed on the abutments as an architectural feature.

Hydraulically, the goal is to provide a bridge opening that is equal to or greater than the existing bridge opening, and to provide clearance for the 100-year event. The underclearance to the existing 100-year event is 0.79 feet. Chapter 9.3.2 of the ConnDOT Drainage Manual recommends an underclearance of 2 feet where practicable. However, at this site the increase to the roadway profile necessary to obtain 2 feet of underclearance is impractical and affects driveways of adjacent property owners. Additionally, design criteria from the USACE requires that a new bridge spans 1.2 times the bank full width. Given that the downstream dam controls the water surface profile, it would be impractical to widen the bridge span that much because it would have significant impacts to adjacent property.

The tables below compare the 2, 10, 25, 50, 100 and 500 year water surface elevations computed for both the ECM and PCM for Alternative 1. The proposed water surface elevations for Alternative 1 are the same as the existing condition for all storm events as indicated in the tables below.

Table 3: 2-Year Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	208.98	208.98	0.0
3216	204.04	204.04	0.0
2876	203.96	203.96	0.0
2446	204.05	204.05	0.0
2096	204.04	204.04	0.0
1821	204.02	204.02	0.0
1801	Main Street Bridge		0.0
1766	204.02	204.02	0.0
1661	204.02	204.02	0.0

Table 4: 10-Year Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	210.66	210.66	0.0
3216	205.20	205.20	0.0
2876	205.28	205.28	0.0
2446	205.41	205.41	0.0
2096	205.39	205.39	0.0
1821	205.31	205.31	0.0
1801	Main Street Bridge		0.0
1766	205.32	205.32	0.0
1661	205.33	205.33	0.0

Table 5: 25-Year Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	211.52	211.52	0.0
3216	205.64	205.64	0.0
2876	205.85	205.85	0.0
2446	205.98	205.98	0.0
2096	205.95	205.95	0.0
1821	205.84	205.84	0.0
1801	Main Street Bridge		0.0
1766	205.85	205.85	0.0
1661	205.87	205.87	0.0

Table 6: 50-Year Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.21	212.21	0.0
3216	206.08	206.07	0.0
2876	206.38	206.38	0.0
2446	206.51	206.51	0.0
2096	206.48	206.47	0.0
1821	206.34	206.34	0.0
1801	Main Street Bridge		0.0
1766	206.34	206.34	0.0
1661	206.37	206.37	0.0

Table 7: 100-Year Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.88	212.88	0.0
3216	206.61	206.61	0.0
2876	206.96	206.96	0.0
2446	207.09	207.09	0.0
2096	207.05	207.05	0.0
1821	206.87	206.87	0.0
1801	Main Street Bridge		0.0
1766	206.88	206.88	0.0
1661	206.92	206.92	0.0

Table 8: 500-Year Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	215.76	215.76	0.0
3216	208.64	208.62	0.0
2876	208.82	208.81	0.0
2446	208.96	208.95	0.0
2096	208.88	208.87	0.0
1821	208.56	208.55	0.0
1801	Main Street Bridge		0.0
1766	208.48	208.48	0.0
1661	208.58	208.58	0.0

Alternative 2 replaces the bridge at its existing location with a wider structure span than Alternative 1. In order to provide adequate effective flow in the upstream and downstream sections that matches the existing conditions, the south abutment was shifted approximately 3 feet out. The hydraulic performance of Alternative 2 is similar to Alternative 1, with proposed water surface elevations throughout the reach for all events the same as the existing condition.

Table 9: 2-Year Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	208.98	208.98	0.0
3216	204.04	204.04	0.0
2876	203.96	203.95	0.0
2446	204.05	204.05	0.0
2096	204.04	204.04	0.0
1821	204.02	204.02	0.0
1801	Main Street Bridge		0.0
1766	204.02	204.02	0.0
1661	204.02	204.02	0.0

Table 10: 10-Year Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	210.66	210.66	0.0
3216	205.20	205.20	0.0
2876	205.28	205.28	0.0
2446	205.41	205.41	0.0
2096	205.39	205.39	0.0
1821	205.31	205.31	0.0
1801	Main Street Bridge		0.0
1766	205.32	205.32	0.0
1661	205.33	205.33	0.0

Table 11: 25-Year Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	211.52	211.52	0.0
3216	205.64	205.64	0.0
2876	205.85	205.84	0.0
2446	205.98	205.98	0.0
2096	205.95	205.95	0.0
1821	205.84	205.84	0.0
1801	Main Street Bridge		0.0
1766	205.85	205.85	0.0
1661	205.87	205.87	0.0

Table 12: 50-Year Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.21	212.21	0.0
3216	206.08	206.07	0.0
2876	206.38	206.37	0.0
2446	206.51	206.51	0.0
2096	206.48	206.47	0.0
1821	206.34	206.33	0.0
1801	Main Street Bridge		0.0
1766	206.34	206.34	0.0
1661	206.37	206.37	0.0

Table 13: 100-Year Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.88	212.88	0.0
3216	206.61	206.61	0.0
2876	206.96	206.96	0.0
2446	207.09	207.09	0.0
2096	207.05	207.04	0.0
1821	206.87	206.87	0.0
1801	Main Street Bridge		0.0
1766	206.88	206.88	0.0
1661	206.92	206.92	0.0

Table 14: 500-Year Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	215.76	215.76	0.0
3216	208.64	208.59	0.0
2876	208.82	208.78	0.0
2446	208.96	208.93	0.0
2096	208.88	208.84	0.0
1821	208.56	208.52	0.0
1801	Main Street Bridge		0.0
1766	208.48	208.48	0.0
1661	208.58	208.58	0.0

Alternative 3 replaces the bridge on a shifted alignment at the upstream end of the existing bridge. In this alternative, the existing trusses remain at the existing bridge location and are used as a pedestrian bridge. The proposed bridge span was increased to place the abutments outside of the channel banks. For hydraulic modelling purposes, the proposed bridge and the pedestrian bridge are included in the model as a single bridge, using a larger bridge length in the direction of flow and the lowest values from each bridge for low chords and clear spans.

Shifting the alignment upstream caused the proposed bridge to cross the first upstream cross section (Section 1821), therefore this cross section was moved 22 feet upstream and renamed section 1843. In order to provide proper section matching between existing and proposed models, section 1821 was also moved in the existing model (for Alternative 3 only).

Although it is preferable to have the same section locations for all three alternatives, it was deemed to be appropriate in this case to have different upstream cross sections because of the significant difference in channel width. The channel width upstream of the bridge at section 1843 is approximately 50% larger than the channel width at section 1821. While moving the upstream section is appropriate for Alternative 3, moving it in the other two alternatives would incorrectly increase the modelled channel width in the first upstream section and skew the results.

The hydraulic performance of Alternative 3 is similar to the other two alternatives, with proposed water surface elevations throughout the reach for all events the same as the existing condition, with the exception of the 500 year event, which shows an increase of 0.1' at several sections.

Table 15: 2-Year Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	208.98	208.98	0.0
3216	204.04	204.04	0.0
2876	203.95	203.95	0.0
2446	204.05	204.05	0.0
2096	204.04	204.04	0.0
1843	204.03	204.03	0.0
1801	Main Street Bridge		0.0
1766	204.02	204.02	0.0
1661	204.02	204.02	0.0

Table 16: 10-Year Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	210.66	210.66	0.0
3216	205.20	205.20	0.0
2876	205.28	205.28	0.0
2446	205.41	205.41	0.0
2096	205.38	205.38	0.0
1843	205.37	205.37	0.0
1801	Main Street Bridge		0.0
1766	205.32	205.32	0.0
1661	205.33	205.33	0.0

Table 17: 25-Year Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	211.52	211.52	0.0
3216	205.64	205.64	0.0
2876	205.84	205.84	0.0
2446	205.98	205.98	0.0
2096	205.95	205.95	0.0
1843	205.92	205.92	0.0
1801	Main Street Bridge		0.0
1766	205.85	205.85	0.0
1661	205.87	205.87	0.0

Table 18: 50-Year Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.21	212.21	0.0
3216	206.07	206.07	0.0
2876	206.37	206.37	0.0
2446	206.51	206.51	0.0
2096	206.47	206.47	0.0
1843	206.44	206.44	0.0
1801	Main Street Bridge		0.0
1766	206.34	206.34	0.0
1661	206.37	206.37	0.0

Table 19: 100-Year Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.88	212.88	0.0
3216	206.61	206.62	0.0
2876	206.96	206.96	0.0
2446	207.10	207.10	0.0
2096	207.05	207.05	0.0
1843	207.00	207.01	0.0
1801	Main Street Bridge		0.0
1766	206.88	206.88	0.0
1661	206.92	206.92	0.0

Table 20: 500-Year Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	215.76	215.76	0.0
3216	208.65	208.71	0.1
2876	208.83	208.88	0.1
2446	208.97	209.02	0.1
2096	208.89	208.94	0.1
1843	208.81	208.86	0.1
1801	Main Street Bridge		0.0
1766	208.48	208.48	0.0
1661	208.58	208.58	0.0

Natural Conditions

The natural conditions model is intended to show the floodplain in the vicinity of the project as it would be without any artificial encroachments or modifications. The natural model is developed by removing all obstructions in the study reach from the ECM. In accordance with CTDEEP's Hydraulic Guidance Document for projects with a downstream dam, two models were run. The first was the natural condition model, which removed all obstructions from the ECM including the Main Street Bridge, associated ineffective flow areas, the upstream pier remnant, and the downstream dam. Since the dam was incorporated into the model by a rating curve at the furthest downstream section, removing the dam was accomplished by changing the boundary condition from a rating curve to normal depth. The slope used for the normal depth boundary condition was 0.62% which is the average slope of the channel through the reach.

The second natural condition model removed the downstream dam but included the proposed bridge. Normal depth was also used as the downstream boundary condition. All three alternatives were modeled in the natural proposed model which are described in the Proposed Condition section above. Tables 21 through 23 compare the 100 year water surface elevations computed for the Natural and Natural Proposed conditions for all three alternatives.

As can be seen from the tables below, the difference in water surface elevations between the two conditions is less than 1.0 feet at all sections with the exception of the first upstream section, which increases 1.1 feet for Alternatives 1 and 2. This increase is not in compliance with the applicable portion of Section 9.3.2 of the ConnDOT Drainage Manual. However as discussed above, the natural condition model does not include the dam, which has a significant effect on the stream at the site. The dam plays a significant role in changing the river morphology, creating ponds on both sides of the proposed structure, and resulting in the constriction of flow at the bridge. Therefore removing the dam does not truly model the natural condition as it would have been prior to its installation. Furthermore, the increase to the natural condition occurs at the first upstream section of the bridge, which is located within the legal right-of-way. The increase is also contained within the channel banks. For these reasons, the increase is believed to be acceptable.

Table 21: Natural vs. Natural Proposed 100–Year Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 88)

River Station	Natural Condition	Natural Proposed Condition	Increase
3891	212.88	212.88	0.0
3216	206.27	206.27	0.0
2876	204.69	204.69	0.0
2446	201.09	201.09	0.0
2096	200.43	200.43	0.0
1821	197.76	198.86	1.1
1801	Main Street Bridge		0.0
1766	195.91	195.93	0.0
1661	190.47	190.47	0.0

Table 22: Natural vs. Natural Proposed 100–Year Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 88)

River Station	Natural Condition	Natural Proposed Condition	Increase
3891	212.88	212.88	0.0
3216	206.27	206.27	0.0
2876	204.69	204.69	0.0
2446	201.09	201.08	0.0
2096	200.43	200.42	0.0
1821	197.76	198.82	1.1
1801	Main Street Bridge		0.0
1766	195.91	195.93	0.0
1661	190.47	190.47	0.0

Table 23: Natural vs. Natural Proposed 100–Year Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 88)

River Station	Natural Condition	Natural Proposed Condition	Increase
3891	212.88	212.88	0.0
3216	206.27	206.27	0.0
2876	204.69	204.69	0.0
2446	200.60	200.70	0.1
2096	198.99	199.61	0.4
1843	198.42	199.28	0.9
1801	Main Street Bridge		0.0
1766	195.91	195.93	0.0
1661	190.47	190.47	0.0

Floodway Analysis

The floodway analysis was performed for the all three alternatives for the 100-year and 10-year FEMA flows. As described in the section entitled Hydraulic Boundary Condition, the HEC-2 rating curve was used as the boundary condition. The rating curve represents the downstream dam which controls the upstream water surface profiles. Typically the floodway analysis uses the base flood water surface elevation from the FIS Floodway Data table as the boundary condition; however, due to the presence of the downstream dam, the rating curve described earlier in the memo was used. This was deemed to be the most appropriate boundary condition, since it resulted in water surface elevations that matched those listed in the FIS (Base flood water surface elevation with floodway). The floodway widths were taken from the FIS floodway data table at FEMA lettered cross sections and measured from the FEMA Flood Insurance Rate Map at all other cross sections. The encroached ECM and PCM models were then compared. The tables below indicate that the water surface elevations for the floodway in the PCM match those in the ECM for all three alternatives.

Table 24: 10-Year Floodway Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	209.97	209.97	0.0
3216	204.74	204.74	0.0
2876	204.73	204.73	0.0
2446	204.85	204.85	0.0
2096	204.83	204.83	0.0
1821	204.76	204.76	0.0
1801	Main Street Bridge		0.0
1766	204.77	204.77	0.0
1661	204.78	204.78	0.0

Table 25: 100-Year Floodway Water Surface Elevations, **Alternative 1** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.00	212.00	0.0
3216	205.96	205.96	0.0
2876	206.23	206.23	0.0
2446	206.37	206.37	0.0
2096	206.33	206.33	0.0
1821	206.14	206.14	0.0
1801	Main Street Bridge		0.0
1766	206.17	206.17	0.0
1661	206.20	206.20	0.0

Table 26: 10-Year Floodway Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	209.97	209.97	0.0
3216	204.74	204.73	0.0
2876	204.73	204.73	0.0
2446	204.85	204.85	0.0
2096	204.83	204.83	0.0
1821	204.76	204.76	0.0
1801	Main Street Bridge		0.0
1766	204.77	204.77	0.0
1661	204.78	204.78	0.0

Table 27: 100-Year Floodway Water Surface Elevations, **Alternative 2** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.00	212.00	0.0
3216	205.96	205.95	0.0
2876	206.23	206.23	0.0
2446	206.37	206.37	0.0
2096	206.33	206.33	0.0
1821	206.14	206.14	0.0
1801	Main Street Bridge		0.0
1766	206.17	206.17	0.0
1661	206.20	206.20	0.0

Table 28: 10-Year Floodway Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	209.97	209.97	0.0
3216	204.72	204.72	0.0
2876	204.71	204.71	0.0
2446	204.83	204.83	0.0
2096	204.81	204.81	0.0
1843	204.77	204.77	0.0
1801	Main Street Bridge		0.0
1766	204.77	204.77	0.0
1661	204.78	204.78	0.0

Table 29: 100-Year Floodway Water Surface Elevations, **Alternative 3** Steel Beam (ft NAVD 1988)

River Station	Existing Conditions	Proposed Conditions	Increase
3891	212.00	212.00	0.0
3216	205.91	205.91	0.0
2876	206.19	206.19	0.0
2446	206.33	206.33	0.0
2096	206.29	206.29	0.0
1843	206.19	206.19	0.0
1801	Main Street Bridge		0.0
1766	206.17	206.17	0.0
1661	206.20	206.20	0.0

Qualitative Scour Assessment

A field visit was conducted to assess the condition of the Tankerhoosen River and to evaluate the potential for scour at the bridge. No scour was evident along the abutments. The Bridge Inspection Report (by Infrastructure Engineers, 11/20/2015) noted areas of degradation and aggradation of up to 1.5', however the variation is not having an effect on the substructure. The soil borings taken at the bridge indicate bedrock at or above the bottom of the channel and below the anticipated footing elevations. Depending on the proposed foundation design, scour may be a factor in determining the depth of the bridge foundation. A quantitative scour analysis will be performed during the final design phase of the project.

Conclusion

The hydraulic analysis indicates that for the 100 year profile, Alternative 1 matches the existing water surface elevations throughout the study reach. This alternative also provides the greatest clearance between the 100-year water surface elevation and the low chord and a larger hydraulic opening. Alternatives 2 and 3 have wider bridge spans relative to the existing bridge, but still match the existing water surface elevations throughout the study reach, with the exception of the 500-year event for Alternative 3. The floodway analysis for all three alternatives shows no increases (measured to 0.00') for either the 10-year or 100-year event. All three alternatives are hydraulically adequate relative to the existing condition. Given the relatively shallow depth of bedrock along with the control provided by the downstream dam, scour is not expected to be an issue. However scour may be a factor in determining the depth of the bridge foundation once a qualitative scour analysis is performed.